Best Practices for Land Degradation Control in Dryland Areas of China

PRC-GEF Partnership on Land Degradation in Dryland Ecosystems
China-Land Degradation Assessment in Drylands

China Forestry Publishing House

Editorial Board

Preface

Land degradation is a prominent ecological problem in dryland areas and a focus of many countries and international organizations. Continual worsening of land degradation in dryland areas caused not only decline of soil fertility and reduction of food production directly impacting on farmers' livelihood, but also deterioration of ecosystems threatening the foundation for human survival. Therefore, it is an obligatory responsibility of countries, international organizations and scientists to improve the ecological situation in dryland areas, to prevent land degradation and to achieve sustainable land management as soon as possible.

China has a wide distribution of dryland and land degradation is severe. Land degradation has become the key factor restraining sustainable economic and social development in dryland areas. In order to improve the ecological conditions in dryland areas, Chinese government and its people have taken many measures for ecological improvement and protection and have made tremendous achievements in land degradation prevention and control, obtaining a series of applicable experiences and techniques which have greatly contributed to ecological improvement and land degradation control in dryland areas.

While committed to ecological improvement and environment protection, Chinese government attaches great importance to strengthening international cooperation and exchange. In 2002, Chinese government established a strategic partnership with the GEF in land degradation control, i.e. China-GEF partnership on land degradation in dryland ecosystems. This was the first partnership of GEF established with a government in ecological fields. The partnership was aimed to create a multiagency, cross-sector and inter-regional integrated natural resource management system, a new approach to addressing land degradation problem from the grassroot. Therefore to stop land degradation, restore dryland ecosystems, reduce poverty, and promote sustainable development in western China and protection of global environment.

In July 2004, under the framework of the China-GEF partnership, a project of capacity building for land degradation control was formally started. The project is implemented in central government and 6 provinces (regions) of Inner Mongolia, Shaanxi, Qinghai, Gansu, Ningxia and Xinjiang. Main objectives of the project are to promote the improvement of laws, regulations and policies related to land degradation control; to strengthen the capacity of national and inter-provincial coordination; to improve provincial and county-level capacity of coordination and operation; improve the capacity of investment projects in land degradation control, establish land degradation monitoring and evaluation system to provide enabling conditions and capacity building for strengthening land degradation control.

In November 2004, the 24th meeting of GEF Council approved the project "Land Degradation Assessment in Drylands (LADA)", which selected 6 countries, i.e. China, Argentina, Senegal, Cuba, Tunis and South Africa for experiment. In January 2007, China's LADA project was formally started, aiming to develop, test and publish a set of improved, demand-based and process-driven methods for assessment of land degradation in dryland areas and to carry out a regional and global assessment of the current dryland ecosystems. By linking to the policies at national level, detailed local assessment and analyses of land degradation, particularly in fragile sites (hot spots) and sites where degradation is under control (bright spots) will be conducted in order to provide decision support to actions for land degradation control in dryland areas.

In order to strengthen cooperation and exchange among international projects, considering the common needs of the two projects, the project China-GEF partnership on land degradation in dryland ecosystems and the China LADA project decided to jointly compile the "Best practices of land degradation control in dryland areas in China" according to the format of WOCAT technical compendium, intending to summarize the successful experiences of land degradation control in China and to systematically introduce the technologies and methodologies used for land degradation in China.

The compilation of intervention models were written by over 30 experts and scholars in the fields of desertification combating, soil and water conservation, water resources, ecology etc. The models involve more than 10 subject areas, covering almost all important technical aspects of land degradation control in China, some of the models have long history of application in China and some are the combinations of traditional and modern technologies. The practices described in the proceedings are the achievements of Chinese farmers who have struggled against land degradation for long time, and also the outcomes of many experts, scholars and local practitioners through their hard working and long time explorations. As a key achievement of the China LADA project and the China-GEF partnership on land degradation in dryland ecosystems, the practices included in the proceedings will certainly make significant contribution to land degradation control and sustainable land management in China and the world.

authors

October, 2008

Contents

Left: Grass grid sand barrier. Photo by Li Chunying
Right: A close shot of the grass grid sand barrier. Photo by Li Chunying

Grass Grid Sand Barrier

Naiman Banner of Inner Mongolia, China

Use straws/stalks, weed or shrub branches to form square lattice or row shape barrier to anchor the dunes and plant trees and grass inside the grids.

The technical demonstration zone is set at Naiman Banner to cover a land area of 8124 square kilometres. The climate conditions at the zone: 6.4°C in annual mean temperature, 362mm in annual precipitation. It is a crop and livestock farming combined region, where soil suffers severe desertification, thus to undermine economic development and local living standard improvement. Therefore, combat-ing desertification is the top priority for local socio-economic development.

The objective of this technique is to fix quicksand, recover vegetation and improve ecological enronment.

The technical steps encompass: (1) set grid or row barriers made up of wheat straw or maize stalks in movable sandlot in spring or autumn. Linear barrier should be configured perpendicular to the wind direction in the sandlots where reciprocating wind or singular direction wind is prevailing; grid barrier suit large area of movable dunes with uncertain wind directions with the size in 1.5mx1.5m grid and 20cm outcropping above ground; (2) upon completion of the barrier, plant trees and grass in the grid: yellow willow (*Salix gordeivii*) 0.3m×1.5m in spacing. The cuttings should be prepared before March and stored in sand, and planted immediately after being prepared in autumn. The size of cuttings is at 40cm in length. Remove dry sand and dig a hole in a depth levelling with the surface, then cuttings are planted; and 3) due protection shall be conducted after barrier is set and trees are planted to ban the entry of outsiders and livestock. Coppicing of the yellow willow is conducted five years later. The project site enclosure may be relieved in June through October to allow pasturing according to vegetation restoration condition.

Three years after barrier constructed, the planted materials may perish into manure and vegetation is formed inside to fetch a good sand fixation effect.

Naiman Banner used this technique to control the sand in Zhanggutai and Weiliansu and achieved out-standing effect. The drifting sand control along Weiliansu road is particularly successful by using the grass grid barrier.

Location: Naiman Banner, Inner Mongolia
Technology area: 812km^2
SWC measure: Vegetation/engineering
Land use: Forest land
Climate: Sub-humid
WOCAT database reference: QT
Related approach: Combating Desertification—Organized by Government and Implemented by Households
Compiled by: Li Chunying, Inner Mongolia Forestry Department; Tian Lü, Inner Mongolia Forestry Survey and Design Institute
Date: August, 2007

Editors' comments: The technology has been used for tens of years. It is proved to be quick, effective, with good benefit but low cost, especially when dealing with tall big drifting dunes.

Classification

Land use problems

Serious harms from wind and dust storms; barren soil; low vegetation cover.

Land use	Climate	Degradation	SWC measure	
				
Forest land: *Salix gordejevii*	Sub-humid	Wind erosion	Management measure	Biological measure

Technical function/impact

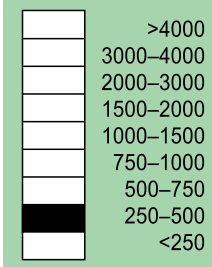
main: - fix drifting sand, prevent dune from burying grassland, farmland and infrastructure
- reduce wind erosion
- improve environmental quality

secondary: - after the stalks rots, it offers nutrition for vegetation growth

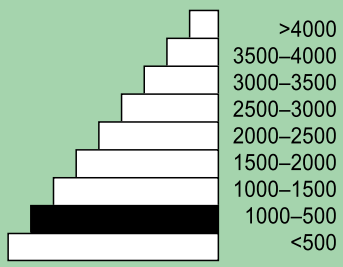
Environment

Natural Environment

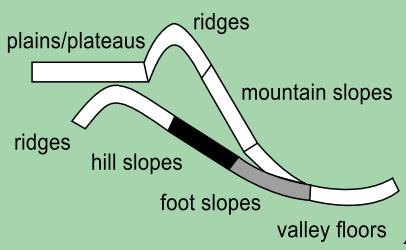
Average annual rainfall (mm)



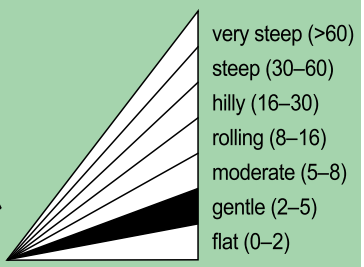
Altitude (m a.s.l.)



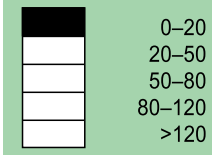
Landform



Slope (%)



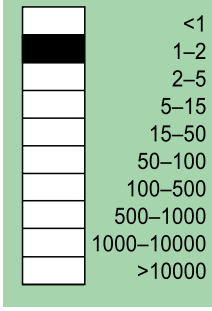
Soil depth (cm)



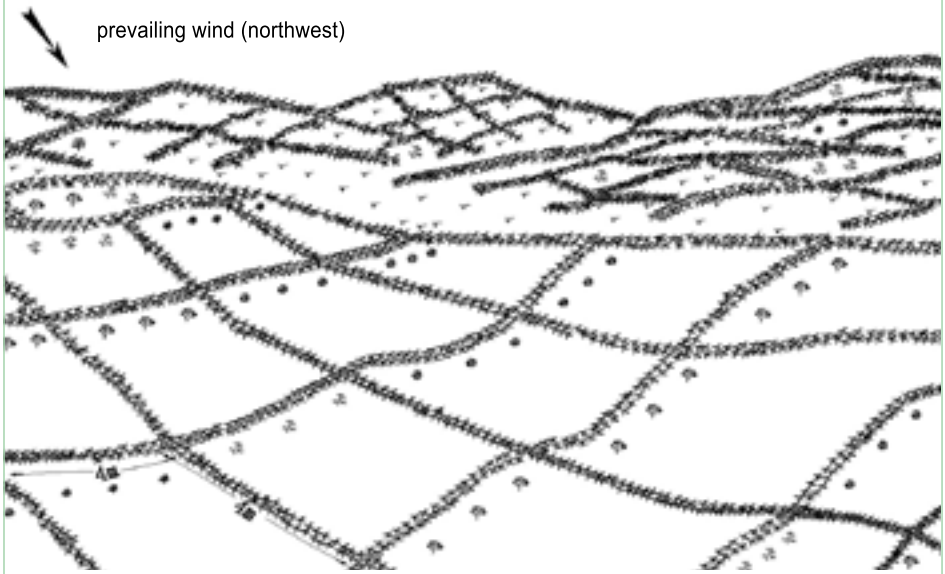
Growing season: 150 days in succession, from April to September
Soil fertility: very low
Soil texture: coarse sandy
Surface stoniness: low
Topsoil organic matter: low (<1%)
Soil drainage: good
Soil erodibility: high

Human environment

Mixed land per household (hm^2)



Land use rights: state or collective
Land ownership: collective or state
Market orientation: for self use or marketing
Level of technical knowledge required: high for technician, moderate for land users
Importance of off-farm income: 10%-50% of total income



Sketch map of mechanical barrier

Technical drawing

Bury crop stalks into sand dunes in grid form or line form as barrier, with the barrier perpendicular to main wind direction. Grid form is done generally at sites with large acreage of continuous sand dunes, depending on the intensity of sand harm. The specifications: 1.5m×1.5m, burial depth 30-40cm, the part above the ground 20-30cm. The line shape sand barrier applies to small area shifting dunes, with row spacing of 1 meter. Upon completion, planting is done inside the grid.

Drawing by Guo Huimei

Implementation activities, inputs and costs

Establishment activities

1. Planning, design and formation of operational plan.
2. Build sand barrier using wheat straw or maize stalk as burial material. Do it in direction perpendicular to main wind force and by deciding the forms in row or in grid and the specifications. Usually 40cm, 1.5m×1.5m, burial depth 30-40cm, the part above the ground 20-30cm; row spacing 1 meter for the line pattern.
3. Plant cuttings of *Salix gordejevii* at wind-facing sides (northwest), at spacing of 0.3m×1.5m, cutting length 40 cm. Planting should be done by removing the dry sand, planting hole depth approximately the height of the cuttings.

Establishment period: about one year.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
Labour	609.8	10
Equipment		
- tractor, spade	18.3	0
Materials		
- barrier material such as wheat straw, seedling	243.9	0
Agricultural		
TOTAL	872.0	7

Maintenance/recurrent activities

1. Replanting.
2. Maintaining the sand barieer.
3. Tending by special guards to avoid human or livestock damages.

Operational period: 2 years.

Maintenance/recurrent inputs and costs per hm^2 per year

Inputs	Costs (US$)	% met by land user
Labour	36.6	10
Equipment		
-tractor, motobikes, spade	18.3	0
Materials		
- barrier material such as wheat straw, seedling	36.6	0
Agricultural		
TOTAL	91.5	4

Remarks: Labor cost at US$3.7/person day; Establishment activities contain sand barrier material at US$91.5/$hm^2$, seedling at US$91.5/hm^2, exchange rate: US$ 1= RMB 8.2 Yuan (at the time when barrier is established).

Assessment

Acceptance/adoption

- The local villagers accept the technology even without incentive measures.
- State or local government's financial support is necessary if for technical extension purpose.

Benefits/costs according to land user

Benefits compared with costs	Short-term	Long-term
establishment	positive	neutral
maintenance/recurrent	positive	neutral

Impacts of the technology

Production and socio-economic benefits

+ +	Increased vegetations generate more benefits of livestock development
+ +	Improved ecological quality offers good ecological environmental for lifeand production of the local residents

Production and socio-economic benefits

	None

Socio-cultural benefits

+ +	Improve awareness of local people on ecological improvement

Socio-cultural disadvantages

	None

Ecological benefits

+ + +	Sand dunes fixation and soil conservation help restoration of vegetations
+ +	Improve ecological environment

Ecological disadvantages

	None

Off-site benefits

+	Reduce the off-site sand and dust storms outside

Off-site disadvantages

	None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Rapid sand fixation and obvious results → Combine with plant measure for even better results.	Heavy labor intensity → Extended use of mechanical method.
Easily obtainable material, low operational cost → Consider choosing more anti-corrosive and cheaper materials.	Easy rot of sand barrier material → Adopt timely biological measures to deal with drifting sandy land.

Key reference(s)

[1] State Forestry Administration. *Forestry ecological improvement and management model in western China*. Beijing: China Forestry Publishing House, 2000

[2] Inner Mongolia Autonomous Region Forestry Department. *Collection of the achievements of science and technology of Inner Mongolia forestry*, 2001

Contact person(s)

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Left: Line-type mechanical sand barrier. Photo by Ding Rong
Right: Grid-type mechanical sand barrier. Photo by Ding Rong

Combating Desertification—Organized by Government and Implemented by Households

Naiman Banner of Inner Mongolia,China

Under unified organization of local government, the farmers and herdsman implement desert control activities, while getting certain financial subsidies of government.

Mechanic barrier is a technical measure taken to anchor sand dunes by crop straw configured in grid or row patterns. This technique fits for control of high and large movable dunes and those along road and railway. Naiman Banner is located amid Horqin Desert, where tall movable dunes are broadly distributed and desertification is severe.

Major dissemination method: unified organization by Banner government; design and technical support provided by Banner forestry administration; farmers are mobilized by township government; uniform construction and maintenance is performed; seedlings and straws subsidies are provided by government; and labour force is provided by villagers. After implementation economic benefit generated and ecological compensation accrue to the land owners.

Major steps: (1) Banner government calls for a meeting to mobilize forest departments and township functionaries to dispose tasks, technology and other work; (2) township government calls for a meeting of farmers to arrange site locations and persons participating in the project; (3) Banner forestry work station implements planning and design and experts from city research institute and technical personnel from Banner forest administration organize technical training to local farmers; (4) township government organizes farmers to implement setup of the barrier and planting, while forest administration provides technical support; and (5) after completion of the project, township government will organize forest guards for sites protection and maintenance.

Funds source: 73% from Banner government, 20% from investment of Three-North Shelterbelt Programme (Phase IV), 7% provided by land users in kind of labour. Government funds and project funds are mainly used to cover cost of seedlings, straws, transport means and maintenance. Due to long distance to the site, inconvenient traffic condition, large labour intensity involved in the project, individual households are hard to complete the tasks, therefore, the method in which farmers provide labour and governments provide funds and organization has been recognized by the villagers.

Naiman Banner has adopted this method to carry out desertification control with remarkable effect, and has completed desertification control project for 13,000hm^2 since 2000. The curb desertification project along Zhanggutai and Weiliansu roads has created some models how to prevent sand encroachment the roads.

Location: Naiman Banner, Inner Mongolia
Land use: Forestr land
Climate: Sub-humid
WOCAT database reference: QA
Related technology: Grass Grid Sand Barrier
Compiled by: Tian Lü, Inner Mongolia Forestry Survey and Design Institute; Zhang Chunmin, Naiman Banner Forestry Bureau
Date: August, 2007

Editors' comments: "Unified implementation under governmental organization with labor input by farmers" is a dissemination method of the project area, established according to local special conditions. This method has been recognized and adopted by majority of local villagers. It is proved to be a very effective method. In the future, with expansion of project, incentive mechanism should be introduced step by step.

Problem, objectives and constraints

Problem

- Farmers' technical knowledge of installing sand barrier is insufficient.
- Inadequate financial support.
- Serious land sandification and pasture degradation.
- Drift dune harms farmland, pasture, traffics and houses, thus leading to emergence of ecological refugees.

Objectives

- Restrain dune movement and improve ecological quality.
- Form steady project financing source.
- Raise awareness of communities in the field of ecological protection.
- Raise the capability of community in sand control and prevention.

Constraints addressed

Major	Specification	Treatment
Economic	Heavy workload and need of plenty of manpower, material and financial resources. The project area is featured by poor economy and communication conditions, and local people's life is hard.	Increase government inputs on ecological improvement for sandy area.
Minor	**Specification**	**Treatment**
Social	Sandy area management is concerned with various sectors, including agriculture, animal husbandry as well as local residents, so unified organization and coordination are necessary.	Establish coordination mechanism of equal participation of stakeholders.

Participation and decision making

Target groups


Decision maker


Land user


Designer


SWC expert

Approach costs met by

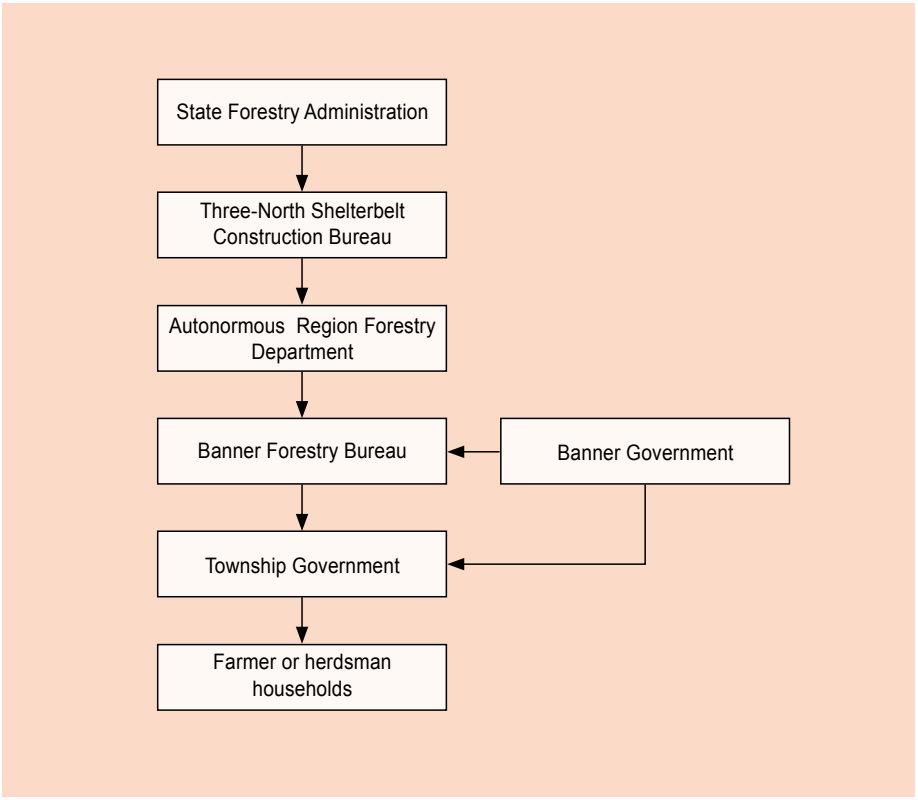
Farmer	7%
Government	93%
TOTAL	100%

Decisions on choice of the technology: Banner government.
Decisions on method of implementing the technology: Banner forestry bureau.
Approach designed by: Technicians of the Banner forestry bureau.

Community involvement

Phase	Involvement	Activities
Initiation	Interaction	Convene mobilization meeting of villagers to discuss and make decision.
Planning	Interaction	Organize discussions on the spot to identify solution, and technicians make site check, measure and prepare work plans.
Implementation	Active	Conduct site training courses on operational technology for the local people, and organize them establishing sand barrier and forest.
Monitoring/evaluation	Passive	Set fixed spot for monitoring to check sand barrier (sampling method), vegetation growth and sand fixation. Villagers may offer some observation data.
Research	No	No participation.

Differences in participation of men and women: Due to the heavy labour requirement, there is less female participation.



Organogram

The financial and work plan of the Three-North Shelterbelt Programme is issued by the State Forestry Administration and delivered at lower level forestry sectors.

Extension and promotion

Training: Training content: basic knowledge of sand barrier installation, e.g. specifications, burial depth, material and required quantity; Training method: explanation and demonstration in the field; The training results are good for trainees that actually execute the operations.

Extension: Professionals of Banner Forestry Bureau go to villages to conduct training on the main topics.

Research: Work stations of the Banner Forestry Bureau conduct studies on the protection benefits generated by mechanical sand barrier.

Importance of land use rights: The desertified land is barren having no direct economic income, nevertheless all the land owners accept the technology. The land use right and ownership rights do not affect the technology application.

Incentive mechanism

Labour: The labour is not paid.

Inputs: Costs of seedling, crop straw, vehicles, maintenance are covered by central and banner government while labor force by local villagers.

Credit: The bank offers micro-loans.

Support of local institutions: The implementation gained reputation of forestry department among local people, increased attention of autonomous region government and central government to the banner forestry bureau; technical ability of Banner forestry Bureau is improved.

Long-term impact of incentives: This is an ecological project, with little economic benefits. The current incentive policy does not facilitate the sustainable use of the technology from long-term point of view.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Measure vegetation coverage, areas of drift/fixed/semi-fixed dunes, study by comparison changes before and after the operation.
Technical	Sand barrier specifications, burial depth and material quality.
Socio-cultural	Survey by questionnaire the awareness of local residents of sandification prevention and views on this technology.
Economic/production	Vegetation restoration, economic benefits of the farming and animal husbandry after project implemented.
Area treated	Survey of treated area, and its error should not exceed 10% compared with planned area.
No. of land users involved	Survey the number of land users and changes of land user structure.
Management of approach	Autonomous region and city authorities are responsible for the survey and interview with local residents. Questionnaire will be made with banner governments, township governments and forestry sector.

Impacts of the approach

Changes as result of monitoring and evaluation: This technology is executed under leadership of banner government and assistance of Three-North Shelterbelts Programme. The intensity of management and villager participation has increased, and the effect is better compared with the past practices.

Improved soil and water management: Shift sand gets is fixed and vegetation is restored.

Adoption of the approach by other projects/land users: This method has been accepted by adjacent areas.

Sustainability: Those with long-term land use right would adopt the technology without long term support. Other types of land users feel hard to keep sustainable application of the technology without government support.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Strong willingness of villagers to participate in project has solved problem of labour supply → Improve the economic subsidy mechanism.	Land use right has impact on farmers enthusiasm → Implement long-term land contracting system.
Easy technological extension and good results of sand control → Combination with development to strengthen effect.	No direct economic benefit of technology → Research on measures on reasonable resource use.

Key reference(s)

[1] State Forestry Administration. *Forestry ecological improvements and management models in Western China*. Beijing: China Forestry Publication House, 2000

[2] Forestry Department of Inner Mongolia Autonomous Region. *Collection of the Achievements of Science and Technology of Forestry in Inner Mongolia*. 2001

Contact person(s)

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Left: High vertical living sand barrier. Photo by Yang Zihui
Right: Sand accumulation function of high vertical living sand barrier. Photo by Yang Zihui

High Vertical Living Sand Barriers

Jiuquan City of Gansu Province, China

High vertical living barrier is a protective barrier set in the wind and sand stricken areas. The barrier with certain height and penetrability is made up of growing plants suitable for dry and sandy conditions to alleviate the wind and sand drifting speed through the rows of plants, and finally piling up the drifting sand. It is an effective sand fixation approach to protect infrastructure from being ravaged.

Vast deserts are distributed in north China where soil is seriously desertified. The railway service has experienced frequent suspensions in Qingshui section of Lanzhou-Xinjiang railway line suffering immense economic losses. In 1980s, the railway department raised funds to construct high vertical living barrier with technical support provided by Gansu Desert Control Research Institute. Since its operation, the project has played an important role in intercepting sand encroachment and protection of normal operation of railway service.

The high vertical living barrier is set in a strip formation in the areas where wind and desert hazard is severe. 2-4 belts of windbreak are proper for the seriously affected areas and 1-2 belts are suitable for lightly affected places. Specifically, the first belt of windbreak should be planted perpendicular to the wind direction about 200m to the rail tracks to be protected at the windward side. Further, windbreaks should be planted in 20m intervals to total 2-4 belts in parallel with the first one. Calligonum klementzii, Haloxylon ammodendron, Salix psammophila, etc. may be planted. 25cm or longer cuttings, or one year old seedlings in 30cm are proper for the plantation of Calligonum and Salix psammophila; one year old seedlings of 30cm in length suits planting of Haloxylon ammodendron. Initial density should be kept in 10-12 trees/m. After tree planted, drip irrigation or other types of irrigation shall be applied in low moisture dunes to facilitate survival of the plants.

High vertical living barrier per hectare cost are: Seedling US$150; Labour US$450; Irrigation equipment US$160, and totally US$760.

Wind and drift sand speed is reduced gradually while passing through belts of windbreaks to retain in the proximity of the barrier and gradually retard the encroachment of desert and the drift sand movement along with growth of the plants. These types of barrier is able to anchor local drift sand and retain the sands blown in from other sources to convert scattered movable little dunes or drift sand into big dunes or form “barrier dam” and sand hill to mitigate dune movement speed and serve the purpose of gathering drift sand.

In the areas with annual rainfall over 150mm, high vertical living barrier may have continuous sand retaining function. This technology is broadly used in desert control for railway and highway and regarded as a sand capture and fixation technology featuring less investment and long-term benefit. Supplementary planting and maintenance should be timely conducted in case of dead trees found. When trees grow up, thinning and trimming should be conducted to maintain 20% penetrability. In dry seasons, water the trees to keep proper moisture. Annual maintenance cost is estimated at US$175 per hm^2.

Location: Jiuquan city, Gansu Province
Technology area: 25km^2
SWC measure: Vegetation measure
Land use: Others
Climate: Arid
WOCAT database reference: QT
Related approach: Researcher-Enterprise Cooperation to Control Desert Harm to Railway by Using Living Barriers
Compiled by: Yang Zihui, and Zhao Ming, Gansu Desert Control Research Institute
Date: August, 2007

Editors’ comments: This technology of high vertical living barrier, featuring satisfactory results, helps to gather sand to form big sand pileups. Accordingly it slows down the drift of sand. As an economical and practical technology of protecting main road, oasis farmland, it deserves extension in similar areas of the world.

Classification

Land use problems

The drifting sand buries the railway.

Land use	Climate	Degradation	SWC measure
			
Calligonum mongolicum, *Haloxylon ammodendron* etc	Arid	Wind erosion	Vegetation measure

Technical function/impact

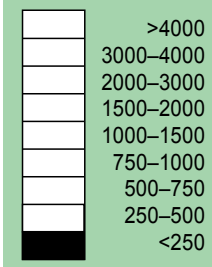
main: - gather the sand and prevent it from moving
- lowing the wind speed

secondary: - add vegetation cover

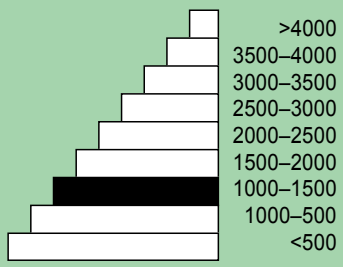
Environment

Natural Environment

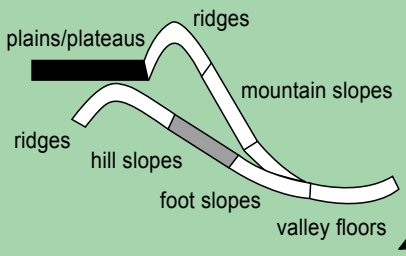
Average annual rainfall (mm)



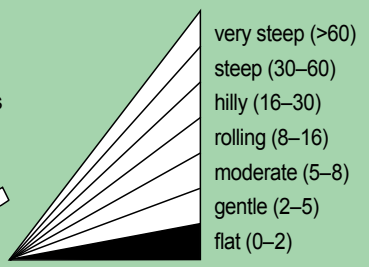
Altitude (m a.s.l.)



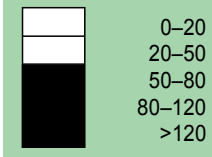
Landform



Slope (%)



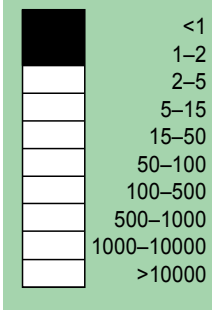
Soil depth (cm)



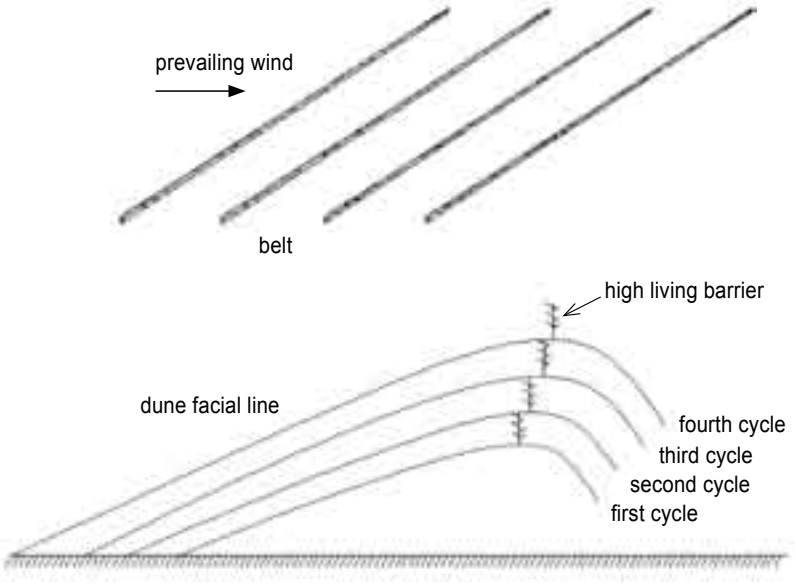
Growing season: 185 days in succession, from April to October
Soil fertility: low
Soil texture: coarse sandy
Surface stoniness: moderate, with intense sand grain
Topsoil organic matter: low (<1%)
Soil drainage: good
Soil erodibility: very high

Human environment

Mixed land per household (hm^2)



Land use rights: collective
Land ownership: state
Market orientation: mixed
Level of technical knowledge required: moderate for extensionists but low for land users
Importance of off-farm income: 10%-50% of the total income



Profile of high vertical barrier planted on line-shaped sand accumulating dunes

Technical drawing

Select suitable plant species and determine row spacing and specifica-tions according to drift sand condition, especially drift intensity, and to form a high vertical barrier.

Drawing by Guo Shujiang

Implementation activities, inputs and costs

Establishment activities

1. High vertical live sand barrier is built in spring.
2. Laying out. On drift sand site, draw straight line perpendicular to the prevailing wind direction for afforestation, at the span of about 20m.
3. Afforestation. Select cuttings of C. *klementzii* (more than 20cm in length and over 0.8 cm in diameter, one year growth branch) and one year seedlings of *Haloxylon ammodendron* for planting, with plant space 10 cm or more. The propotion between C. *klementzii* and *Haloxylon ammodendron* is 10:1.
4. Watering. Watering of one time is necessary when the soil moisture is low at the planting time.

Establishment time: 2 years.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
Labour	450	100
Equipment		
- mainly for irrigation: bucket, spade, water vehicle, dripping irrigation equipment etc.	160	100
Materials		
- Seedlings and clonal cuttings etc. Agricultural	150	100
TOTAL	660	100

Maintenance/recurrent activities

1. Check the plant survival condition in the spring following the establishment of the plant barrier, conduct replanting to the unplanted or dead. When replanting the high quality one year old big seedling should be adopted and the dead one should be removed. Seedlings should be used for *C. klementzii*.
2. The live sand barrier built should be looked after by specialized people to avoid damages of domestic animals.
3. At the planting year and in the following years, irrigate the plants when the sandy soil moisture content is low.

Maintenance/recurrent inputs and costs per hm^2 per year

Inputs	Costs (US$)	% met by land user
Labour	100	100
Equipment		
- mainly for irrigation: bucket, spade, water vehicle, dripping irrigation equipment etc.	60	100
Materials		
- seedlings	15	100
Agricultural		
TOTAL	175	100

Remarks: none.

Assessment

Acceptance/adoption

- If economic incentive is available, more householders would accept the technology.
- Without economic subsidy, less people adopt the technology, and those that accept are the households directly suffered from drift sand.
- The future tendency is that the technology is to be adopted for sand dust storm treatment of the main road, oasis in which the local government and the transportation sector shall cofinance with householder participation.

Benefits/costs according to land user

Benefit the land users both ecologically and economically.

Benefits compared with costs	Short-term	Long-term
establishment	very positive	very positive
maintenance/recurrent	very positive	very positive

Impacts of the technology

Production and socio-economic benefits

+ + +	Prevent sand burying road and other facilities
+ +	Improve local industrial and agricultural production conditions

Production and socio-economic disadvantages

None

Socio-cultural benefits

+ +	Raise farmers' awareness of sand fixation

Socio-cultural disadvantages

None

Ecological benefits

+ + +	Fix drift sand
+ + +	Reduce ground wind speed
+ +	Add vegetation cover of the sand area

Ecological disadvantages

– None

Off-site benefits

+ + +	Fix drift sand, reduce wind speed, protect farmland and other facilities

Off-site disadvantages

None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Control drift sand burying road and facilities → Combine with mechanical measure.	Consume dune moisture → Use reasonable plant density and management measures.
Reduce wind speed and improve production condition → Combine with shelterbelt forest construction.	
Raise vegetation cover and improve ecological condition → Continue to extend application of this technology.	

Key reference(s)

[1] Dong Zhi, Li Hongli, Hu Chunyuan, Zuo Hejun. *Benefit and cost comparative study of wind breaking and sand fixation benefits to the desert highway by different measures*, the *Journal of Soil and Water Conservation*, 2006

[2] Cao Bo, Sun Baoping, Gao Yong, etc. *Wind breaking benefit of High vertical Salix psammophlla barriers*. *Chinese Soil and Water Conservation Science*, 2007

[3] Gansu Minqin Desert Control Experimental Station. *Gansu Desert and the Control*. LanZhou: Gansu People's Press, 1974

Contact person(s)

Yang Zihui, Gansu Desert Control Research Institute. Tel: 13993539746. Email: zihyang@126.com

Left: Sand fixation by high vertical sand barrier. Photo by Yang Zihui
Right: Newly established high vertical living barriers. Photo by Yang Zihui

Researcher-Enterprise Cooperation to Control Desert Harm to Railway by Using Living Barriers

Jiuquan City of Gansu Province, China

Enterprise (railway service) and scientific research institutions are in cooperation to use the research result "High Vertical Living Barrier Technology". The research institute and the railway enterprise have established a technology dissemination team to organize farmers to join the railway desert control program to maintain smooth running of railway service.

The railway service has experienced frequent suspensions in the Qingshui section of Jiuquan City of Lanzhou-Xinjiang railway line, due to trans-boundary drift sand intrusion, the railway service department has to spend substantial manpower and money to remove the sand each year. In 1990s, the railway service department raised funds to construct high vertical living barriers with technical support provided by Gansu Desert Control Research Institute. Since its operation, the project has played an important role in interception of sand encroachment and protection of normal operation of railway service.

In early 1991, Qingshui section of Lanzhou-Xinjiang railway line suffered substantial sand disaster. Lanzhou Railway Bureau asked Gansu Sand Control Research Institute for technical support to bring sand hazard in control. After negotiation, it was decided the Bureau would raise funds and the Institute provided technical service to jointly control the disaster. Desert control leadership group was set up by the Maintenance Department of Lanzhou Railway Bureau and Gansu Desert Control Research Institute, and "Qingshui Rail Section Desert Control Group" was established to involve technical personnel from Qingshui desert control work department and the Institute. The group has worked under the leadership group to carry out survey, design and planning for the desert control tasks and high vertical living sand barriers was employed for control of the sand harm. By the end of March, 1991, they got seedlings and equipment in place and conducted field training to some farmers, while technicians were explaining the technology alongside demonstrative operation. Thereafter, the farmer trainees became the trainers to more farmers to add to the skilled workers involved in the project, so that the project was rapidly completed.

Cash compensation for labour was adopted as the incentive to encourage farmers to participate. And the compensation was 760 US dollars per hectare of barriers and annual maintenance came to 175 US dollars.

High vertical living barrier has been proven of important function in anchoring local drift sand and retaining sand blown in from other locations to integrate small movable dunes into big ones or form "sand dam" and to diminish dune movement speed and gather sands. This is an effective approach to protect farmland, road and ecosystem.

Location: Jiuquan city, Gansu Province
Land use: Others
Climate: Arid
WOCAT database reference: QA
Related technology: High Vertical Living Sand Barriers
Compiled by: Yang zihui, and Zhao Ming, Gansu Desert Control Research Institute
Date: August, 2007

Editors' comments: Financed by the enterprise and technically supported by the research institute, and encouraged by cash payment, the local farmers are mobilized to install high vertical living barriers, to stabilize drift sand by gathering plenty of sand forming tall big dunes. Consequently, sand drifting slows down, and the project can play important role in protecting main roads, oasis farmland and the facilities.

Problem, objectives and constraints

Problem

- Lack of effective organization, capital fund, and the community in need of technology of high vertical live sand barrier.
- Without direct economic benefits the community's enthusiasm to participate is low.
- Drift sand goes with wind endangering farmland, village, road and channel.
- Sand dust cause environmental pollution.

Objectives

- Form a technical extension mechanism by integrating researchers and extensionists.
- Raise community participation.
- Raise community's capability in ecological protection.
- Protect farmland, road and other facilities from harms of sand storms.
- Guarantee traffic operation, increase income, improve environment condition, raise people's living standard.

Constraints addressed

Major	Specification	Treatment
Economic	Project site is located in desert are with backward economy, and farmer's input level is limited.	Form the state-locality-farmer co-financing mechanism: the state offers funds, the locality offers materials such as production tools etc, and the farmers offer paid labor.
Technical	Farmer in lack of technology to build high vertical living barrier.	By site demonstrations, training courses etc, to let the farmers learn this technology.
Minor	**Specification**	**Treatment**
Social	Farmer's enthusiasm is low due to no direct economic outcome.	Conduct training to improve farmers' awareness on ecological protection, and offer incentives.

Participation and decision making

Target groups


SWC expert


Land user


Decision maker

Approach costs met by

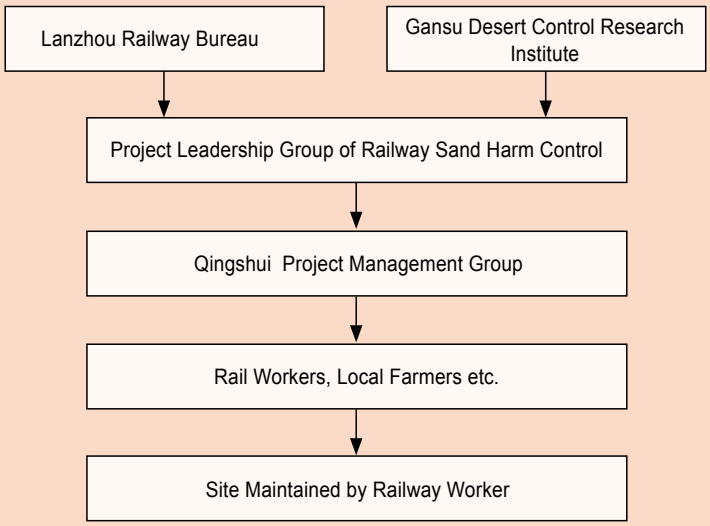
Railway management sector	100%
TOTAL	100%

Decisions on choice of the technology: This is by joint efforts of desert control experts, the railway management department, and with local farmer participation.
Decisions on method of implementing the technology: Technical route for the technology enforcement is decided by SWC experts and railway management department.
Approach designed by: Methods are designed by desert control experts along with technology extensionists.

Community involvement

Phase	Involvement	Activities
Initiation	Interaction	The farmers familiar with local conditions participate in surveying dust storm affected area, determining project scope, convening community meeting with aim at mobilizing villagers.
Planning	Interaction	Sand control experts with technological extensionists design operational plan, while the railway department should raise capital funds and the community farmers should participate by offering labor force.
Implementation	Payment/incentive	Farmers work to build and maintain the high vertical sand barriers.
Monitoring/evaluation		
Research		

Differences in participation of men and women: Done mainly by male labor.



Organogram

The railway department and research unit set up together the railway sand harm project leadership group, with subgroups of Qingshui railway project group of sand control for railway comprising technicians of railway and sand control experts from the research institute. The Qingshui project group will mobilize farmers by technical training and to organize the farmers for installation of high vertical living sand barrier. Upon completion, the railway department will be responsible for maintenance of project area.

Extension and promotion

Training: By lectures and site demos, the training covers the operational procedures; trainees are the staff of railway department and the farmers. Training result is good.

Extension: Railway department offers funds, the research unit offers technology, farmers offer labor. The railway department and the research unit form a unified Technological Extension Group. The extension result is satisfactory.

Research: The organization of the research is the Sand Control Experimental Station, and the research on installation technology improvement and method optimization.

Importance of land use rights: Land use right and ownership of land are all in collective forms (railway department). Due to the fact that no direct economic benefits are available to farmers, the extension performance is affected. With cash incentives, the farmers will actively participate.

Incentives

Labour: Labor is paid, at US$ 5 per work day.

Inputs: This method needs inputs of tractor, watering utilities, spade etc., transport fuel should be subsidized, simple tools can be supplied by farmers.

Credit: Loan is not necessary.

Support of local institutions: The project brings to local government projects to combat desertification and central government or international community may provide inputs. It will promote capacity building of local forestry sectors (through training and project management etc.).

Long-term impact of incentives: From a long period viewpoint, the function of incentive mechanism is positive, by encouraging more householders' participation. In case of no incentive mechanism, land users may continue this technology, because drift sand endangers farmland and facilities.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Site measure dune moisture after the fixation, survival and growth of the plants etc.
Technical	Observe conditions of drift sand fixation.
Socio-cultural	Site visit to farmers to understand their thoughts regarding fixing drift sand.
Economic/production	No direct benefits.
Area treated	Measure the area of forest, road etc that adopted this technology.
No. of land users involved	
Management of approach	Periodic monitoring and evaluation of the treatment benefits.

Impacts of the approach

Changes as result of monitoring and evaluation: No change.

Improved soil and water management: Drift sand accumulates and becomes stable.

Adoption of the approach by other projects/land users: Very windy sites adopt this technology to build shelter belt forest to guarantee normal traffic operation; the technology helps improve ecological environment of oasis and prevent wind harms at oasis.

Sustainability: With support of departments of railway and high way, the technology can be used sustainably.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Railway department and researchers work together, to transfer research accomplishment into productivity → To further raise the performance of cooperative technical extension.	Low farmer participation level → Reinforce the education of farmers in protecting environment.
Easy operation and low technical requirement to workers → Reinforce farmers' recognition of drift sand fixation.	Collective land use right affects the technical application → Education to farmers regarding caring of public welfare.
	Underdeveloped technical extension system → Reinforce organizational capability construction, and improve the transformation performance of technological achievement.

Key reference(s)

Gansu Minqin Desert Control Experimental Station. *Gansu desert and the control*. Lanzhou: Gansu People's Press, 1974

Contact person(s)

Yang Zihui, Gansu Desert Control Research Institute. Tel: 19993539746. Email: zihyang@126.com

Left: Young forest formed on sandyland through aerial seeding. Photo by Ding Rong
Right: Vegetation restored through aerial seedling. Photo by LÜ Wei

Vegetation Establishment by Aerial Seeding

Dalate Banner of Inner Mongolia,China

Airplanes loaded with tree/herbage seeds fly over the planting site for aerial seeding in the sandlot relying on natural wind to have the seeds covered and precipitation to water the seeds for germination, rooting and growth to restore vegetation.

The project site is located in Kubuqi Desert in the western part of Dalate Banner, south of Hetao Irrigated Plain and north of Mu Us Desert. Mobile and semi-mobile dunes dominate the region in linear and crescent dunes as main types. The site has 300mm annual rainfall, continental climate, aeolian soil, saline meadow soil and light saline soil, etc. *Artemisia ordosica, Hedysarum mongolicum, Artemisia desterorum Spreng, Caragana korshinskii Kom, Calligonum mongolicum*, most of which are of drought and saline soil tolerant plants.

Aerial seeding features rapid, highly efficient, low cost and large area planting to allow vegetation restoration so that it is the leading technological method adopted by Dalate Banner in the National forest Protection Project. This technology aims at increasing forest and herbage vegetation, retarding wind and sand harm, improving local and surrounding ecological conditions.

Technology implementation procedures: (1) Selection of seeding area – hard-accessed desert sites in continuum with wide inter-dune slopes suitable for forestation. The site should be at least 330 hm^2, with the area suitable for aerial seeding representing at least 70% of the total site, relative altitude < 15m being < 10% of the seeding area, vegetation cover 5%-10%, groundwater depth 3-5m, annual mean precipitation about 300mm and dune density below 0.6. (2) Seed selection – Psammophilous plants featuring natural surface coverage, high degree of rooting and stability, strong water absorption, fast sprouting, rapid rooting, and high utilization. Main species include Artemisia sphaerocephala Krasch, *Astragalus huangheensis, Hedysarum mongolicum, Hedysarum scoparium* Eisch.et Mey, *Melilotus suaveolens* Ledeb, etc. (3) Seeding operation – manned signal navigation or GPS navigation should be adopted in accordance with local conditions and crew technical skills. (4) Sowing volume, width and flight altitude – the seeding direction should be identical to prevailing wind and west-east course should be avoided to the maximal practical extent. The seeding length should be determined per the number of belts completed under max seed capacity of the plane and the seeding width shall not be less than 70% of the specification designed. Seeding width should be kept in 50-100m according to flight altitude. Unit area seed quantity should not be less than 50% of the design and the position accuracy should be greater than 85%. To maintain uniform seeding and diminish missing out, there should be 15% overlapping areas in between two belts. (5) Site maintenance tending – after seeding, fence should be built to ban the entry of unrelated persons and animals.

This project features good ecological and economic benefits. As shown in observation, the site vegetation coverage is increased by 20% on average and dunes are basically anchored and ecosystem in gradually recovery. Seven years after the aerial seeding, coppicing harvest can be made and pasture may resume to proper utilization.

Location: Dalate Banner, Inner Mongolia
Technology area: 2660 hm^2.
SWC measure: Vegetation measure
Land use: Sandy land
Climate: Semi-arid
WOCAT database reference: QT
Related approach: Aerial Seeding Afforestation Supported by Natural Forest Protection Programme
Compiled by: Liu Zhanhai, Dalate Banner Forestry Bureau of Inner Mongolia; Tian LÜ, Inner Mongolia Forestry Survey and Design Institute
Date: September, 2007

Editors' comments: In the ecological fragile semi-arid sandy dust areas, aerial seeding afforestation and vegetation regeneration is a quick and cost effective vegetation restoration technology suitable for large area operation. This technology is suitable for sandy areas with annual precipitation over 300 mm, and has now been extended in areas with suitable conditions in China.

Classification

Land use problems

Severe wind erosion and sandification; low vegetation cover and in degradation. barren soil.

Land use | **Climate** | **Degradation** | **SWC measure**

Forest | Grazing | Semi-arid | Wind erosion | Biological measure

Technical function/impact

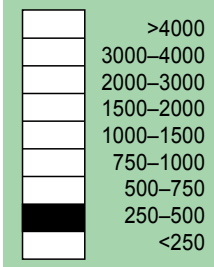
main: - restore vegetation quickly
- fix drift sand
- add vegetation cover

secondary: - improve soil fertility
- reduce wind velocity

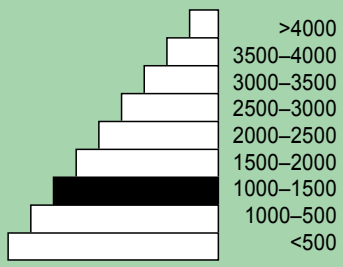
Environment

Natural Environment

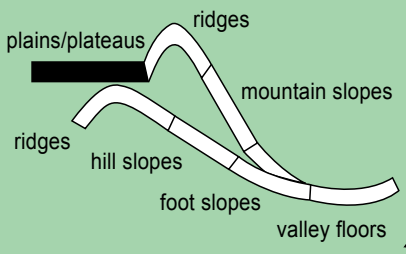
Average annual rainfall (mm)



Altitude (m a.s.l.)

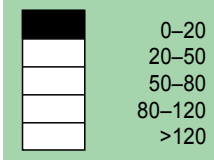


Landform



Slope (%)

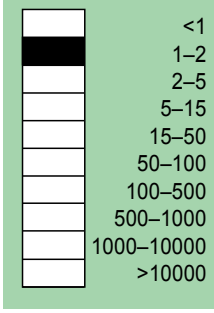
Soil depth (cm)



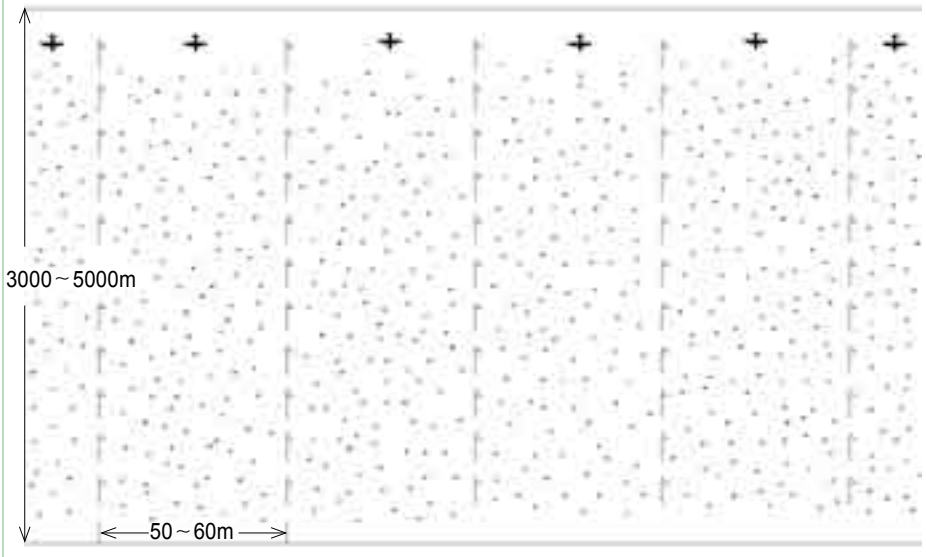
Growing season: 150 days in succession, from April to September
Soil fertility: low
Soil texture: coarse sandy
Surface stoniness: moderate
Topsoil organic matter: low
Soil drainage: moderate
Soil erodibility: high

Human environment

Mixed land per household (hm^2)



Land use rights: collectives or individuals
Land ownership: the state or collectives
Market orientation: mixed
Level of technical knowledge required: high to the technical extensionists and moderate to land user
Importance of off-farm income: 10%-50% of total income



Aerial seeding vegetation establishment on sandy land

Technical drawing

Flight height: 70-80m;

Flight width: 50-100m;

Dune density of the sowing area: <0.6;

The sowing direction complies with the local dominant wind direction.

Drawing by Guo Huimei

Implementation activities, inputs and costs

Establishment activities

1. Planning design. Finalize the seed sowing area location and determine the seed ratio.
2. Seed preparation. Seeds of *Hedysarum mongolicum, Hedysarum scoparium*, *Astragalus adsurgens*, and *Artemisia sphaerocephala*, 1500g/hm^2 for each species; *Caragana korshinskii* 7500g/hm^2, mixing with multi-effect compound dose to repel pests and retain moisture.
3. Airplane operations. Plan the flight route on topography map of the scale 10000:1, marking geographical locations. When flying, route signs and sample plots should be installed, for airplane to follow course accurately and examine sowing uniformity.
4. Flight time. From end May to early June.
5. Man assisted seed covering.

Establishment time: 1 year.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
Labour	18.3	0
Equipment		
- airplane rental, field vehicles	36.7	0
Materials		
- coated seeds	36.7	0
Agricultural		
TOTAL	91.7	0

Maintenance/recurrent activities

1. Reseeding.
2. Site closure for protection. After seed broadcasting, the sowed area should be enclosed for 5 years, and special people be arranged to carry out tending, planting, transplanting the dense growth to the sparse growth to guarantee afforestation survival rate.

Establishment time: 4 years.

Maintenance/recurrent inputs and costs per hm^2 per year

Inputs	Costs (US$)	% met by land user
Labour	6.1	0
Equipment	9.1	0
Materials	9.1	0
Agricultural		
TOTAL	24.3	0

Remarks: labor price at US$3.7/person day, exchange rate at establishment: US$1= RMB8.2yuan.

Assessment

Acceptance/adoption

- This technology is implemented by professionals, with little farmer/herdsman participation.
- The project area is located at remote sandyland with low population, so they hold neutral attitude to the technology.

Benefits/costs according to land user	Benefits compared with costs	Short-term	Long-term
	establishment	neutral	very positive
	maintenance/recurrent	neutral	very positve

Impacts of the technology

Production and socio-economic benefits

++	Improve pasture quality and production
++	Protect farmland and pasture
++	Improve farmer and herdsman's production and living environment

Production and socio-economic disadvantages

−	Some negative impact on livestock grazing in short-term

Socio-cultural benefits

++	Improve local people's recognition and activity to airplane assisted afforestation for sand control

Socio-cultural disadvantages

	None

Ecological benefits

+++	Sandland vegetation recovered and vegetation cover added
+++	Control shift sand and reduce wind and sand disasters

Ecological disadvantages

	None

Off-site benefits

++	Protection and shelter role to the neighboring farmland, pasture, and houses from the sand disasters

Off-site disadvantages

	None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Larger operational coverage and high work efficiency → Further extension to suitable areas.	Easy germination above the ground after seed sowing → After broadcast put sheep flock to the operational area to bury seed by sheep stepping; or make seed into pellet.
The effect of vegetation recovery is notable → Reinforced artificial supplementary measures.	Sowed seeds and seedlings vulnerable to damages by birds, rats, and rabbits → Mix seed with animal repellent to avoid these damages.
Add biodiversity → Research on forest-herbage mixed planting to establish steady vegetation community.	Airplane flight easy to be affected by weather conditions → Communication with meteorological stations to select scientifically the flight and broadcast dates.

Key reference(s)

[1] Desertification Prevention and Control Management Center of the State Forestry Administration. *Practical Technologies and Pattern for Sand Control in China*. Beijing: China Environment Science Press, 2001

[2] *China National Standard of Aerial Afforestation Technical Standard*. By China National Administration of Quality Supervision and Inspection, and China National Standard Management Committee, 2005

Contact person(s)

Tian LÜ, Inner Mongolia Forestry Survey and Design Institute. Tel: 0471-5953487. Email: tianlv001@sina.com

Left: A camp for the aerial seed-sowing afforestation. Photo by Ding Rong
Right: Aerial seeding afforestation in operations. Photo by Liu Zhanhai

Aerial Seeding Afforestation Supported by Natural Forest Protection Programme

Dalate Banner, Inner Mongolia, China

Professional aerial seeding team is hired for afforestation operation to quicken the forest vegetation recovery and ecological improvement based on the National Natural Forest Protection Project implementation.

As one of the aerial seeding project sites, the western part of Kubuqi Desert has vast desertified land, severe wind erosion and inconvenient traffic conditions so that large scale artificial afforestation is hard to implement. Aerial seeding operation is the most effective way for afforestation in this region. The aerial seeding in this project site started in 1950s and has obtained satisfactory results. The operation has been continuously improved. The implementation of the National Natural Forest Protection Project has provided a great space for aerial seeding technology utilization and promoted the improvement of aerial seeding organization management and advancement of seeding technology.

Natural Forest Projection Project is one of national key forestry projects for restoration of natural forest vegetation by means of reducing site disturbance and using artificial measures. The state funded the project for natural forest maintenance and created employment for redundant workers. RMB750 per hectare was invested from the national treasury for project site, while aerial seeding afforestation is the main task under the project.

Operation procedures: (1) The State Administration of Forestry assigned aerial seeding tasks to the region and the tasks were broken down to banner/county forestry departments. (2) Banner forestry departments are responsible for planning and implementation of seeding site and technical steps. (3) Town governments sign contract with farmers and provide funds for aerial seeding and the farmers are responsible for maintenance tending. The ecological compensation and income from coppicing harvest will accrue to the farmers; (4) Banner forestry departments organize professionals and rent planes to carry out aerial seeding operation. (5) Banner forestry departments organize experts to assess the seeding results.

Based on the national project implementation, aerial seeding technology is scaled up and remarkable advantage and effect have been achieved. In recent years, aerial seeding afforestation areas are equivalent to the sums of the previous decades. The current state investment of RMB750 yuan per hectare is several times as much as that in the past. The ecological benefit and compensation policy have greatly encouraged local farmers, and the ecological compensation policy of public-purpose forest will further improve and advance this technology implementation.

In the technology dissemination there are some problems. At present, there are fewer regions in favorable conditions for aerial seeding, so that we should advance the project in more remote and large deserts, and the technological extension shall require additional investment and cost.

Location: Dalate Banner, Inner Mongolia
Land use: Sandy land
Climate: Semi-arid
WOCAT database reference: QA
Related technology: Vegetation Establishment by Aerial Seeding
Compiled by: Tian LÜ, Inner Mongolia Forestry Survey and Design Institute; Liu Zhanhai, Dalate Banner Forestry Bureau of Inner Mongolia
Date: September, 2007

Editors' comments: Based on the National Natural Forest Protection Program, the aerial seed broadcast afforestation technology has been effectively and steadily extended. The farmers and herdsmen are satisfactory with the technology, and the capability of forestry department has been improved. This is a technology effective in restoring vegetation on large scale in the sandland areas and it deserves application with similar conditions and demands.

Problem, objectives and constraints

Problem

- Project area is far away from residential area, with inconvenient traffic making artificial afforestation very difficult.
- Lack of funds for technical extension.
- Lack of effective organization.

Objectives

- Form effective technology extension mechanism.
- Raise householder participation.
- Establish steady channel of technology financing.

Constraints addressed

Major	Specification	Treatment
Technical	Households in lack of SWC knowledge and technology, including using airplane for afforestation.	Forestry department and technicians offer support.
Economic	Land users short of fund for treating degraded land.	Increase state financing, make efforts to obtain financing form all sources including international donors.
Minor	**Specification**	**Treatment**
Orgnizaional management	Inadequate publicity.	Forestry department organize training sessions by site demonstrations.

Participation and decision making

Target groups


Planner


Decision maker


Land user

Approach costs met by:

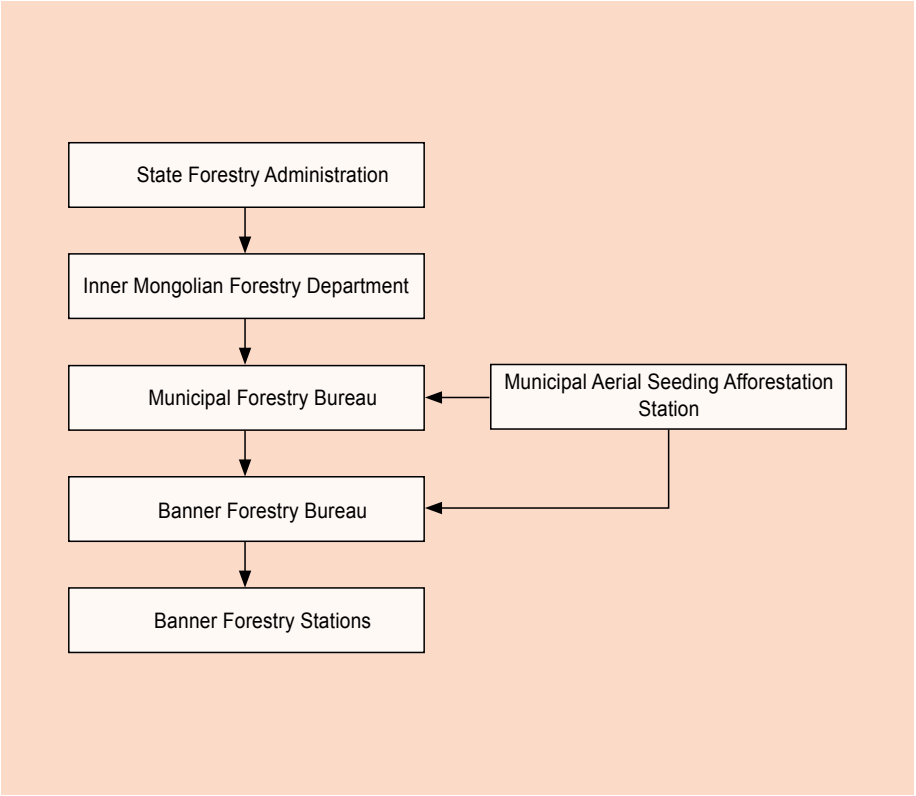
State	100%
TOTAL	100%

Decisions on choice of the technology: Datlate Banner Forestry Department.
Decisions on method of implementing the technology: Dalate Banner Forestry Department.
Approach designed by: Forestry experts of Erdos Municipal Aerial Seeding Afforestation Station.

Community involvement

Phase	Involvement	Activities
Initiation	Interactive	Town government informs householders of the aerial seeding afforestation policies, has consultation with them by signing implementation and maintenance agreement.
Planning	Interactive	Householders identify their land plots in the project area.
Implementation	Not involved	
Monitoring/evaluation	Not involved	
Research	Not involved	

Differences in participation of men and women: Both men and women participate in the project, but mainly by men.



Organogram

The financial and work plan of the Three-North Shelterbelt Programme is issued by the State Forestry Administration and delivered at lower level forestry sectors.

Extension and promotion

Training: By experiment and demonstration as well as holding training courses, the farmers and herdsmen are informed of the importance of aerial seeding afforestation and maintenance tending. The training effect is good.

Extension: Technology extension is done by forestry departments, in forms of establishing demonstration areas, site teaching etc. The related topics are technology of coated seed, tree and herbage mixing ratio, and planning of flight direction and speed, etc.

Research: Undertaken by Erdos Municipal Aerial Seeding Afforestation Station and Dalate Forestry Work Station, on topics of airplane flight altitude for afforestation seed broadcasting, flight speed impact on afforestation effect, etc..

Importance of land use rights: The project areas land use rights belong to farmers and herdsmen. Usually these areas are far away from residential sites and the land is barren with low utilization value, thus farmers and herdsmen hold positive attitude to state investment to improve land situation. The land rights have little impact on the technological extension.

Incentive mechanism

Labour: The implementation mainly involves participation of Banner Forestry Work Station technicians that are on the payroll of the government.

Inputs: Seeds, seed coating materials, and airplane rental; all costs are covered by the state.

Credit: No loan is used.

Support of local institutions: Technical application raised local farmer and herdsmen's recognition to the forestry department, and promoted the technical capability of the forestry departments and staff.

Long-term impact of incentives: The long-term impact of the project incentive mechanism is negligible, because the technology application is mainly driven by policies and laws.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Improvement of grass quality and production, increase of vegetation cover. Calculated based on site measurement.
Technical	Aerial seeding afforestation technology, sowing width, flight height, seed use quantity.
Socio-cultural	Improvement of local farmer and herdsman's knowledge of desertification treatment. By questionnaire.
Economic/production	No economic profit in short-term.
Area treated	Satellite remote sensing to help with monitoring acreage of the treated area and its vegetation condition.
No. of land users involved	Inventory based on investigation to understand land user quantity and its structural changes.
Management of approach	Directly managed by the regional and municipal forestry bureaus.

Impacts of the approach

Changes as result of monitoring and evaluation: The implementation of key national programs attracted attention of the government and the society to the project technology. The previous unitary participation of forestry department alone changed gradually into multiple participation with governmental mobilization plus participation of the meteorological, agricultural sectors.

Improved soil and water management: The enforcement of the technology helps fixing drift sand, increasing vegetation cover and raise land productivity.

Adoption of the approach by other projects/land users: This technology has been adopted in areas suitable for aerial seedling afforestation.

Sustainability: With project policy and finance support for long-term, the sustainability is guaranteed. Otherwise it would be difficult.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Top-down extension mechanism is highly efficient → To continue to adopt policy and administrative means to emphasize adoption of this technology wherever the conditions are suitable.	Community participation level is low → Application of participatory approach for involving more farmers.
Economical use of labor and the efficiency is high → To further improve the technology by studying the disposition of tree species and optimal ratio of seed sowing.	

Key reference(s)

[1] Desertification Prevention and Control Management Center of the State Forestry Administration. *Practical Technologies and Pattern for Sand Control in China*. Beijing: China Environment Science Press, 2001

[2] *China national standard of aerial seedling afforestation*. By China National Administration of Quality Supervision and Inspection, and China National Standard Management Committee, 2005

Contact person(s)

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Left: Sand control system built alongside the railway by following the principle of "sand fixation with sand control measures". Photo by George Casey (USA)'
Right: Semi-hidden wheat straw grid barrier sized 1m×1m at drifting dune site, with planted drought-tolerant bushes planted at inside. Photo by Li Xiaobao.

Sandy Land Management for Protecting Railway

Shapotou of Ningxia, China

In accordance with principle "anchoring-centered and anchoring and impedance combined", railway desert control technical system is established with combination of mechanic and biological measures.

The demonstration zone is situated in Shapotou of Zhouwei City, Ningxia Autonomous Region. There are 186.2mm in rainfall, wind erosion and sand encroachment to the land resulting in soil degradation, and no groundwater available for irrigating vegetations. Baotou-Lanzhou railway line crosses the zone, where are densely distributed high dunes to constitute serious threat to the safety of railway operation. Therefore, it is a vital for the railway desert control project to fix quicksand, ensure the track from being buried and smooth operation of railway service. This technology was implemented as early as in 1955 in Shapotou, and has henceforth extended along the sides of the railway line and become a stable "anchoring-centered and anchoring and impedance combined" railway desert control technical system through a long time evolution.

The sand barrier system consists of two fundamental belts: (1) the foremost barrier made of high fence in windward side; and (2) semi-hidden wheat straw grid (1mx1m) barrier and drought-tolerant shrubs planted inside the grids to make up artificial vegetation barrier zone. Impedance belt and anchor belt are arranged in prevailing wind direction to form protective area in both sides of the rail as a railway desert control system.

This system has successfully solved the key technical constraint of vegetation plantation in drought area with less than 200mm annual precipitation by proving the ecological recovery feasibility. It is indicated that drought tolerant shrub-based vegetation restoration system is the best model for ecosystem recovery in desertified steppe. At initial stage of vegetation establishment, the shrubs and barrier can effectively reduce intense wind erosion in the surface to enable more stability of sand physical system and deposition of atmospheric dust and nutrition in top of the dunes to create favourable niche for vegetation inhabiting and growth and colonization of cryptogamous plants to allow more stability of vegetation system.

For 50 years of evolution, cryptogamous plants have developed to more than 40 species. In addition, there are 16 species of herbages, 28 species of birds, 50 species of insects and 23 species of large animals healthily growing and living in the project site. Biological diversity restoration has enabled relatively singular sand fixation vegetation into a desert ecosystem in complex structure and functions. Through consecutive research and monitoring over the past half century, it is scientifically proven that regional ecosystem and biological diversity recovery through ecological engineering method is viable in drought regions of China.

Location: Shapotou of Zhongwei city, Ningxia
Technology area: 40 km^2
SWC measure: Vegetation, engineering
Land use: Shifting dunes
Climate: Arid
WOCAT database reference: QT
Related approach: Biological and Engineering Integrated Control of Drifting Sand Harm Along Railway
Compiled by: Li Xinrong, the Shapotou Experimental Station, Cold and Arid Region Institute, Chinese Academy of Sciences
Date: August, 2007

Editors' comments: Via the practice of more than 50 years this technology has become a successful pattern to be adopted at arid areas with annual precipitation less than 200 mm for combating drifting sand. It is of low cost, effect rapid, broad suitability, low maintenance cost, therefore now has been applied extensively in cultural heritage protection, beach drifting sand management, highway and railway construction etc, such as Dunhuang Grotto Protection, Taklimakan Oilfield highway construction in Xinjiang, and the Qinghai-Tibet railway etc.

Classification

Land use problems

Mobility of the dune is strong and the surface is instable, leading to incidence of wind erosion and sand burials; Soil earth evolves slowly, with mechanical component of sand grain mainly, and the silt sand and clay particle content is very low; Soil fertility is low; lack of surface water, underground water too deep to be used by plants, extremely arid soil.

Land use

Grassland and forest: *Compositae, Caragana, Eragrostis* etc.

Climate

Arid

Degradation

Wind erosion

SWC measure

Mechanical measures

Vegetation measures

Technical function/impact

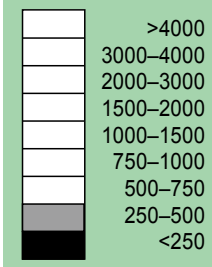
main: - fix drift sand
- add vegetation cover
- promote soil formation process

secondary: - improve soil fertility
- add biodiversity and bio-production

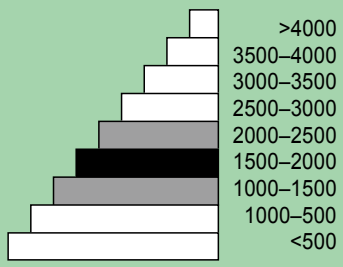
Environment

Natural Environment

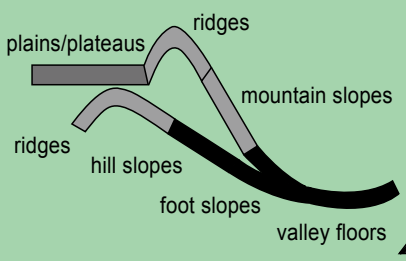
Average annual rainfall (mm)



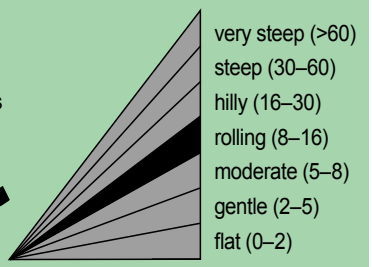
Altitude (m a.s.l.)



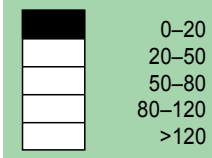
Landform



Slope (%)



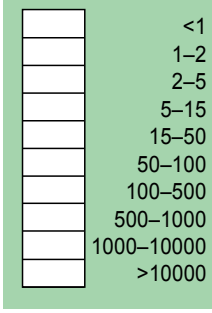
Soil depth (cm)



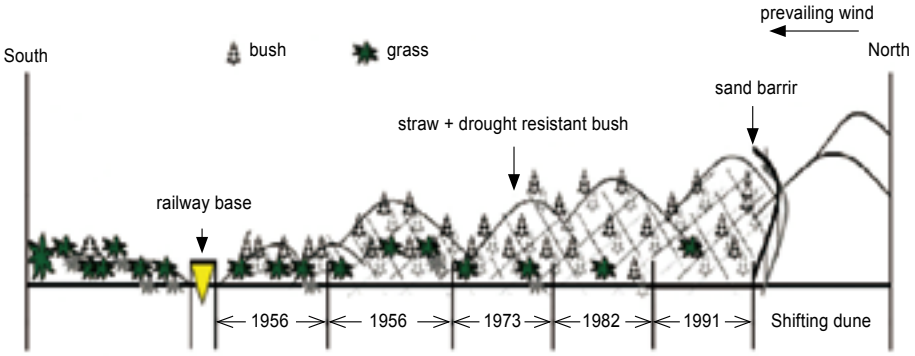
Growing season: 220 days in succession, from April to October
Soil fertility: very low. Light alkaline, with some capability of nitrogen fixing
Soil texture: sand grain mainly, small amount of clay particle whose content will grow with sand fixation
Surface stoniness: none
Topsoil organic matter: very low in general, but shall grow obviously with the sand fixation work
Soil drainage: relatively good
Soil erodibility: from moderate to high

Human environment

Mixed land per household (hm^2)



Land use rights: state owned
Land ownership: state owned
Market orientation: self use
Level of technical knowledge required: moderate for the technical extensionists and land users
Importance of off-farm income: <10%



Technical drawing

The sand control project of the Shapotou section of Baotou-Lanzhou railway line consists of two major parts. The first part is the sand barrier located at the wind-facing frontier part of the drifting sand; The other part is semi-hidden grid barrier sized 1m×1m at drifting dune site, with planted drought-tolerant bush belt planted at proper density inside.

Drawing by Li Xinrong

Implementation activities, inputs and costs

Establishment activities

1. The high-rise sand barrier is installed at the wind-facing frontier part of the drifting sand dunes to curb the sand.
2. The grass grid sized 1m×1m is established on the dunes between the above sand barrier and the railway.
3. Without irrigation, drought-tolerant bushes are planted at proper density inside the grass grid.

Establishment process: started in 1955, and completed within 5 years.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
Labour	600	100
Equipment		
- spade	100	100
Materials		
- wheat straw	460	100
Agricultural		
- seedlings	260	100
TOTAL	1420	100

Maintenance/recurrent activities

1. Rebuild the grass grid at the sections with initial traces of wind erosion.

Maintenance/recurrent inputs and costs per hm^2 per year

Inputs	Costs (US$)	% met by land user
Labour	13	100
Equipment		
- spade	2	100
Materials		
- wheat straw	10	100
Agricultural		
- seedlings	10	100
TOTAL	35	100

Remarks: none.

Assessment

Acceptance/adoption

Benefits/costs according to land user	Benefits compared with costs	Short-term	Long-term
	establishment	positive	very positive
	maintenance/recurrent	positive	very positive

Impacts of the technology

Production and socio-economic benefits

+ + +	Control drifting sand harms, ensure railway normal operation
+ +	Speed up eco-tourism industry of the sandy areas

Production and socio-economic disadvantages

	None

Socio-cultural benefits

+ + +	Extension of the desert management and sand control knowledge

Socio-cultural disadvantages

	None

Ecological benefits

+ + +	Fix drifting sand
+ + +	Add vegetation cover and improve climate condition
+ + +	Promote soil formation process and add soil fertility
+ + +	Improve soil moisture and soil structure
+ + +	Add biodiversity and bio production

Ecological disadvantages

	None

Off-site benefits

+ + +	Reduce sand and dust storm of the adjacent areas

Off-site disadvantages

	None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Control effectively drift sand → Combine vegetation measure with other measures.	Easily affected by human factors → Close the treated areas for rehabilitation.
Easy maintenance → Strengthen training and technical extension and mobilize activity of the local people.	Ecological benefit hard to be transformed into practical economic benefit, so local people do not actively participate in → Adopt ecological benefit compensation mechanism.

Key reference(s)

[1] Li Minggang, Liu Yingxin. *Sand-fixing forestation study at Zhongwei section of the Tengger Desert of the Baotou-Lanzhou railway line*. Research report collection of forest soil institute. Chinese Academy of Forestry Science. Beijing: Science Press, 1960

[2] Shapotou Experimental Station, Cold and Arid Region Institute, Chinese Academy of Sciences. *Studies of drifting sand treatment at Shapotou area of Tengger Desert*. Yin Chuan: Ningxia People's Press,1980

[3] Li X.R.. *Influence of variation of soil spatial heterogeneity on vegetation restoration*. Science in China Ser. D Earth Sciences 2005, 48(11): 2020-2031

[4] Li X.R., Xiao H.L., He M.Z. *Grass grid barrier for habitant restoration in extremely arid desert regions*. Ecological Engineering 2006, 28:149-157

Contact person(s)

Li Xinrong, the Shapotou Experimental Station, Cold and Arid Region Institute, Chinese Academy of Sciences. Tel: 0931-8277921. Email: lxinrong@lzb.ac.cn

Left: Semi-hidden wheat straw grid sand barrier sized 1m×1m at drifting dune site. Photo by Li Xinrong
Right: Planted drought-tolerant shrubs at proper density inside the wheat straw grid. Photo by Li Xiaojun

Biological and Engineering Integrated Control of Drifting Sand Harm Along Railway

Shapotou of Ningxia, China

This project was funded by national government and implemented by research institute that was in charge of setting pilot program, solving technical problems arisen from implementation and the project design. Railway and forestry departments, and Chinese Academy of Sciences mobilized human resources and equipment for project construction, and railway forest farms were responsible for post-construction maintenance.

In the early days after new China's founding (1949), the central government decided to construct railway connecting the two industrial cities Baotou and Lanzhou in order to speed up development of national economy in northwest China. This project was included in national capital construction program under 1st Five-year Plan. The rail line crosses Tengger Desert for six times and along the line there are shifting dunes, in which the tallest and most fluctuating square shaped dunes are distributed in the section between Mengjiawan and Yingshuiqiao in Zhongwei County. In 1955 the Ministry of Railway commissioned the Chinese Academy of Sciences to undertake the research to tackle this problem. In 1956, the Scientific Research Institute under the Ministry of Railway and the design institute No.1 and forest and soil institute of Chinese Academy of Sciences jointly established Zhongwei Railway Desert Control Workstation (former organization of Chinese Academy of Sciences (CAS) Shapotou Desert Experiment and Research Station), to carry out desert fixation research.

The project team also decided to adopt high-rise barrier and semi-hidden grass grid techniques. The establishment of the sandbreak belts along the rail line in southeast edge of Tengger Desert started in 1956 and furthered in 1964, 1973, 1982 and 1991 respectively to form present railway sand fixation system of 1km in width, 40km in length and 40km^2 in area. This achievement won the top prize of technology advancement issued by CAS and special prize of national science and technology advancement.

This technology has been broadly applied to desert road and railway constructions, cultural heritage protection, and so forth, including Mogao Grottoes in Dunhuang City, road construction in Taklimakan Oilfield, desert control system for Qinghai- Tibet Railway, Green Corridor project in Mali Republic, etc. The overall technical objective is to protect the facilities in the desert region and reduce drifting sand detriment.

This project has maintained railway operation safe and improved regional ecological environment, and significant economic benefit has been generated in the project sites. Meanwhile, the awareness of the community on ecosystem protection has been strengthened and sand prevention and control knowledge and technologies have scaled up.

Location: Shapotou of Zhongwei City, Ningxia
Land use: Shifting dunes, fixed sandyland after treatment
Climate: Arid
WOCAT database reference: QA
Related technology: Sandy Land Management for Protecting Railway
Compiled by: Li Xinrong, the Shapotou Experimental Station, Cold and Arid Region Institute, Chinese Academy of Sciences
Date: August, 2007

Editors' comments: This technology has been applied extensively in cultural heritage protection, beach drifting sand management, highway and railway construction etc., such as Mogao Grottoes in Dunhuang City, Taklimakan oilfield highway construction in Xinjiang, and the Qinghai-Tibet railway etc.

Problem, objectives and constraints

Problem

- Community in lack of the technology of biological control of drifting sand along railway in desert area.
- No direct economic benefit, so the community has low enthusiasm of participation.

Objectives

- Control harm of drifting sand to guarantee unblocked railway operation.
- Raise production and restore biodiversity.
- Form railway drifting sand control method and technical system by integrated measures.
- Raise community's enthusiasm of participation.
- Raising communities' ability to control drifting sand along railway and its ecological protection awareness.

Constraints addressed

Major	Specification	Treatment
Technical	Lack of the technology of integrated control of drifting sand along railway.	Training and extension to activate the local villagers. Strengthened cooperation among departments of railway, meteorology, geography, soil, forestry etc.
Minor	**Specification**	**Treatment**
Fanancial	Community incapable of the needed investment.	State financing.
Social	No direct economic benefit, so the community's en thusiasm of participation is low.	Adopt incentive mechanism, promote eco-tourism development.

Participation and decision making

Target groups


SWC experts


Decision makers


Planning department


Land

Approach costs met by

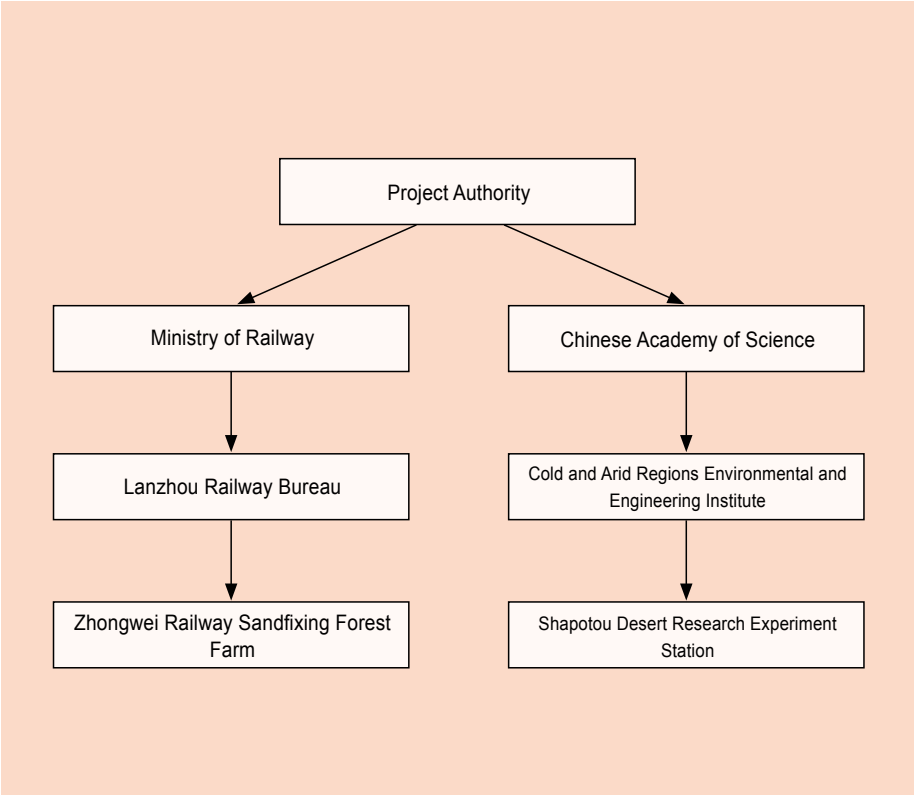
Now wholly financed by government	100%
TOTAL	100%

Decisions on choice of the technology: Sand control experts, ecologists.
Decisions on method of implementing the technology: Sand control experts and ecologists mainly.
Approach designed by: Sand control experts, ecologists.

Community involvement

Phase	Involvement	Activities
Initiation	Not involved	
Planning	Not involved	
Implementation	Payment	Civil works and vegetation building activities of the railway protection project area.
Monitoring/evaluation	Not involved	
Research	Not involved	

Differences in participation of men and women: Done mainly by male labor.



Organogram

To guarantee Baotou-Lanzhou railway line unharmed from the drifting sand, in 1955, the Ministry of Railway entrusted the Chinese Academy of Sciences (CAS) to undertake this task. In 1956 spring, a work team was established based on the CAS Forest Soil Research Institute to use plant to control drifting sand along railway, thus a permanent research started. In 1957, the Zhongwei sand fixing forest farm was set up, and in 1959 CAS set up the Shapotou sand control experiment station to make further studies and solve sand harms to railway. In 1978, Shapotou Sand Experiment Station was administrated by the CAS Lanzhou Desert Research Institute.

Extension and promotion

Training: Training topics include: sand barrier establishment technology; semi-hidden wheat straw grid establishment technology; Irrigation-free vegetation establishment technology. Training forms include: site visiting, technology explanation; Trainees are community residents and local technicians. Regarding the training effect, the better effects for the technical persons such as those from forestry department, forest farm etc than farmers in general.

Extension: Railway based protection system successfully established. Through integrated formation of complete ecological restoration model to control drifting sand and the theoretical model, the related experts and technicians popularize the technology to similar areas.

Research: This is mainly on: (1) dust storm harm investigation along the railway line after the project; (2) performance and mechanism of the sand barrier to control drifting sand; (3) vegetation evolution features after project is completed; (4) soil formation process and mechanism; (5) technology of artificial vegetation based on free irrigation; (6) impact of artificial vegetation on ecosystem hydrological feature and the mechanism; (7) vegetation stability artificial maintenance mechanism at arid sites. Comprehensive studies on atmosphere, biology, soil and moisture. The research is conducted by SDRES, and the research results raised operability and the scientific quality of the method.

Importance of land use rights: The land is state owned, which is helpful for the construction and maintenance of the project that is in public welfare nature.

Incentives

Labour: With compensation payment, local people participated actively.

Inputs: the state government.

Credit: No loan is available. Direct investment form government is adopted.

Support of local institutions: The technology guaranteed normal operation of railway, so produced direct economic benefits. At the same time, it promoted the input of government to both railway and forestry departments, and promoted the institutional capacity of the work staff.

Long-term impact of incentives: It is negative.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Long-term site positioned monitoring on related indicators of biology, soil, moisture and atmosphere etc.
Technical	Long-term site positioned monitoring integrated technical system on drifting sand.
Socio-cultural	Questionnaire survey of the dissemination level of sand control technology and related knowledge.
Economic/production	Actual calculation of ensuring unblocked railway to create economic benefit over 10 billion RMB Yuan roughly.
Area treated	Actual calculation concludes that compared with the control area, the treated area has obvious ecological, economic and social benefits.
No. of land users involved	Actual calculation: apart from application in Baotou-Lanzhou railway line, the technology has been used in Dunhuang Grotto Protection, Taklimakan oilfield highway construction in Xinjiang, and the Qinghai-Tibet railway etc.
Management of approach	Technical training and extension.

Impacts of the approach

Changes as result of monitoring and evaluation: No obvious change identified.

Improved soil and water management: The technology promotes gathering of the atmospheric dust in the surface drifting sand. At the same time the cryptogamic plants and soil microorganism promote soil formation process, to have the site earth evolve from aeolian sandy soil to normal calcisols-Aridisoles soil, which will be good foundation for the biological soil crusting and higher plant settling invasion. In this trend, the former floating dune may change gradually into steady steppe desert ecosystem.

Adoption of the approach by other projects/land users: This technology has been applied extensively in cultural heritage protection, beach drifting sand management, highway and railway construction etc, such as China Dunhuang Grotto Protection in Gansu, Taklimakan oilfield highway construction in Xinjiang, and the Qinghai-Tibet railway etc.

Sustainability: Without long-term government support, the land users may find it hard to apply this technology.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Research, demonstration and application in close combination → Explore long term extension mechanism.	High financial input → Set up cofinancing mechanism.
Notable social benefit → The continuous support to the project.	Hard transformation of ecological result into economic benefit, so participation enthusiasm of the locality is affected → Establishment of compensation mechanism to ecological benefit and conduct eco-tourism.

Key reference(s)

[1] Li Minggang, Liu Yingxin. *Sand-fixing forestation study at Zhongwei section of the Tengger Desert of the Baotou-Lanzhou railway line*. Research report collection of forest soil institute. Chinese Academy of Forestry Science. Beijing: Science Press, 1960

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[4] Li X.R., Xiao H.L., He M.Z. *Grass grid barrier for habitant restoration in extremely arid desert regions*. Ecological Engineering, 2006, 28:149-157

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Left: Bio-protection system for desert highway. Photo By Xu Xinwen
Right: Water source of drip irrigation. Photo by Xu Xinwen

Bio-protection System for Desert Highway

Taklamakan Desert of Xinjiang, China

This technology is used to establish a drip irrigation system in order to utilize highly mineralized groundwater in the shifting sand affected region. Desert tolerant plant species, such as *Haloxylon ammodendron*, *Tamarix chinensis* and *Calligonum mongolicum* are planted to form a shelterbelt system to intercept shifting sand.

By the technology highly mineralized groundwater resource and resistant plant species are used to form a biological desert control system to ensure long-term and safe operation of highway. According to salinity of groundwater, high tolerant species are introduced. According to regional wind and sand environmental characteristics and plant biological property, the project layout design should form a proper biological desert tretment system. Before shelter is established, mechanic barriers (fence barrier or grass grids barrier) are employed to fix shifting sand, reduce harm to seedlings and raise plant survival rate. According to unit well water flow yield (determined by hydrologic condition), shelterbelt width and water requirement of seedling, well spacing is determined to allow even distribution in the project site and well location shall be designed at higher elevation and in the centre of irrigation area. Drip irrigation system should be independent with well unit as system centre. Each system consists of head, pipeline net and accessories.

Technique application process: (1) Survey available water resource, its quality and volume, and identify plant adaptability; (2) Study wind and sand harms and determine species and structure of shelterbelt; (3) Determine scope of well irrigation based on single well water flow; (4) conduct project design; (5) Start establishment process; and (6) follow up maintenance with focuses on regular inspection and maintenance of irrigation system. Selection of plant species, saline water irrigation regime and salt contents adjustment are the core technique of this technolog. This technology may be applied for desert roads or biological control of sand harm in farming and industrial region.

The genera of *Haloxylon*, *Tamarix* and *Calligonum* are more suitable to desert environment. Several species for Tamarix genus can be adopted including *Tamarix hispida* Willd, *Tamarix chinensis* Lour etc. There are options for *Calligonum* including the arbor *calligonum*. Mixed forest by lines is often adopted as a typical pattern of shelterbelt. The width of shelterbelt at windward side is larger than that of shelterbelt at leeward. The shelterbelt at windward side is consists of 2 belts for sand break plus 1 belt for sand fixation; and shelterbelt at leeward is consists of 1 belt for sandbreak and 1 belt for sand fixation. The planting spacing is 1mx1m. There is no need for land preparation due to drip irrigation.

The drip irrigation system adopts imbedded emitter in 1m spacing (depending on tree spacing) with subsidiary pipe spacing usually at 2m (depending on row spacing). Salt ion mainly consists of Na^+ and Cl^- in 2-30g/L mineralization. Irrigation water quota is set at 20L/tree-time and irrigation periods last 15 days in March, April and May; 10 days in June, July and August; 15 days in September and October, and one time in November.

Location: Inner part of the Taklamakan Desert
Technology area: 31.8km long,72-78m wide,3km^2
SWC measure: Planted bush vegetation
Land use: Drift dune before treatment, fixed sandy land after treatment
Climate: Extremely arid
WOCAT database reference: QT
Related approach: Integrated Pilot Project of Shifting Sand Control for Highway
Compiled by: Lei Jiaqiang, Xu Xinwen, Xinjiang Ecological and Geographic Institute, Chinese Academy of Sciences
Date: September, 2008

Editors' comments: Widely used in Tarim Desert highway, the technology has helped establish successfully a highway shelterbelt of 436 km. The technology is featured by the technology of using highly mineralized water for irrigation and drifting sand control bio-system disposition technology. This technology can be applied at all sand control areas with site underground water source or nearby water source. It is effective in sand harm prevention, desertified land development, and sand industrial development.

Classification

Land use problems

The shifting sands of this desert move fast that the surface of sands is not stable, which results in wind erosion and burial. The soil skeleton is strong, and soil formation development is weak. Regarding its mechanical formation the sand granule is fine or extra fine. The content of silt and clay is low. The soil features high porosity, low organic matter and low fertility. There are little surface water with associated low air humidity and high temperature in air and soil surface.

Land use	Climate	Degradation	SWC measure
			
Forestation: *Tamarix chinensis, Haloxylon ammodendron, Calligonum mongolicum*	Arid	Wind erosion	Mechanical measures

Technical function/impact

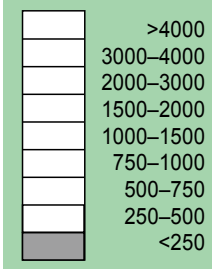
main: - fix drifting sand
- reduce wind force
- add coarseness of the earth surface
- lower the temperature and add moisture

secondary: - add soil fertility

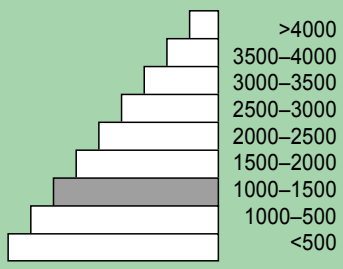
Environment

Natural Environment

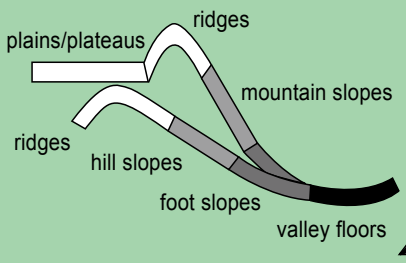
Average annual rainfall (mm)



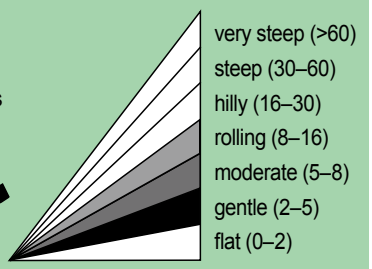
Altitude (m a.s.l.)



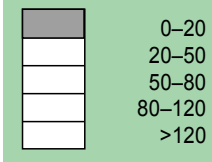
Landform



Slope (%)



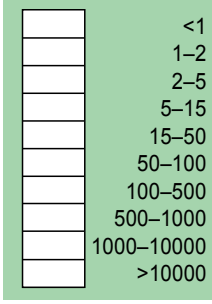
Soil depth (cm)



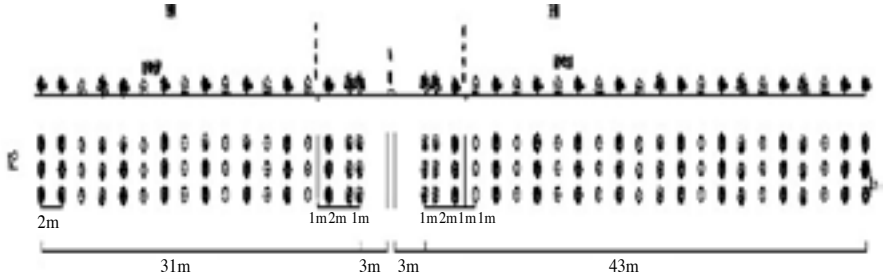
Growing season: 240 days, from April to September
Soil fertility: very low, strong alkali
Soil texture: mainly fine or extra fine sand
Surface stoniness: no
Topsoil organic matter: very low(<1%)
Soil drainage: very good
Soil erodibility: high

Human environment

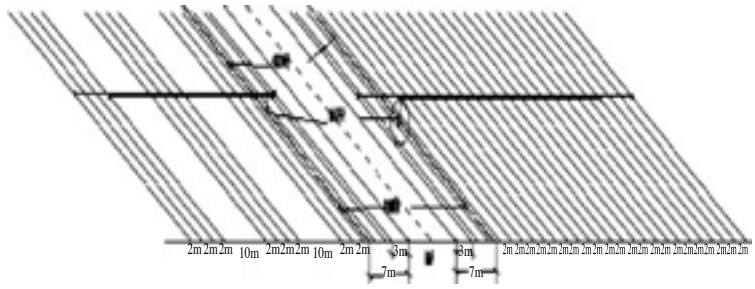
Mixed land per household (hm^2)



Land use rights: enterprise
Land ownership: state owned
Market orientation: mixed
Level of technical knowledge required: moderate to technical extensionists and land users
Importance of off-farm income: over 50% of the total income



Structure of forest belt



Irrigation system

Technical drawing

The drawing reflects the disposition of the dripping irrigation network and shelterbelt structure.

Implementation activities, inputs and costs

Establishment activities

1. Establishment of dripping irrigation system.
2. Infrastructure and facilities, including construction of electricity transmission network, well drilling, wellhouse, road construction of residential zone, valve well and drainage well.
3. Auxiliary facilities, including diesel generator set and grass grid sand barrier (to promote survival)
4. Planting of the seedlings.
5. Maintenance of forest land, including irrigation, plant pest and disease control, supplementary planting. Most wells adopt diesel set to generate electricity and some adopt power line transmission. The equipment for construction includes transportation vehicles, well drilling equipment, electricity transmission facilities, dripping irrigation system as well as planting tools.

Establishment period: 1-2 years.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
Labour	2953	59
Equipment		
- cranes, clamshell car, desert bulldozer, well drilling machine, generator, water transport vehicle, mixer and spade etc.	489	59
Materials		
- electricity system (diesel generator, power lines for electricity transmission), pinelines of irrigation	2734	59
Agricultural		
- seedlings	187	59
TOTAL	6363	59

Maintenance/recurrent activities

1. Irrigation system maintenance.
2. Forest land fertilization.
3. Technical maintenance of power supply system.

Most electricity generators use diesel oil, while some adopt power line transmission. During growth season, the diesel oil generator works for 8 hours every day in average, and the diesel oil and worker's life necessarities are transported every half month.

Maintenance/recurrent inputs and costs per ha hm^2 year

(Land user: Xinjiang Tarim Oilfield Company)

Inputs	Costs (US$)	% met by land user
Labour	229	100
Equipment		
- depriciation of diesel electricity generator, diesel, vehicle for transporting life necessarities of hte workers	118	100
Materials		
- diesel, dripping irrigation repair, life necessarities of hte workers	161	100
Agricultural		
- fertilizer	47	100
TOTAL	555	100

Remarks: none.

Assessment

Acceptance/adoption

- Now all production bases of the Tarim Oilfield Company adopt this technology to establish shelterbelt system.
- It is reported, that the second desert highway in Xinjiang (i.e. Hetan-Alaer highway) will also adopt this technology to establish system.

Benefits/costs according to land user

It is contributive to regional economic development. It has good ecological benefit. The establishment and maintenance costs are high, but its function lasts long.

Benefits compared with costs	Short-term	Long-term
establishment	positive	very positive
maintenance/recurrent	positive	very positive

Impacts of the technology

Production and socio-economic benefits

+ +	Ensure desert highway normal operation
+ +	Produce plant seed and scions
+ +	Promote ecological industrial development

Production and socio-economic disadvantages

	None

Socio-cultural benefits

+ + +	Improve desert highway sand control knowledge
+ + +	Strengthen institutional building for sand control organizations

Socio-cultural disadvantages

	None

Ecological benefits

+ + +	Enrich landscape diversity of project area
+ + +	Lower temperature and increase moisture, reduce sand harms to improve human living environment in desert area
+ +	Promote soil formation and improve soil fertility
+ +	Improve niche and biodiversity

Ecological disadvantages

	None

Off-site benefits

+ +	Ensure natural resource development, traffic development, and regional economic development. Provide a sand control and ecological improvement model to both home and abroad

Off-site disadvantages

	None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Efficiently control drifting sand → Improve shelterbelt system, strengthen maintenance and promote sustainable development.	Single species in shelterbelt → Introduce other superior sand-fixation species.
Reduce wind speed – Undertake optimization of shelterbelt and strengthen its research and extension.	High cost of pumping irrigation → Use solar energy system.
Use inferior water resource → Strengthen management of irrigation system and further improve use of inferior water resource.	High maintenance cost → To support project by using funds, generated by developing ecological industries within the project.
Obvious ecological benefit → Increase economic outcome by developing ecological industries within the project.	

Key reference(s)

Xiang jianmin, Li Shengyu, Mai guangrong et al. *Establishment and Maintenance of Tarim desert highway ecological shelterbelt project*. Soil and Water Conservation Newsletter, 2006, 26 (5): 39-42

Contact person(s)

Lei Jiaqiang, Xinjiang Research Institute of Geography and Ecology, Chinese Academy of Science. Tel 0991-7885345. Email: desert@ms.xjb.ac.cn

Left: Forestation at the Tazhong Oilfield Base. Photo by Xu Xinwen.
Right: Forestation at the Hade Oilfield Base. Photo by Xu Xinwen.

Integrated Pilot Project of Shifting Sand Control for Highway

Taklimakan Desert of Xinjiang, China

This project is powered by joint investment of government and enterprise, implemented and organized by enterprise with a pilot project conducted by research institutes to solve technical problems and make project designs. Various firms are contracted to supply labours and machineries for construction. Post-completion maintenance is performed by special greening work team.

In 2002, PetroChina Tarim Subsidiary Company Limited and the Xinjiang Institute of Ecology and Geography (XIEG) of Chinese Academy of Sciences (CAS) made a project proposal. In 2003, XIEG of CAS in cooperation with Daqing Oilfield Construction Institute and Cold and Arid Regions Environmental and Engineering Research Institute worked out a master planning, including preliminary design and implementation design. Meanwhile, a consultation with relevant experts was conducted for optimization of these designs.

Tarim desert highway shelterbelt ecological project with a total length of 436 km and width of 72-78m crosses the Taklimakan Desert from north to south. The shelterbelt has 144 wells dug to water 20 million trees and covers 3128hm^2. It is the longest artificial green corridor in the world. In January 2007, this project was appraised and ranked fifth of the top ten scientific and technologic news in China in 2006.

Tarim desert highway shelterbelt ecological project commenced on June 17, 2003. Layout of well drilling and irrigation system was completed at the end of the year. The target of planting for Phase I was completed in spring of 2004; the target of planting for Phase II completed in spring of 2005.

This technology has been widely used in other oil fields of the Tarim Oilfield Base. The overall objective of this project is to protect facilities in the desert and reduce sand threats. The main outcome of the project is environmental improvement; therefore, dissemination of its technology requires joint inputs and efforts by government and enterprises.

In addition to protect safe operation of the desert highway, the project can improve the quality of ecological environment and produce ecological benefits. Moreover, certain economic benefit can be generated based on ecological industrial development. The implementation of the project can also enhance the local residents' awareness of ecological improvement and knowledge of desertification control. Project implementation needs a great deal of manpower, so that large number of job opportunities is created. Tarim desert highway shelterbelt ecological project is invested by National Development and Reform Commission and PetroChina Company and implemented by Tarim Oil Field of PetroChina.

Location: Inland part of the Taklimakan Desert
Land use: Drifting sandy land
Climate: Extremely arid
WOCAT database reference: QA
Related technology: Bio-protection System for Desert Highways
Compiled by: Lei Jiaqiang, Xu Xinwen, Xinjiang Research Institute of Geography and Ecology, Chinese Academy of Science
Date: September, 2008

Editors' comments: The technology now is successfully used in the Tarim Desert highway project by establishing 436 km long shelterbelt. The main features of this technology are the use of highly mineralized water for forestation and the technique of bio-control system of drifting sand. This technology can be applied to all desert areas where underground water resource or other water resources are available.

Problem, objectives and constraints

Problem

- Lack of technology of drift sand biological control for desert highway.
- High cost and input for drift sand biological control, but grass-roots level has no financial resources.
- Drift sand harms highway traffic, thus impacting exploration of oil and gas resource for a long period.

Objectives

- Fix the drift sand, prevent and delay the movement of dunes to guarantee smooth highway traffic.
- Reinforce sand control capacity of desert highway to combat sand harms to highway.
- Develop highly mineralized underground water resource of desert area for irrigating forestation.
- Select, identify and introduce plant species with high tolerance, explore the related technologies of breeding, planting, irrigation and tending maintenance.

Constraints addressed

Major	Specification	Treatment
Technical	Lack of drift sand biological control technology and mineralized water irrigation technology for shelerbelt of highway.	Carry out underground hydrological survey and comparison of irrigation options; select species with high resistance from known non-native species for gradient test of tolerance resistance of species to highly mineralized water.
Economic	The costs of establishment and maintenance of shelterbelts are very high.	Without this project the enterprises should spend a huge investment for sand control for a long period. With the project enterprise can reduce the total investment and can also generate economic benefits to some extent by developing ecological industry, thus the generated benefits can be used for the project expenditure.
Lack of overall community participation	Community has no overall participation, because the project requires huge investment and generates very limited economic benefits.	Add the economic benefit of the technology and attract community participation.

Participation and decision making

Target groups


Decision maker


Design staff


SWC experts


Land users

Approach costs met by

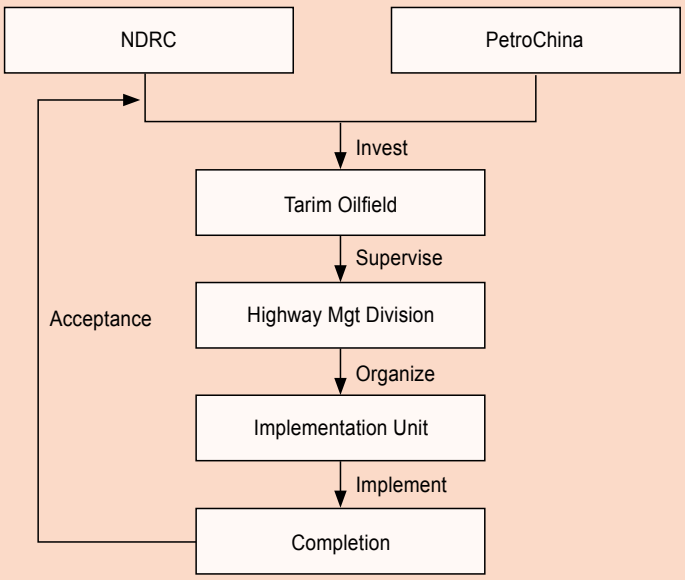
Government	44%
Enterprise	56%
TOTAL	100%

Decisions on choice of the technology: Experts of PetroChina Tarim Subsidiary Company and CAS Xinjiang Institute of Ecology and Geography.
Decisions on method of implementing the technology: Experts of PetroChina Tarim Subsidery Company, CAS Institute of Ecology and Geography, Lanzhou Cold and Arid Regions Research Institute.
Approach designed by: Jointly by expert of CAS Xinjiang Institute of Ecology and Geography, Lanzhou Cold and Arid Region Research Institute, and Daqing Oilfield Design Academy.

Community involvement

Phase	Involvement	Activities
Initiation	No	
Planning	No	
Implementation	Active	Local community farmers are recruited to attend project implementation by growing and transporting seedlings, planting, establishing the irrigation system etc.
Monitoring/evaluation	No	
Research	No	

Differences in participation of men and women: No difference.



Organogram

NDRC offers capital funds, PetroChina offers counterpart funds, and the project is organized for implementation by Tarim Oilfield Company (TOC). The TOC Highway Management Office takes the responsibility for actual organization of project design, implementation and post-completion maintenance. NDRC and PetroChina will accept and check project implementation.

Extension and promotion

Training: Training topics are: forestation technology with using salty water, inoculation of *Herba Cistanches*. The forms of training include site visit and technical explanation. Excellent results for research institutes, good results for enterprises, and moderate for farmers (due to their limited knowledge).

Extension: Method, key steps, organization, and capability for further extension.

Research: The following items are under research: (1) environmental survey on sand harm to the project area and sand threats to highway; (2) forestation site type classification of project area ; (3) test and studies of forestation by using salty water and experiments of seedlings breeding and cultivation; (4) test of seedling tolerance to highly mineralized water; (5) optimized design of shelterbelt structure and irrigation system; (6) analysis of regional underground water carrying capacity and analysis of project impact on underground water; (7) research of *Herba Cistanches* inoculation and processing technology, related to desert highway. These studies/research are organized by Tarim Oilfield Company, and undertaken by the CAS Xinjiang Institute of Ecology and Geography, and Cold and Arid Region Environment Institute. The research will enable the technology to have more scientific nature and operability.

Importance of land use rights: Land is owned by state, and land use right can be owned by institutions/collectives or individuals. Therefore, the state ownership is in favor of project implementation, especially the project has strong public welfare nature.

Incentives

Labour: The labor is paid.

Inputs: The inputs include well construction equipment with the vehicles and materials; pumps, diesel engine and diesel oil; dripping irrigation facilities; reeds, hand-operated hay cutter, plain-edge spade etc., which are used for mechanical sand barrier; tree seedlings and planting spade. Of the above, the costs for water pumping engine and fuels, seedlings, drip irrigation facility and materials are jointly covered by the state and the enterprises while the project maintenance cost - by oilfield company alone.

Credit: No loan, because it is a direct investment by state.

Support of local institutions: The technology has reduced highway maintenance cost, thus produced indirect economic benefits. At the same time *Herba Cistanches* inoculation promotes local ecological industry with direct economic benefit. The project demonstration and technical consultancy improves the capacity of the SWC and agricultural organizations.

Long-term impact of incentives: Negative impact.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Method: instrument measuration plus site survey. Indicator: wind velocity reduciton rate, sand shift reduction rate, sand face erosion intensity, sand harm incidence rate on road.
Technical	Method: sampling survey, questionaire of the management workers. Indicator: single well daily output in average and time of irrigation, survival rate of seedlings in shelterbelt, seedling growth potential, normal operation rate of the irrigaiotn system.
Socio-cultural	Method: sampling survey of the residential areas, questionaire of the management workers. Indicator: degree of recognizing importance of shelterbelt and implementation rate of environmental proteciton actions.
Economic/production	None.
Area treated	Method: site measurement. Indicator: expected environmental improvement rate of the project area.
No. of land users involved	
Management of approach	Method: sampling survey, questionaire of the management workers. Indicator: qualification rate of management method.

Impacts of the approach

Changes as result of monitoring and evaluation: No major change is identified.

Improved soil and water management: After the desert highway shelterbelts are established, the sand in the shelterbelts is stabilizes, the drifting sand is intercepted by the belts, so the highway sand harm is minimized and the land management level is raised; in addition, utilization possibility of highly mineralized water is explored.

Adoption of the approach by other projects/land users: Due to the high project cost and low economic benefits, farmers are not willing to accept it; apart from the Tarim Desert Highway project, this bio-protection system has not be popularized in nonproject areas. But No.1 Tazhong highway and Hetan-Alaer desert highway have the intention to adopt this technology. At the same time, Libya expressed its cooperation intention to use it.

Sustainability: As long as the Tarim oil/gas production continues its operation, the traffic lifeline of Tarim desert highway should be guaranteed. The oilfield company will continue developing shelterbelts using the existing technology. Moreover, Tarim desert highway is of great significance for economic development and traffic in southern Xinjiang, and the local government pays attention to the sustainable development of the highway. Considering huge investment for establishment of shelterbelts, the technology can not be adopted without adequate funds.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Research, demonstration and application is in integration → Explore more effective extension mechanism.	High cost of establishment → Continuous investment by enterprise while seeking international financing.
Notable social benefit → The continuous support from project be maintained.	Top-down demonstration and extension, no community participation → Encourage community to participate.

Key reference(s)

Xiang jianmin, Li Shengyu, Mai guangrong et al. *Establishment and Maintenance of Tarim desert highway ecological shelterbelt project*. Soil and Water Conservation Newsletter, 2006, 26 (5): 39-42

Contact person(s)

Lei Jiaqiang, Xinjiang Research Institute of Geography and Ecology, Chinese Academy of Science. Tel: 0991-7885345. Email: desert@ms.xjb.ac.cn

Left: a. Harvesting forage; b. Silage process; c. Artificial grassland; d. Hay preparation. Photo by Yu Qiang, Tu Ga
Right: Forage planting; processing facilities. Photo by Cong Zijie

Barn Feeding in Captive of Livestock

Zhenglanqi Banner of Inner Mongolia, China

The ecological conservation measures are taken in the seriously degraded pastoral area. The banned grazing promotes decentralized population and livestock, thus reduces presure on rangeland and gives the natural pastureland an opportunity to resume its vitality.

Project area is located in seriously sandificated region of Zhenglanqi Banner, Inner-Mongolia with an area of 467km^2 in 5 townships. Owing to overgrazing the pastureland degrades seriously. Main technical measures taken are as follows: (1) Arrange reset-tlement to move herdsmen to an area with good conditions of water source. (2) Develop artificial grassland, basic pastureland, forage grass and feeds base with available water supply; (3) Strengthen infrastructure construction such as water source; (4) Establish small water source facilities; (5) Develop downstream industry of milk cow and mutton sheep and turn traditional free grazing and extensive management into intensive feeding.

Now the project has resettled 2077 persons of 540 households. Total of residence area 19440m^2 have been constructed. New development includes: warm shed - 21600m^2, transmission line - 10km, milk cow – 1000 heads, maize for silage use - 360hm^2, dig wells - 540. Total project investment is 25.5 million Yuan, among them resettlement funds 1.35 milliom Yuan, credit 4.8 million Yuan, funds raised by themselves 7.2 million Yuan. (for purchasing milk cow).

Through implementation of project famers and herdsmen have got net income of over 2000 Yuan per capita, thus they have a sustainable way of being rich. The experience can be summed up as “enclosure and resettlement arrangement”, “industrilization of livestock”, “urbanization”, “rehabilitation of vegetation”etc.

The above-mentioned measures has promoted restoration of ecological environment and improved the production and living conditions of herdsmen.

Location: Zhenglanqi Banner of Xilin Gol League, Inner-Mongolia
Technology area: 467km^2 (among them resettlement: 0.2km^2)
SWC measure: Agronomy/ vegetation/engineering/management etc.
Land use: Pasture/others
Climate: Semi-arid
WOCAT database reference: QT
Related approach: Barn Feeding in Captivity
Compiled by: Liu Aijun etc. Rangeland Survey and Design Institute, Inner-Mongolia Agricultural and pastoral Academy of Sciences
Date: September, 2007

Editors’ comments: Economic compensation is favourable to herdsmen and change of production pattern. This technique promotes production, economic benefit and sustanable development in grassland area.

Classification

Land use problems

Grassland degradation, sandification, imbalance of grassland and livestock; out-dated production pattern; poor situation of community.

Land use

Artifitial grass-land and maize for silage

Climate

Semi-arid

Degradation

Degradation of grassland vegetation

Wind erosion

SWC measure

Management measures

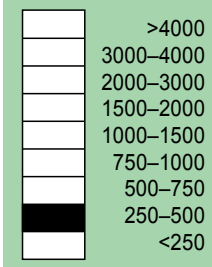
Technical function/impact

main: - enclosure of degraded rangeland for vegetation restoration
- barn feeding in captivity during enclosure period

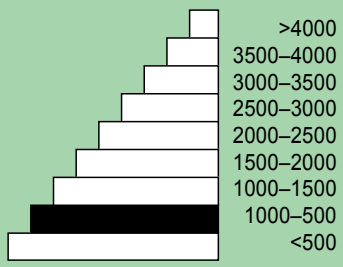
Environment

Natural Environment

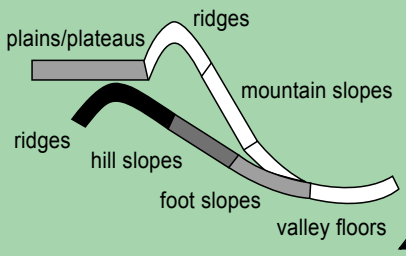
Average annual rainfall (mm)



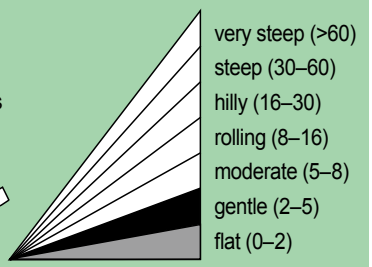
Altitude (m a.s.l.)



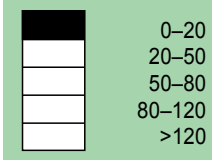
Landform



Slope (%)



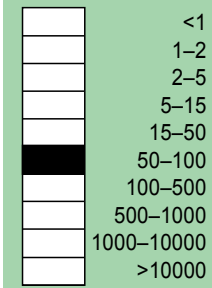
Soil depth (cm)



Growing season: continuously last 150days, April to August
Soil fertility: low
Soil texture: coarse (sandy)
Surface stoniness: no
Topsoil organic matter: low
Soil drainage: good
Soil erodibility: high

Human environment

Mixed land per household (hm^2)



Land use rights: individual
Land ownership: collective
Market orientation: mixed
Level of technical knowledge required: medium for both extensions workers and land users
Importance of off-farm income: < 10% of the total income

Note

Barn feeding is a complicate system. After banned grazing herdsmen leave homeland and arrive to resettled village. The production pattern is changed. They will raise milk cow. Therefore it is necessary to train herdsmen. In the same time they will plant forage and process it. Intensive breeding with optimized feeds is an only way for herdsmen for developing animal husbandry.

Photo by Liu Aijun etc.

Implementation activities, inputs and costs

Establishment activities

1. Establish artificial grassland (high yield maize for silage, including land preparation, fertilizer application, sowing, irrigation etc.).
2. Build stall barn.
3. Establish silage.
4. Dig wells.
5. Management.

Construction period: 1 year.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
Labor (Cost calculation is not applicable)	1.5	0
Equipment		
- forage processing, dig wells, land reparation, irrigation etc.	37.0	0
Material		
- homeland	34.0	100
Agriculture		
- cultivation, fertilization etc.	1.0	100
TOTAL	73.5	46

Maintenance/recurrent activities

1. Processing maize for silage and put it into storage, and feeding milk cow according to the feed formula in late August.
2. Livestock farming activities include everyday feeding and milking.
3. Disease control: It includes regular vaccination, expelling worms, disinfection and quarantine etc.

Maintenance/recurrent inputs and costs per hm^2 per year

Inputs	Costs (US$)	% met by land user
labor(do not calculate)		
Equipment		
Material		
- forage cost, feeding etc.	4.8	100
Agriculture		
- disease control	0.3	0
TOTAL	5.1	100

Remarks: labor: 500,000 Yuan (RMB), Infrastructure: 13 million Yuan, milk cow (raised by themselves):12 million Yuan; demonstration area: 47,000 hm^2. 1milk cow needs 5400 kg of forage; 0.3Yuan/kg. Cost for establishment of 1 mu forage base:100 Yuan/mu; disease control: 100 Yuan /cow. Year. (1 hm^2 = 15 mu)

Assessment

Acceptance/adoption

- Government provides inputs as follows: builds infrastructure, including residence, shed etc. helps them to dig wells, fence, develops forage base and provides technical service.
- Under these conditions herdsmen are willing to put funds for purchasing milk cow and adopt the technique.
- Total of 540 households accept this technique if incentive provided.
- No household can accept this tech-nique, if no incentive provided.

Benefits/costs according to land user	Benefits compared with costs	Short-term	Long-term
	establishment	positive	neutral
	maintenance/recurrent	active	active

Impacts of the technology

Production and socio-economic benefits	Production and socio-economic disadvantages
+ + + Promote change of management pattern of animal husbandry industry and adjustment of industry structure in pastoral area	None
+ + + Increase forage production	
+ + + Increase herdsmen's income	

Socio-cultural benefits	Socio-cultural disadvantages
+ + + Constitute harmonios community, eliminate poverty, promote social steady and prosperity	– – The traditional pastoral culture is gradually disappear

Ecological benefits	Ecological disadvantages
+ + + Increase vegetation coverage and grass height, decrease surface runoff	None
+ + + Improve soil structure, increase soil organic content	

Off-site benefits	Off-site disadvantages
+ + + Decrease the floating dust and improve ecological condition	None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Improve ecology → Continue extension of technique	Herdsmen accept higher technique slowly → Should establish long term training mechanism
Change of animal husbundary production from traditional grazing to barn feeding → Must control herdsman population and arrange re-settlement	It is difficult to change traditional grazing practice of herdsmen → Enhance publicity, increase capital and technical investment and establish morden animal husbandry industry based on the science
Vegetation restoration has good results → After vegetation restored it is necessary to make planning and divide rangeland into rotational plots and implement rotational grazing	

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[1] Du Qinglin. *Sustainable Development Strategy of China Prataculture*. Beijing: China Agriculture Press, 2006
[2] Zhao Xueyan. *Survey and Thinking about Ecological Immigrant and Herders Settling of Alpine Pasture*. China Grassland Journal, 2007, 2: 94-101
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Contact person(s)

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Left: New constructed migration village. Photo by Cong Zijie
Right: Rear livestock in warm shed. Photo by Cong Zijie

Barn Feeding in Captivity

Zhenglanqi Banner of Inner Mongolia, China

After grazing on rangeland banned the livestock (mainly the milk cow) is kept in captivity with barn feeding, using concentrates, combining with forage in an intensive management manner.

Demonstration area is located in Zhenglanqi Banner, Inner-Mongolia. Owing to facts that population increases, land desertifies, rangeland degrades and biodiversity worsens, thus people's life greatly suffers from worsened environment and socio-economic sustainable development is restricted. The method of barn feeding in captivity is a way out of restoring rangeland and promoting economic development.

Since 2002 Zhenglanqi Banner has carried out a strategy of "Enclose rangeland and arrange resettlement" according to Xilin Gol League's master plant. Some herdsmen and livestock thus have been resettled from ecologically fragile region to an appropriate area.

The construction of new village for resettled villagers has adhered the plinciple of high standart. Soon after resettlement completed some sown pastureland, basic pastureland, forage grass and feeds base with available water supply have been established. Moreover, small-size water source facilities and water saving irrgation are prioritized. In addition to that the village develops maize sillage by cultivating selected superior maize varieties. In the same time it is necessary to adjust the industrial structure, improve the management and administration, carry out the intensive managemant and industrialized development.

After project completed, the People's Congress of Zhenglanqi Banner (equal to county level) has passsed a resolution entitled **The Management Measures of Ban-ned Grazing on Pastureland in Ecological Improvement Project Area.** The management and maintenance organizations at three levels (Banner, township and village) have been established and improved. The contract of resposibility has been signed between above-mentioned three level organizations, which has clearly defined the responsibility, power and duty. Regarding extension, Banner government organizes herdsmen and technicians to see experimental demonstration in the field. Such arrangements play a role of demonstration and guidance. The extension mainly relies on sectorial deparments at provincial level. They provide financial support and help the household to establish some facilities (e.g. the sillage pits). The extension department at provincial level provides free training for herdsmen regarding key techniques (e.g. sillage).

Location: Zhenglanqi, Xilinguole league
Land use: Pasture
Climate: Semi-arid
WOCAT database reference: QA
Related technology: Barn Feeding in Captive of Livestock
Editors' comments: Liu Aijun, Rangeland Survey and Design Institute, Inner-Mongolia Agricultural and pastoral Academy of Sciences
Date: September, 2007

Editors' comments: Implement of the project have got success. The efficient is obvious. There are an important significance for the ecological environment , promote the local production structure and sustainable development of the economy and sociality.

Problem, objectives and constraints

Problem

- It needs large amount of the capital investment, efficient management and scientific technique in order to realize resettlement and barn feeding in captivity.
- For a long time the pastoral area was under disordered management, and it lacks experience and integrated market.
- Under such situation adoption of this technique is difficult.

Objectives

- To form an effective extension mechanism.
- To Increase participation of communities.
- To improve the infrastructure of communities.
- To decrease the pressure on pastureland through the ecological resettlement and barn feeding in captivity.

Constraints addressed

Major	Specification	Treatment
Technically	Lack of the intensive management experience and rearing technique of the milk cow.	Implement efficient measures to conduct education and technical training.
Socially	Herdsmen feel difficult to adapt the mode of production and life.	Change concept of herdsmen and introduce new management and administration modes through policy guidance.
Economically	The pastoral region has poorly developed economy, herdsmen lack funds and subsidy standard is low.	Extend subsidy period and raise its standard.
Minor	**Specification**	**Treatment**
Socially	No production,supply and marketing system is available, thus the produced milk has no guaranteed market.	Adopt measures to guarantee purchase of milk.

Participation and decision making

Target groups


Land user


Decision maker


Specialist of land planning

Approach costs met by

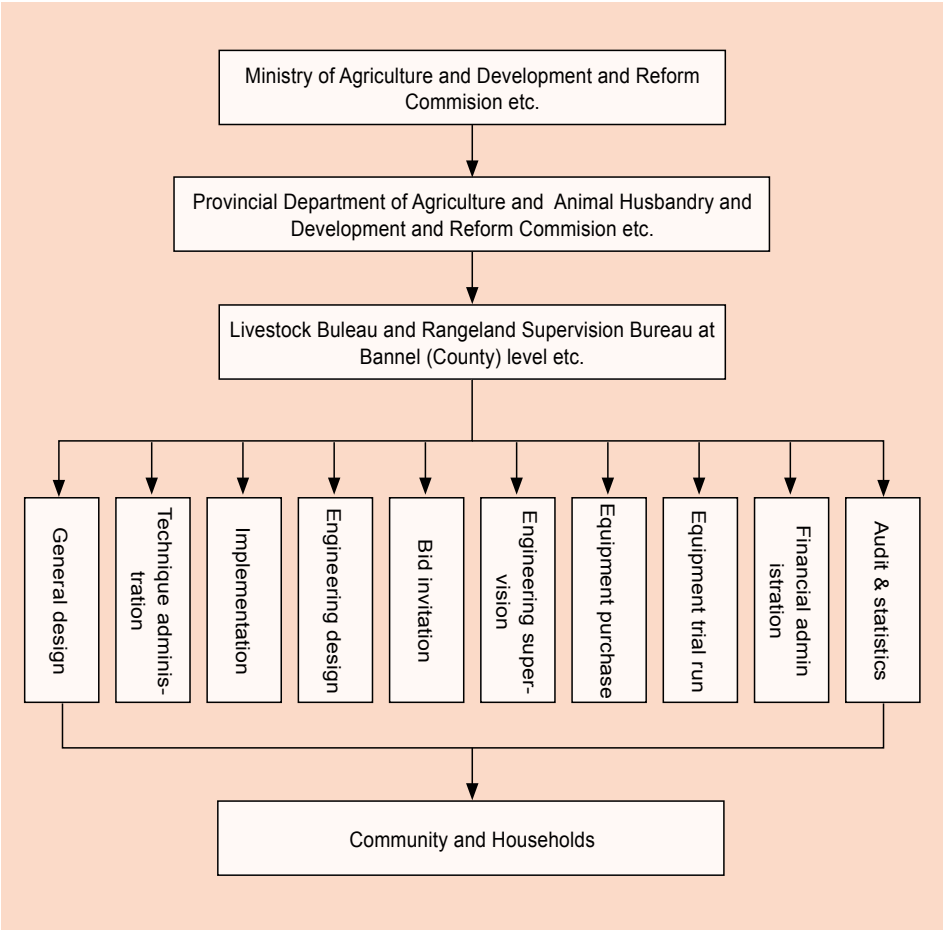
State investment(infrastructure etc.)	50%
Local investment and fund raised by households themselves (for milk cow purchase)	50%
TOTAL	100%

Decisions on choice of the technology: This technique is proposed by animal husbandry administration sector and local government, assigned by state or province authority, and used by land user.
Decisions on method of implementing the technology: Relevant local sector organizes the implementation, sector of technical extension makes design and provides technical service, helps land users to complete the task and instruct herdsmen to operate.
Approach designed by: The project area or Banner (county) government put forward implement program, land user collects the data, and specialists from province or local government participates in design.

Community involvement

Phase	Involvement	Activities
Initiation	Negative	Community basically does not participate in.
Planning	Passive	Community is responsible for provision of the basic data.
Implementation	Interaction	Community and households participate in project activities according to the design.
Monitoring/evaluation	Passive	Participate in investigation.
Research	Not participate	

Differences in participation of men and women: Women's participation is more than that of men, and women bear the daily operation activity.



Organogram

Organizational administration
After project funds delivered, a leadership group is set up. It's task is to coordinate relationship between the relevant units. The specialist group is responsible for the technical guidance.

Funds administration
Strengthen the system of check and audit of the funds use, and aggregate data of funds use. It is necessary to audit at the end of project.

Operation management
Prior to implementation it is necessary to prepare detailed implementation plan and operation flow. Local technicians should provide technical service and inspection. Regular or irregular technical training, instruction and quality check are necessary in favour of playing a role of demonstration.

Extension and promotion

Training: The emphasis of training is made on technique of barn feeding in captivity. The target persons of raining are technicians at grassroot level. The results of training are good for technicians at grassroot level. And medium - for herdsmen. The forms of training are diversified, including teaching books, pamphlets, etc. Technicians are dispatched to project area to conduct training courses for herdsmen of villages in both Chinese and local Mongolian languages.

Extension: After project area constructed, local herdsmen and technicians are organized to learn the project lessons. It is very positive in terms of demonstration role. Extension mainly relies on provincial and local sector, which provide partial funds for construction of facilities for households (e.g. silage). They also demonstrate key technique operation on the spot.

Research: No.

Importance of land use rights: Land ownership and land use right have a certain impact on the extension. Herdsmen do not like leave their own land, but the policy and the fact of pasture degradation force them to accept such this technique.

Incentives

Labour: Herdsmen provide labor input.

Inputs: The government provides inputs of following projects: drinking water facilities, residential houses, livestock sheds, agriculture machines, wells and fenced enclosure etc.

Credit: Loan with low Interest.

Support of local institutions: Application of the technique has a positive impact on capacity building, improves infrastructure of community, and possibly brings more projects in favour of capacity building of local sectors of forestry and animal husbandry (through training and projects) .

Long-term impact of incentives: If government cancels or decreases the incentives or allowance, it will impact the sustainability of the project. Without the incentives the herdsmen will not use the technique.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	On-the-spot investigation of the vegetation coverage, height, production and grass composition.
Technical	Household survey on the difficulty of the project extension and improvment.
Socio-cultural	Survey on the school enrolment rate, women position and illiteracy rate.
Economic/production	Survey and statiscis, household survey: product circulation and market.
Area treated	Field survey on the ecological, economic and social benefits.
No. of land users involved	Survey and statistics: the number of households using this technique is 540.
Management of approach	Household survey is conducted by the sector of grassland and livestock. The sector also checks the balance of the grass and livestock and the status of management and maintenance.

Impacts of the approach

Changes as result of monitoring and evaluation: During the time of extension the extension sector allocates some funds for project households to support construction of necessary facilities to encourage their willingness of accepting the technique.

Improved soil and water management: Increase vegetation coverage, increase soil organic content and strenghen capacity of water and soil conservation of grassland.

Adoption of the approach by other projects/land users: In the neighbour cities and counties the approach has been used by other projects and users, for instance in Ortos city, results are very good.

Sustainability: It depends on the investment of the government and awareness of the herdsmen as well as economical income. Without incentives the herdsmen will not continue to use the technique.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
High efficiency of the extension mechanism → Continue to improve capacity of extension.	Participation rate is low → Introduce participatory tool.
Adopt incentive measures → Increase coverage.	Shortage of funds during implementationv → Need to establish the principle of ecological compensation.
	Low qualification of herdsmen → Improve and perfect the social service system.
	Herdsmen's enthusiasm is not high → Help the herdsmen to overcome difficulty, let them to change the concept in order to go the way to wealth by development of efficient livestock.

Key reference(s)

[1] Du Qinglin. *Sustainable Development Strategy Of China Prataculture*. Beijing: China Agriculture Press, 2006

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Left: The herder transports water for livestock by a tractor.
Right: A pump operated by a windmill.
Photo by Tu Ga

Rotational Grazing

Hexigten Banner of Inner Mongolia, China

Pasture is divided into several plots based on its productivity, and grazing period and grazing systems are fixed according to the carrying capacity of each plot.

The demonstration plots were identified at spring and autumn ranges in Jiri village and Hongqi village of Baiyinchagan township of Hexigten Banner of Inner Mongolia Autonomous Region. There around plots were rivers, lakes and residential areas, and grasslands degraded seriously because of tramples by livestock when drinking water. Perennial forages such as *Leymus chinensis* and Stipa disappeared in community, and many rangelands were dominated by *Artemisia* and forbs. Hexigten Banner initiated the project of rotational grazing in order to improve the living and production conditions of herdsmen, prompt reform of local production systems and preserve the ecological environment of grasslands. The main target of the project was to achieve the balance of pasture utilization, rational development of water resources, and eventually realize the balance between grass and livestock all the year through rotational grazing in summer and autumn and crops grown for silage, etc..

Project initiated in 2002, and central government allocated 8 million yuan as a special ear-marked funds . Total area of demonstration was 10,000 hm^2 with 279 designed plots of 31 units.

Technical contents of rotational grazing mainly included: (1) Balance the utilization of rangelands through dividing the rangeland into units; (2) Solve the problem of water shortage by means of windmill, water tank and water transportation by tractors, etc;(3) Cultivate high-yielding forage crop at small scale with irrigation and fertilizer application; (4) Establish silage to supply forage all the year; (5) Strengthen control of diseases of livestock and improve rangeland management.

The problem of water shortage for livestock can be solved in the following ways: (1) To enclose an area within demonstration plot serving as water storage for live-stock under the conditions if there are river or lake available. (2) In the rolling areas, one drinking point should be created for two plots. Dig well near the pasture track, and every well was equipped with a windmill. A pitcher with capacity of 16 ton of water should be installed around each windmill. (3) If landform of plot is flat, the pitcher should be built at high terrace in favour of water flow in pipeline to grazing area.

Location: Hexigten Banner of Chifeng City, Inner Mongolia Autonomous Region
Technology area: 10,000hm^2
SWC measure: Management measures
Land use: Pasture
Climate: Semi-arid continental climate
WOCAT database reference: QT
Related approach: Extending Rotational grazing and Improving Rangeland Management
Compiled by: Liu Aijun, Rangeland Survey and Design Institute, Inner-Mongolia Agricultural and pastoral Academy of Sciences
Date: September, 2007

Editors' comments: Hexigten Banner had initiated the projects of rotational grazing extensively and highly leveled since 2002, which was a typical and well-tried demonstration of rotational grazing. Projects of rotational grazing are good examples for the improvements of pasturing areas, and they are propitious to grassland protection. Since then vegetation recovery of degraded grasslands have been realized, and obvious improvements of ecological environment and living conditions of herdsmen in project areas have been seen, and economic advantages for local herders, etc., have been felt.

Classification

Land use problems

- Grasslands degraded seriously, and perennial forages such as *Leymus chinensis* and Stipa disappeared. Many rangelands were dominated by *Artemisia* and forbs, and a part of pastures suffered from desertification.

Land use | **Climate** | **Degradation** | **Measure**

Over grazing | Extensive pasture | Semi-arid | Vegetation degradation | Wind erosion | Management measures

Technical function/impact

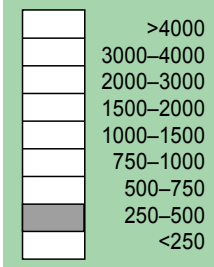
main: - recovery of forage growth
- increase of vegetation coverage
- decrease of desertification
- improvement of grassland productivity
- sustainable use of resources

secondary: - improvement of knowledge of herdsmen and change of their traditional concept
- generation of more income through changed mode of production
- improvement of industrial structure

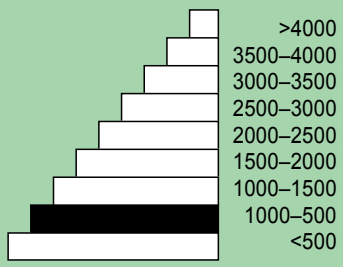
Environment

Natural Environment

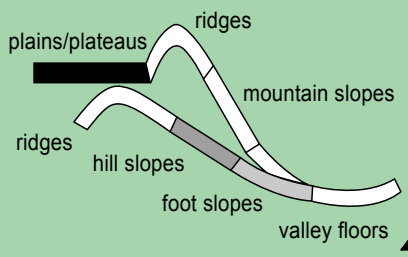
Average annual rainfall (mm)



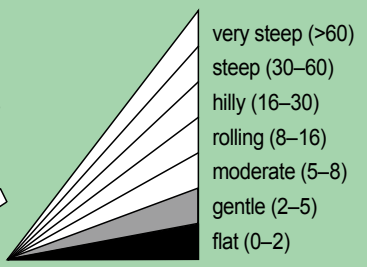
Altitude (m a.s.l.)



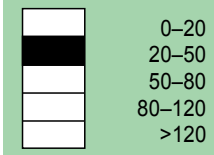
Landform



Slope (%)



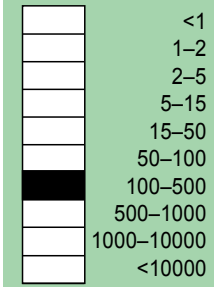
Soil depth (cm)



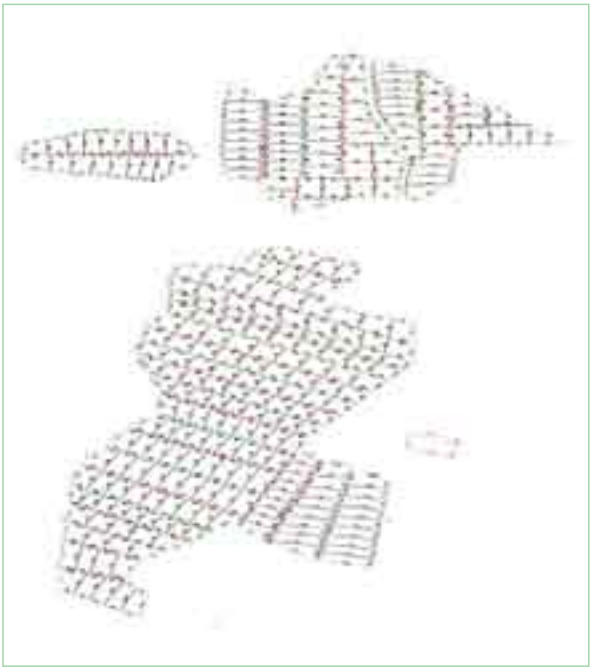
Growing season: 150d, (April to early September)
Soil fertility: medium
Soil texture: medium (loamy texture)
Surface stoniness: scarce
Topsoil organic matter: medium
Soil drainage: better
Soil erodibility: medium

Human environment

Mixed land per household (hm^2)



Land use rights: private
Land ownership: collective ownership
Market orientation: mixed
Level of technical knowledge required: popularization operator: above media; land user: media
Importance of off-farm income: less than 10%



Technical drawing

Five barbed wire fences around rotational grazing units were used and the pillars of enclosures were made up of cements. Plots were divided by zinc coated fences, and added a barbed wire at the top of the fences. Gate of each plot was welded by steel pipes.

Three ways to solve the problem of live-stock drinking according to the practices: (1) In the units where rivers or lakes are in existence, livestock drinks water in a specially allocated public area using surface water. (2) In the areas of rolling terrain, one drinking point should be created for every two units. Dig wells in the plots near pasture track, and provided a windmill for each well. A water pitcher with capacity of 16 ton is installed close to each windmill and pasture track. Auto drinking trough was installed. (3) In the units with flat relief, settings of each pitcher were upraised and diverted water to the grazing plots by pipes. Total operation area was 10,000 hm^2 according design.

Implementation activities, inputs and costs

Establishment activities

1. Planning design themes and building drawings.
2. Establishing enclosures, which included 31 units and 278 plots; 15 pasture tracks and each was 12 m in width.
3. Digging wells and fitting windmills for water.
4. Developing high yielding forage basis.

Project initiated in 2002 and lasted for 5 years.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
Labour	12	0
Equipment		
- tractors, shovels, etc.	40	0
Materials		
- mechanical enclosures, water equippments, etc.	46	0
Agricultural		
- seeds, fertilizer, pesticides, etc.	13	0
TOTAL	111	0

Maintenance/recurrent activities

1. Enclosure mending.
2. Machine services and related cost is at expense of the project households.
3. Land arrangement: Forage basis were leveled ground and sowed by project housh-olders as spring drew near. Non-mechanized operations would be adopted because of small working areas.

The sustainability and demonstration effects of projects should be ensured by enclosure mending, machines protecting, land arrangement, etc, when the project areas were built.

Maintenance/recurrent inputs and costs per hm^2 per year

Inputs	Costs (US$)	% met by land user
Labour	0.3	100
Equipment	0.5	100
Materials	0.1	100
Agricultural		
TOTAL	0.9	100

Remarks: Project households would afford the management costs, and there were no fixed costs of maintenance and labor hours. So it was different to calculate maintenance cost. Results in this table were survey data, instead of calculated results by some standards.

Assessment

Acceptance/adoption

Benefits/costs according to land user	Benefits compared with costs	Short-term	Long-term
	establishment	active	active
	maintenance/recurrent	active	active

Impacts of the technology

Production and socio-economic benefits

+ + +	Livestock gained weight
+ + +	Production methods of animal husbandury optimized and herdsmen's income increased
+ +	Saved labor was transferred to second and third industries

Production and socio-economic disadvantages

– – –	Irrational structure of livestock herds and inefficiency of livestock improvement
– – –	Misact ion of balance system between grass and livestock
– –	Increased economic burdens for herdsmen and labor intensity

Socio-cultural benefits

+ + +	Scientific technologies were improved and herdsmen's traditional concept changed

Socio-cultural disadvantages

– –	Less chance for women's involvement

Ecological benefits

+ + +	Pabular forages and grass coverage increased
+ + +	Grazing intensity were lessened
+ +	Water and soil conservation were strengthened
+ +	Degradation was halted

Ecological disadvantages

	None

Off-site benefits

+ + +	Climate of sandy storm was lightened

Off-site disadvantages

	None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Over grazing was controlled and was in favour of pasture recovery → Keep on popularization.	Contradiction between rotational grazing and increasing incomes → Intensify financial supports and credit.
Industrial structure and economic advantages were improved → Intensify livestock improvement and increase the individual merit. Circulation channel and slaughtering rate should be further strengthened.	Technological services could not meet the demands → Perfect technical service system of community.
Improvement of ecological environment and infrastructure in pastoral regions → Increasing more inputs to infrastructure, and increase more public sources for pastoral regions, such as electricity, traffic, communication, education and medical care, etc.	

Key reference(s)

[1] Du Qinglin. *Sustainable Development Strategy of China Prataculture*. China Agriculture Press, 2006

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Left: Plots of rotational grazing in Hexigten banner.
Right: Construction and management in rotational grazing plots.
Photo by Tu Ga

Extending Rotational Grazing and Improving Rangeland Management

Hexigten Banner of Inner Mongolia, China

Rangelands are divided into several plots, which are used in a balanced rotational way for livestock. It provides an opportunity of rehabilitation of rangelands and favours rational use.

Hexigten Banner, located in northeast of Chifeng City on the south edge of Daxing'anling Mountain, is adjacent to Otindag Sandy Land. It is an animal husbandry-centered banner. Due to overgrazing, degradation of grassland and decreased productivity, the central government decided to encourage suspend grazing and use rotational grazing with a subsidy in cash and food. Rotational grazing has promoted vegetation recovery, ecological environment improvement and poverty reduction.

The project started at 2002. Due to support, provided by the Ministry of Agriculture and Department of Animal Husbandry of Inner Mongolia, and assistance, given by Inner Mongolia Institute of Grassland Survey and Design, Animal Husbandry Bureau of Chifeng City and Animal Husbandry Bureau of the Banner, the project covering 10,000 hm^2 has achieved an outstanding success during 2 years. The project funds, which came from budget of central government as ear-marked funds, have been used for establishment of infrastructure, including enclosure and drinking facilities. The funds raised by herdsmen are used mainly for purchasing production facilities and daily necessities.

In order to better manage project the government of the Banner has set a Leadership Group with the Banner leader as the leader of the group. The leaders of relevant sectors are the members of the group. The Bureau of Animal Husbandry of the Banner is in charge of routine operation. The Bureau of Animal Husbandry of the Banner has formulated management regulations, which clearly define ownership. Responsibilities of management and maintenance have been specified in contract. Every household has its obligations for managing its grazing units, including maintenance and possible repairing work of enclosures. Every unit must appoint a person for overall supervision and coordination. The Grassland Supervision Office of the Banner is responsible for check of carrying capacity. Any overgrazing and excessive use of pasture land is forbidden.

At present, total area of natural rangeland under rotational grazing amounts to 4.6 million hm^2 in Inner Mongolia autonomous Region. As monitoring results indicate, that vegetation coverage and production is increased by more than 30%, and carrying capacity is increased by 15% due to rotational grazing, The degraded rangelands have signs of positive succession. The ecological environment of pasture land is improved and incomes of herdsmen increased.

Location: Hexigten Banner of Chifeng City, Inner Mongolia
Land use: Pasture land
Climate: Semi-arid
WOCAT database reference: QA
Related technology: Rotational Grazing
Compiled by: Liu Aijun, Rangeland Survey and Design Institute, Inner-Mongolia Agricultural and pastoral Academy of Sciences
Date: September, 2007

Editors' comments: Ecological compensation is an important measure both in improving incomes for farmers and herdsmen and economic development of steppe zones. The precondition of rotational grazing is the guaranteed survival right and development right of herdsmen. The project can be sustainable only when herdsmen have more generated income and local economy has continued development.

Problem, objectives and constraints

Problem

- A gap exists between recognized importance of rotational grazing by herdsmen and its overall extension.
- Methodology cannot be operational without adequate financing, and training is also important.
- The long term compensation and incentive mechanism is the key of technical application.

Objectives

- To establish effective mechanism of technical extension.
- To improve awareness of ecological protection in communities.
- To increase participation of communities.
- To solve the contradiction between limited rangeland and growing demand of animal husbandry.
- To improve the production environment, protect and recover vegetation.
- To increase the contribution rate of scientific progress and innovation of science and technology to ecological management.

Constraints addressed

Major	Specification	Treatment
Economic aspect	Large investment at the initial stage and high cost of management are the heavy burden for herdsmen, moreover, the income generated by herdsmen decreased in short time.	Government provides financial support and preferential policy to herdsmen and awards and incentives to project households.
Social aspect	Rotational grazing is not a commonly acceptable grazing system, and most herdsmen, having traditional free grazing habits, feel difficult to change their concepts.	Strictly follow the system of a balance between rangeland and livestock. To this end, it is necessary to speed up livesock improvement, increase production performance and profits, strengthen publicity and improve awareness of herdsmen with an aim to reduce animal heads and increase income.
Minor	**Specification**	**Treatment**
Technological aspect	As herdsmen lack knowledge of animal management, and it is not easy to popularize the technology through out pastoral regions.	Technical training should be strengthened and social service system in pastoral region will be established and perfected.

Participation and decision making

Target groups


Land user


Decision maker


Land planner


SWC Experts

Approach costs met by

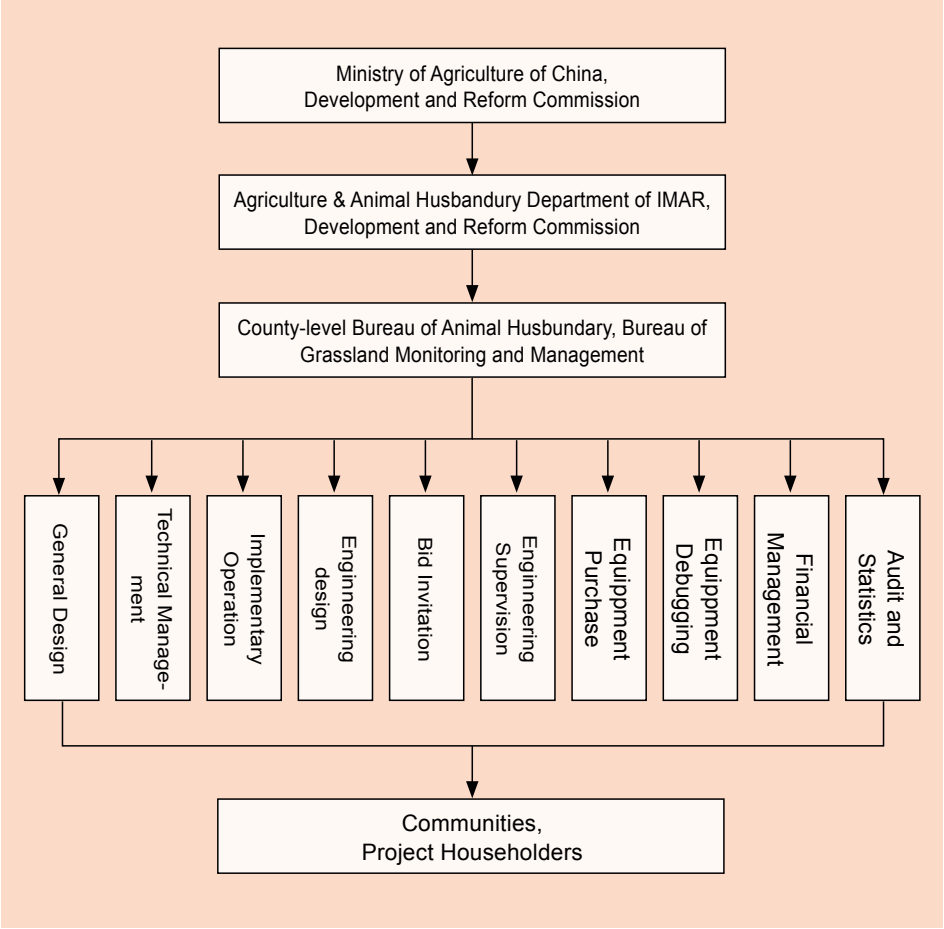
State investment	50%
Local funds	50%
Total	100%

Decisions on choice of the technology: This technology will be provided by rangeland experts.
Decisions on method of implementing the technology: It is implemented by the Banner Animal Husbandry Bureau, and the technical extension institution is in charge of design and providing technical operation to herdsmen in the field.
Approach designed by: Operation design will be provided by national or provincial experts, and land users participate in adaptation.

Community involvement

Phase	Involvement	Activities
Initiation	Passive	Delegates of herdsmen, directors of villages or groups and some herdsmen participated in the activities of information consultations and questionnaire survey.
Planning	Interactive	Herdsmen participated in the selection of project area and demarcation of the range area and livestock scales of rotational grazing.
Implementation	Interactive	Community and people who are relevant to profits, participated in the consultations and discussions, and staff are organized for implementation according to plan; in the mean time they put forward their improved opinions.
Monitoring/evaluation	Participated	Herdsmen monitored the conditions of rangeland health and livestock production under the directions of technicians.
Research	Did not participate	Herdsmen scarcely participated in the scientific research works of rotational grazing.

Differences in participation of men and women: Grazing works were generally assumed by men before rotational grazing implemented. After rotational grazing implemented, women instead of men were responsible for the task of feeding, drinking, delivering lamb, chopping grass and milking, etc. Even summer grazing were undertook by women. Women assumed responsibility for almost all the housework in their families.



Organogram

Management and implementation of the project were conducted up and down. Firstly the national administration puts forward a project plan, and subsequently the plan went forth to provincelevel management departments. Project with funds finally reached banners and countries. Banners and counties are responsible for design, setting up management committee and bid invitation. As a last step, the project must be implemented on concrete places and households.

Extension and promotion

Training: Technicians assigned by province provided free-of-charge trainings, through which herdsmen could learn the rules of rotational grazing. In average, one person from each household was trained in the forms of textbooks, information booklets, TV media, door-to-door interviews with households, etc. Validation of training was good for technicians and was medium for herdsmen.

Extension: Extension mainly was conducted by provincial and local technical sectors. Provincial sector was responsible for the project design, and project groups of Banners (Counties) were responsible for implementation. At present, the demonstration results were quite good, but herdsmen had no willingness to use rotational grazing, because of the huge investment at early stage. Therefore, method of rotational grazing will be used widely by herdsmen, if governments provide more inputs.

Research: It included livestock nutrition, adjustment balance of grass and livestock, and grassland monitoring and evaluation, etc.

Importance of land use rights: There was no significant impact of land use right on project implementation.

Incentives

Labour: Volunteer labour inputs by herdsmen.

Inputs: Government provided the costs of infrastructure construction, which were used for purchasing enclosures, angle irons, digging wells, windmills, livestock improvement and disease control, etc.

Credit: Banks provided interest-free of low-interest loans.

Support of local institutions: The implementation of projects promoted capacity building, because project brought funds and technology.

Long-term impact of incentives: Long-term impacts would be positive, but reduced input by government might have impact on popularization of rotational grazing. Demonstration zone played a strong role in popularization. It is believed that this method of rational grazing, as a scientific system of grassland utilization would be finally accepted by herdsmen with their improved awareness and knowledge on rotational grazing.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Field monitoring and investigation: forage coverage, height, species and productivity of available forages.
Technical	Investigation: number, weight of livestock, carrying capacities and forage yields.
Socio-cultural	Questionnaire: household survey. Items included enrolment rate for children, proportion of students entering schools of a higher grade, educational costs, etc. Cultural activities of communities were also included.
Economic/production	Statistical survey, monitoring and census: forage yield, herdsmen incomes.
Area treated	Field investigation. Areas of rotational grazing were statistically used.
No. of land users involved	Statistical survey indicated: 15 households accepted the technology of rotational grazing.
Management of approach	Household investigations were undertaken by grass-root supervision sector of grassland. The task was to check balance of grass and livestock and project management and maintenance.

Impacts of the approach

Changes as result of monitoring and evaluation: Training forms were various. Some foreign projects conducted trainings, which could provide costs and training venues. Most women actively participated in the trainings. Scientific and technological abilities of herdsmen were increased, and some traditional concepts were changed. It greatly changed the modes of animal husbandry production.

Improved soil and water management: Water and land resources were rationally used. Rangeland condition and soil organic matter were improved. Moisture-holding capacity of grassland was enhanced.

Adoption of the approach by other projects/land users: Project was demonstrated in ten Leagues (cities) and 36 Banners (counties). Rotational grazing areas popularized by grassland design departments of Inner Mongolia reached 10,045,00 mu (1 hm^2 =15 mu). Beijing-Tianjin Sand Control Programme and the Programme of Conversion of Grazing Area to Grassland have adopted the technology of rotational grazing.

Sustainability: Application of rotational grazing technology was guided by government investment, and willingness of herdsmen to pay increased from 100 yuan to a 1000 yuan. Some herdsmen were willing to pay match funds with government in 5%-10%. Herdsmen should be the main body of investment and construction from a long-term point of view; however, herdsmen would not apply the technology of rotational grazing consciously in near future, if there were no incentives or projects supports.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
High efficiency of popularization → Abilities of extension department should be further improved.	Economic burdens of herdsmen were increased → More inputs should be increased and encourage herdsmen to make more inpus.
Encouragement measures should be adopted → Enlarging the demonstration areas.	Backward in technologies and services → Services of science and technology should be reformed and social service system in pastoral region should be further improved.
Rotational grazing with lease-holding household groups adopted → Further Improved rotational grazing mechanism with lease-holding household groups.	Women had less chance for participation → Participatory approach should be adopted.
	Low education level of herdsmen → Strengthening training and education to change traditional concepts of management.

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[1] Du Qinglin. *Sustainable Development Strategy Of China Prataculture*. Beijing: China Agriculture Press, 2006
[2] Zhao Xueyan. *Survey and Thinking about Ecological Immigrant and Herders Settling of Alpine Pasture*, China Grassland Journal, 2007, 2, 94-101
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Contact person(s)

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Left: Downstream slope of medium-size dam
Right: Medium-size dam without spillway
Photo by Wang Yongjun

Silt Storage Dam

Yulin County of Shaanxi Province, China

Silt storage dam is a kind of building, which is constructed at all levels of channels in areas with soil and water loss for forming farmland.

Silt storage dam, also called as production dam, is a special and unique gully control project in area with serious soil and water loss in the Loess Plateau. The demonstration site, located in Yulin County, Shaanxi Province of China, belongs to Loess Hilly-gully Region with temperate continental monsoon climate. The amount of average annual rainfall is 480 mm. The maximum amount of Soil erosion modulus is 15000t/km^2·a. The land use type is farmland.

Silt storage dam structure: Large dam consists of dam, sluice tunnel, spillway. Medium-small dam consists of dam and spillway. There are three kinds of dam in demonstration area: small dam with control area of less than 0.5km^2, medium dam 0.5-3km^2 and the key project 3-10km^2.

Construction process: Site selection and topographic map measurement; design (hydrologic computation, dam height determination, dam section determination, size of discharge building).

Construction: Rolled earth dam construction. First: alignment, Second: dam foundation and bank slope treatment; Third: Dam filling; (1) soil material selection; (2) pave the soil; (3) compaction (stratified compaction, depth is less than 20 cm).

Hydraulic filling dam. First: water storage. (1) base flow accumulation; (2) hold seasonal flood water; (3) hold ice water; (4) upstream running water; (5) reserve water by water storage dam heightening; (6)shift water from neighbour channel. Second: Earth pits selection. nearby the filling body, 20-30cm higher than the filling body; The soil with lower clay content. Third: construction site layout. (1) earth pits layout; (2) layout of mudmaking ditch and mudtransport; (3) road layout; Forth: pump station construction. (1) station site selection; (2) pump selection; Fifth: field division and earth dike construction. (1) field division; (2) earth dike construction; Sixth: mudmaking and filling; Seventh: drainage; Eighth: top capping; Ninth: dam body clearance.

Maintenance: (1) Daily maintenance includes: keeping dam crest and dam slope complete. (2) Crack maintenance includes: excavation and earth-fill method and grouting method. (3) Leakage maintenance includes throwing earth method, grouting method, clay covering method and so on. (4) Landslide maintenance includes: excavation and earth-fill method, dam slope mitigation and seeping convention by trenching method.

Location: Yulin County, Shaanxi Province
Technology area: 75km^2
SWC measure: Mechanical practice
Land use: Others
Climate: Semi-arid
WOCAT database reference: QT
Related approach: Silt Storage Dam for Forming Farmland
Compiled by: Wang Yongjun, Qi Shi, Institute of Soil and Water Conservation, Beijing Forestry University
Date: September, 2007

Editors' comments: Desilting dam is a main measure to treat small watershed channels. Its function: sediment storage; prevent valley trenching; prevent banks wider; control channel gravitational erosion; adjust channel runoff; utilize water sources rationally; relief channel and reservoir sedimentation; improve basin environment; develop rural economy. Desilting dam construction in the Loess Plateau becomes an important component of local farmland construction.

Classification

Land use problems

Arid climate, rainstorms, serious soil and water loss; Organic matter layer has been peeled off and eroded, soil impoverishment; Vegetation coverage is low, vegetation is in poor growth.

Land use | **Climate** | **Degradation** | **SWC measure**

Farmland | Agroforest | Semi-arid | Water erosion | Vegetation destruction | Wind erosion | Mechanical measure | Biological measure

Technical function/impact

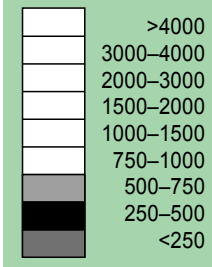
main:
- holding sediment, reduce the amount of sediment rushed into the Yellow River
- silt storage forming new farmland
- flood control and disaster reduction to protect downstream
- raise the effective utilization rate of rainfall resources
- relief pressure of water deficit for production, livelihood and ecological use

secondary:
- use dam as road to improve transportation condition
- improve living condition
- promote the construction of the new rural area
- promote the development of the rural economy

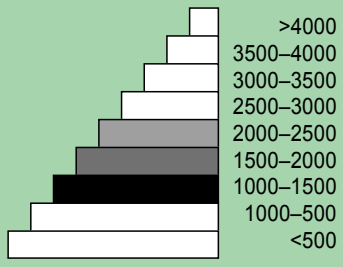
Environment

Natural Environment

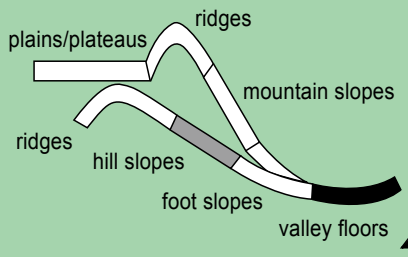
Average annual rainfall (mm)



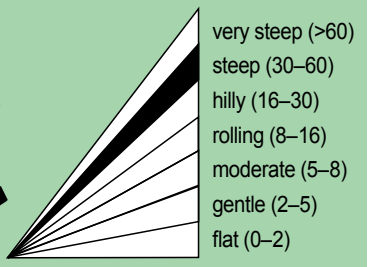
Altitude (m a.s.l.)



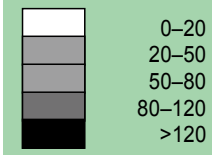
Landform



Slope (%)



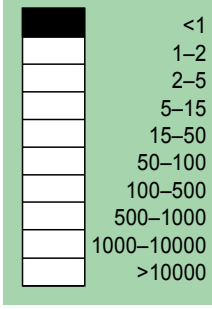
Soil depth (cm)



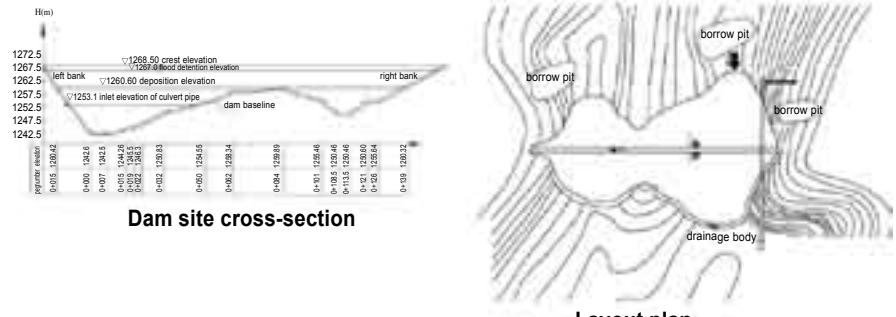
Growing season: 185 days(from April to September)
Soil fertility: low
Soil texture: medium (loam)
Surface stoniness: NA
Topsoil organic matter: low
Soil drainage: good
Soil erodibility: very high

Human environment

Mixed land per household (hm^2)

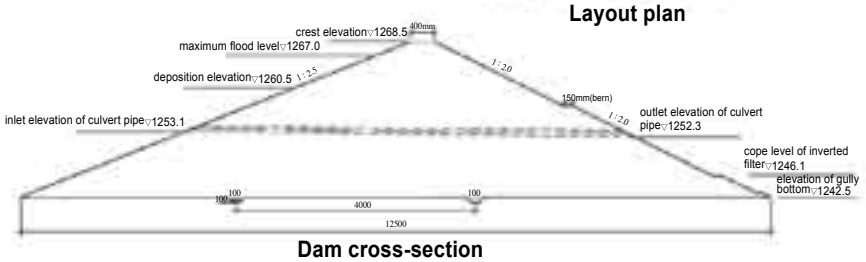


Land use rights: private
Land ownership: state
Market orientation: mixed
Level of technical knowledge required: technician: high; land user: low
Importance of off-farm income: 10%-50% of the total income



Dam site cross-section

Layout plan



Dam cross-section

Technical drawing

Dam site cross-section is measured. Layout plan is measured 1:500 topographic map. It contains three borrow earth pits. Seen from the dam cross-section, there is a berm. Connecting slot is constructed under the dam.

Drawing by Wang Yongjun, Qi Shi

Implementation activities, inputs and costs

Establishment activities

1. Local borrow selection(avoid destructing vegetation).
2. Slope cutting (make borrow slope smaller than safety gradient) ; Stone bank slope less than 1:0.6; Earth bank slope less than 1:1.5; Slope must not be cutted into step.
3. Pave soil(rolled depth should be less than 20cm by labor and less than 25cm by caterpillar).
4. Compaction.
5. The construction period of earth dam lasts about 1 year.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
Labour	12000	0
Equipment/tools		
- 74kW bulldozer	5000	0
Materials		
- earth material - loose-stone - precast concrete	15000 2500 4000	0
Agricultural		
- planting grass on downstream slope	600	0
TOTAL	38500	0

Maintenance/recurrent activities

1. Supervision.
2. Fix damaged dam, earth filling.
3. Maintenance of offlet, artificial patrol: check whether offlet is blocked or damaged. Clear up it and repair it in time to ensure normal use during the rainy season.
4. Dam body Maintenance: Prevent the damage caused by rainstorm erosion during the rainy season. Patrol and mend in time if damaged.

Maintenance/recurrent inputs and costs per hm^2 per year

Inputs	Costs (US$)	% met by land user
Labour	30-60	30
Equipment		
- shovel	5-10	100
Materials		
- earth material - stone	15-30 15-60	30 0
Agricultural		
- vegetation Maintenance for slope protection	10-15	100
TOTAL	75-175	52

Remarks: The construction expenses of silt storage dam contain: construction material, labor, mechanic and independent cost and contingent fund. Computation of these expenses is based on the material price of the same year. Maintenance cost is determined according to the local labor price. Exchange rate: 8.278.

Assessment

Acceptance/adoption

- Most of the land users accept the construction and maintenance of silt storage dam.
- With the incentive mechanism, 98% of farmers have a willingness of participation in dam construction.
- While without incentive mechanism, some 80% of farmers can accept.

Benefits/costs according to land user

At initial stage, dam construction took up farm land, thus farmers' income is decreased and cost increased temporally. After dam built-up, farmers could develop aquiculture or irrigation.

Benefits/costs ratio	Short-term	Long-term
establishment	very positive	very positive
maintenance/recurrent	very positive	neutrality

Impacts of the technology

Production and socio-economic benefits

+ + +	Increasing cultivated area, improve grain yield
+ + +	Improving availability of rainfall resource
+ +	Mitigating shortage of water use(for life, production, ecology)
+ +	Helpful to fishery breeding

Production and socio-economic disadvantages

	None

Socio-cultural benefits

+	Strenthen capacity buildin of the construction and soil & water conservation departments
+	Improving knowledge of farmers on soil and water conservation

Socio-cultural disadvantages

	None

Ecological benefits

+ + +	Blocking sediment and storing soil, thus reducing sediment of the Yellow River
+ + +	Raising erosion basis, keeping gully slope stable
+ + +	Flood control and disaster reduction, protect safety of the downstream area
+ +	Improving regional environment

Ecological disadvantages

–	Dam construction may destroy surrounding environment and increase soil and water loss

Off-site benefits

+ +	Reduce downstream flood and channel sedimentation

Off-site disadvantages

–	Reduction of runoff of downstream river

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Combining slope and channel treatment to prevent soil and water loss → Combining engineering and biological measures, develop comprehensive treatment .	High cost → Creation of multiple investment mechanism.
Reducing and preventing channel erosion → Continuing silt storage dam project.	Disjunction among construction, management and use exists in the dam construction management → Clearly define ownership and carry out the principle of unified "responsibility, right and benefit".
Increasing availability of rainfall resource → Conducting a study on dry farming and technical extension.	

Key reference(s)

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Left: Silt storage dam under construction.
Right: Silt storage dam after construction.
Photo by Wang Yongjun

Silt Storage Dam for Forming Farmland

Yulin County of Shaanxi Province, China

Silt storage dam is a kind of building, which is constructed at all levels of channels in soil and water erosion areas for forming farmland. The farmland made in this way is called dam land.

Silt storage dam, as an effective engineering measure for soil and water conservation and reducing sediment of the lower reach of the Yellow River, is a project which is invested by government, designed and extended by water conservation department and implemented by enterprises.

The Silt storage dam for forming farmland is built by four steps: (1) project application; (2) feasibility study of Dam system; (3) primary design; and (4) implementation.

The invitation for bid is a way of project implementation and the construction unit selected for implementation shouldhave qualification and high prestige. The following issues should be emphasised during the project implementation: (1) examination of construction company qualification; (2) quality of construction materials; (3) quality supervision during the construction; (4) middle stage acceptance check; (5) supervision of construction methods and technology.

The ways of silt storage dam popularization are as follows: firstly, it can be extended from pilot site to other area by demonstration; secondly, let local government and land users realize the benefits of silt storage dam by different media, so as to promote the development of dam construction; thirdly, encouraging the local government and land users actively to build silt storage dam by taking all kinds of incentive measures, particularly cash payment, and supplementary measures, including priority of accessing and contracting the dam land.

During construction of silt storage dam, land users can obtain cash for work. The participation of land users not only promotes development of silting dam, but also solves the problems caused by land use right.

The main approach of dam construction can be expressed as: government plays a leading role with support from local departments; enterprises are responsible for implementation and farmers take part in construction.

The silt storage dam system can improve environment of project area, promote the economic development, increase the forest and grass cover, the amount of storage and infiltration of rainfall, reduce flood and converse slope farmland to forest and grass in favour of economic development of the basin.

Location: Yulin County, Shaanxi Province
Land use: Others
Climate: Semi-arid
WOCAT database reference: QA
Related technology: Silt Storage Dam
Compiled by: Wang Yongjun, Qi Shi, Institute of Soil and Water Conservation, Beijing Forestry University
Date: September, 2007

Editors' comments: Gully treatment is an important component of ecological construction in the Loess Plateau. This implementation method is popularized by demonstration. The main approach of construction of silt storage dam is as follows: government plays a leading role with support from local departments; enterprises are responsible for implementation and farmers take part in construction. This method is widely adopted in Loess Plateau and Northern China.

Problem, objectives and constraints

Problem

- Lack of effective mechanism to organize farmers.
- Lack of Channel treatment knowledge.
- Lack of funds.
- Poor willingness of participation by Farmers.

Objectives

- Forming effective investment and popularization mechanisms.
- Conducting training course, increasing investment for intelligence, training more designers and constructors.
- Carrying out Multi-channel investment mechanisms. Greater part of investment is made by the government and local departments support, and use social funds as more as possible.
- Taking all possible measures to encourage farmers' participation in silt storage dam construction and strengthen awareness education on possible benefits brought by silt storage dam.

Constraints addressed

Major	**Specification**	**Treatment**
Economic factors	Insufficient national investment, demonstration sites belong to underdeveloped area, local finance is limited, thus has no sufficient funds to support.	Government budget should have ear-marked funds for increasing investment.
Technique factors	Design and construction need qualified technicians.	Strengthen technical training of related designers and planners.
Minor	**Specification**	**Treatment**
Social factors	Local residents lack soil and water conservation knowledge. Insufficient understanding of the functions of silting storage dam. Insufficient attention to management and maintenance.	Strengthening science popularization and training if possible.
Natural factors	Gully crossing, Terrain breaking, inconvenient transportation, great difficulty of construction.	Replace road with dam, so as to increase land utilization rate.

Participation and decision making

Target groups


Desicion makers


Experts


Designers


Land users

Approach costs met by

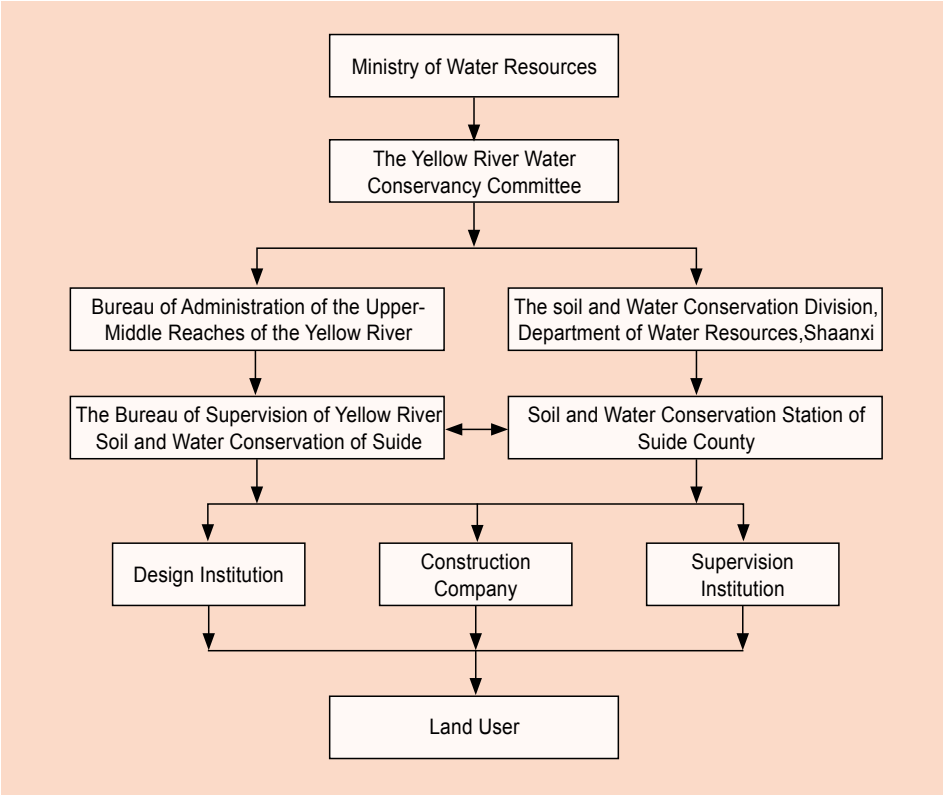
Government investment	80%
Local department funds	20%
TOTAL	100%

Decisions on choice of the technology: Ministry of Water Resources, Yellow River Conservancy Commission.
Decisions on method of implementing the technology: Upper and Middle Reaches Administration of the Yellow River Conservancy Commission.
Approach designed by: National experts .

Community involvement

Phase	**Involvement**	**Activities**
Initiation	Interaction	Conduct preparation meeting and ascertain awareness education plan.
Planning	Not involved	
Implementation	Interaction	Participate in construction of silting dam.
Monitoring/evaluation	Not involved	
Research	Not involved	

Differences in participation of men and women: Great difference. Men mainly deal with field surveying. While women deal with indoor work such as data treatment.



Organogram

Materials supply: The bureau of supervision of Yellow River soil and water conservation of Suide.

Drawing: Wang Yongjun, Qi Shi

Extension and promotion

Training: Training subjects: design and planning and daily maintenance of silt storage dam; flood control and ensuring harvest, planting in dam land. Training types: training course, seminar, guidelines book. Training results: good results for Designers and fair results for local farmers.

Extension: Silt storage dam construction technology contains: rolled fill and sluicing-siltation damming techniques. The extension depends on government, and driven by demonstration. Main institutions: local government, soil and water conservation station. However, lack of funds will affect the extension.

Research: Main programs: Research on sediment reduction controlling model in the main sources of Yellow River coarse sediment, which includes: Soil erosion law of coarse sediment sources; Study on allocation model of control measures; Study on distribution pattern of channel dam system. Study on sustainable utilization of water resources, which includes: Water resources evaluation; Study on natural rainfall collection technology; Study on flood resource utilization; Optimal allocation of water resource.

Importance of land use rights: Property Right is not clear and it affects project implementation.

Incentives

Labour: The labour is recruited with cash payment.

Inputs: Government investment, Local department support. Other inputs such as soil material, stone, steel bar, cement, diesel oil, tractors, bulldozers, tree seedlings, fry and so on are needed in addition to funds.

Credit: Government investment and local department funds without credit.

Support of local institutions: For the design and construction of silt storage dam, local soil and water conservation stations can get financial benefits from national government investment on one hand, and by, it also improves capability of the local soil and water conservation departments through training , seminar and technical meeting on the other hand.

Long-term impact of incentives: Incentives can ensure successful accomplishment and operation of silt storage dam. Because of the time limits of the use right of silt storage dam, it is difficult for farmers to maintain the dam over a long period of time, so there is a risk for future operations of the dam. If the responsibility, power and interest can be reasonably guaranteed, farmers will maintain the dams positively, even no incentives be provided.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Methods: measurement; investigation; setting monitoring plots. Indicators: detention volume; rainfall; erosion; dam reservoir deposition.
Technical	Methods: investigation. Indicators: dam leakage; landslide; crack; preservation degree and damages of water discharge buildings.
Socio-cultural	Methods: sampling survey in residential area; questionnaire of workers. Indicators: degrees of approval of Debris flow protection importance, action performance.
Economic/production	Methods: random investigation. Indicators: input-output; yield increasing benefit; protection input; engle's coefficient.
Area treated	Methods: sampling survey. Indicators: change of area of land forming and vegetation area.
No. of land users involved	Household survey.
Management of approach	Methods: questionnaire; household survey. Indicators: satisfaction to the silt storage dam; satisfaction to the constructors' working attitude.

Impacts of the approach

Changes as result of monitoring and evaluation: Extension method has great changes. It shows as follows: firstly, getting rid of traditional extension of national mandatory; secondly, achieving multiple investments; thirdly, the dam system has become an important component of local ecological development.

Improved soil and water management: Increasing the availability of rainfall resources; mitigating the pressure of water supply for production, living and ecology; decreasing the sediment into the Yellow River; increasing the arable land area and raising the yield production; promoting conversion of slope farmland to forest and grassland; reducing slope vegetation destruction.

Adoption of the approach by other projects/land users: Silt storage dam has been extended to Shanxi, Ningxia, Qinghai, and Henan Provinces.

Sustainability: As the high cost of silt storage dam and relatively slow returns, land users have difficulty to afford the high construction cost of the dam without government support.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Top-down model, efficient extension system → Extend dam system construction in large-scale.	Lack of national investmnet → Allocate special funds; Strenthen investment and construction; Achieve diversified Investment.
Intercepting sediment efficiently, reducing gully erosion, provide better conditions for improving basic farmland → Developing aquiculture and economic forest.	Property right and responsibility of dam land are not clear → Defining property rights and it's ownership; Guarantee the sustainable development of silt storage dam.
Increasing farmland area → Combining treatment with development to push techniques application.	Extension system is not perfect, and it mainly relies on national, local government and soil and water conservation department → Establishing and perfecting extension system, setting up technical extension department to guarantee the extension in time and effectively.
Demonstration driving, Plot-local radiation → Take full attention of extension, improve radiant area as possible.	

Key reference(s)

[1] Fan Ruiyu, *Dam system ecological engineering of Loess Plateau*. Zhengzhou: Yellow River Water Conservancy Publishing House, 2004

[2] Bureau of administration of the upper-middle reaches of the Yellow River. *Experimental study on silt storage dam*. Beijing: China Plan Publish House, 2005

Contact person(s)

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Left: Long distance view of check dams construction in Xifeng
Right: Close-up scenery. Photo by Lei Xiaobo

Check Dam

Xifeng County of Gansu Province, China

Check dam is a kind of sediment storage dam of 5m below and is built in channels to control the down cutting of channel bed.

The technical demonstration site is located at the Loess plateau with continental monsoon climate, drought and less rain in winter and spring, moderate rainfall in summer and autumn. The amount of average annual rainfall is 556.5 mm and the amount of water surface evaporation is 1491.0 mm. The average frost-free period is155 days, soil types are Heilu soil, loessal soil and alluvial soil. Medium soil fertility which is suitable for growing forest and grass. Runoff modulus is 8894 $m^3/a \cdot km^2$, erosion modulus is 4350 $t/km^2 \cdot a$. The amount of surface runoff of Yuan tableland accounts for 67.4 percent of the total watershed and sediment accounts for 12.3% of the total.

According to the materials, the check dam types are earth check dam, stone check dam, stone loaded by bamboo cylinder check dam, concrete check dam, biological check dam etc..

Arrangement: (1) Section: Height of 0.4 to 5.0m, top width of 1.0 to 1.5m, upstream slope: 1:0.5 to 1:1.5, downstream slope of 1:0.3 to 1:1.0. (2) Space: Check dam spacing $L = H / (I\text{-}Ic)$, where H for height; I for original gully gradient; Ic for gradient between the two check dams. In technical demonstration site the space in general is from 50 to 70 m. (3) Spillway: the spillway of check dam can be set in one end of check dam. The section size is determined by designed flood peak. In general the bottom width is set from 0.8 to 1.0 m in the technical demonstration site. (4) Check dam is arranged in the upper reaches of main channel and the branches with larger gradient. Specifically, the check dam location is selected in narrow channel with large sediment storage capacity.

Construction steps: (1) Line location and clean base: according to the dimention of the design, make out the scheme of the dam base, on the ground, clear and remo-ve the silt layer and weathered layer to a solid bedrock or earth layer bulid combina-tion groove s on the two sides of gully cliff with a size of 0.5 m to 1.0m both in width and depth; (2) After foundation preparation, layered filling and ramming, the thickness of filling is about 0.2 m to 0.25m, ramming stone roller or compaction ma-chine can be used as compaction equipment, dry bulk density is controlled between 1.5 t/m^3 and 1.8t/m^3; (3) Spillway excavation, the section dimentions are determined by the design flood; upstream slope is placed by cement laid stone masonry and pointing joint also to prevent seepage.

Location: Xifeng, Gansu
Technology area: 36.3km^2 of demonstration
SWC measure: Engineering measure
Land use: Slopeland and economic forest
Climate: Semi-arid
WOCAT database reference: QT
Related approach: Check Dam Approach
Compiled by: Wang Yongjun, Shi Yu, Lei Xiaobo, Institute of Soil and Water Conservation, Beijing Forestry University
Date: September, 2007

Editors' comments: Check dam is widely used for soil and water conservation nation and worldwide, such as Europe and Japan.

Classification

Land use problems

Land use | **Climate** | **Degradation** | **SWC measure**

Lash forest | Agriculture/forestry/animal husbandry | sub-humid | Erosion water | Vegetation destruction | Mechanical measures

Technical function/impact

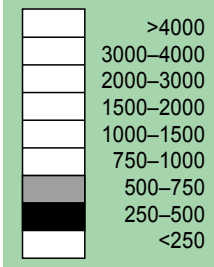
main: - prevent the channel down cutting and channel bank expansion
- stabilize toe of slope, prevent landslide
- sediment holding
- decreasing channel gradient and reducing the flood risk
- permanent check dams could prevent/mitigate debris flow damages

secondary: - silting farmland and developing economic forest

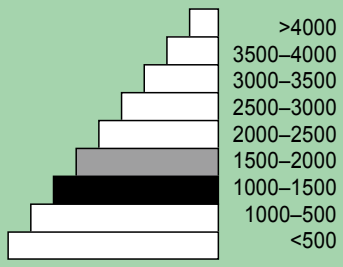
Environment

Natural Environment

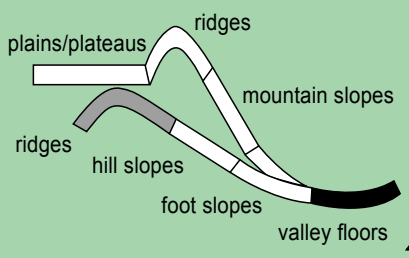
Average annual rainfall (mm)



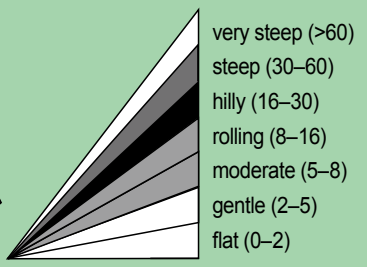
Altitude (m a.s.l.)



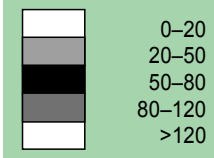
Landform



Slope (%)



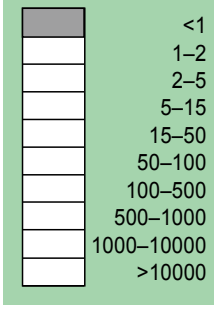
Soil depth (cm)



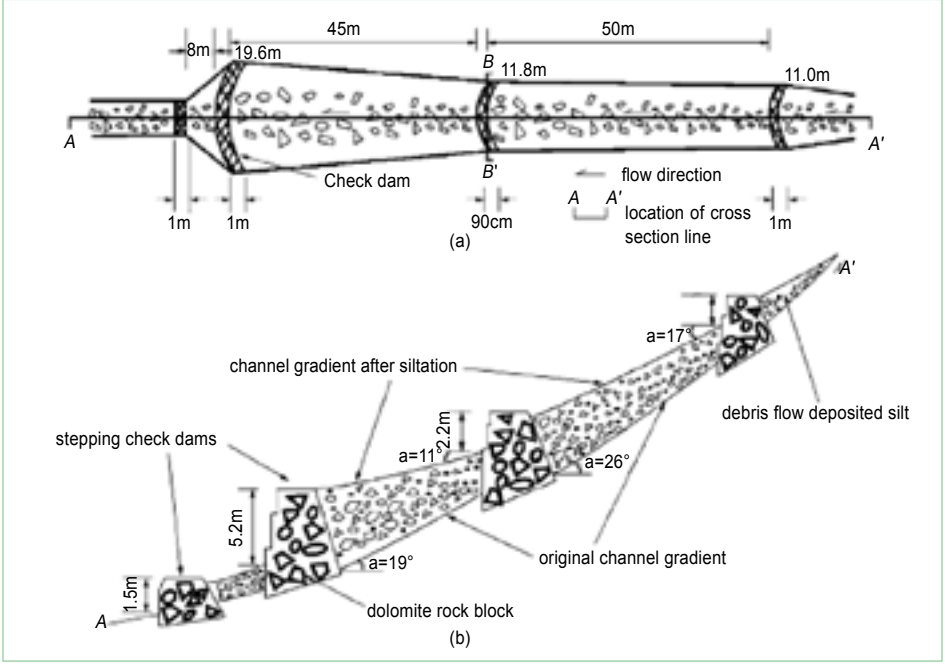
Growing season: 180days(from April to November)
Soil fertility: low
Soil texture: medium particles, a number of fine particles
Surface stoniness: NA
Topsoil organic matter: low
Soil drainage: good
Soil erodibility: higher

Human environment

Mixed land per household (hm^2)



Land use rights: private
Land ownership: state
Market orientation: complex
Level of technical knowledge required: medium
Importance of off-farm income: It is important, accounting for over 50% of total income



Technical drawing

This image describes the dams building located in Duozhaogou. (a) transverse section plan (b) vertical section plan. There is a need for a certain distance and gradi-ents between the two neighboring check dams.

Drawing by Shi Yu

Implementation activities, inputs and costs

Establishment activities

1. Site selection and design.
2. Line location and clean base: according to the dimension of the design, make out the scheme of the dam base, on the ground, clear and remove the silt layer and weathered layer to a solid bedrock or earth layer, build combination grooves on the two sides of gully cliff with a size of 0.5 m to 1.0m both in width and depth.
3. After foundation preparation, layered filling and ramming, the thickness of filling is about 0.2 m to 0.25m, ramming stone roller or compaction machine can be used as compaction equipment, dry bulk density is controlled between 1.5 t/m^3 and 1.8t/m^3.

Spillway excavation, the section dimensions are determined by the design flood, upstream slope is placed by cement laid stone masonry and pointing joint also to prevent seepage.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
Labour	1000	0
Equipment		
- transportation tools	2000	0
Materials		
- cement, stone, sand	1000	0
Agricultural		
TOTAL	4000	0

Maintenance/recurrent activities

1. When building earth check dam, it should be combined with vegetation measures. That means: trees and grass should be planted in the outside of check dam and around the check dam.
2. Regular checks need to be done and also be timely re-paired; The renovation and reinforcement works should be done in non-growing season and before the flood season. The check dam needs to be raised when the deposition is full; the inspection should be done after floods, if gap found, it should be repaired immediately.

Maintenance/recurrent inputs and costs per hm^2 per year

Inputs	Costs (US$)	% met by land user
Labour	100	100
Equipment		
- transportation tools	100	100
Materials		
- cement, stone, sand	300	100
Agricultural		
TOTAL	500	100

Remarks: The project investment paid mainly by government, local farmers input labor, materials and equipment provided by local department or company.

Assessment

Acceptance/adoption

- Due to incentive measures taken, including cash payment, agricultural skills training, subsidies of tools, fertilizer, seeds, etc., priority access to land use rights, and other incentives, the relevant policies are accepted by local residents, who have contributed a certain amount of labors and tools for the project.
- Encouraged by the incentive policies about 80% of rural households accepted this method and even 80% of rural people accepted this method without incentive policies applied.

Benefits/costs according to land user

Land users do not need to bear the cost. The land silted from the earth check dam can be used for cultivation of crops, fast-growing trees, economic forest and medicinal plants. The land users can get a greater economic benefits

Benefits compared with costs	Short-term	Long-term
establishment	positive	positive
maintenance/operation	positive	very positive

Impacts of the technology

Production and socio-economic benefits

+ +	Warping land, increasing available farmland, promote agricultural production, increase farmer's income
+ +	Increasing the effecitve use of rainfall resources

Production and socio-economic disadvantages

None

Socio-cultural benefits

+ + +	Develop environmentally-friendly rural areas, promote harmony between man and nature
+ + +	Promoting the development of new countryside
+ +	Popularizing soil and water conservation knowledge

Socio-cultural disadvantages

None

Ecological benefits

+ + +	Elevating erosion basis, preventing down cutting
+ + +	Holding and restoring sediment
+ +	Prolong flow concentration duration
+ +	Preventing landslide and debris flow
+ +	Improving local residental environment

Ecological disadvantages

None

Off-site benefits

+ + Mitigating downstream channel siltation and water pollution

Off-site disadvantages

– Decreasing the downstream water discharge

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Erosion control to decrease sediment → Check dams building.	Large investment, → Multi-level investment system, including central government investment with local support, labor input by farmers, and foreign and social investment.
Effective use of rainfall resources → Compound management combining with plant cultivation and aquaculture.	Disturbance of the earth's surface, causing ecological destruction → Combining biological measures.
Increasing farmer's income → Completing irrigation facility and planting economic forest.	
Mitigating debris flow and flood loss →Making planning and design cooperating with watershed management.	

Key reference(s)

[1] Luzheng. *Eco-development model of soil and water conservation in China*. Beijing: Science publish house. 2003

[2] Liu changming, Wang lixian, Xiajun. *The study on ecological environment construction and scientific development strategy of allocation of water resources*. Beijing: Science publish house, 2004

Contact person(s)

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left: Overlook of check dams construction in Xifeng
right: Nearby view of check dams constructionin Xifeng
Photo by Lei Xiaobo

Check Dam Approach

Xifeng County of Gansu Province, China

Check dam is a kind of sediment storage dam built on valey to control the down cutting.

Xifeng county is one of the key areas of soil erosion control in China. In order to reduce the local soil erosion, and also to bring certain economic benefits to local residents, the Ministry of Water Resources is in charge of check dam construction activities.

Check dam is widely used in controlling soil erosion. The training is a main approach to promotion of the check dam technology. It is necessary to mobilize local people to participate in construction, while providing to them some cash subsidies. In such a way local people can get economic benefits, and strengthen their awareness and knowledge of soil and water conservation.

Implemetation procedure: (1) site selection and design; (2) material preparation, labor rec-ruitment and temporary road buliding; (3) main project construction.

Main objectives: (1) Elevating erosion basis of channel bed to prevent the channel down cutting and channel bank expansion, and decrease channel gradient. (2) Storing silt and reducing the amount of sediment, transported into the rivers. (3) Decreasing channel flow rates and reducing the flood risk of the lower reaches. (4) Debris flow control by use of strong permanent check dams. (5) Making channel silted to form sediment-covered terraces for future use.

The construction cost of check dam is determined by project quality requirements, difficulty of construction, work size, construction technology, and some other factors. Regional factors have also an important impact. Therefore, the investment is mainly made by government with local supporting funds. Check dam construction is often associated with plant cultivation, aquaculture design and other measures to make comprehensive use of sediment retention and water storage. It can increase agricultural productivity and farmers' income in addition to improve local environment.

Location: Xifeng Country, Gansu Province, China
Land use: Slopeland/economic forest
Climate: Semi-arid
WOCAT database reference: QA
Related technology: Check Dam
Compiled by: Wang Yongjun, Lei Xiaobo, Shi Yu, Institute of Soil and Water Conservation, Beijing Forestry University
Date: September, 2007

Editors' comments: Check dam works can generate significant benefits by storing and reducing sediment; it also can effectively increase the use of rainfall resources, improve the local environment and raise crop yield and farmers' income.

Problem, objectives and constraints

Problem

- Serious debris flow, which causes tremendous economic loss and threats to the residents safety.
- Serious soil erosion, especially down cutting and expansion of gully.
- Poor local economy, lack of funds and technology for soil erosion control.

Objectives

- Fixation and raise of erosion basis, preventing down cutting of channel and channel bank expansion.
- Making channel silted to form sediment-covered terraces for farming.
- Decreasing channel gradient and flow rates and reducing the flood risk of the lower reaches.

Constraints addressed

Major	Specification	Treatment
Technique factors	Check dam design and construction need qualified technicians.	Professionals and training.
Economic factors	More investment needed for mortar stone check dam.	Government and company investment to develop eco-industry.
Minor	**Specification**	**Treatment**
Social factors	Unawareness of soil and conservation knowledge.	Strengthening education and training.

Participation and decision making

Target groups


Desicion makers


Designer


Experts

Approach costs met by

Government investment	90%
Enterprises support	10%
TOTAL	100%

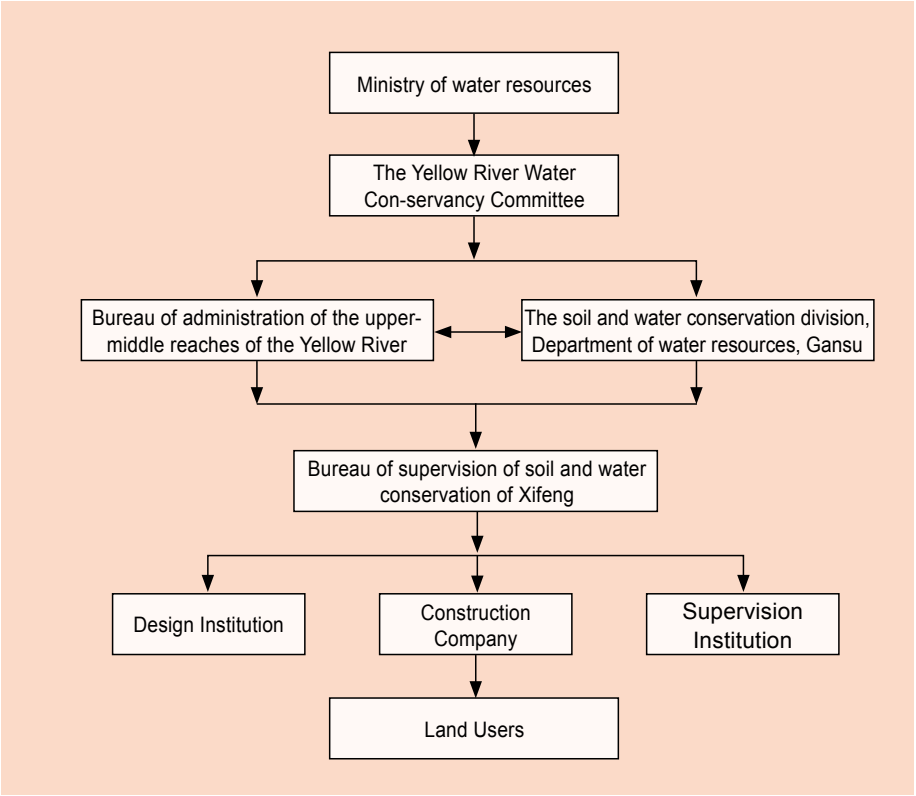
Decisions on choice of the technology: SWC experts.
Decisions on method of implementing the technology: SWC experts.
Approach designed by: National experts.

Community involvement

Check dam is built in the area where debris flow often occurs, few residents, public activities, no community involvement

Phase	Involvement	Activities
Initiation	NA	
Planning	NA	
Implementation	NA	
Monitoring/evaluation	NA	
Research	NA	

Differences in participation of men and women: NA.



Organogram

Extension and promotion

Training: The content includes basic issues of check dam building, knowledge of soil and water conservation, methods for controlling debris flow and torrent, etc. Better effect for technicians than local residents.

Extension: Related technique standards and information, such as check dam size, technical key point. It should be supported by local government, extended by demonstration. The related organizations including local government and soil & water conservation department play a very important role in the issue. But the extension could be impacted by financial reasons.

Research: The programs of debris flow mechanism, debris flow control measures, bench land use have being carried out.

Importance of land use rights: Ownership of land by state is helpful to project implementation.

Incentive mechanism

Labour: Construction Company bids for construction project; construction quality is supervised by supervision experts; and the construction company organizes workers to work on. The cost is paid in accordance with the quantity and quality of construction. Do more, pay more and high quality with more pay.

Inputs: The investment includes materials such as stones, sand, cement and others, various types of vehicles and other transport equipment, technical personnel and labor, and design cost. Most of input is purchased and paid by the state and a small part of cost paid by company sponsors.

Credit: NA.

Support of local institutions: The application of check dam has positive economic significance because of bringing national funds. Furthermore, it can promote capacity-building of the local Soil and Water agencies and the agricultural institutions through training and projects implementation.

Long-term impact of incentives: Incentive mechanism has a very positive impact on the smooth implementation of projects and long-term maintenance.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Methods: monitoring sites identification, RS application, related instruments. Indicators: debris flow frequency,speed,volume, time and damage.
Technical	Methods: long-term maintenance and repair immediately when required. Indicators: damage degree etc.
Socio-cultural	Methods: sampling survey and questionnaire. Indicators: accredited attitude for debris flow control and participation in check dam building.
Economic/production	NA
Area treated	Methods: site survey. Indicators: control area.
No. of land users involved	NA
Management of approach	Methods: sampling survey and questionnaire. Indicators: science and rationality of Management.

Impacts of the approach

Changes as result of monitoring and evaluation: Economic efficiency of input, structure suitability, long term maintenance.

Improved soil and water management: Hazard area is decreased, destructive force is lowered; debris flow is controlled to a large extent. At the same time the environment is obviously improved, diversified business models are formed and the local economy is improved.

Adoption of the approach by other projects/land users: The method will help to control debris flow; the check dam is widely used.

Sustainability: Construction cost is quite high, but direct economic benefit is not obvious, therefore, it needs national government investment. It is difficult to carry out check dam construction without long-term support.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Erosion control to decrease sediment → Check dams building.	Large investment, → Multi-level investment system, which includes national investment with local support, labor input by farmers, and use of foreign and social funds.
More effective use of rainfall resources → Develop compound management with cultivation and aquaculture.	After abolition of the compulsory labor and accumulative labor service, the enthusiasm and willingness of farmers to participation is lowered → Some measures shoule be taken by government at all levels to stimulte and encourage farmers to participate in the construction work.
Increasing farmer's income → Completing irrigation facility and establishing economic forest.	
Mitigating damage caused by debris flow and floods → Making planning and design on watershed management.	

Key reference(s)

[1] Liuzheng. *Eco-development model of soil and water conservation in China*. Beijing: Science publish house, 2003

[2] Liu changming, Wang lixian, Xiajun. *The study on ecological environment construction and scientific development strategy of allocation of water resources*. Beijing: Science publish house, 2004

Contact person(s)

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Left: Fish scale and adverse-slope site preparation at steep slopes. Photo by Wang Yaolin
Right: Planted seedling in the prepared pit. Photo by Dou Hongqi

Fish-Scale Pit Adverse-Slope Site Preparation

Pingliang City of Gansu Province, China

Site preparation is conducted by altering the micro terrain of slope with gradient over 20° into a fish scale pit at adverse slope with setting shrub and grass to prevent soil and water erosion.

Technical pilot is set in Kongtong district of Pingliang City, the eastern part of Gansu Province. The natural conditions feature meagre and uneven precipitation, crisscross gullies distributed in scattered manner, loose loess soil and severe soil erosion. In long water and soil conservation practice, local departments of forestry and water & soil conservation have summarized experiences and effective biological erosion control measures. The fish-scale pit technique is one of them. It is an engineering and vegetation combined erosion control measure, which is suitable for steep slope and broken hilly lands. Its main function is to intercept surface runoff and increase soil moisture in favour of raised plant survival rate. It features simple construction, flexible and less restriction by landform, satisfactory result in water conservation to allow high survival rate of trees planted.

The fish-scale pit specifications include large pit (0.8-1.5m in length and 0.6-1m in width) and small pit (0.7m in length and 0.5m in width) with their depth ranging from 0.6 to 0.8m. The large pit can be used for medium slope with thick soil and good vegetation while small pit for slopes with thin soil, steep gradient and broken landscape.

Fish-scale pit construction procedure: dig semi-circle shaped pits with the pit spacing of 2m and pit layout in delta arrangement. The outer edge is constructed in lune shaped earth bank. Put top soil aside and use base soil to build the bank 20-25cm high. Backfill the top soil in the pit and keep the opening horizontal or slightly inclined inward. The tree should be planted in the middle or lower parts of the pit, instead of upper part, to prevent the plant from being silted.

Fish-scale pit maintenance: the pits may be flooded in heavy rain or storm in the first and second year after construction. Therefore, repair and maintenance are required to restore them pursuant to above specifications.

Fish-scale pit can change light, heat and moisture conditions in the pit and increase soil water content up by 40% and plant survival rate by 37%. It has minor detriment to original landscape and vegetation. It is a protective vegetation recovery technology.

Fish-scale pit technology is simple, easy-operating, at a low cost, without need for mechanic operation. With little disturbance to environment, it does not result in extra soil erosion and operation is not affected by seasons. In 1950s and 1960s, fish-scale pit site preparation was applied in Kongtong District achieving high survival rate and effective control over soil erosion. This technique can be adopted by integrating with other technologies such as contour terracing, levelled slope platform etc. for greater role in local ecological construction.

Location: Kongtong District, Pingliang City, Gansu Province
Technology area: 140km^2
SWC measure: Engineering and vegetation
Land use: Forest land
Climate: Semi-humid
WOCAT database reference: QT
Related approach: Project Based Fish-Scale Pit Site Preparation for Forestation
Compiled by: Wang Yaolin, GEF/OP12 Project Management Office, Gansu Sand Control Research Institute; Dou Hongqi, Kongtong District Fruit Industry Bureau of Pingliang City
Date: Revised in September 2007

Editors' comments: This technology is applied generally for afforestation at steep slopes of loess plateau in Gansu Province. The application is simple and effective, so it is a major soil and water conservation measure for loess plateau ecological improvement. It is now mainly used in the public owned land forestation, and technological extension done offered by forestry and water resource departments with incentives.

Classification

Land use problems

Steep slope, poor water retention capability of soil, and low forestation survival rate; low vegetation cover and serious soil and water erosion; low utilization rate of slope surface runoff.

Land use	Climate	Degradation	SWC measure
			
Perennial arbor or bush	Sub-humid	Water erosion	Mechanical measure

Technical function/impact

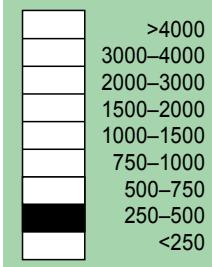
main: - change micro topography
- retain runoff, improve soil water retaining ability
- improve vegetation environment and tree survival rate
- detain silt and reduce soil and water erosion

secondary: - alleviate silt inflow into Yellow River
- increase vegetation cover
- improvement of ecological condition

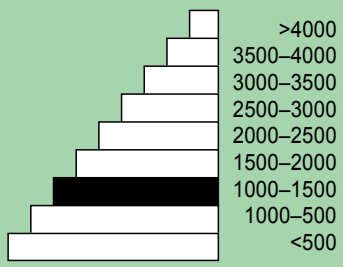
Environment

Natural Environment

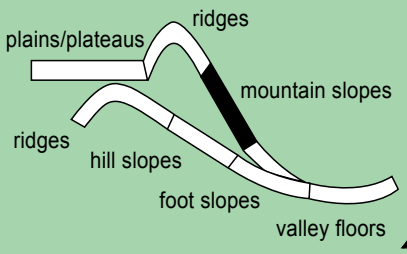
Average annual rainfall (mm)



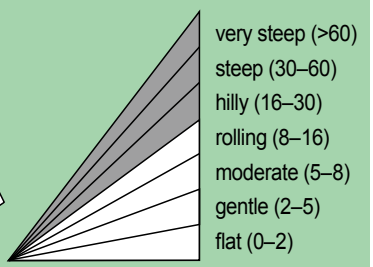
Altitude (m a.s.l.)



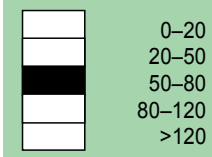
Landform



Slope (%)



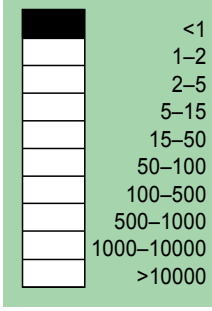
Soil depth (cm)



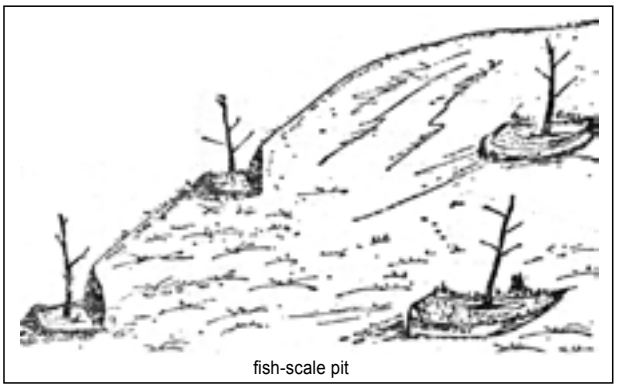
Growing season: 160 days in succession, from May to October
Soil fertility: low
Soil texture: moderate loam
Surface stoniness: moderate
Topsoil organic matter: low(<1%)
Soil drainage: moderate
Soil erodibility: high

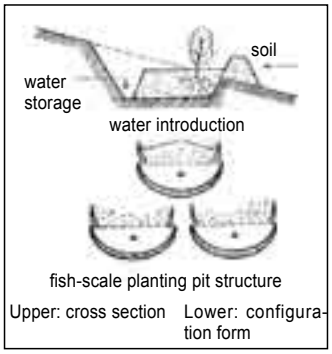
Human environment

Mixed land per household (hm^2)



Land use rights: collective
Land ownership: state owned
Market orientation: selling or self use
Level of technical knowledge required: moderate for technical extensionists and land users
Importance of off-farm income: 10%-50% of total income


fish-scale pit



fish-scale planting pit structure

Upper: cross section Lower: configuration form

Technical drawing

Upper: By the fish scale pit preparation, micro typography is changed, and the prepared pits are distributed in delta form on slope surface.

Lower: The inner earth is dug out to make protection edge while the original surface soil be refilled to the dug pit. The plant is planted at the middle and lower parts of the pit. The specifications: 80-150cm long, 50-100cm wide, 30-40cm deep.

Implementation activities, inputs and costs

Establishment activities

1. Pit positions are set along the conture line.
2. Dig semicircular pit, pile up topsoil aside the pit, base earth piled beneath pit; Build semicircular protection edge of 30 cm outside the pit, put back topsoil into pit; Open one ditch at both left and right sides of the pit for rainwater collection.
3. Planting at the middle and lower parts of the pit.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
Labour	253	0
Equipment: spade	2	100
Materials		
Other: training etc	4.7	0
TOTAL	259.7	0.7

Maintenance/recurrent activities

1.repair pit in autumn and spring by rebuilding the rainwater damaged earth edge.
2.Dredge the water inducing ditches of both sides.

Maintenance/recurrent inputs and costs per hm^2 per year

Inputs	Costs (US$)	% met by land user
Labour	10.7	100
Equipment such as tools		
Materials		
Other		
TOTAL	10.7	100

Remarks: The cost refers to the labour cost paid by government to farmers or herdsmen for their labour input to the state or collective owned land; Depreciation cost for farmer or herdsman's tool uses and technical training cost are based on tool actual wastage rate and subsidy to the trainers; labour cost is calculated at 40 Yuan per person day. Exchange rate: US$ 1 = RMB 7.5 Yuan.

Assessment

Acceptance/adoption

- All households in the project area used this technology for slope wasteland afforestation.
- Forestry and water resources departments are disseminating the technology.
- The land use right belong to the collective or state, so the farmers accept the method passively.
- With no external financial support, extending the technology is difficult.

Benefits/costs according to land user

Benefits compared with costs	Short-term	Long-term
establishment	high input, low benefit	low input, high benefit
maintenance/recurrent	high input, low benefit	low input, high benefit

Impacts of the technology

Production and socio-economic benefits

+ + +	Improved tree survival
+	Income increased

Production and socio-economic disadvantages

	None

Socio-cultural benefits

+ +	Improved living environment and quality

Socio-cultural disadvantages

– –	High labour intensity

Ecological benefits

+ + +	Reduce soil and water erosion
+ + +	Increase soil moisture
+ + +	Improve survival rate of forestation
+ +	Increase vegetation cover
+ +	Reduce silt to the downstream

Ecological disadvantages

	None

Off-site benefits

+ +	Reduce soil and water erosion and reduce downstream river silt

Off-site disadvantages

–	Reduce runoff of downstream river course

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Intercept runoff → More vigorously technical extension.	Difficulty in dissimilation → Forest land use right refrom.
Retain silt → Combinations with other measures for enlarged effect.	Difficult application without project support → Make project sustainable.
Raise tree survival rate → Add pit mulching technology to improve sur-vival rate and growth.	
Improved soil condition → Suitable legume plants planted.	

Key reference(s)

Wang Hui, Liu Qianzhi, Wang Jie. *Integrated Treatment Technology of Combating Desertification*. Beijing: China Forestry Publishing House, 1998

Contact person(s)

Wang Yaolin, GEF/OP12 Project Management Office, Gansu Sand Control Research Institute. Tel: 0931-8412816. Email: gansu@gefop12.cn

Left: Fish scale site preparation. Photo by Dou Hongqi
Right: Villagers meeting to discuss technology of fish scale site preparation. Photo by Dou Hongqi

Project Based Fish-Scale Pit Site Preparation for Forestation

Pingliang City of Gansu Province, China

Project-based and led by government fish-scale pit site preparation is undertaken, through publicity among local residents, and achieve success. It has improved site conditions, developed runoff forestry and improved ecological environment.

The water and soil conservation work is carried out mainly through project im-plementation and technology dissemination is the responsibility of water and soil conservation depart-ment, forestry administration, etc. In recent years, the central government has launched projects of "Conversion of Farmland to Forest", "Desertification Control", "Integrated Small Watershed Management", and the World Bank funded Loess Plateau Projects (Phase I and II) as well as "DFID Watershed Management" projects, which have brought to Gansu loess plateau a new opportunity of letting water and soil conservation work to step up to a new stage.

Technology dissemination has been carried out via villager meeting, field demonstration and household visit to introduce the technology. Before site preparation is conducted, villager meeting is held and the technicians from forestry administration or soil conservation department will give lectures to the residents to let them be aware of the significance of water and soil conservation.

Fish-scale pit expense will be covered by the project and local government. The farmers will be paid in cash for their labour input. And in some areas, local farmers are willing to make labour input in the project. The seedling cost is paid by project and local government.

The government owns the right to use the arid lands suitable for forestation and there is no direct economic benefit from barren hill forestation, dam construction and other water and soil conservation projects. Farmers are passive to accept water and soil conservation tasks. Therefore, it is difficult to scale up the project without compensation for the labour input of farmers. At present, the pilot project site has begun forest ownership reform, and auction the use right of the barren hills and lands for 50 years duration. Such action has greatly stimulated the enthusiasm of local residents for participation in water and soil conservation and ecological improvement.

Location: Kongtong District of Pingliang city, Gansu Province
Land use: Forest land
Climate: Sub-humid arid
WOCAT database reference: QA
Related technology: Fish-Scale Pit Adverse-Slope Site Preparation
Compiled by: Wang Yaolin, GEF/OP12 Project Management Office, Gansu Sand Control Research Institute; Dou Hongqi, Kongtong District Fruit Industry Bureau of Pingliang City
Date: Revised in September 2007

Editors' comments: The technology is applied now relying on the technical promotion efforts done by departments of forestry, water resources and agriculture, with incentive of projects. It is easy operation and low cost, with very notable effect in retaining rainwater and improving soil moisture. It has been regarded as important SWC and runoff forestry measure, and applied widely in SWC projects and cash forest development in China.

Problem, objectives and constraints

Problem

- Community feels shortage of available funds.
- Lack of effective organization.
- No direct economic benefit, so the farmers participation enthusiasm is low.
- Serious soil and water erosion.
- Poor site conditions and low survival rate of planting.

Objectives

- Establish technical extension mechanism of sustainable development.
- Raise community's participation level.
- Creation of a swc model for stakeholders' equal participation.
- Improve ecological condition.

Constraints addressed

Major	Specification	Treatment
Land tenure	The state owns land use right, so the farmers are passive in participation.	Reform the forest land tenure,including auctioning and leas ing etc.
Social aspect	Extension done solely through government, without farmer's active participation.	Establish incentive mechanism, strengthen demonstration, and combine with the tenure reform.
Financial	Shortage of financing, a little project support, and low subsidies to farmer labour input.	Gain more project support and add subsidies to farmers.

Participation and decision making

Target groups


Land user


SWC expert


Planning expert


Decision maker

Approach costs met by

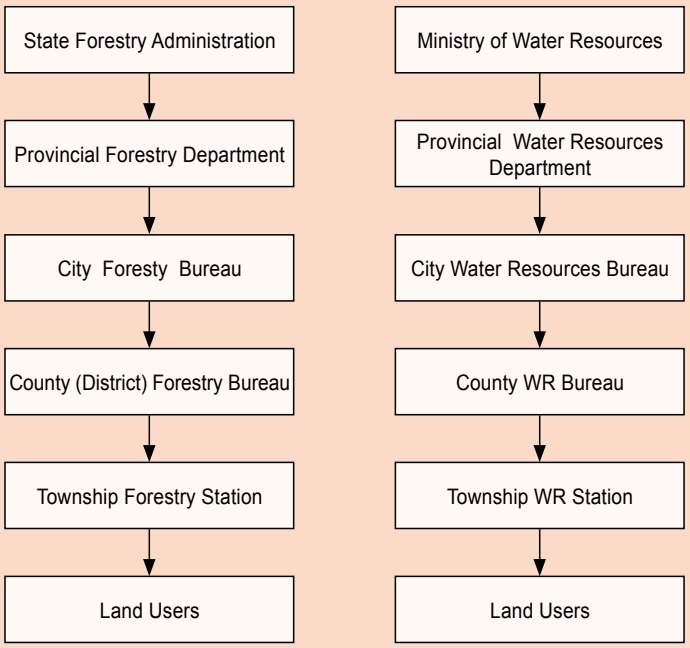
Government	99.3%
Farmers(depreciation of tools)	0.7%
TOTAL	100%

Decisions on choice of the technology: Water Resources Bureau and Forestry Bureau of the county.
Decisions on method of implementing the technology: Water Resources Bureau and Forestry Bureau of the county.
Approach designed by: National experts of forestry and water resources.

Community involvement

Phase	Involvement	Activities
Initiation	Interaction	Meetings or publicity by interview in householders.
Planning	Passive	Provide information of the actual situation of the site.
Implementation	Passive	Local farmers and herdsman are employed to implement the technology and project by contributing labour.
Monitoring/evaluation	Passive	Technicians visit the households for interview.
Research	None	None.

Differences in participation of men and women: The technology needs labor to work on remote slopes, so mainly done by male labour.



Organogram

Left: Fish scale pit planting site preparation technology is supported by State Frestry Administration through projects.

Right: Fish scale pit planting site preparation technology is also supported by Ministry of Water Resources through projects.

Extension and promotion

Training: Technical staff by training meeting, site explanations of fish scale structure, role and construction requirement, and at the same time species selection and planting method. The training effect is good.

Extension: Technical extension conducted by county water resources and forestry technological extension organizations, in forms of meetings and field demonstrations.

Research: Research is conducted at provincial level, and mainly on how to raise moisture utilization rate, increase wood increment; Farmers do not participate in research.

Importance of land use rights: The land ownership and use right of barren mountain belong to the state or collective , whcih affected negatively the technological application.

Incentive mechanism

Labour: Labor force is paid at the prevailing price level.

Inputs: Seedlings are supplied with project financing, and tools supplied by farmers.

Credit: Some projects use credit.

Support of local institutions: The training of this technology improved the capacity of local bureau staff of water resources, forestry and agriculture. The technology also helped gain support of international donor supported projects.

Long-term impact of incentives: The long-term influence of project support is positive; With project support, the possibility for farmers to invests using this technology is low. The long term negative impact is neutral.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Change of soil moisture, runoff quantity, sediment delivery modulus.
Technical	Survival rate of planted seedlings, vegetation cover change.
Socio-cultural	Survey the awareness of villagers on the technology including the its function and benefit.
Economic/production	Growth increment of the seedlings.
Area treated	Survey the acreage that adopt the technology every yeare.
No. of land users involved	Survey the number of households involved in participation and that of directly benefited households.
Management of approach	Use methods of observation and site survey to regularly investigate the acreage that adopt the technology and the benefit.

Impacts of the approach

Changes as result of monitoring and evaluation: The technical extension method has evolved from direct popularization pushed by government to the current government-led, incentive motivated technical extension. Now the technology is being applied in cash forest cultivation on slopeland.

Improved soil and water management: It alleviated soil erosion significantly, improved the moisture condition of soil, and raised the utilization rate of slope surface runoff.

Adoption of the approach by other projects/land users: The technology is now also used for slope maintenance of highway and railway.

Sustainability: Without financial support, application of this technology will be hard.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Incentive measures promote the technical enforcement → Implement project to maintain the financing.	Single technical extension model → Establishment of more effective and motivating incentive mechanism and models, and promote farmers participation in the extension considering combination with forest land tenure reform.
High efficiency of the extension mechanism → Further raise capability of technical staff in provision of technical service.	Forest land is owned by collective, therefore it is a disadvantageous factor to strengthen achievements of project → Reform the forest land tenure.

Key reference(s)

Wang Hui, Liu Qianzhi, Wang Jie. *Integrated Treatment Technology of Combating Desertification*. Beijing: China Forestry Publishing House, 1998

Contact person(s)

Wang Yaolin, GEF/OP12 Project Management Office, Gansu Sand Control Research Institute. Tel :0931-8412816. Email: gansu@gefop12.cn

Zhuanglang Loess Terraces

Zhuanglang County of Gansu Province, China

Level bench terraces on the Loess Plateau is used to convert eroded and degraded sloping land into a series of terraces suitable for cultivation.

The Loess Plateau in north-central China is characterised by very deep loess parent material (up to 200 m),that is highly erodible and the source of most of the sediment in the lower reaches of the Yellow River.

The plateau is highly dissected by deep gullied valleys and gorges. The steep slopes, occupying 30%-40% of the plateau area, have been heavily degraded by severe top soil and gully erosion. Over the whole Loess Plateau approximately 73,350 km^2 of these erosion prone slopes have been conserved by terraces.

In the case study area (Zhuanglang County) the land that is suitable for terracing has been completely covered. The total terraces area 1088 km^2 accounting for 90% of the slopes and proceeding form valley to the ridge. The terraces comprise a riser of earth, with vertical or steeply sloping sides and an approximately flat bed (level bench). Depending on farmers preference some terrace beds are edged by a raised lip (a small earth ridge) which retains rainwater, others remain without lip. The semi-arid climate does not require a drainage system. For typical hillside terraces on slopes of 25%-35% the bed with is about 3.5-5 meters with a 1-2 meter riser, involving moving about 2000-2500 cubic meters of soil (see table of technical specifications). Generally the rivers are not specifically protected, but there may be some natural grasses growing on the upper part. The lower part of the river is cut vertically into the original soil surface, and has no grass cover, being dry and compact. However it is not erosion-prone since it has a stable structure.

Over most of the Loess Plateau, the soil is very deep and therefore well suited to terrace construction. In addition to downstream benefits, the purpose is to create a better environment for crop production through improved moisture conservation, and improved farming operations. In an average rainfall year, crop yields on terraces land are more than 3 times higher than they used to be on unterraced sloping land. The implication is that terrace construction – though labour intensive pays back in only three to four years when combined with agronomic improvements (such as applying farm yard manure and planting green manure). Some farmers try to make the best use of the upper part of terraces risers by planting cash trees or forage cropsincluding *Hippophae rhamnoides* (seabuckthorn), *Caragana korshinskii* (peashrub) and some leguminous grass. This is locally termed “terrace bund economy”. The plants stabilise the risers and at the same time provides extra benefit.

Left: Aerial view over zhuanglang county Where 90% of the hillsides are covered with terraces. Reducing runoff and erosion,maintaining soil fertility and making farming operations easier are key for rainfed agriculture in this semi-arid environment. Photo by He Yu
Right: A 4m high terraces riser, where the part is vertical and baredemonstrating the stability of the loess soil at this depth. The upper part is sloping, and stabilised with grasses, bushes and trees. Photo by Hanspeter Liniger

Location: Zhuanglang County, Gansu Province (loess plateau region), china
Technology area: 1080km^2
SWC measure: Structural
Climate: Semi-arid
WOCAT database reference: QT CHN45
Related approach: Terrace Approach
Compiled by: Wang Yaolin, GEF/OP12 Project Management Office, Gansu Sand Control Research Institute; Wen Meili, Department of Resources and Environment Science, Beijing Normal University, China; Bai Zhanguo, World Soil Information, Wageningen, Netherlands.
Date: March, 2006

Editors’ comments: China has history of terraces construction dating back thousands of years-for both rainfed crops and paddy rice.In the period since the 1950s’ the loess Plateau region has been extensively terraced to reduce off – site sediment levels in the Yellow River, and to create better conditions for crop production.The results are effective and spectacular covering an area of over 73,000 km^2.

Classification

Land use problems

Cultivation of unterraced hillside slopes leads to serious soil erosion and problems of downstream sedimentation. Loss of topical and rainwater in uncontrolled runoff has contributed declining crop yields.

Land use		Climate		Degradation				SWC measure			
											
Farmland	Cash froest	Semi-arid		Water erosion	Chemical Fertility decline			Mechanical measure			

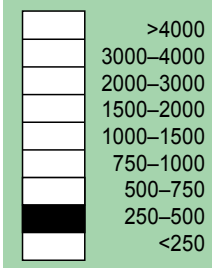
Technical function/impact

main: - reduction of slope angle/slope length
- retain runoff in -situ
- increase infiltration
- water harvesting/increase water stored in soil
- reduces downstream flooding and sediment deposition (a nation /regional concern)

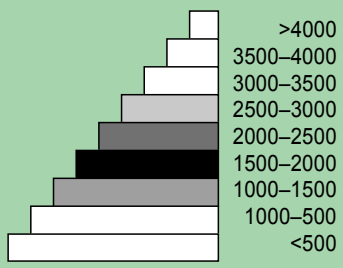
Environment

Natural Environment

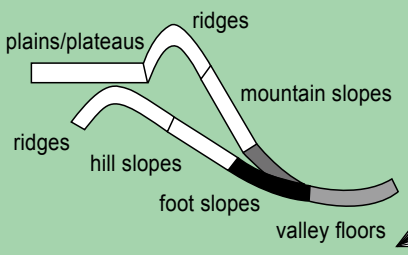
Average annual rainfall (mm)



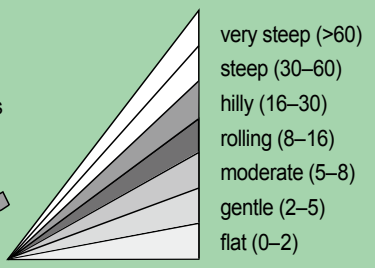
Altitude (m a.s.l.)



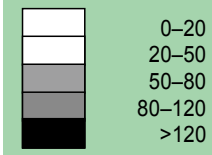
Landform



Slope (%)



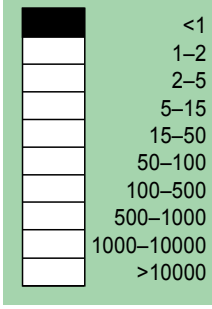
Soil depth (cm)



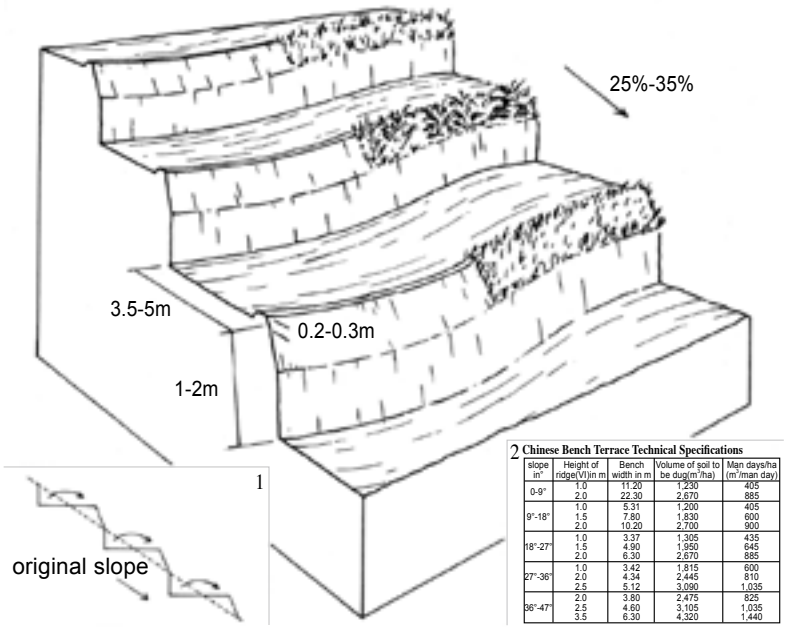
Growing season: 160 days (May to September)
Soil fertility: medium to low
Soil texture: medium (loam)
Surface stoniness: no loose stone
Topsoil organic matter: low <1%)
Soil drainage: good
Soil erodibility: very high

Human environment

Mixed land per household (hm^2)



Land use rights: cropland :individual ,subject to reallocation by authorities ;forest land: communal (organised)
Land ownership: state
Market orientation: mixed (subsistence/commercial):cash crop (peas)and food crops(potatoes, wheat, maize, millet, sorghum)
Level of technical knowledge required: field staff/extension worker: high, land user: low
Importance of off-farm income: 10%/10%-50%/ of all income: working in construction ,temporary employments



2 Chinese Bench Terrace Technical Specifications

slope in°	Height of ridge(V)in m	Bench width in m	Volume of soil to be dug(m³/ha)	Man days/ha (m³/man day)
0-9°	1.0	11.20	1,230	405
	2.0	22.30	2,670	885
9°-18°	1.0	5.31	1,200	405
	1.5	7.80	1,830	600
	2.0	10.20	2,700	900
18°-27°	1.0	3.37	1,305	435
	1.5	4.90	1,950	645
	2.0	6.30	2,670	885
27°-36°	1.0	3.42	1,815	600
	2.0	4.34	2,445	810
	2.5	5.12	3,090	1,035
36°-47°	2.0	3.80	2,475	825
	2.5	4.60	3,105	1,035
	3.5	6.30	4,320	1,440

Technical drawing

Layout of level bench terraces on the loess plateau; the lower vertical section is cut into the compacted soil. Natural grassesor planted grass/shrub species protect the more erodible and less steep upper part of the riser.

The low "lip" is optional.

Insert1: method of construction: the volume of soil to be excavated from the hill-slope (see table below) equals the volume "returned" to form the outer part of the terrace.

Insert2:Chinese Bench Terrace Technical Specifications.

Implementation activities, inputs and costs

Establishment activities

1. Contour lines are marked out using pegs to show the location for the base of each terrace wall (after harvest in September)
2. A trench is dug out along the marked line to serve as the founda-tion for the terrace wall.
3. The topsoil between the pegged lines is removed and put aside.
4. Alternative ways of construction the wall/riser and bed: (a) Sub-soil is placed in the trench and compacted to form the base of the terrace is then place behind the wall. The wall is progressively built up (by compacting earth) with the excavated soil placed behind until a level terrace has been formed.(b) terraces may be built without constructing an initial wall: soil excavated form the upper part of the (eventual) to help build up the wall/riser. This is done progressively.
5. The wall is raised slightly higher to form a lip to retain rainwater on the terrace bed(optional).
6. The set-aside topsoil is then spread over the terrace surface.

Duration of establishment: 3-4months.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
Labour		
Construction: 600m person days	1200	97
- survey	60	0
Equipment		
- shovel, 2-wheel cars	30	100
materials		
- earth(2000-2500)	0	0
TOTAL	1290	93

Maintenance/recurrent activities

1. Repairing any collapses in the terrace wall-often caused heavy storms.
2. Re-levelling of the terraces where necessary.

This work is usually done by hand, using shovels and 2-wheel cars.

Maintenance/recurrent inputs and costs per hm^2 per year

Inputs	Costs (US$)	% met by land user
Labour	25	97
equipment		
- tools (shovel.2-wheel cars)	10	100
materials		
- earth(1-2m^3)	0	0
TOTAL	35	98

Remarks: calculations above are base on the following situation: slopes of about 25%-35%, bed width of 3.5-6m, and a 1-2m high rise, involving moving about 2000-2500 cubic meters of soil. Note: these calcuation are base on several years experience in zhuanglang: that is why they differ in some respects from the standardised table above.

Assessment

Acceptance/adoption

- The technology was implemented on a large scale through government initiated mass campaigns.
- Through government intervention the area that is suitable for terracing has been covered.
- Uncertainty over future land use rights limits the willingness of households to meet the costs of terrace construction.

Benefits/costs according to land user

Benefits compared with costs	Short-term	Long-term
establishment	negative	very positive
maintenance/recurrent	positive	very positive

Impacts of the technology

Production and socio-economic benefits

+ + +	Crop yield increase (wheat :from 750-900 kg/hm^2 before terracing to 3000-3750 kg/hm^2 within 3-4 years:includes agronomic improvements)
+ + +	Easier field operation
+	Farm income increase

Production and socio-economic disadvantages

–	Reduced production (first year only)

Socio-cultural benefits

+ +	Community institution strengthening
+ +	Improved knowledge SWC/erosion

Socio-cultural disadvantages

	None

Ecological benefits

+ + +	Soil loss reduction
+ + +	Increase in soil moisture

Ecological disadvantages

	None

Off-site benefits

+ + +	Reduce doenstream siltation
+ +	Reduce doenstream flooding
+ +	Educe transported sediments

Off-site disadvantages

– –	Reduced river flows

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Reduced erosion, loss of rainwater through runoff and fertility loss → Maintain the quality of terrace construction.	Decrease in production in first year → Apply manure and fertilizer.
Increased soil moisture → Construct/maintain a terrace lip to retain rainwater on the terrace.	Terrace riser can be destroyed by storms → Good andtimely repair and maintaince.
Increased crop production → Combine with improved crop husbandry.	High crost/input for construction and establishment → There is no real alternatives to labour –Intensive terracing.
Easier field oiperations → The level terrace is easy to cultivate.	High loss of soil moisure due to evaporation form the soil suiface. wind erosion due to tillage → Protect soil surface for example by conservation agriculture –comprising permanent cover ,crop rotation ,reduced tillage- could be supplementary agronomic and vegetative options.

Contact person(s)
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Left: Mass mobilisation showing people from several villages helping each others. Initially farmers were not paid but from the 1980s onards farmers recieved cash and other support for their work. Photo from terraces in China, Ministry of Agriculture
Right: Construction of terrace risers following instructions given by a specialist. Photo from terraces in China, Ministry of Agriculture

Terrace Approach

Zhuanglang County of Gansu Province, China

Highly organised campaign to assist land users in creating terraces: support and planning from national down to local level.

Before 1964, the slopes on China's Loess Plateau was cultivated by machinery. Consequently soil and water lost at high rates, and fertility and yields declined. Accessibility to cultivated land became more and more difficult due to dissection by gullies. The first terraces were established by self-mobilisation of the local land users. However there was no standard design. Furthermore, as the individual plots were very small and scattered all over the village land, terracing needed better coordination, Between 1964 and 1978, the local government at the county level took the initiative of organising farmers and planning terrace implementation according to specific technical design on a larger scale. At that time the land was still managed by production brigades. People were organised to collectively terrace the land on the village basis covering around 2000 hectares each year. Labour was unpaid.

The Yellow River Conservancy Commission (YRCC) came into being in 1948-and the Upper and Middle Yellow River Bureau in 1977. This gave greater impetus to the implementation of SWC in the Loess Plateau. After 1978, the use rights were allocated to individuals (though official ownership was still vested in the state). SEC specialists and county level SWC bureau started to work with groups of farmers who had land use rights within a given area. Survey and design were carried out. The farmers organised themselves, consolidated the parcels of land, and then after the conservation work was done they redistributed the terraced fields.

In 1980s the government started to financially support land users involved in SWC projects. Subsidies ranged from (approx)US$ 20/hm^2 in projects at county level, to US$ 55/hm^2 when World Bank projects were involved. tools were provided by farmer themselves. Then, in 1988 a nationwide project in SWC-which originally was proposed at county level-was approved by the national government. Furthermore, in 1991 a national law on SWC came into force. Protection of the Yellow River and associated dams became a priority at regional and national levels. In total, within Zhuanglang County, 60 SWC specialists/extensionists cover an area of 1550km^2,and most of the terraces were built with low levels of subsidies. Annual plans about implementation of new SWC measure were made during summer. Small areas were designed at county level. Implementation then took place winter. Terracing was implemented first there, where access was easiest and nearest or where villages located.

Location: Zhuanglang County, Gansu Province loess plateau region, Norhern China, people's Repubic of China
Land use: Cropland
Climate: Semi-arid
WOCAT database reference: QA CHN45
Related technology: Zhuanglang loess terraces
Compiled by: Wang Yaolin, GEF/OP12 Project Management Office, Gansu Sand Control Research Institute; Wen Meili, Department of Resources and Environment Science, Beijing Normal University, China; Bai Zhangguo, World Soil Information Wageningen, Netherlands
Date: May 2002, updated October 2005

Editors' comments: The terraces covering china's loess Plateau are one of the most outstanding SWC achievements in the world. The evolution of this remarkable feat is worthy of note. It is an example of local initiative developing into an organized, structured campaign. The implementation process, through local government initially, and then taken up at national level, was supported by legislation and mass mobilisation.

Problem, objectives and constraints

Problem

- Lack of organisation, capital and technical knowledge in farmer communities to counter the underlying problems of water loss, soil loss, fertility decline and downstream effects on the yellow river (floods and sediment) at catchment level.
- Absence or poor maintenance of erosion control measures.

Objectives

- Water conservation (this is a semi-arid area).
- Soil conservation: reduce soil loss on the slopping and erosion-prone land of loess plateau.
- Enhancing soil fertility, and consequently production.
- Improve people's living conditions.
- Protect the Yellow river, avoid floods and reducing the sediment load.

Constraints addressed

Legal	Land users leased the land form the state and land users' right were insecure in the long term. Investments in SWC were not encouraged.	National government persuade land users to implement terraces by selling the benefits(increased yield and easier workability of the land) after 1978,individual user rights motivated farmers to invest in SWC.
Technical	Poor knowledge of how to reduce water loss, soil loss and fertility loss. Technical solutions were needed at the catchment level, involving the whole population.	Enhanced guidance by SWC specialists.
financial	Intially frmers were not paid and as they hd no iediate benefit from ,or security over ,the use of the land ,the investment in construction was a heavy burden on poor farmers.	After 1988, labour inputs by farmers started to be partly covered by subsidies provided by local and national government.

Participation and decision making

Target groups


Land users


Planners


Politicians/decision makers

Approach costs met by

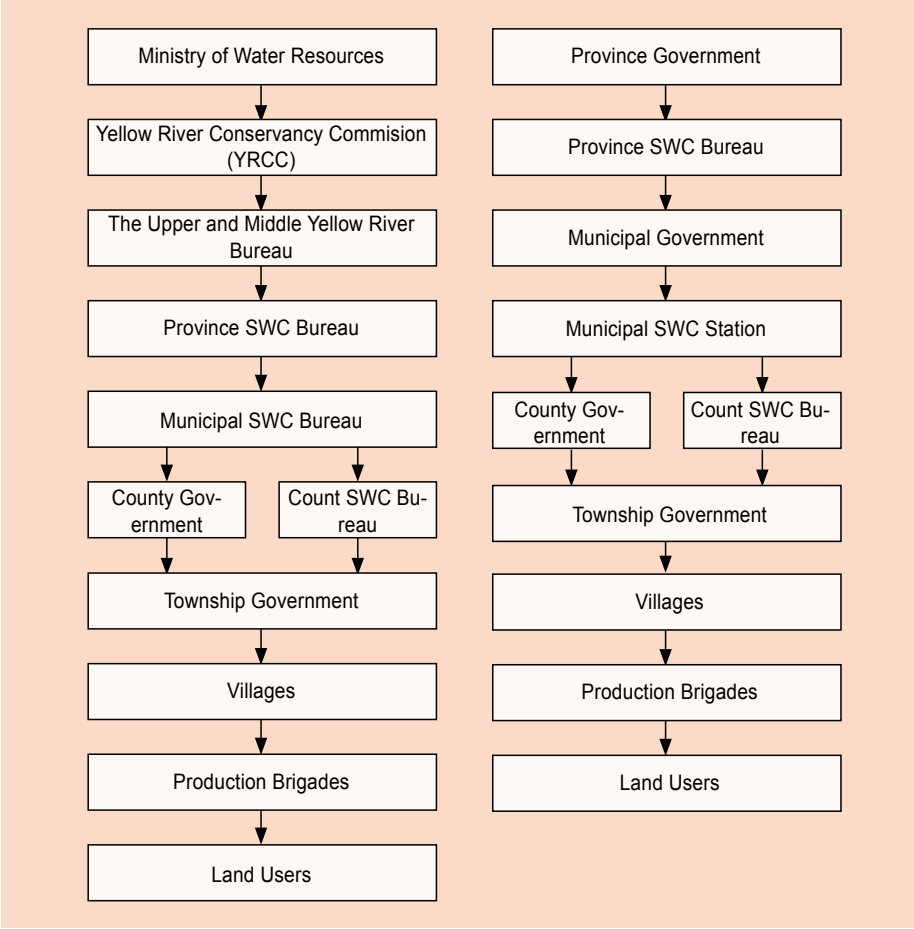
Government	10%
Community/local	90%
Total	100%

Decisions on choice of the technology: QA2.1.5.1mainly made by SWC specialists with consultation of land users
Decisions on method of implementing the technology:
Approach designed by:

Community involvement

Phase	Involvement	Activities
Initiation	Self-mobilisation/interactive	Land users started implementing terraces but SWC specialists at the country level assisted in designing standards for terrace construction and township governments and production brigades organised whole villages and watersheds
Planning	passive	Being consulted in the planning phase. Experienced peasants may be involved in introducing the local situation
Implementation	Interactive	Major organisation done through the SWC Bureau specialists with the village organisation including land users ware actively involver in implementation
Monitoring/evaluation	none	Reporting .no participation of land users.
Research	none	On-station research. No participation of land users.

Differences in participation of men and women: For manual labour, men can do more work and they have greater technical knowledge and skill related to terrace construction than women.



Organogram

Terrace construction supported by projects from MWR,YRCC and international organisations (left)and terrace construction supported by provincial funds (right).

Extension and promotion

Training: Until 1978 the pyramid system was used; the country leve trained the township level,which trained the villlage level,which in turn rained the production brigades/farmers,who then trained other production brigades and farmers.
Training was on-the-job, focussing on design aid construction of terraces on shoping land (provided by the county level specoalists and by land users from villages where implementation areas,and farm visits-these were effective for all target groups.

Extension: The pyraid system is also used for extension At each goverment level(at the county distinct and provincial levels)there is a SWC division which is in charge of SWC activities including extension (demonstration , farm visits, etc).Effectiveness with respect to land users has been good. With rural economic development, more and more land users plan to invest SWC activities, including terrace making. The extension system is quite adequate to ensure continuation of activities.

Research: Mostly on-station research; carried out at the provincial and national levels, mostly by technical staff. Land users have not been involved .Topics covered include economics/marketing, ecology, technology, Terrace building is based on scientific design, according to local conditions.

Importance of land use rights: The ownership of the land and its resources belongs to state and communities: land users can only lease the land for a period of time. Due to uncertainty over future user rights and possible reallocation of the land every few years(5,10 or 20)by the village in response to changes in population and household needs, additional investments into land /SWC measures may be hindered .1978 a first major change took place by allocating some individual land use rights.

Incentive mechanism

Labour: In the 1960s and 1970s farmers were not paid for their labour onputs. Form the 1980s onwards the goverment started to reward the community for establishment of terraces with cash;projects paid on the basis of area treated,and at different rates.

Inputs: Shovels and carts were provided by land users.

Credit: credit was available at interest rates (0.5%-1%per year) lower than the market rates.

Support of local institutions: Finacial support to local institution was made available through SWC Bureaus.

Long-term impact of incentives: As mero and more payment is currently being made to land users on the basis of the area treated. land users rely more and more on being paid for investments into SWC .The willingness to invest in SWCmearured without receiving financial support has decreased. Thus the use of incentives in the current approach is considered to have a negative long-term impact.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Regular measurements of runoff loss, sediment load soil moisture.
Technical	Regular measurements of structure of terraced areas slope of risers, levelness of terrace surface.
Socio-cultural	Ad hoc observations of land users' perceptions of terraces.
Economic/production	Regular measurements of yield, income of land users.
Area treated	Regular measurements of terraced area.
No. of land users involved	Ad hoc measurements of the numbers of farmers directly involved in terracing and farmers benefited directly.
Management of approach	Ad hoc observations of number of small watersheds terraced.

Impacts of the approach

Changes as result of monitoring and evaluation: The approach changed fundamentally from self-mobilisation to organised mass movements guided by the government.

Improved soil and water management: Soil and water management have improved a lot: easier workability, intensified land use, in-situ water retention, top soil and fertilizer/manure are not washed away, etc.

Adoption of the approach by other projects/land users: As the Zhuanglang area was one of the pioneering areas for the Loess Plateau other regions were able to profit from the approach has been applied over the whole Loess Plateau-though the level of subsidies for construction is much higher under Word Bank projects.

Sustainability: Given the recent escalation in payments made to land users for implementation under certain projects it seems that the costs will be too high to sustain. Currently the Ministry of Finance is demanding that in-depth cost-benefit analyses are carried out involving environmental, social as well as economic assessment.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Efficient organization, planning to cover a large area, which is very susceptible to land degradation.	High costs;farmers depend on external support from goverment ,they are not willing to invest theor labour without payments(as it used to be in communisr times) → New approach; give farmers loans for construction as now they use machines to do the work. In addition, search for cheaper SWC technologies and for improving the benefits.
Heavy investment made by the land local as well as national government to reduce land degradation.	The steeper slopes which are also further away from the village are now often not cultivated and main-tained as they are too fat and marginal in production → Solutions need to be these areas, eg afforestation.
Many people involved and trained at different levels (pyramid system: see training/extension); commitment by all stakeholders.	
The collective activities/organisation strengthens the community and enhances social stability and coherence within villages; collective activities are expanded to other sectors, such as road construction ,supply of agrochemical inputs, etc.	

*No recommendations provided on how to sustain/improve the Strengthens in this case study.

Key reference(s)

[1] *Water and Soil Conservation*. Department of Yellow River Water Resources Committee of Ministry of Water Resources and Electric Power, 1987

[2] Jiangdingsheng. ACTA CONSERVATION SOLI ET AQUAE SINICA. *Discussion on section design of the terrace on the Loess Plateau*,1987, 2: 28-35

Contact person(s)

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Left: Shelterbelt of *Pinus sylvestris* var. *mongolica*. Photo by Jin Weimin
Right: Natural regeneration of *Pinus sylvestris* var. *mongolica.* Photo by Jin Weimin

Plantation of *Pinus sylvestris* var. *mongolica* at Sandyland

Hulunbuir of Inner Mongolia, China

Naturally regenerated seedlings of *Pinus sylvestris* are used for forestation in sandlot to anchor shift sand and safeguard grazing pastures

The project site is situated in Hulunbuir Desert, namely Evenki Autonomous Banner of Hulunbuir City of Inner Mongolia. This desert is located in the western part of Daxing'anling Mountain and distributed in strip shape along Yimin River and Hailar River. There are fixed and semi-fixed dunes, zonality soil is casta-nozems with high sand content, and non-zonality soil is aeolian soil. Typical grassland vegetation and forest vegetation are distributed in eastern part.

To control desertification and improve local environment, the forestry administration and local residents have conducted ecological improvement activities based on the "Three-North" Shelterbelt Programme. The aim is to protect pasture and improve local ecological condition by establishing forest shelterbelt, using pinus sylvestris enclosure and rehabilitation measures to anchor drift sand.

Steps of technical measures implementation as follows: (1) Prior to forestation season in spring, select 30-100cm high naturally regenerated seedlings of *Pinus sylvestris* from natural well grown forest or nursery grown seedlings. Mother soil lump is retained when the wild seedlings are dug to keep more than 80% of the roots intact inside the lump. (2) Site is prepared in holes with specifications suiting the wild seedling size, i.e. the diameter of hole should be 20cm wider than that of soil lump. The seedling collar should be positioned 15cm below the ground to form a dent for holding water. Thor-ough irrigation should be made in case of large seedling and dry soil. (3) Establish forest patch with mixed tree and grass or belt based on site conditions. In general, at dune areas where is a rolling landform, forest patch should be established in 4mx4m or 6mx6m spacing. (4) Supplementary planting should be conducted in the following year to maintain at least 85% survival rate. Special guards shall be assigned to patrol and guard the sites, and fence should be erected at places with frequent human and livestock activities.

The project has been implemented for more than two decades and the preliminary observation shows that desert has basically been stabilized; grass yield increased by 10% and *Pinus sylvestris* standing volume increment is of $3m^3/hm^2$, indicating remarkable benefits.

Location: Erwenki Banner of Hulunbeir City of Inner Mongolia
Technology area: 100 km^2
SWC measure: Vegetation, engineering, management
Land use: Grazing, forest land
Climate: Sub-humid
WOCAT database reference: QT
Related approach: Recovering Ecosystem of Hulunbuir Sandysland Based on Three North Shelterbelt Programme
Compiled by: Jin Weimin, Hulunbeir City Forestry Bureau; Tian Lü, Inner Mongolia Forestry Survey and Design Institute
Date: August, 2007

Editors' comments: This technology adopts naturally regenerated seedlings of *Pinus sylvestris* var. *mongolica* for desertification control afforestation. With strong adaptability of seedlings to site, the survival rate is high. At the same time, the pattern of planting arrangements is forest - grass patch. It accords with natural vegetation requirement. The technology is suitable to the local conditions and can be a good reference for other similar areas.

Classification

Land use problems

Serious wind erosion and land degradation; vegetation degradation and biodiversity reduction; barren soil and poor land productivity.

Land use	Climate	Degradation	SWC measure
 Forest land	 Grazing	 Sub-humid	 Wind erosion	 Biological measure

Technical function/impact

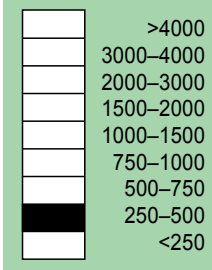
main: - fix drift sand and control wind erosion
- reduce wind speed
- add vegetation cover
- improve micro environment

secondary: - enrich biodiversity
- improve awareness of local people on ecology

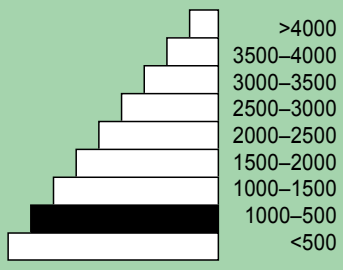
Environment

Natural Environment

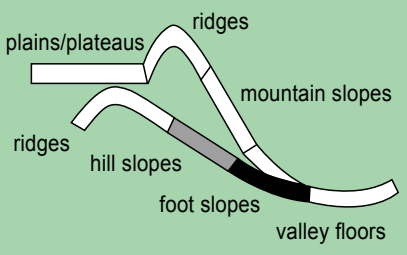
Average annual rainfall (mm)



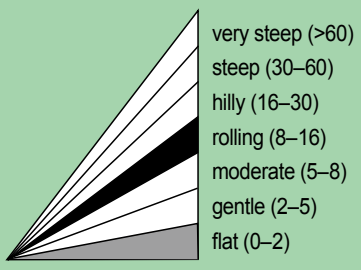
Altitude (m a.s.l.)



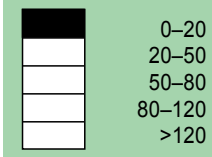
Landform



Slope (%)



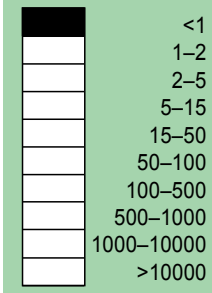
Soil depth (cm)



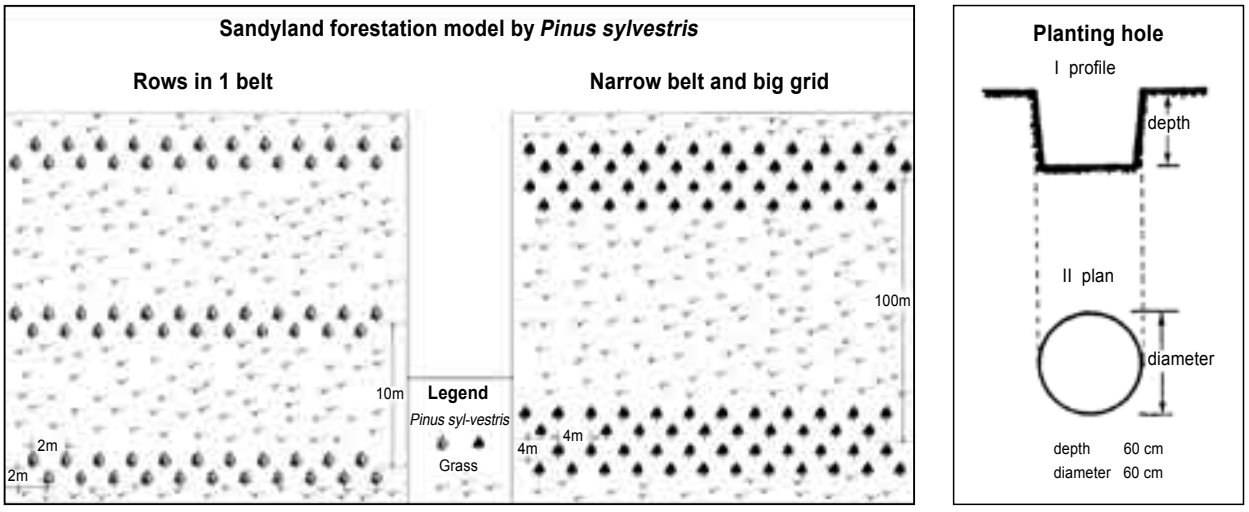
Growing season: 100 days in succession, from May to August
Soil fertility: low
Soil texture: coarse sandy
Surface stoniness: moderate
Topsoil organic matter: low (<1%)
Soil drainage: good
Soil erodibility: high

Human environment

Mixed land per household (hm^2)



Land use rights: state, collective or individual
Land ownership: state or collective
Market orientation: mixed
Level of technical knowledge required: moderate for technical extensionists and low to land users
Importance of off-farm income: 10%-50% of total income



Technical drawing

Based on site features, build forest-grass mixed small patch and shelterbelt, with two rows of arbor trees in one belt. The forestation specifications: row spacing 2m×2m, belt spacing 8-10m; or adopt the narrow belt, large grid pattern at 2-6 rows in one belt, plant/row spacing of 2m×2m and 4m×4m respectively, belt spacing 100-500 m.

Drawing by Guo Huimei

Implementation activities, inputs and costs

Establishment activities

1.Consultation with land users, reach agreement of implementation, allocating planting plots and signing contract.
2. Select naturally regenerated seedlings of *Pinus sylvestris* var. *mongolica* and lift them. The seedlings should contain mother root soil lump that contains more than 80% of the rooting system. Before transportation, the root system should be wrapped with wheat straw to keep moisture.
3. Site preparation in hole shape, with hole diameter 20 cm more than that of seedling soil lump diameter.
4. Based on regional features, build forest-grass mixed small-area patch and shelterbelt. In general, clustered patch forests are for dune areas with rising and falling slopes.

Establishment time: 1 year.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
Labour	73.2	0
Equipment		
- tractor, water vehicle	18.3	0
Materials		
- seedlings	91.5	0
Agricultural		
TOTAL	183.0	0

Maintenance/recurrent activities

1. Carry out replanting in the first spring following the planting to guarantee 85% or more survival rate.
2. Fences set up at sites with frequent disturbance of hu-man or domestic animal.
3. Arrange special guards to protect and maintain forest.

Operational time: 3 years replanting, tending all year round.

Maintenance/recurrent inputs and costs per hm^2 per year

Inputs	Costs (US$)	% met by land user
Labour	11.0	0
Equipment		
- tractor, water vehicle	6.1	0
Materials		
- seedlings	18.3	0
Agricultural		
TOTAL	35.4	0

Remarks: labour cost at US$3.7/person day, Establishment activities contain seedlings at US$91.5/hm^2. Maintenance/recurrent activities contain re-planting at US$18.3/hm^2. Exchange rate (at establishment) : US$1= RMB 8.2Yuan.

Assessment

- Operational cost is totally covered by proejct, and the proejct ecological benefits and long term economic benefits accure to the farmers and herds-men, who are therefore active to the proeject technology.
- In case if the operational cost to be covered by the farmers and herdsman, they do not accept.

Benefits/costs according to land user

The land users were neutral to the technology application. With the development process of recovered vegetation and increased economic benefit, the land users have become more active to the project.

Benefits compared with costs	Short-term	Long-term
establishment	neutral	very positive
maintenance/recurrent	neutral	very positive

Impacts of the technology

Production and socio-economic benefits

+ +	Adjust structure of agricultural and animal husbandry industries
+	Protect the pasture land and increase fodder produciotn

Production and socio-economic disadvantages

–	Grazing income is reduced in short term period

Socio-cultural benefits

+ +	Contribute to imporving awareness of local residents on ecology and promote social harmornous development

Socio-cultural disadvantages

None

Ecological benefits

+ + +	Fix sand, break wind, and curb desertification
+ +	Increase vegetation cover and improve micro environment
+	Increase biodiverstiy and protect ecosystem stability

Ecological disadvantages

None

Off-site benefits

+	Reduce wind/sand harms and damages off-site

Off-site disadvantages

None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Stable forest-grass community and good protection benefit → Further study the forest-grass arrangement pattern at different site conditions.	Seedling lifting causes soil and water erosion easily → Do not lift seedlings in concentrated locations and back fill the earth after seedling lifting.
High adaptability and survival rate of the naturally regenerated seedlings → Study to improve seedling production quantity.	

Key reference(s)

[1] Inner Mongolia Forestry Department. *Studies on forestation of Pinus sylvestris* var. *mongolica at different site conditions. Collection of Technological Research Achievements in Inner Mongolia* (2001-2005). 2006: 42-44

[2] Inner Mongolia Forestry Department. *Forestation Technology of Pinus sylvestris* var. *mongolica at Sandyland*. 2001: 152-154

Contact person(s)

Tian Lü, Inner Mongolia Forestry Survey and Design Institute. Tel: 0471-5953487. Email: tianlv001@sina.com

Left: Site lectursiing of the technology to farmers and herdsmen. Photo by Jin Weimin
Right: Planted site of *Pinus sylvestris* var. *mongolica.* Photo by Jin Weimin

Recovering Ecosystem of Hulunbuir Sandysland Based on Three North Shelterbelt Programme

Ewenki Banner of Inner Mongolia, China

Forestation of *Pinus sylvestris* etc. to build forest shelter belt for ecological and pasture protection in Hulunbuir sandyland is based on the Three-North Shelterbelt Programme.

The project site is located in the Hulunbuir sandyland in the eastern part of Inner Mongolia. The sandy-land is distributed in a strip shape along Yimin River and Hailar River. Overgrazing and drought have caused further desertification of sandyland and vegetation degradation and caused subsequent negative impacts upon local economic development and normal life of residents.

This technology is developed at basis of the implementation of Three-North Shelterbelt Programme and local sandyland improvement programmes to curb sandification, increase forest and grass vegetation, safeguard pastures and improve local environment. The target of planting is to reach survival rate more than 85% of *pinus sylvestris* thus forming a clustered forest and grass landscape. The Three-North Shelterbelt Programme is a key national programme and now it is in Phase IV. Till now total of 13,300 ha have been planted in this project area. In comparison with previous phases, Phase IV is the project with highest investment and largest area of forestation. The forestry administration is responsible for organization of the implementation with the following procedures: the forestry bureau in Hulun-buir City assign forestation work to the forestry bureau at banner level which negotiate with herdsmen or forest farms and sign land use agreement with them; The banner forestry bureaus purchase seedling, do the planning design and employ forest farm staff and local farmers for forestation; Land users, herdsmen or forest farm staff will maintain the planted forests, and the ecological compensation and income derived from forest products and timber belonging to the land users.

The implementation has witnessed changing process of local residents' awareness. For the first three programme phases, there was indistinct income from the programme for local residents due to limited government investment, so that they were not active toward the participation in programme. During implementation of Phase IV, local farmers and forest farm staff are turning to apply for more forestation work owing to increased national financial support. As a result, wind erosion of the pastures and sandification are being resolved with significantly improved local ecosystem.

The project site is located in traditional pasture region and forest development requires occupation of a part of grazing land, so the income of livestock production decreased slightly. To this end, this conflict calls for balanced coordination between short and long-term benefits when conducting the technical extension.

Location: Evenki Banner of Hulunbeir City, Inner Mongolia
Land use: Forest land
Climate: Sub-humid
WOCAT database reference: QA
Related technology: Plantation of *Pinus sylvestris* var. *mongolica* at Sandyland
Compiled by: Tian Lü, Inner Mongolia Forestry Survey and Design Institute; Jin Weimin, Hulunbeir City Forestry Bureau
Date: August, 2007

Editors' comments: Based on the national Three-North Shelterbelt Programme and local sandyland desertification control programmes, this technology has been proved to have strong adaptability and high efficiency. The project implementation is in consolidated form and upon completion of planning activities, the farmer and herdsmen households sign contract to maintain and tend the treated land. The contracting system has activated enthusiasm of farmers and guaranteed project quality.

Problem, objectives and constraints

Problem

- Lack of effective mechanism to organize and mobilize herdsmen.
- Extended forestry project takes a part of grazing land, leading to land use conflicts.
- Herdsmen in lack of enthusiasm of participation.
- Vegetation degradation and land desertification affects production and life.

Objectives

- Coordination of different stakeholders and formation of effective technical extension mechanism.
- Raising awareness of community on ecological protection.
- Checking wind and fixing drift sand, adding forest vegetation to realize both ecological and economic targets.

Constraints addressed

Major	Specification	Treatment
Funds	Limited local financing resources affected extension area of the technology.	Central government provides more support and the local government makes available funds from multiple channels.
Land use	Conflict between Forest and pasture land use is out standing,because forestation occupies a part of pas ture land and affect herdsmn income.	Government provides to herdsmen proper compensation.
Minor	**Specification**	**Treatment**
Management	The forest land and pasture land are mixed up, and more animal husbandry activities are conducted, therefore forest protection and maintenance are dif ficult to be fully implemented.	Intensify publicity, and set up award-punishment regime. Set up fence at vulnerable sites.

Participation and decision making

Target groups


Land user


Design staff


Decision maker

Approach costs met by

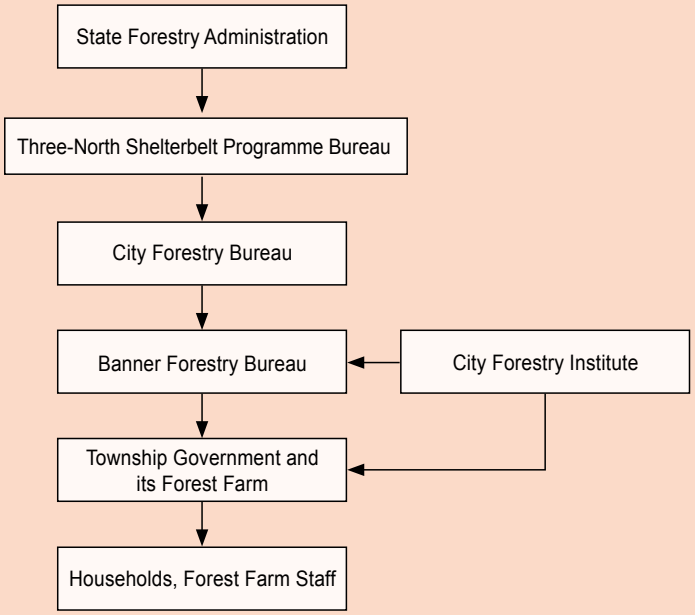
State government	80%
Counterpart fund by city and banner government	20%
TOTAL	100%

Decisions on choice of the technology: Banner forestry bureau.
Decisions on method of implementing the technology: Banner government.
Approach designed by: City forestry experts.

Community involvement

Phase	Involvement	Activities
Initiation	Interaction	Households participate in training, and sign contracts with government.
Planning	Interaction	Learn the technical method and finalize the planting plots with technicians.
Implementation	Active	Site preparation, planting and tending etc.
Monitoring/evaluation	Interaction	Offer observation data.
Research	Passive	Offer observation data.

Differences in participation of men and women: Male labour takes about 80%; female labour takes about 20%.



Organogram

The project task and financing plan is issued by State Forestry Administration (SFA) and deliver to local forestry units through Three-North Shelter-belt Programme.

Extension and promotion

Training: The technical staff of the banner forestry work stations conducted training to land users by lectures, site demonstrations etc.. The training result is good.

Extension: The banner forestry work stations and township forestry work stations are responsible for technical extension, and the emphasis is made on seedling lifting technique, site preparation specifications, plant technique etc. The result is good.

Research: The city forestry research institute conducted research on establishment of artificial community *Pinus sylvestris* var. *mongolica* and the sand fixation effect. This method has been applied in project and has produced benefits, thus herdsmen with pleasure accept this technology.

Importance of land use rights: At the beginning herdsmen households didn't understand the project and technology, so they held indifferent attitude. Along with the raising benefits of project, their attitude has become positive. In general, land tenure has certain influence on project technology application.

Incentive

Labour: The banner forestry bureau organized forest farm staff and herdsmen to participate in project and paid for their labour input.

Inputs: Forestry bureau provides materials and machinery such as seedlings, tractors and water vehicles, the workers provide small facilities such as spades.

Credit: Bank provides loan to local government for purchasing seedlings.

Support of local institutions: Local government being responsible for coordination and mobilization, holds positive attitude to the technology.

Long-term impact of incentives: Without above-mentioned incentives, the technology is hard to be implemented.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Wind speed, amount of wind erosion.
Technical	Survey survival rate; sampling plot survey of community composition; survival rate of forest *Pinus sylvestris* var. *mongolica,* forest and grass community composition.
Socio-cultural	Questionnaire and site survey of the acceptance of the technology by local residents.
Economic/production	Survey and calculate the agriculture/grazing economic benefits to the local community after proejct is implementated several years later.
Area treated	Survey the treated area and the changes related to land types.
No. of land users involved	Survey to find out the quantity of the land users and the structural changes.
Management of approach	Questionnaire and site survey of the area using the technology.

Impacts of the approach

Changes as result of monitoring and evaluation: At initial stage, due to less investment and limited benefits, the public enthusiasm of participation was low. Along with investment increase and the benefit accumulated, the participation become popular.

Improved soil and water management: The management of forest land has been effectively strengthened.

Adoption of the approach by other projects/land users: The method has been extended in neighboring areas.

Sustainability: Contracting for long period can bring certain profits. Land users without long-term support may continue to adopt the technology.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Extension efficiency is high → The extension capability of government can be strengthened further	Farmer participation level is low → Introducing participatory tools in the entire process
Contracting system of forest land is favouring protection and maintenance → Improve the land contracting system	

Key reference(s)

[1] Inner Mongolia Forestry Department. *Studies on forestation of Pinus sylvestris* var. *mongolica at different site conditions. Collection of Technological Research Achievements in Inner Mongolia* (2001-2005). 2006: 42-44
[2] Inner Mongolia Forestry Department. *Forestation Technology of Pinus sylvestris* var. *mongolica at Sandyland*. 2001: 152-154

Contact person(s)

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Left: Bird's-eye view of farmland shelterbelt on dryland. Photo by Ding Rong
Right: Close shot of farmland shelterbelt on dryland. Photo by Li Xianyu

Farmland Shelterbelt on Dryland

Aohan Banner of Inner Mongolia, China

The shelterbelt in shape of grid can be established on dryland (rain-fed cropland) without irrigation.

The technological demonstration plot is located in Aohan Banner, the eastern part of Inner Mongolia and the south of Horqin Desert. Hills and sandlot dominate this area. The demonstration plot is a semi-arid area with poor natural conditions. This area is featuring shortage of both surface and ground water resources, so most farmlands are rain fed. The crops often suffer from gust and cold wave. Sometimes there is no harvest at all. Establishment of shelterbelts is an essential, imperative and necessary measure to ensure stable and high yield of farming products.

The key points of the technique are as follows: (1) Site selection – hillside land or sand-covered cropland with slope less than 15°. (2) Shelterbelt configuration – narrow belt, small grid with ventilation configuration. Main belt is has three rows of trees at spacing 2mx2m; the ancillary (side) belt has two rows of trees at spacing 2mx2m. The spacing of main belts is 300m and that of ancillary belts is 400-500m. The main belt should be arranged perpendicular to prevailing wind direction and the ancillary belts should be perpendicular to the main belts. (3) Species selection - *P. X Simopyramidalis* chon-Lin CV, *Populus simonii* × *P. nigra* and *Populus* × *beijingensis* W. Y. Hsu or other tolerant and fast-growing poplars species or varieties. (4) Site preparation – conduct site preparation in rainy season one year earlier before planting in semi-underground or level trough form. (5) Seedling preparation – dig out the seedlings several days before planting date and sufficiently watering before lifting. Wet soil should be used to keep moisture of the roots of the lifted seedling and wrap the roots with wheat straw or plastic cloth when the seedlings are to be shipped. Soak them completely in water for 48h before planting. (6) Planting – April and May are best planting seasons. Place the seedling upright in the hole and backfill soil in layers and tread it firmly in each layer. Water the seedling sufficiently after planting and make 20-30cm high drought-resistant soil pile surrounding the seedling. (7) Maintenance measures – build wall at 1m distance to trees of edge row to prevent detriment by human or livestock.

The farmland shelterbelt in Aohan Banner has produced good economic and ecological benefits. The observation indicates that farmlands guarded by the shelterbelt have less wind erosion and increased resistance to natural disasters and additional 10% of crop output increased. As revealed in some estimation, each hectare of forest can increase five cubic meters of growing stock. Such remarkable predictable economic benefits promote great enthusiasm of farmers to participate in the project. At present, almost all dry lands in Aohan Banner have had farmland shelterbelts.

Location: Aohan Banner, Inner Mongolia
Technology area: 2000km^2
SWC measure: Vegetation
Land use: Cropland
Climate: Sub-humid
WOCAT database reference: QT
Related approach: Farmland Shelterbelt on Dryland, Led by Government
Compiled by: Li Chunying, Inner Mongolia Forestry Department; Tian Lü, Inner Mongolia Forestry Survey and Design Institute.
Date: August, 2007

Editors' comments: This technology is suitable for hill land and sand-covered rain-fed cropland. It needs less investment but produces good protection effect. At the same time, the forest belt at mature stage can be felled for timber use to realize ecological and economic benefits. Now, this technology has been widely extended in areas with serious sand harm of Inner Mongolia autonomous region. This technology has good potential to be adopted for similar areas.

Classification

Land use problems

Serious wind erosion; crops are easily affected by extreme weather conditions; land economic benefits is low in general.

Land use	Climate	Degradation	SWC measure
			
Cropland: potato	Sub-humid	Wind erosion	Biological measurer

Technical function/impact

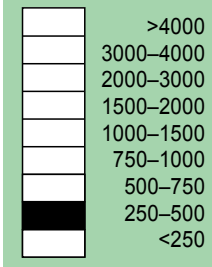
main: - reduce wind erosion
- prevent sand burials
- prevent the crops from mechanical or freezing harms

secondary: - reduce evaporation
- improve micro climate of the farmland

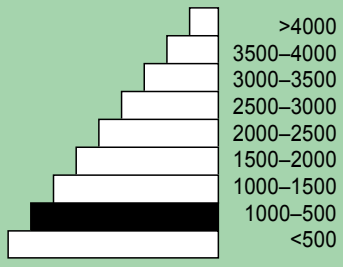
Environment

Natural Environment

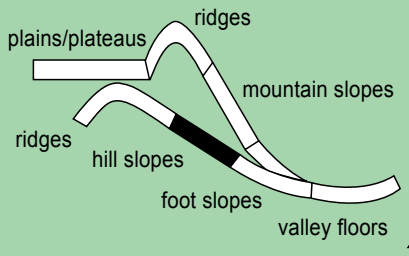
Average annual rainfall (mm)



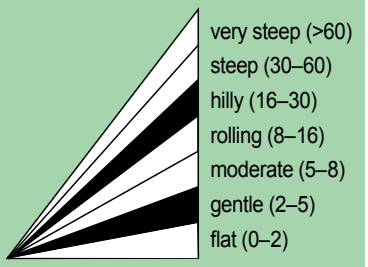
Altitude (m a.s.l.)



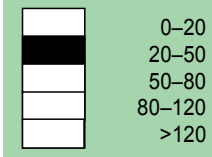
Landform



Slope (%)



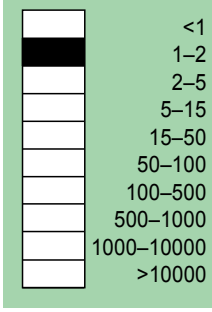
Soil depth (cm)



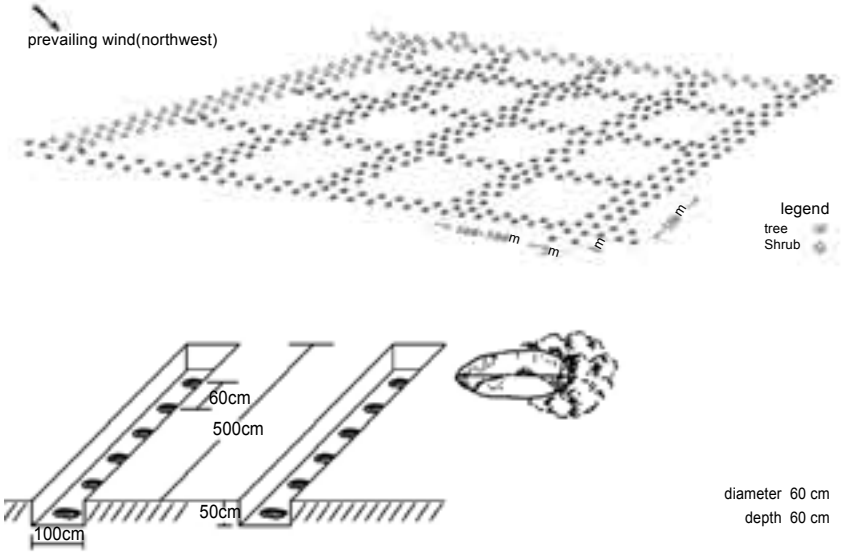
Growing season: 150 days in succession, from April to September
Soil fertility: moderate
Soil texture: moderate (loamy)
Surface stoniness: no
Topsoil organic matter: moderate (1%-3%)
Soil drainage: moderate
Soil erodibility: high

Human environment

Mixed land per household (hm^2)



Land use rights: individual
Land ownership: collective
Market orientation: self use
Level of technical knowledge required: moderate for technical extensionists and low to land user
Importance of off-farm income: less than 10% of the total income



Model of rain-fed farmland shelterbelt

Technical drawing

Pattern design: spacing: 2m×2m, two lines belt with grid size: 300m×500m or 500m×500m.

Semi-underground site preparation: 4-6m long, 1 m wide, 0.5m deep; Inside prepare the planting pits with size 0.6m×0.6m×0.6m.

Drawing by Guo Huimei, Inner Mongolia Forestry Monitering and Planning Institute.

Implementation activities, inputs and costs

Establishment activities

1. Preparation investigation: determine location and technical methodology.
2. Farmer and government sign afforestation contract.
3. Planting design.
4. Selection of tree species.
5. Site preparation. Done at rainy season one year before planting.
6. Seedlings.
7. Planting. Put seedling upright the planting hole, fill in earth, tread and water earth.
8. Maintenance protection. One meter away from the trees of edge row, dig a gully with 1m wide at upper edge, 0.8m wide bottom edge and build walls aside the gully to avoid human or domestic animal damages. Three years of maintenance tending.

Establishmet time: 1 year.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
Labour	54.9	100
Equipment		
- tractor, water trasport vehicle	36.6	0
Materials		
- seedling	609.8	0
Agricultural		
TOTAL	701.3	7.8

Maintenance/recurrent activities

1. Artifial weeding between forest belts, twice a year watering in spring and autumn.
2. Supplemental planting In spring of the year following the initial plating.
3. Arrange special guards for protecting shelterbelts.

Maintenance/recurrent inputs and costs per hm^2 per year

Inputs	Costs (US$)	% met by land user
Labour	36.6	100
Equipment		
- tractor, water trasport vehicle	18.3	0
Materials		
- seedling, pesticide	60.0	0
Agricultural		
TOTAL	114.9	31.85

Remarks: Labor price at US$3.7/peron day; seedlings used during maintenance are for replanting; Exchange rate (at establishment): US$1= RMB 8.2 yuan.

Assessment

Acceptance/adoption

- With existing incentive mechanism, most households accept this technology.
- Without incentive mechanism most households do not accept this technology.
- If the comparative benefit of farmland shelterbelt is high, farmer households can accept the technology.

Benefits/costs according to land user

The farmland shelterbelt brings to farmer households direct benefit, and government provides considerable subsidy, so the enthusiasm of farmer household is very high.

Benefits compared with costs	Short-term	Long-term
establishment	neutral	very positive
maintenance/recurrent	neutral	very positive

Impacts of the technology

Production and socio-economic benefits

+ + +	Improve the growth environment of the crops and enssure high and stable output of farmaland
+ +	Increase timber standing volume and generate economic income

Production and socio-economic disadvantages

–	The trees have some effect on neighboring crops, and thus reducing crop output

Socio-cultural benefits

+	Enrich farmers' knowledge of ecologcal improvement and protection

Socio-cultural disadvantages

	None

Ecological benefits

+ +	Reduce wind erosion
+	Prevent sand burials
+	Reduce evaporaion

Ecological disadvantages

–	None

Off-site benefits

+ + +	Reduce sand dust weather days, absorbing carbon dioxide and releasing oxygen

Off-site disadvantages

	None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Protection performance is good → Further extension.	Forest belt has effect on neighboring crops → Introduce proper species and conduct root cutting to mitigate the effect.
Have certain economic benefits → Explore possibility of planting cash trees for higher output.	Single tree species adopted → Introduce more forest species suitable for shelterbelt.

Key reference(s)

[1] Inner Mongolia Forestry Departmetn. *Technique of farmland shelterbelt establishment on rain-fed farmland*: Appropriate forestry technology. 2001: 116-118

[2] Desertification Combating and Management Center of State Forestry Administration. *Applied technology and pattern of desertification control in China*. Beijing: China environmental science press, 2001

Contact person(s)

Tian Lü, Inner Mongolia Forestry Survey and Design Institute. Tel: 0471-5953487. Email: tianlv001@sina.com

Left: Farmland shelterbelt net on dryland. Photo by Li Chunying
Right: Farmland shelterbelt for rain-fed crop. Photo by Li Xianyu

Farmland Shelterbelt on Dryland, Led by Government

Aohan Banner of Inner Mongolia, China

Farmland shelterbelt establishment on dryland is organized by Banner (county) government and implemented by forestry administrations.

Farmland shelterbelt with a history of decades in Inner Mongolia is a shelter forest planted around farmland to prevent wind and chilly harms. Many forestation models have been built up for various locations through years of practice in the light of local conditions, such as Taiping model of Chifeng City, Zhandanzhao model of Erdos City, etc. The Aohan farmland shelterbelt model is the results of summing up achievement of technicians and farmers in their long-term practices.

As early as in 1950s, Aohan farmers started planting poplars surrounding farmland to counter the sand-storm and cold wave and achieved obvious success. The forestry administration of Chifeng City has summed up their experience in shelterbelt construction and proposed a narrow belt and small grid model. Shelterbelt building in 1950s and 1960s experienced rapid development. In 1990s, along with national key ecological projects implemented, farmland shelterbelt establishment in Aohan entered an ex-press track and shelterbelt network has basically formed throughout the Banner.

Aohan Banner shelterbelt construction has been led by the government with the forestry bureau responsible for planning and provision of technical service. Township government is responsible for organization of implementation and signing contracts with local farmers for operation of shelterbelt. Technology dissemination has followed principle of “uniform planning, uniform construction, uniform management and household contracting system”, including (1) Banner government undertake an educational campaign on benefits of shelterbelt and demonstration in order to gain farmers recogni-tion. According to official planning, the land for shelterbelt should be reserved based on signed contracts; (2) the forestry administration prepares project implementation plan and provides technical service ; (3) township government loan is used forestablishment and maintenance of farmland shelterbelt, and a special team is assigned for planting shelterbelt trees and supplementary planting in three years; and (4) the township government organizes special forest guards to protect the established forest.

15 years later after its establishment, regeneration felling may be conducted and the income from timber harvest is distributed in 4:3:3 ratio, i.e. 40% to village committee, 30% to forest guards and 30% to farmers, thus all stakeholders can enjoy benefits. It is a good approach to protect shelterbelt forest. The farmers have recognized farmland shelterbelt and its economic benefits. Farmers have played positive role in construction of farmland shelterbelt. At present, there are 200,000hm^2 of farmlands encircled by shelterbelt and satisfactory ecological and economic benefit has been achieved.

Location: Aohan banner, Inner Mongolia
Land use: Forest land, farmland
Climate: Semi-arid
WOCAT database reference: QA
Related technology: Farmland Shelterbelt on Dryland
Compiled by: Tian Lü, Inner Mongolia Forestry Survey and Design Institute; Li Chunying, Inner Mongolia Forestry Department
Date: August, 2007

Editors’ comments: This technology has shown obvious benefit in Aohan banner, where the project was implemented by unified planning and professional team, and establishment quality is well guaranteed. All stakeholders share the benefits. This technology is warmly welcomed by farmers and herdsman. As a whole, the progress of project is satisfactory. The technology has a broad impact on surrounding area.

Problem, objectives and constraints

Problem

- The short term benefit is low.
- Poor awareness of the farmers on the project benefits.
- The expertise of the professional teams awaits further improvement.

Objectives

- Form effective technical extension mechanism.
- Improve households' awareness on ecological protection.
- Increase economic income of project participants.

Constraints addressed

Major	Specification	Treatment
Economic aspect	The growth period of shelterbelt is long and economic profit of the initial stage is low, farmers' enthusiasm is not high.	At initial stage, proper subsidy is needed.
Law and policy	Annual allowable cut quota limits regeneration of trees of shelterbelt.	Increase annual allowable cut quota.
Minor	**Specification**	**Treatment**
Organizational management	Inadequate publicity and training.	Banner government allocates special funds for publicity and training.

Participation and decision making

Target groups


Land user


Designer


Decision maker

Approach costs met by

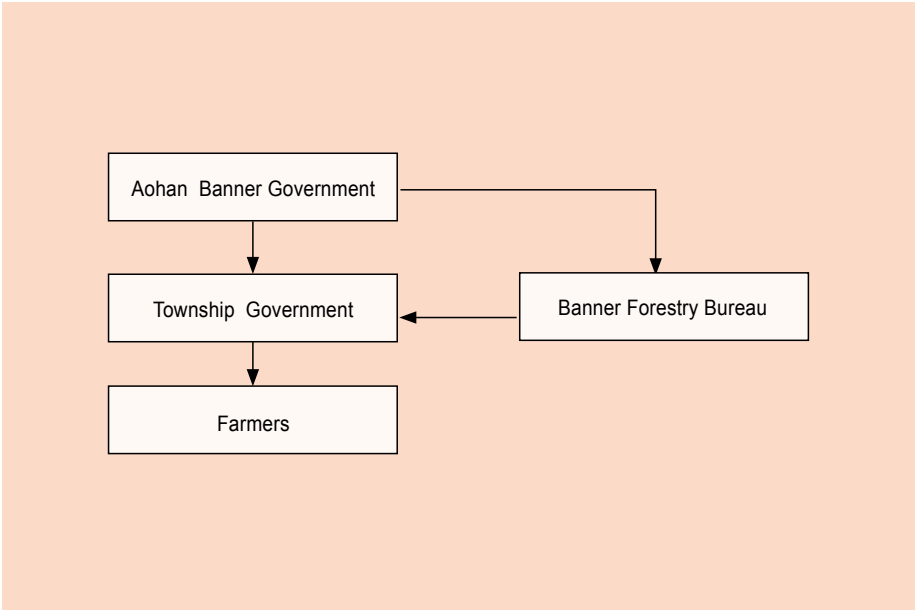
Township government loan	100%
TOTAL	100%

Decisions on choice of the technology: Government of banner (county) and township.
Decisions on method of implementing the technology: Banner forestry bureau.
Approach designed by: Banner forestry experts.

Community involvement

Phase	Involvement	Activities
Initiation	Interactive	Governmental managers and technicians put forward tentative ideas for community meeting discussion. Sign contract with land owners.
Planning	Interactive	Settle precise location of sites for farmers.
Implementation	Active	Attend technical training courses, participate in site preparation, planting and later stage management.
Monitoring/evaluation	Passive	Households offer observation data.
Research	Passive	Households offer observation data.

Differences in participation of men and women: Both men and women are active in participation. More man labors are used.



Organogram

The technical extension is jointly organized by the banner government and the township government.

Extension and promotion

Training: Banner forestry station technicians are responsible for training in forms of lecturing and site demonstration. The training topics are benefits of shelterbelts, key technique etc. The training effect to farmers is good.

Extension: Extension is undertaken by the township government with support of banner forestry bureau. The extension is undertaken in the form of demonstration at the land reserved by contrct. The effect is good.

Research: Research is done by banner forestry bureau and city forestry institute. Related research covers technique establishment of farmland shelterbelts, protection benefit monitoring, increased agricultural crops by shelterbelt etc. Results of research play positive role in project benefits.

Importance of land use rights: The land is reserved according to contracts, and it is owned by collectives. It has no negative impact on technology application.

Incentive mechanism

Labour: Labor force is organized by the township government and paid at market price, normally RMB 30 Yuan per person day.

Inputs: All project costs such as seedlings, machinery and labor are paid by the township governmental loan.

Credit: Bank provides interest-subsidized or low interest loan.

Support of local institutions: Technology application raised households' favor for the forestry bureau and township government, also strengthened the organizational capability of the governmental organizations.

Long-term impact of incentives: For long term, incentive mechanism is positive to the technological application because the incentives encourage more and more farmers and herdsman to participate in the project. Without above-mentioned incentive mechanism, the application is more difficult.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Measure the wind speed and temperature inside and outside the farmland shelterbelts.
Technical	Investigate survival rate and preservation rate, tree growing potential and forest maintenance condition.
Socio-cultural	Sampling check of the role of farmland shelterbelt in improving agricultural production environment, raising technical level and improving the life quality of farmers and herdsmen.
Economic/production	Conduct statistics of grain production, timber output and farmer/herdsman income increase after the farmland shelterbelt is established.
Area treated	Sampling check of the farmland shelterbelt area and the preservation condition.
No. of land users involved	Sampling survey of land users quantity and their structure.
Management of approach	Questionnaire and site survey to lower-level management by higher level department.

Impacts of the approach

Changes as result of monitoring and evaluation: At initial stage of the project implementation, the households did not see any direct benefits, so they held negative attitude to the project. With the benefit appearing, the enthusiasm of households recovered and became higher.

Improved soil and water management: Wind erosion of soil controlled and soil fertility increased.

Adoption of the approach by other projects/land users: technology is adopted also by the department of animal husbandry.

Sustainability: Because of good ecological and economic benefits of the project, the land users will use the technology continuously even without long term support.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Extension efficiency is high → Further strengthening extension capability of the government.	The level of farmer participation is low → Application of participatory tools.
Take incentive measures → Enlarge technology coverage.	Economic return period is long → Considering proper compensation at early stage of establishment.

Key reference(s)

[1] Inner Mongolia Forestry Departmetn. *Technique of farmland shelterbelt establishment on rain-fed farmland*: Appropriate forestry technology. 2001: 116-118

[2] Desertification Combating and Management Center of State Forestry Administration. *Applied technology and pattern of desertification control in China*. Beijing: China environmental science press, 2001

Contact person(s)

Tian Lü, Inner Mongolia Forestry Survey and Design Institute. Tel: 0471-5953487. Email: tianlv001@sina.com

Left: deep planted forest at Dulan County. Qinghai. Photo by Qi Chengde
Right: vigorous forest grown on the sand land. Photo by Qi Chengde

Deep Planting of Poplar at High Cold Arid Sandy Land

Dulan County of Qinghai Province, China

Poplar cuttings are adopted for deep planting at high altitude cold plateau desert to remarkably increase survival rate and improve psammophilous vegetation for sand fixation and wind breaking.

The technology demonstration zone is located in Dulan County, Qinghai Province, southeastern part of Qaidam Basin. The county has 3 towns and 6 townships, 75,000 in population (55,600 farmers and herdsmen), a total area of 48,392km^2. It is in a temperate zone desert, with short hot summer, dry climate, low precipitation (37.9-296mm) that concentrated June thru September, 70-90days of frostfree period, 2.27 million hectares of natural meadow (1.66 million ha usable), 623,000hm^2 of desertified grassland and 12,400hm^2 of farmland. With deteriorating wind erosion and desertification some farmland and roads are threatened.

Technical implementation steps (1) Cutting preparation – select health branches of 1-2 years old of 8-15 years old *Populus cathayana*. The cuttings should be with 3cm in diameter and free of pest or disease. Make cuttings to approximately 1.5m long. (2) Cutting treatment – soak the cuttings in flowing water for about 40days until bark turns to white with light yellowish protrusion, use ABT rooting powder for treatment. (3) Site preparation – start site preparation in mid May, 1.5mx2m in spacing, 0.8-1m in hole depth. Remove dry sand from the hole before preparation. (4) Planting – planting depth is 1m and keep the trunk 50cm above the ground level. Plant the cuttings immediately after the planting pit is dug. Drill steel of 3cm diameter may be used to dig the hole for cutting forestation. (5) Set sand barrier – for small patch of drifting sand, use gravel or straw to set 2mx2m grid sand barrier and sow seeds of *Caragana Korshinskii* Kom, *Artemisia filifolia* or deeply plant trees in the grid.

This technology is successfully adopted for 10,700hm^2. in Hainan Prefecture (Guinan, Gonghe counties) and Haixi Prefecture (Wuland, Dulan counties) increasing plant survival rate from 60% to more than 90% . It promotes forest and grass vegetation growth without irrigation, reduces dune movement and wind/sand harms.

Location: Dulan County, Qinghai Province
Technology area: 107km^2
SWC measure: Vegetation and engineering
Land use: Sandy land, degraded grazing land
Climate: Semi-arid/arid
WOCAT database reference: QT
Related approach: Deep Planting with Poplar Cutting at High Cold Desert
Compiled by: Qi Chengde, Qinghai Provincial Forestry Bureau
Date: September, 2007

Editors' comments: This technology can raise forestation survival rate without irrigation to effectively increase vegetation for wind breaking and shift sand fixing. This technology applies at the high and cold sandy land of desert ecosystem. In Hainan prefecture (Guinan County, Gonghe County) and Haixi prefecture (Dulan County, Wulan County) of Qinghai,10700 hm^2. has been planted for demonstration and the survival rate reached 90%, and the sandy land vegetation cover reached over 10% which efficiently alleviated the desertification expansion speed.

Classification

Land use problems

Land use | **Climate** | **Degradation** | **Measure**

Land for forestaion | Grazing pasture | Semi–arid | Wind erosion | Management measure | Mechanical measures | Biological measures

Technical function/impact

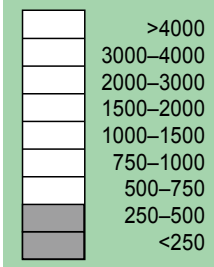
main: - use deep ground moisture to raise forestation survival rate
- fix drifting sand
- add vegetation cover

secondary: - reduce wind speed
- protect farmland and pasture

Environment

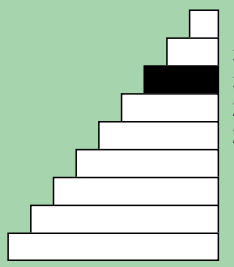
Natural Environment

Average annual rainfall (mm)



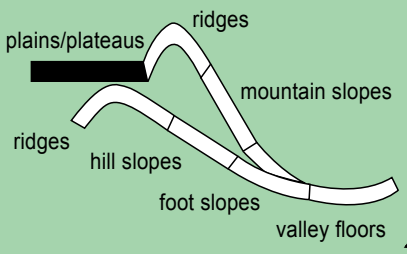
>4000
3000–4000
2000–3000
1500–2000
1000–1500
750–1000
500–750
250–500
<250

Altitude (m a.s.l.)

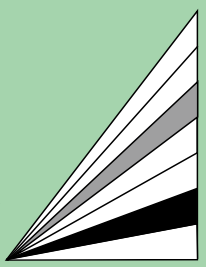


>4000
3500–4000
3000–3500
2500–3000
2000–2500
1500–2000
1000–1500
1000–500
<500

Landform



Slope (%)



very steep (>60)
steep (30–60)
hilly (16–30)
rolling (8–16)
moderate (5–8)
gentle (2–5)
flat (0–2)

Soil depth (cm)

0–20
20–50
50–80
80–120
>120

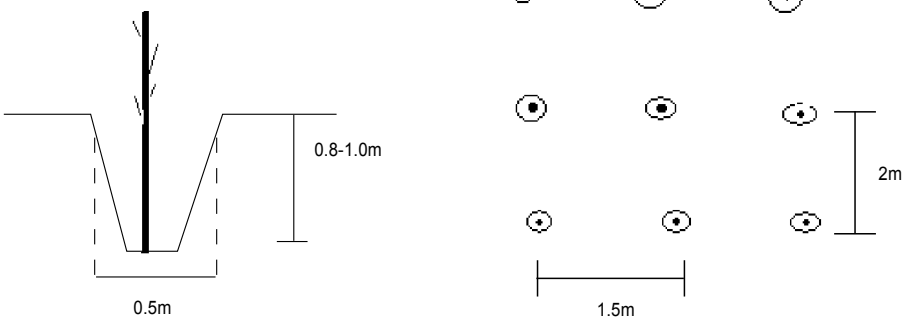
Growing season: 90 days in succession, from June to September
Soil fertility: low
Soil texture: coarse sandy
Surface stoniness: moderate (plenty of loose gravel)
Topsoil organic matter: low (<1%)
Soil drainage: moderate
Soil erodibility: very high

Human environment

Mixed land per household (hm^2)

<1
1–2
2–5
5–15
15–50
50–100
100–500
500–1000
1000–10000
>10000

Land use rights: collective or individual
Land ownership: collective
Market orientation: self use
Level of technical knowledge required: moderate for the technical extensionists and low to land users
Importance of off-farm income: 10%-50% of total income



Profile of Poplar deep planting **Spacing of Poplar deep planting**

Technical drawing

Left: Profile of Poplar deep planting

Right: Spacing of Poplar deep planting

Drawing by Qi Chengde

Implementation activities, inputs and costs

Establishment activities

1. Cutting preparation In March when the poplar sap start flowing, identify 8-15 years old *Populus cathayana* for preparation of 1.5 meters long, diameter over 3 cm cuttings from the 1-2 years old vigorous healthy branches without incidence of pests or diseases. In early April put the prepared cuttings into running water for soaking of about 40 days around to see appearance of the bark surface in white color.
2. Pre-planting treatment. Use 0.1% density mg/L ABT for treatment of the poplar cuttings .
3. Planting. Digging planting pit and plant right afterwords. The pit is 0.8- 1 metre in depth. The pit can also be drilled with steel rod at about 3 cm diameter for inserting afforestation.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
Labour	89.88	0
Equipment		
- spade, steel rod, transport vehicles etc.	39.35	5
Materials		
- seedlings, gravel, crop straw	299.6	0
Agricultural		
- pesticide, grass seeds, ABT etc	20	0
TOTAL	448.83	0

Maintenance/recurrent activities

1. Management (enclosure protection, forest patrolling, pest/disease prevention and control).
The forestation land should install iron wire fence and arrange community patrolling workers to protect the forest. The local forestry sector should offer proper subsidy for the maintenance while the pest/diseases control should be managed by local forestry bureau, which has to provide working facilities and medicament, and labor is offered by land users.
2. Maintenance (supplementary planting, enclosure protection).
For the sites with planting survival rate less than 70%, supplementary planting should be done in the following year; For the first 5 years following the planting, timely maintaining repair should be conducted to the fence to prevent forest damages from domestic animals.

Maintenance/recurrent inputs and costs per hm^2 per year

Inputs	Costs (US$)	% met by land user
Labour	87.67	0
Equipment		
- spade, steel rod, transport vehicles etc.		0
Materials		
- seedlings, gravel, crop straw	130.52	0
Agricultural		
- pesticide, grass seeds, ABT etc	20	0
TOTAL	238.19	0

Remarks: For establishment, poplar seedlings US$299.6, site preparation and planting 45 person day hm^2 at RMB 15 yuan/person day; Technical maintainance and operations include tending, supplementary plating, pest managment, fence protection, the costs levels: supplementary planting including seedling US$150.52 /yr (for designed density 220 plants, supplementary planting rate of 30%), other US$ 87.67.

Assessment

Acceptance/adoption

Benefits/costs according to land user

Benefits compared with costs	Short-term	Long-term
establishment	very positive	very positive
maintenance/recurrent	very positive	moderate

Impacts of the technology

Production and socio-economic benefits

+ + + Wind breaking and sand fixing, protecting farmland and grazing land

+ + Promote rural and grazing area development

Production and socio-economic disadvantages

None

Socio-cultural benefits

+ + Add knowledge of desertification control

Socio-cultural disadvantages

None

Ecological benefits

+ + + Reduce wind speed and reduce wind eroison

+ + Reduce sand and dust storms

+ + Improve ecological environment

Ecological disadvantages

None

Off-site benefits

+ + + Reduce sandy weather days

Off-site disadvantages

None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Notable effect in fixing drifting sand → Enlarge technological application area.	Wind and drifting sand affected the planting survival rate → Install small grids in advance at areas of serious sandy harms.
Reduce wind speed → Also meanwhile add bushes and grass for higher vegetation cover.	Pure poplar forest easily suffer from pests/diseases → After the drifting sand is fixed, plant psammophytes bushes in diversity.
No irrigation → Study the moisture equilibrium, design reasonable afforestation density to prevent premature decline of the established forest.	

Key reference(s)

[1] *Forestry ecological improvement and the operational patterns in China*. Beijing: China Forestry Publication House, 2003

[2] Du Qilin, Xu Shengwang. *Preliminary study report of forestation in Qaidam Gonghe Basin*. Forestry Science and Technology, 2006 (5)

Contact person(s)

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Left: Initial success of the poplar plantation at the sandy land using deep planting technique. Photo by Qi Chengde
Right: Farmers and herdsman dig planting pit for the planting. Photo by Qi Chengde

Deep Planting with Poplar Cutting at High Cold Desert

Gonghe County of Qinghai Province, China

To diminish the wind harm in Gonghe County and Qaidam Basin in Qinghai Province and to increase vegetation coverage in desertified land in favour of protecting farmland and grassland, Dulan County forestry administration carried out poplar deep planting experiment and achieved success over 1993-1996. Qinghai Forestry Bureau managed to propose this technique to State Forestry Administration as a dissemination project acquiring RMB250,000 for technical extension in Guinan County, Gonghe County of Hainan Prefecture and Wulan County and Dulan County of Haixi Prefecture to scale up poplar cutting deep planting forestation technology at drought desertified land.

The dissemination method includes technical training, site meeting, etc. The cost of seedling was covered by the project and other costs covered by county forestry bureaus as per arranged by provincial forestry bureau according to the extended acreage. Farmers were encouraged to participate in the project at the average local labor payment rate (RMB15/work day) and satisfactory result was achieved. After forestation completion, tree survival rate was very high and the farmers by witnessing desert forestation success and the effect of control over dune movement mastered this technology. Later on many local farmers applied this technology in forestation of their courtyard and the contracted work for desertified land control.

This technology has been applied in forestation in Hainan and Haixi Prefectures for 10,700hm^2 accumulatively. After deep plantation, the poplar survival rate reached 90% and psammophilous vegetation came more than 10%, so that dune expansion has been effectively retarded to give a good effect of wind and sand control.

Location: Gonghe county, Qaidam Basin of Qinghai Province
Land use: Forest land, grassland
Climate: Arid, semi-arid
WOCAT database reference: QA
Related technology: Deep Planting of Poplar at High Cold Arid Sandy Land
Compiled by: Qi Chengde, Qinghai Provincial Forestry Bureau
Date: September, 2007

Editors' comments: The deep planting technology of poplar at high cold arid sandy land can raise forestation survival rate without irrigation. It is effective in removing natural harms by increasing vegetation, checking wind and fixing shifting sand. This technology applies to the high and cold sandy land of desert ecosystem.

Problem, objectives and constraints

Problem

- The sand and dust storm in arid areas of western China is a serious land degradation form.
- The shifting dune often buries farmland, grassland and even villages as well as infrastructure facilities such as highway.
- However, due to the lack of effective organization and technical measures and direct economic project benefits, the local participation enthusiasm is low.

Objectives

- Form effective technology extension mechanism.
- Curb dune flow and improve ecological condition.
- Raise community's awareness in ecological protection.
- Raise community's participation level.
- Check wind, fix shifting sand and reduce harms.

Constraints addressed

Major	Specification	Treatment
Economic aspect	Land users short of fund for treating degraded land that isdegraded, without benefit in short period, so the farmers and herdsman are not willing to make investment.	Government offers free seedlings and subsidizes subsidizes labor input.
Minor	**Specification**	**Treatment**
Policy and law	Tending is necessary after the planting including fence installation and formulation of tending and maintenance measures.	Formulate sandy area vegetation protection methods.

Participation and decision making

Target groups


Land user


Design staff


Extensionists

Approach costs met by

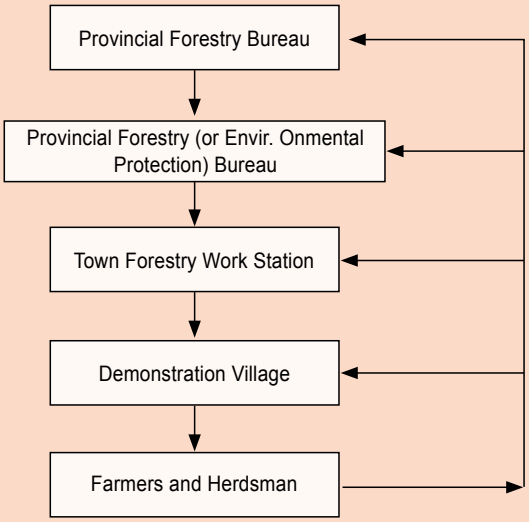
Government	95%
Farmer and herdsman	5%
TOTAL	100%

Decisions on choice of the technology: Proposed by the sand control technician of local forestry department and to be selected by local community.
Decisions on method of implementing the technology: Forestry expert and land users approve the technical route.
Approach designed by: Land users and local technicians of sand control.

Community involvement

Phase	Involvement	Activities
Initiation	Interaction	Demand investigation, training, selection of sandified land treatment method.
Planning	Interaction	Decide work scale, implementation site plot.
Implementation	Active	Offer labor to plant and to install enclosure fence.
Monitoring/evaluation	Self motivated	Inspection check tree survival condition and report to local forestry department.
Research	Passive	Research work mainly undertaken by the county forestry technicians.

Differences in participation of men and women: More male labor in spring and more female labor in summer and autumn.



Organogram

The provincial forestry bureau incorporates the technical extension into project work plan and provide funds based on investigation results. County and township forestry bureaus are responsible for project design and technical supervision. Demonstration villages organize villagers to participate in the project activities. Villagers put forward their demands.

In the course of implementation, the demands of villagers were reported to the upper level forestry administration up to provincial forestry bureau.

Extension and promotion

Training: Training topics include planting pattern design, plot planning. Trainees are township forestry technicians to guarantee good training effect. The training of planting technology and maintenance protection measures are mainly for farmers and herdsmen, and its training effect is moderate. The forms of training include: the township technicians adopt indoor lectures and teaching, the villagers were learning on the spot.

Extension: Through the above methods especially guidance and training on-the-spot, the poplar deep planting technology is introduced to farmers and herdsmen for application at the high and cold arid sandy land plots. For the extension work, the two key technical issues are qualified seedlings and deep planting. Extension is done mainly by township or county forestry stations. Following the implementation, the technical extensionists should have interview with farmers and herdsmen and assess the extension results especially the forest survival rate, and to deal with possible problems.

Research: The technical extension work stations of the provincial forestry bureau and forestry stations of county forestry bureau work together to study the planting patterns and tree species selection etc.

Importance of land use rights: The land owner needs to agree to treat their degraded land.

Incentive mechanism

Labour: Labour is paid, at the standard of RMB15 Yuan/work day.
Inputs: The input include poplar cuttings and vehicles (tractors) which will be provided by the project financing. Planting tools (spades, drill rods) are from villagers.

Credit: No credit is used.

Support of local institutions: The project activity promoted capacity building of local forestry organizations and enhanced governmentfarmer/herdsman relationship.

Long-term impact of incentives: The knowledge of farmers and herdsmen for environment was expanded, and they can get benefit from the project activity of treating degraded land.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Site measurement, indicator: wind speed, rainfall etc. as well as desertification area and expansion speed.
Technical	For tree survival rate, forestation preservation rate, sample spot-checking once a year. Make statistics of survival rate. From the second year after planting, investigate the forest preservation rate.
Socio-cultural	Note down the major local cultural activities.
Economic/production	Record upon visit survey to see whether local land owners' income increase or decrease.
Area treated	Use GPS to measure treated acreage.
No. of land users involved	Note down by tabulation the concerned land users and make statistics.
Management of approach	Establish files and build up working regulations.

Impacts of the approach

Changes as result of monitoring and evaluation: To address the threats of high wind speed, quick desertification expansion, it is necessary to use grass grid or clay sand barrier to fix the sand at begining, and then plant the poplar deeply.

Adoption of the approach by other projects/land users: This technology is used in the easily dersertified area in western Qinghai province.

Sustainability: Through demonstration and continued improvement of species diversity to improve ecosystem stability.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Easy technology for operation → Government provides continued funds and establish incentive mechanism.	The technology has no direct economic benefits and alternative species is limited → Make further experiment and researches.

Key reference(s)

[1] *Forestry ecological improvement and the operational patterns in China*. Beijing: China Forestry Publication House, 2003

[2] Du Qilin, Xu Shengwang. *Preliminary study report of forestation in Qaidam Gonghe Basin*. Forestry Science and Technology, 2006 (5)

Contact person(s)

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Left: Poplar "Two rows in one belt" forestation. Photo by Tian Lü
Right: Large deep trench prepared. Photo by Li Chunying

"Two Rows in One Belt" Forestation Model

Aohan Banner of Inner Mongolia, China

Plantation of two rows of arbor tree (poplar) to form one shelterbelt with grain and grass planted between the two belts, thus to maximize the utilization of light, heat, water and other resources for improved forest and grass growth and production.

The project site is situated in the transitional area from central and northern Aohan Banner to Horqin Desert. The site with fluctuating landform has annual precipitation of 350mm and 2400-2600mm evaporation. Besides, it has 130-140 days of frost-free period. The groundwater level is 10-15m, with no irrigation condition.

At the project site most forest planted previously grew as "small aged trees" owing to over-density and insufficient supply of nutrients, water, light and heat. This has affected not only economic benefit of the trees, but undermined the ecological proficiency.

Major technical steps: (1) Tree (grass) species selection - *Populus simonii* and *P*. × *Simopyramidalis* chon-Lin cv trees, alfalfa and other forage legumes and millet and potato crops are selected. (2) Planting model – trees are planted to form a shelterbelt with two rows at 2m in plant spacing and 4-5m in row spacing, 660 trees/hm^2 in planting density. In between the belts alfalfa and other forage legumes or millet and potato are planted. (3) Site preparation – mechanic ploughing for a depth of 30cm in spring and dig planting holes in 50cmx50cmx50cm. (4) Seedling selection – select seedlings reserved over winter, stem diameter over 3cm, without pest/disease harm and mechanic damage. (5) Planting season – plant trees in May and the plantation should be made immediately after the seedling is delivered to site. (6) Maintenance – water the trees once in late May, June, July and October respectively and conduct pest control twice a year mainly for *Cerambycidae* and *Cicadella viridis*, and prevent animal biting and human damage. Right after plantation is completed, plant alfalfa or crops between the belts in plough seeding at 30cm in row spacing and 15kg of seeds sowed per hectare.

It is estimated that "Two rows in one belt" forestation requires 1000 trees/hm^2 or about RMB2500 Yuan; 15kg of grass seed for RMB150 Yuan, water, fertilizer and pesticide for RMB300 Yuan to total RMB2950 Yuan per hectare (the contractors supply labour by them-selves, thus it is not calculated herein).

Two rows in one belt forestation model has realized fast growth of forest, shrub and grass and increased not only vegetation, but also land utilization. It promotes the increase of local farmers income, so that it is very popular with local residents. This technology is suitable for dissemination in three-north regions.

Location: Aohan Banner, Inner Mongolia
Technology area: 2000km^2
SWC measure: Vegetation
Land use: Forest land
Climate: Semi-arid, semi-humid
WOCAT database reference: QT
Related approach: Forest Edge Effect to Achieve Economic and Ecologic Win-Win
Compiled by: Tian Lü, Inner Mongolia Forestry Survey and Design Institute; Li Chunying, Inner Mongolia Forestry Department
Date: August, 2007

Editors' comments: This technology resolved efficiently the contradiction between forest growth and water-temperature inadequacy in the arid or semi-arid areas of northern China. the technology is featured by rapid growth, shorter harvest cycle, and high integrated forest benefit. For the bush afforestation, applica-tion this planting disposition technology "Two rows in one belt" is done by combining bushes and grasses, which can prevent land degrada-tion, raise land utilization rate, promote farmer and herdsmen income.

Classification

Land use problems

Serious wind erosion and sandification; barren soil; low yield of cropland production and poor economic benefit.

Land use	Climate	Degradation	SWC measure
			
Agroforestry	Sub-humid	Wind erosion	Biologiccal measure

Technical function/impact

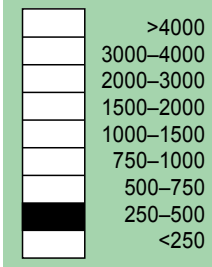
main: - stabilize the sandy land
- alleviate wind erosion
- raise land economic benefit

secondary: - encourage the local farmers to manage the land in scientific way and enrich farmers' technological awareness

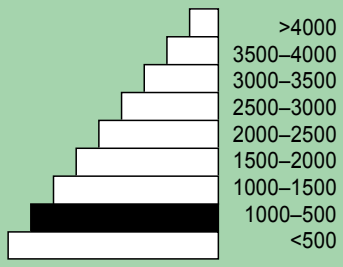
Environment

Natural Environment

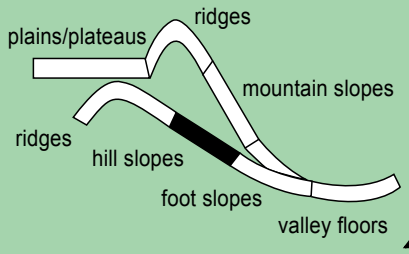
Average annual rainfall (mm)



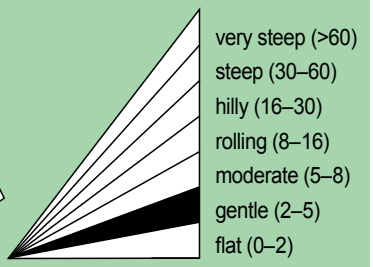
Altitude (m a.s.l.)



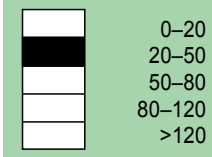
Landform



Slope (%)



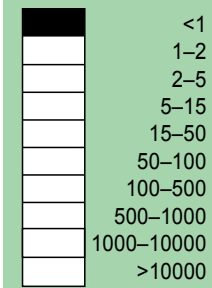
Soil depth (cm)



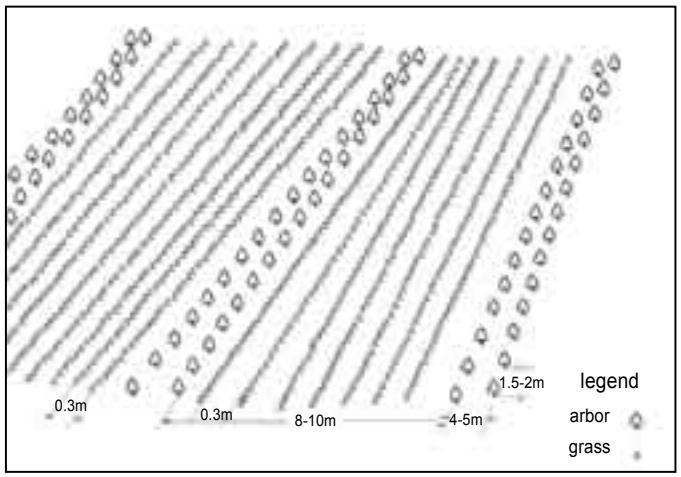
Growing season: 120 days in succession, from May to August
Soil fertility: low
Soil texture: coarse(sandy)/moderate(loamy)/thin(clay)
Surface stoniness: moderate
Topsoil organic matter: moderate (1%-3%)
Soil drainage: moderate
Soil erodibility: high

Human environment

Mixed land per household (hm^2)



Land use rights: collective or individual
Land ownership: state or collective
Market orientation: mixed
Level of technical knowledge required: high to the technical extensionists and moderate to land users
Importance of off-farm income: 10%-50% of total income



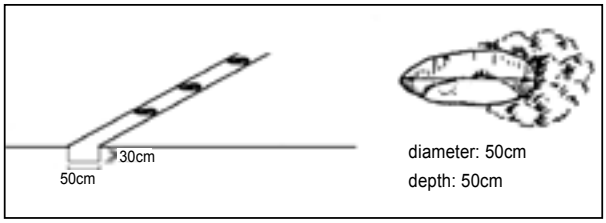
Two rows in plus one belt sandy land forestation

Technical drawing

Use engine-driven plough to prepare line-type deep trench, 30cm deep; In the trench identify points to dig 50cm×50cm×50cm planting holes.

Plant species disposition: 2 lines of arbor tree at row spacing 4-5 m and plant spacing 1.5 -2 m, and belt spacing 8-10 m. The plants distributes in delta form.

Drawing by Guo Huimei



Stip site preparation diagram

Implementation activities, inputs and costs

Establishment activities

1.Site preparation. In spring, use engine-driven plough to prepare line-type deep trench, 30cm deep; In the trench ditch identify points to dig 50cm×50cm×50cm planting holes.
2. Planting. In spring, use current-year grown seedling, or 2-yr old root and 2-yr old stem poplar seedling for planting, Two rows in one belt, 2 metres for plant spacing, 4-5 meters for row spacing, 8-10 metres for belt spacing.
3.Between the belts, carry out agro-forestry intercropping with grain crop or grasses. The grass can be *Medicago sativa, Astragalus adsurgens* etc.

Construction period: 2 years.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
ILabour	73.2	100
Equipment		
- tractor, trench plough, water transport vehicle	18.3	50
Materials		
- seed, tree seedlings	36.6	0
Agricultural		
- fertilizer, water	18.3	0
TOTAL	146.4	56

Maintenance/recurrent activities

1.In the same year of planting, conduct watering to the site in later May, June, July and October respectively, and carry out prevention and control of plant pest/diseases twice a year.
2. In the three years following the initial planting, conduct watering every year at least one time in spring.
3. Arrange special guards for forest patrolling all the year round to prevent damages by human and domestic animal.

Maintenance/recurrent inputs and costs per hm^2 per year

Inputs	Costs (US$)	% met by land user
Labour	54.9	100
Equipment		
- water transport vehicle,hoe	9.1	50
Materials		
- seed, tree seedlings (replanting, resowing)	18.3	0
Agricultural		
- pesticide, water	18.3	0
TOTAL	100.6	59

Remarks: Labor price at US$ 3.7/person day (the average level over the past 5 years); seedling cost includes the replanting or resowing costs during maintainece tending; Exchange rate at the establishment time:US$1=RMB 8.2yuan.

Assessment

Acceptance/adoption

- According to current incentive condition, the most households can accept this technology.
- Without incentives households hold negative attitude to the technology. Those accessible to incentives accepts the technology.

Benefits/costs according to land user

This project integrates forest ecological improvement and cropping economy leading to balanced ecological and economic outcomes, so it is welcome by farmers.

Benefits compared with costs	Short-term	Long-term
establishment	neutral	very positive
maintenance/recurrent	very positive	very positive

Impacts of the technology

Production and socio-economic benefits

+ + +	Produce timber, and agricural crops too
+ +	Change the single (forestry or agriculture) managemnt model into integrated model

Production and socio-economic disadvantages

None

Socio-cultural benefits

+ +	Publicize and demonstrate more resonable land managemtn technology and imporve people's technical qualification.

Socio-cultural disadvantages

None

Ecological benefits

+ +	Stabilize sandy land
+ +	Reduce wind erosion

Ecological disadvantages

–	Vegetation shall consume some water, so has a impact on regional water balance

Off-site benefits

+	Alleviate sand dust storm in a larger area

Off-site disadvantages

None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Follow the "edge effect" of plant growth, so the plant increment is higher → Further study the spacing of different tree species and crops to better use the edge effect.	Arbor tree has negative impact on the growth of agricultural crops → Adopt such measures as root cutting to alleviate the negative impact.
Notable effect in checking wind and fixing the shift sand → Deepen the research and diversify the dispositione	Lack of bush disposition → Adopt arbor tree belt or bush belt based on site condition.
Adopt low density arbor forest disposition, which accords with the local natural characteristics and the near-nature forestry concept → Research further by adding more disposition patterns	

Key reference(s)

[1] Inner Mongolia Forestry Department. "*Two rows in one belt*" *poplar afforestation technical research and extension*. Inner Mongolia forestry science and technology achievements (1995- 2001). 2001. 54-55

[2] Aohan Banner Forestry Bureau. "*Two rows in one belt*" *afforestation technology at dryland*. unpubished data for internal reference. 2004

Contact person(s)

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Left: "Two rows in one belt" distant view. Photo by Li Chunying
Right: "Two rows in one belt" close view. Photo by Ding Rong

Forest Edge Effect to Achieve Economic and Ecologic Win-Win

Aohan Banner of Inner Mongolia, China

Based on summing up experience of previous practices and deepening research, the forest edge effect has been upgraded and utilized. Through dissemination of its application good effect has been achieved and forest economic and ecologic benefits are embodied.

During long time of local forestry development the forest technicians have been seeking a vegetation configuration model, in which water and heat conditions can be fully utilized to continuously increase forest output. In 1985, Inner Mongolia Department of Science and Technology proposed this project. In the following ten years, the Aohan Forestry Bureau created a forestation model "Two rows in one belt". In 1998, the model passed the appraisal and in the following two years won the top prize of technical advancement of the Inner Mongolia Forestry Department, and the third prize of technical advancement by the Inner Mongolia Autonomous Region.

This model began scaling up from 1990 in Three-North Shelterbelt Programme", which was initiated in 1978. It is a large national forestation programme covering vast territory in northeast, north and northwest part of China. In 2001 the programme entered Phase IV, which will last for ten years. The central government invests RMB1500 Yuan per hectare in the project sites. In June 2000, Beijing-Tianjin dust and sandstorm source control programme was launched to cover Horqin Desert and Otindag Desert, subordinating to jurisdiction of Chifeng City. This project has components of forestry, water conservation, livestock and resettlement. Powered by these key national programmes, the "Two rows in one belt" forestation model has won rapid development. At present, this model has been scaled up in about 20,000hm^2 in Aohan Banner and total area using this model in Inner Mongolia accounts for 800,000ha.

Main dissemination method: the banner government takes the lead, township government is responsible for organization and banner forestry bureau is in charge of developing plan and design of the project for consolidated technical implementation. The government has conducted publicity among the farmers to determine project participants according to voluntary principle and to locate the land sites. The banner and township technicians are responsible for training. The farmers sign land use contract and carry out operations to benefit from the project.

"Two rows in one belt" shelterbelt model coincides with the characteristics of local climate, soil condition and natural vegetation distribution. In accordance with forest stand edge effect principle, light and heat conditions are fully utilized to obtain outstanding economic and ecological benefits and the model has been widely recognized by local residents.

Location: Aohan banner, Inner Mongolia
Land use: Forest land
Climate: Semi-arid, semi-humid
WOCAT database reference: QA
Related technology: "Two Rows in One Belt" Forestation Model
Compiled by: Li Chunying, Inner Mongolia Forestry Department; Tian Lü, Inner Mongolia Forestry Survey and Design Institute
Date: August, 2007

Editors' comments: "Two rows in one belt" technology considered both economic and ecological benefits, so this extension was well affirmed by local communities. The technological extension followed the principle of "government offers incentives and households are voluntary in participation", and the effect is very good. Therefore this technology deserves summing up and dissemination.

Problem, objectives and constraints

Problem

- Lack of funds for extension management.
- Households lack relevant technical knowledge.
- The land is barren with long process forgenerating economic benefits.

Objectives

- Increase government support.
- Form effective technical extension mechanism.
- Explore a forest vegetation development pattern, which is compatible with market demand and suits local natural condition, and to realize coordinated ecological and economic development.

Constraints addressed

Major	Specification	Treatment
Economic aspect	The input of this method is higher than normal field cropping, with slightly lower benefit.	Government gives certain economic compensation.
Minor	**Specification**	**Treatment**
Ideological aspect	The change of traditional concept on crop planting is slow.	Reinforce education, especially the ecological knowledge.

Participation and decision making

Target groups


SWC expert


Design staff


Land user


Decision maker

Approach costs met by

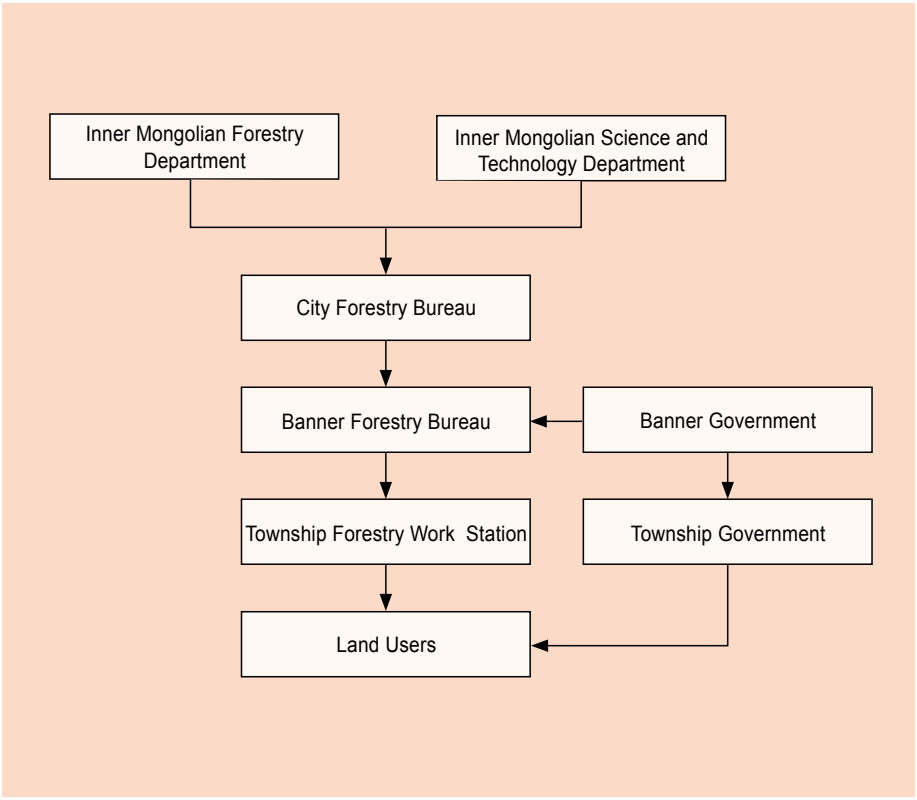
Government	44%
Farmers	56%
TOTAL	100%

Decisions on choice of the technology: Land user.
Decisions on method of implementing the technology: Aohan Banner Forestry Bureau, forestry work station.
Approach designed by: Forestry experts of the banner.

Community involvement

Phase	Involvement	Activities
Initiation	Passive	Local forestry sector and township government organize farmers and of forest farm staff to convene meetings where they can get knowledge about implementing technique and relevant policy.
Planning	Interactive	Local community, farmers and forest farm staff participate in allocating the sites.
Implementation	Active	Farmers and forest farm staff conduct tree planting, maintenance and tending etc.
Monitoring/evaluation	Interactive	Farmers and forest farm staff offer observation data.
Research	No participation	No participation.

Differences in participation of men and women: Stronger labor is needed: male labor 70%, female labor 30%.



Organogram

Project proposal approved by Science and Technology Department while technologial extension undertaken by forestry bureaus.

Extension and promotion

Training: Training is mainly targeted at farmers and technicians of township forestry work stations, with the topics of national forestry policy, site preparation, afforestation method etc., in forms of lecturing, site demonstration etc. The training effect is good.

Extension: Technology extension is the responsibility of banner forestry bureau, and implemented specifically by township forestry work stations. The technicians have contracts with households for the extension work. Their key work task includes selection of tree and grass species, quality appraisal, specifications of site preparation, planting technology etc.

Research: Research work is undertaken by city and banner forestry technicians, and farmers, the staff of forestry farms do not participate.

Importance of land use rights: Farmers and forest farm staff implement the project on their own land (land use right), so land tenure has no impact on technology extension.

Incentive mechanism

Labour: The implementation of this project adopts the form of individual contracting, so the labor force provision is usually resolved by households themselves.

Inputs: Seed and seedlings are offered free of charge by government while the tools such as tractor, plough and hoe are provided by the contractors.

Credit: Government offers to every household a micro loan of RMB 3000-5000 Yuan.

Support of local institutions: Technical application strengthened the level of local forestry project management, also increased recognition of community and farmers for forestry administration.

Long-term impact of incentives: Project incentive mechanism will guarantee long-term adoption of technology, but once the mechanism is weakened or stopped, negative effect will appear and even the technology application be terminated.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Check the precipitation level from nearby meteorology station, and sampling the soil for testing of water content and organic matter content.
Technical	According to standards, inspect and check site preparation, planting density; make statistics to the ratio between the survived quantity and planted quantity.
Socio-cultural	Questionnaire or telephone to inquire the local people's attitude to this project.
Economic/production	Weigh crop production and compare with production of similar land.
Area treated	Site measure of treated area.
No. of land users involved	Conduct statistics of and analyze land user quantity, their cultural level and income etc.
Management of approach	City and autonomous region forestry managers investigate on-the-spot the management status of the project.

Impacts of the approach

Changes as result of monitoring and evaluation: At the beginning the government had plenty of publicity activities in order to persuade and mobilize people. With the development of project and the accumulated benefits, the land users became active to accept technology.

Improved soil and water management: The sand dust storm in the project area has been obviously reduced compared with that before project, level of management is improved significantly, and tree/crop growth is obviously increased.

Adoption of the approach by other projects/land users: This method has now been adopted in most banners or counties (70%) of the whole autonomous region, especially in the implementation of the key national forestry ecological programmes such as the programme on conversion of farmland to forest/grass, and the Beijing-Tianjin Dust and Sandstorms source control programme etc.

Sustainability: Because of the good economic benefits, the technology can be adopted continuously without long term support. However, without incentives or project support, enthusiasm of farmers in using the technology may drop apparently.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Government support plus farmers willingness to participate are helpful to mobilize farmers' initiative to extend the technology → To further improve the extension mechanism.	Training mechanism needs improvement → Government increases its financial support to forestry training.
Economic benefits are obvious, so it is welcome by farmers → Further coordinate the relations of different aspects.	
Helpful for rural industrial restructure → Make planning as earlier as possible regarding the technology-related industrial development.	

Key reference(s)

[1] Inner Mongolia Forestry Department. "*Two rows in one belt*" *poplar afforestation technical research and extension*. Inner Mongolia forestry science and technology achievements (1995- 2001). 2001. 54-55

[2] Aohan Banner Forestry Bureau. "*Two rows in one belt*" *afforestation technology at dryland*. unpubished data for internal reference. 2004

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Left: Walnut – wheat intercropping in Hetan County, Xinjiang. Photo by Zhu Yuwei
Right: Farmers grafting walnut at the cotton filed in Hetan County, Xinjiang. Photo by Zhu Yuwei

Walnut and Crop Interplanting on Oasis

Hetan County of Xinjiang, China

Plantation of walnut (*Juglans regia*) is established on densely populated oasis along the irrigation canals or in high density, based on agro-forestry pattern.

The demonstration zone is located in Hetan County of the southern part of Tarim Basin and adjacent to Taklimakan Desert. The site is featured by drought climate of warm temperate zone, 50mm annual precipitation and severe ecological conditions. The land degradation is expressed by wind erosion, sandification and soil secondary salinization. The land productivity is decreasing. The per-capita farmland is 0.1hm^2. At the low-yield farmland walnut-crop intercropping pattern can effectively reduce wind erosion and sand harms, increase efficiency of land, water, fertilizer and sunlight, thus resulting in increased production value and farmers income.

Main technical measures of this model are: (1) two types of configuration: (i) sublateral canal type: under this type it is necessary to change sublateral canal to a permanent canal. A row of walnut trees is planted on the sublateral canal with density of 70 trees/hm^2; (ii)dense planting type: under this type walnut trees are planted in a patch form with density of 500/ha. (2) select high quality planting stock and properly arrange pollination trees. The walnut trees are planted in a row along the sublateral. (3) establish cutting nursery for superior genetic quality have this done according to the need of the planned planting area; (4) select vigorous seedlings for plantation with the specifications: 1.2m high, 1.5cm or over in diameter, 30cm in rooting range, two years old; (5) forestation – tree planting can be done in spring or autumn. Open ditches and dig holes to plant the tree with application of 1kg fermented humus manure for each hole; (6) grafting – conduct scion or bud grafting in the second spring or summer after the planting; and (7) tree and soil management – trimming, watering and fertilizer management. Limited fruiting may start from the second year after grafting and in the 3rd year the production per tree may reach 150-200g.

Hetan has a long history of walnut cultivation. Owing to limited adoption of high quality genetic varieties in mid 1990s, the production was poor. In addition, walnut tree were tall with large canopy that has negative impact on the surrounding crop growth, so that farmers were not active toward it. With introduced better varieties, walnut farmers have benefited from increased income. The government supplied free walnut seedlings and farmers as contractors of the land provide labour, fertilizer and expense incurred in graft operation. Since 2000, walnut has been planted in immense scale in Hetan, Moyu and Luopu counties and now as one major income source of local residents.

Note: "Zha 343", "Xinfeng", "Wen 185", "Xinxin 2" are the codes for superior walnut cultivars, "Zha" stands for Zhamutai in Wensu County, "Xinfeng" means big harvest, "Wen" is the abbreviation for Wensu County. The figures 343, 185 and 2 are the codes used in the experiment.

Location: Hetan County located at the southern edge of the Tarim Basin, Xinjiang
Technology area: 200km^2
SWC measure: Vegetation
Land use: Cropland, orchard
Climate: Extremely arid
WOCAT database reference: QT
Related approach: Walnut and Intercropping Farming
Compiled by: Liu Kang, Liu Yuhua, Chen Qimin, zhu Yuwei, Tai Yuren, Li Tipu, Xinjiang Branch of Chinese Academy of Forestry
Date: September, 2007

Editors' comments: The technology is applied at arid oasis area of temperate zone. It can restrain field wind erosion, land desertification and declined land productivity. It can raise utilization rate of agricultural natural resources, increase unit area output value and farmer's income. Now this intercropping pattern has been adopted in Hetan, Kashi, Akesu in Xinjiang in large scale.

Classification

Land use problems

Rich sand materials and sparse vegetation. Wind erosion with expanding desertification; Soil alklinization, dry hot wind disasters happen frequently reducing crop production.

Land use | **Climate** | **Degradation** | **SWC measure**

Agroforestry | Cash forest | Extremely arid | Wind erosion | Vegetation degradation | Management measure

Technical function/impact

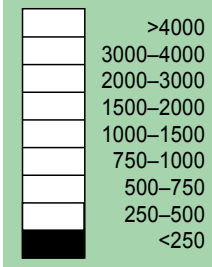
main: - reduce wind speed
- prevent wind erosion
- reduce cropland underground water table
- add ground surface coverage
- reduce soil surface evaporation and plough layer salt accumulation

secondary: - reduce sand sources
- add soil organic matter content

Environment

Natural Environment

Average annual rainfall (mm)



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750–1000
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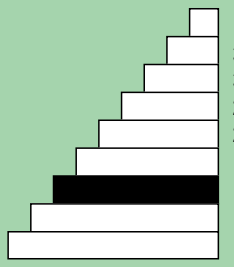
250–500
<250

Altitude (m a.s.l.)



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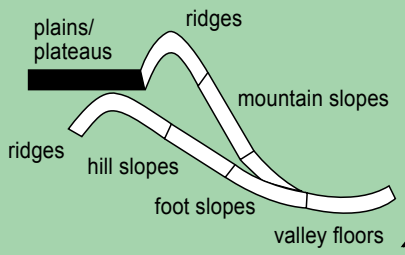
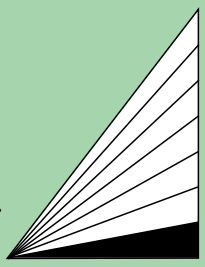
Landform

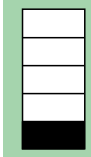


Slope (%)



very steep (>60)
steep (30–60)
hilly (16–30)
rolling (8–16)
moderate (5–8)
gentle (2–5)
flat (0–2)

Soil depth (cm)



0–20
20–50
50–80
80–120
>120

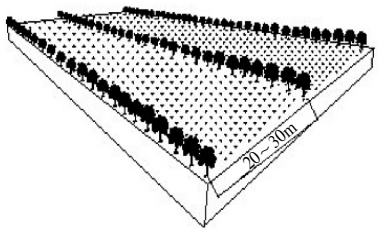
Growing season: 210 days in succession , form March to October
Soil fertility: moderate
Soil texture: moderate (fine sand, loamy)
Surface stoniness: none
Topsoil organic matter: moderate (1%-3%)
Soil drainage: high or moderate
Soil erodibility: very high

Human environment

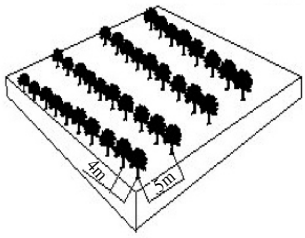
Mixed land per household (hm^2)

<1
1–2
2–5
5–15
15–50
50–100
100–500
500–1000
1000–10000
>10000

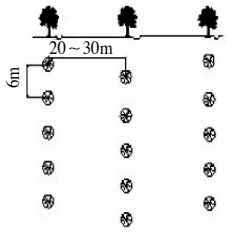
Land use rights: state, collective or individual
Land ownership: state
Market orientation: mixed
Level of technical knowledge required: high to the technical extensionists and moderate to land user
Importance of off-farm income: <10% of the total income



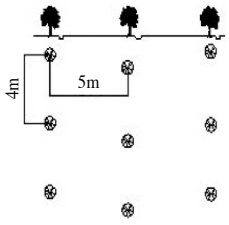
Drawing 1 Field irrigaiton canal intercropping model of *Jugians Regia*



Drawing 3 Dense planting intercropping model of *Jugians Regia*



Drawing 2 Field irrigaiton canal intercropping model of *Jugians Regia*



Drawing 4 Dense planting intercropping model of *Jugians Regia*

Technical drawing

Drawing 1: The sublateral canal intercropping pattern sketch

plant walnut with the crops in the forest belts and along the 20-30m long subleteral canal

Drawing 2: The sublateral canal intercropping pattern disposition

Depending on the walnut varieties, the plant spacing is usually 6m

Drawing 3: The dense planting intercropping sketch

Drawing 4: The dense planting intercropping disposition

The planting spacing is 4m×5m.

Drawing by Chen Qimin

Implementation activities, inputs and costs

Establishment activities

1. Forestation. In spring or autumn, do site preparation and dig ditches and pits for planting. The specifications of the ditch: ditch lower base 1m wide, 0.8m wide upper base, 0.4 m for ditch depth; along the ditch sides build low bank about 0.3m higher than farmland; the dug planting pit 50cm×50cm×50cm; Before planting, use farmyard manure 1kg as base fertilizer and irrigate immediately after planting, repeat the watering 10-20 days later.
2.Grafting. In spring and summer following the planting year, carry out scion or bud grafting.

Establishment time: 2 years.

Establishment inputs and costs per hm²

Inputs	Costs (US$) canal	Costs (US$) dense	% met by land user
Labour	6	40	100%
Equipment			
Vehicles	10	50	0%
Materials			
- seedlings (grafting included)	70	500	15%
Agricultural			
TOTAL	86	590	19%

Maintenance/recurrent activities

1. tree forming, pruning etc.
2. irrigation and fertilization.
3. pest and disease control.

Maintenance/recurrent inputs and costs per hm² per year

Inputs	Costs (US$) canal	Costs (US$) dense	% met by land user
Labour	40	200	100%
Equipment			
Materials			
- fertilizer and pest/ disease control	80	400	100%
Agricultural			
TOTAL	120	600	100%

Remarks: Labour cost at US$ 4 /person day, seedling grafting included at US$ 1 /plant, irrigation is done with the crops so the costs not included.

Assessment

Acceptance/adoption

- Within the planned by forestry bureau walnut-crop inter-planting project area all households accept the technology, either actively or after government guidance.
- Most household adopt the technology through project support, some other households make investment by themselves to carry out walnut-crop interplanting.
- Government takes the responsibility of technological extension. The forestry bureaus and staff are responsible for technical training and supervision, through convening site meetings, establishing demonstration plots as well as enacting incentive measures. The incentive measures are free supply of walnut seedlings, training and technical service by state government and county forestry bureau.
- With walnut prices stable or rising, the technology can be adopted continuously, household accepts this technology because of good economic profit.

Benefits/costs according to land user

Benefits compared with costs	Short-term	Long-term
Establishment	positive	very positive
maintenance/recurrent	positive	very positive

Impacts of the technology

Production and socio-economic benefits

+ + +	Improve land productivity
+ + +	Improve unit area production value and add farmer's income
+ +	Promote rural community development

Production and socio-economic disadvantages

–	After the canopy of walnut trees with patch pattern is closed, the crop growth is limited, thus leading to reduce crop production area

Socio-cultural benefits

+ +	Enhance farmers' awareness on protecting environment and planting cash tree

Socio-cultural disadvantages

None

Ecological benefits

+ + +	Prevent cropland sandification
+ + +	Curb cropland salinization
+	Reduce wind speed
+	Add vegetation cover

Ecological disadvantages

None

Off-site benefits

+ + +	Reduce sand sources

Off-site disadvantages

None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Water and nutrient utilization rate is high → Precise irrigation and prescribed fertilization.	Trees shade and roots development affect growth and the output of crops → Walnut plantation at suitable density.
Utilization rate of solar energy is high, leading to high unit area output value →Adopt superior species and conduct pruning reasonably.	
Control of harm caused by sand dust storms → Integration with farmland shelter protection forest.	

Key reference(s)

[1] Liu Kang, Liu Yuhua etc. Study of the development options of ecological-economic shelter protection forest system in Xinjiang. Shelter Protection Forest Science and Technology, December 1992 (the establishment edition) .
[2] Liu Yu Hua, Wen Hua et al. Agroforestry and its major cultivation patterns, Xinjiang Forestry Science And Technology, 1996(1).

Contact person(s)

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Left: Technical training to farmers on walnut tree pruning. Photo by Chen Qimin
Right: Walnut collection by farmers. Photo by Zhu Yuwei.

Walnut and Intercropping Farming

Hetan County of Xinjiang, China

Under government guidance, forestry administration supplies walnut seedlings at free-of-charge basis and technical training to farmers is conducted on intercropping technique.

The purpose is to increase farmland vegetation coverage, reduce wind speed, control farmland wind erosion and soil degradation. The technology will meanwhile increase oasis area, utilization of water, fertilizer and light and other natural resources, increase unit area production and the income to farmers. Through effective organization and management and training programs conducted, farmer's technical quality and ecological construction participation enthusiasm are increased.

Hetan is of extreme dry climate, abundant sand sources, frequent windy days and severe natural ecological condition. If farmland has low and medium yield, walnut with intercropping is an effective approach to curb land degradation. Under assistance of invited experts and technicians some walnut and intercropping demonstration plots are set up. The technology scales up to broader locations. During project implementation, county forestry bureau is responsible for implementing planning, which will be approved by prefecture forestry bureau. The bureau will conduct village-based training to local technicians and farmers for implementation. The staff of county forestry bureau is responsible for supervision and inspection in contracted villages. Their work is a key indicator of staff annual performance. The farmers as land contractors are responsible for labour inputs, as well as cost of fertilizer, planting, partial/complete grafting, and tending operations. Technical dissemination networks are built at prefecture, county, township and village levels including prefecture forest technical extension station, county forestry bureau or the extension station, township forestry station, and skilled villagers. Technical teams at various levels are also established to make decision, review project plans and formulate acceptance standards.

Project implementation includes the following stages: (1) pilot plot planning for forestation; (2) signing contract with farmers for planting, maintenance, and clarifying forestation density, configuration type, survival rate and young tree tending requirement and acceptance criteria; (3) technical training – the key point in the training encompasses seedling standard, good seedling selection and pollination method, grafting and tending management; (4) forestation and tending under technical guidance. During forestation season and other production seasons, professional technicians will conduct training and (5) acceptance: the graft survival rate is set at 90%. To encourage farmer playing an active role in walnut intercropping operation, incentive measures should be taken through seedling, training and pest/disease control services, to be provided to them at free-of-charge basis and graft subsidies to be granted to encourage them to better implement the project.

Location: Hetan County located at the southern edge of the Tarim River Basin, Xinjiang
Land use: Cropland, orchard
Climate: Extremely arid
WOCAT database reference: QA
Related technology: Walnut and Crop Interplanting On Oasis
Compiled by: Liu Kang, Liu Yuhua, Chen Qimin, Zhu Yuwei, Tai Yuren, Li Tipu, Xinjiang Branch of Chinese Academy of Forestry
Date: September, 2007

Editors' comments: Walnut intercropping can raise land productivity and increase income of the framers. This technology can be applied at oasis of temperate zone in the world. In China it has been popularized in Hetan, Kashi, Aksu of Xinjiang, playing important role in promoting rural socio-economic development.

Problem, objectives and constraints

Problem

- Lack of effective organization, and community participation level is low.
- Lack of funds.
- Community in lack of walnut intercropping technical knowledge.
- Land management level is low.
- Cropland wind erosion and sandification: in winter and spring the cropland is exposed to strong wind, and the farmland is eroded and sandified.
- Secondary salinization of farmland. The high temperature and strong sunshine in summer lead to vigorous evaporation, bringing salt to the soil surface.
- Land productivity decline. This is due to wind erosion and sandification, and soil salinization.

Objectives

- Form effective extension mechanism.
- Raise the community capability in ecological protection and integrated development.
- Raise community participation level.
- Curb cropland wind erosion and sandification.
- Alleviate farmland salinization.
- Raise per unit area yield and increase farmer income.

Constraints addressed

Major	Specification	Treatment
Economic aspect	The old arid oases are densely populated and the per capita cropland land is limited. The farmers live on the cropland with low income level. They have weak capability to make cash input to mainte nance project.	Vigorously reinforce governmental financial support and public dona-tion to farmers.
Minor	**Specification**	**Treatment**
Technical aspesct	The educational level of the farmers is generally low and their technical knowledge about forest intercropping is limited.	Reinforce technological training and guidance.

Participation and decision making

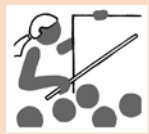
Target groups


Deciison maker


Planner


SWC expert


Land user


Teacher and student

Approach costs met by

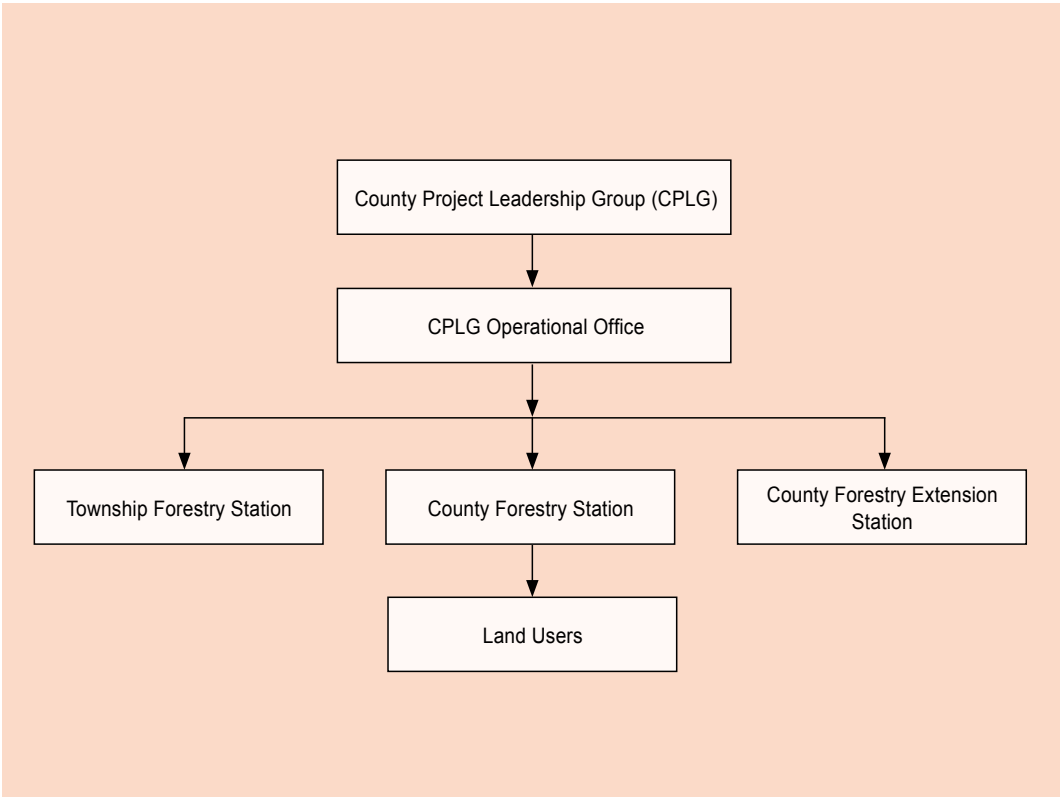
State	66%
The local public	10%
Local government	5%
Land user(farmer)	19%
TOTAL	100%

Decisions on choice of the technology: Hetan prefecture government.
Decisions on method of implementing the technology: Hetan county government.
Approach designed by: Jointly by the forestry experts of the autonomous region, prefecture and the county.

Community involvement

Phase	Involvement	Activities
Initiation	Active	Some farmers participate in seedling cultivation.
Planning	Active	Community and farmers put forward suggestions for planning.
Implementation	Active	Farmers accept technical training, conduct planting and tending, irrigation and fertilization conducted in unified manner by the village communities.
Monitoring/evaluation	Active	Communities and farmers offer collabouration.
Research	Active	Community farmers offer collabourative support to researchers.

Differences in participation of men and women: Equal in the participation.



Organogram

Set up the county project leadership group (CPLG)with the responsible deputy county chief as the group leader, and CPLG office in the county forestry bureau for organizing forestry related organization staff for project implementation.

Extension and promotion

Training: Key training topics are selection of superior species, pollination arrangement, grafting and graft tending management. The forms include on-the-spot explanations and demonstrations. It is found that the training effect has positive correlation with education level. The training effect to the middle aged men is good, moderate to the old and poor effect to women.

Extension: Prefecture forestry bureau organize to establish demonstration plots integrating planning, growing seedlings, forestation, grafting, and forest intercropping. The established extension network covers county forestry bureau (station), township forestry work station and village technical experts with defined work responsibilities. The extension effect is good when good genetic quality of walnut is introduced. It is suggested that technical training to individual households be improved.

Research: Since 1990s, the Chinese academy of Forestry Science Xinjiang branch and Xinjiang Agriculture University have kept walnut intercropping research, mainly on (1) selection of walnut superior species for intercropping and pollination tree arrangement; (2) high yielding walnut intercropping technology; (3) ecological benefit of walnut-intercropping. These researches have provided technical support to field production in southern Xinjiang.

Importance of land use rights: The land tenure has impact on technical extension. The land area contracted by households is less than 1 ha per household, too small for intensive management.

Incentives

Labour: Labour mainly provided by the farmers that contract the land, with exception of some individual farmers with difficulties so that the community or government mobilizes compulsory labour to help.

Inputs: County forestry bureau using national finances to provide free of charge walnut seedlings to households, to subsidize the grafting cost, and to carry out free of charge technical service of plant pest/diseases control; the farmers that contract the land devote labour and provide fertilizer and responsible for tending management.

Credit: No bank loan is available for the project in general.

Support of local institutions: The funds for capacity building of county forestry bureau are very limited, so the project offered little support to local organizations except in raising the qualification of the local forestry bureau technicians.

Long-term impact of incentives: Ecological condition of Farmland is improved, farmers income increased, and the technology promoted rural socio-economic development. The technology can generate both ecological and economic benefits, so even without incentive measures, farmers will adopt the technology.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Site measure wind speed and soil erosion intensity in the field.
Technical	Forestation survival rate, by site survey.
Socio-cultural	Social stability.
Economic/production	Per plant production, per unit area production value.
Area treated	Soil wind erosion, land secondary salinization.
No. of land users involved	Quantity of households that adopt the technology, by surveys.
Management of approach	The sustainability of the technology.

Impacts of the approach

Changes as result of monitoring and evaluation: This is an old technology adopted by framers to improve the farmland ecological and economic outputs, but not done for scale benefit. The governments called for forest- intercropping in 1990, but it was not very attractive to farmers due to the low single plant production and the forest threatens crop growth. The technology developed in this century raised the economic benefits for the use of improved walnut planting stock, so farmers are willing to adopt this technique.

Improved soil and water management: Irrigation or fertilization shall serve both the crop and the tree for higher operational efficiency improving physical and chemical properties of the soil.

Adoption of the approach by other projects/land users: It has now been widely extended in Hetan, Kashi, Akesu of Xinjiang.

Sustainability: One walnut tree after entering peak fruiting season can produce 30 kg of walnut for very good income. Land users use this technology continuously even without long term incentives.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Both ecological and economic benefits are good → Reinforce walnut genetic management by popularizing superior seeds.	Difficulty in tending management → Reinforce technical training.
Effective extension mechanism → Further enhance the capability of the technical extensionists.	The conflict between walnut and crop can be too big to eliminate → Conduct technological studies to tackle key problems.

Key reference(s)

[1] Liu Kang, Liu Yuhua etc. Study of the development options of ecological-economic shelter protection forest system in Xinjiang. Shelter Protection Forest Science and Technology, December 1992 (the establishment edition) .

[2] Liu Yu Hua, Wen Hua et al. Agroforestry and its major cultivation patterns, Xinjiang Forestry Science And Technology, 1996(1).

Contact person(s)

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Left: Oasissheterbelt network in Xinjiang. Photo by Liu Bin
Right: Integrrated oasis farmland shelterbelt and road development in Bageqi township, Hetan County of Xinjiang. Photo by Liu Yuhua

Oasis Shelterbelt Network with Narrow-belt and Small-grid

Hetan County of Xinjiang, China

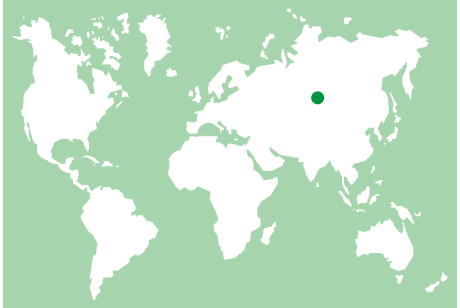
The farmland shelterbelt network is established along ditches and roads in areas with serious sand storm harms.

Hetan County is located in the southern brink of Tarim Basin (Taklimakan Desert), the hinterland of Eurasia and in warm temperate zone with extremely dry climatic. The area of this county is of 40,900km^2, and 95% is mountainous areas, 1.3% is plain oasis, 3.7% of desert. Sand and wind harm is quite severe. Per-capita arable land is merely 0.1hm^2 at this oasis. Soil degradation is expressed in the form of wind erosion, sandification and secondary soil salinization, therefore, the land productivity is extremely low.

Establishment of shelterbelt network is aimed to increase vegetation coverage, reduce wind/sand harms, maintain oases stability, ensure crops stable/high yield, and to meet the demand for timber and firewood by local residents.

Major technical measures under this model include: (1) Shelterbelt layout – configure main belt and ancillary belt perpendicular and parallel to the prevailing wind direction respectively. The spacing for main belt is 200-250m and ancillary belt is 400-600m. In case if the main belt is hard to set in perpendicular to wind direction, then its angle to the prevailing wind shall not be less than 45^o. (2) Seedling requirements: 2 years old, 2.5-3m high,1.5cm collar diameter, vigorous cuttings of *Populus alba* var. *pyramidalis* are adopted; (3) Site preparation and planting: in the same year when the site is prepared, stumping is conducted by wrapping the wounds with film; (4) Irrigation: initial watering should be made immediately after planting, followed by second watering, irrigation intensity at 7500m^3/hm^2 per year; (5) Young growth tending: the pruning height shall not exceed one third of stem height for the first three years. Wheat, vegetables, melons may be intercropped or soil loosening/weeding once or twice a year to increase soil water conservancy and reduce waste of water resource; (6) Pest/disease control: biological and chemical integrated control measures; and (7) thinning and regeneration: conduct thinning by every other plant for every 4 – 5 years, rotation cutting at the time of 15 – 20 years olds.

Hetan County started establishment of farmland shelterbelt network in 1978 and completed in 1986 with more than 3000hm^2 of forest planted at a cost of US$1600/hm^2 and the maintenance expense of US$90/hm^2. The cost was covered mainly by the investment of the Three-North Shelterbelt Programme. The maintenance is mainly financed by the farmers who have contracted the project. With the forest network, the field wind speed is reduced by 25%-47% to prevent crops from being harmed by sandstorm. The per-unit crop yield has increased by 20%-30% and over 50% in the naturally unfavorable years. In the meanwhile, forest inventory has indicated that annual increment of standing volume is of 15m^3/hm^2 with annual revenue of US$1500. The improved environment has laid solid foundation for alleviation poverty and peace and contentment life.



Location: Hetan County located at the southern edge of Tarim Basin, Xinjiang
Technology area: Technical demonstration project area 289km^2(forestation area 30km^2)
Climate: Extremely arid
SWC measure: Vegetation
Land use: Farmlamd, orchard
WOCAT database reference: QT
Related approach: Farmland Shelterbelt Network on Oasis
Compiled by: Liu Kang, Liu Yuhua, Chen Qimin, Zhu Yuwei, Tai Yuren, Li Tipu, Xinjiang Branch of Chinese Academy of Forestry
Date: September, 2007

Editors' comments: Xinjiang is largest arid area of China, with oasis area taking 4.2% of its territory area. Most of the oases in Xinjiang are separated apart by or surrounded by desert or Gobi desert, with very harsh ecological conditions. Farmland shelterbelt network as one component of the infrastructure construction for the arid oasis farmland is the environmental foundation to improve oasis ecological conditions and maintain oasis ecological balance.

Classification

Land use problems

Wind erosion, desert expansion;soil salinization, low vegetation cover; low yield of crop production

Land use | **Climate** | **Degradation** | **SWC measure**

Annual crops | Agro-forestry | Cash forest | Extremely arid | Wind erosion | Vegetation degradation | Vegetation measure

Technical function/impact

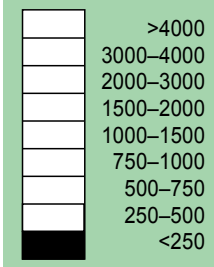
main: - reduce wind speed
- curb wind erosion
- improve farmland micro climate
- tree transpiration lowers field ground water table, reduce salt accumulation at the plough horizon

secondary: - reduce sand dust storm
- regulate local climate

Environment

Natural Environment

Average annual rainfall (mm)



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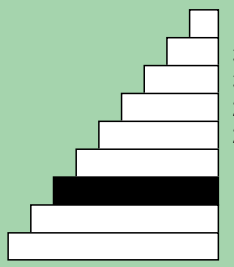
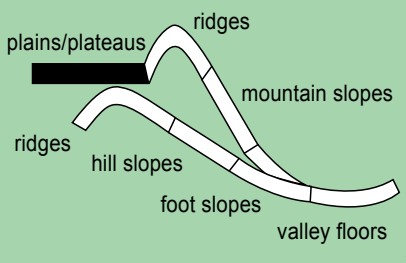
750–1000
500–750
250–500
<250

Altitude (m a.s.l.)

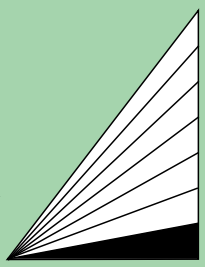


>4000
3500–4000
3000–3500
2500–3000
2000–2500
1500–2000
1000–1500
1000–500
<500

Landform

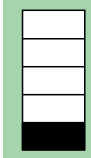


Slope (%)



very steep (>60)
steep (30–60)
hilly (16–30)
rolling (8–16)
moderate (5–8)
gentle (2–5)
flat (0–2)

Soil depth (cm)



0–20
20–50
50–80
80–120
>120

Growing season: 210 days in succession, from march to October
Soil fertility: moderate
Soil texture: moderate (fine sand, loamy)
Surface stoniness: none
Topsoil organic matter: moderate(1%-3%)
Soil drainage: moderate or high
Soil erodibility: very high

Human environment

Mixed land per household (hm^2)

<1
1–2
2–5
5–15
15–50
50–100
100–500
500–1000
1000–10000
>10000

Land use rights: state, collective or individual
Land ownership: state
Market orientation: mixed
Level of technical knowledge required: moderate to technical extensionists and land users
Importance of off-farm income: less than 10% of the total income

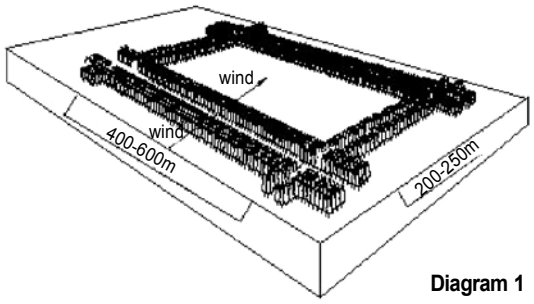


Diagram 1

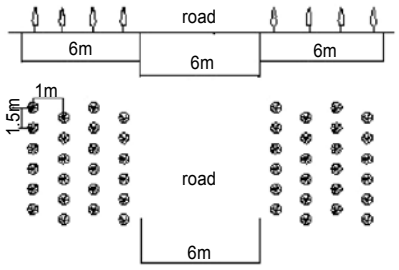


Diagram 2

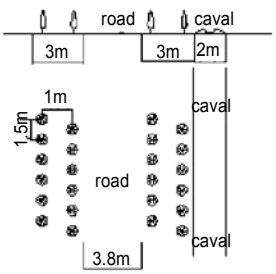


Diagram 3

Technical drawing

Diagram 1: General planting pattern
The main forest belt and auxiliary forest belt are perpendicular to and parallel with the prevailing wind direction, main forest belt spacing 200-250m,auxiliary forest belt spacing 400-600m.

Diagram 2: Main forest belt disposition
forest belt(4 rows)+ road (6m)+ forest belt(4 rows), spacing at1×1.5m

Diagram 3: Auxiliary forest belt disposition
Forest belt (2 rows)+ road (3.8m)+ forest belt (2 rows)+ irrigation channel (above the ground), spacing1m×1.5m.

Drawings by Chen Qimin

Implementation activities, inputs and costs

Establishment activities

1. Planning design. Forest belt, channel, road and field road are integrated, disposed with main forest belt and auxiliary forest belt.
2. Species selection. *Populus alba* cv.*Pyramidalis*, and *Populus alba*, hybrid poplar, *Elaeagnus angustifolia* etc..
3. Seedling preparation. Adopt vigorous cutting seedling 2.5 - 3m high, 2 years old, collar diameter more than 1.5 cm.
4. Site preparation: level the forestation bed, open ditches with low bank.
5. Planting. Dig planting pit for planting, cut the stem after forestation to 1.5-1.8m, wrapping the wounds with plastic film.
6. Irrigation. After forestation, do immediate watering and repeat the watering right afterwards.

Before planting, use bulldozer for site preparation, and build irrigation channel and road working 24 hours a day. One day before planting, seedlings should be delivered at site for bedding in earth. Machinery can be borrowed or rent to reduce cost (project implementation consumes only limited diesel and petrol).
Establishment of the project usually takes 2-3 years for completion.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
Labour	240	0%
Equipment		
- bulldozer, trucks, spade	260	0%
Materials		
- seedlings	800	0%
Agricultural		
- channel and road building	30	0%
TOTAL	1600	0%

Maintenance/recurrent activities

1.Irrigation: 5 times a year, at the quota of $7500m^3/hm^2 \cdot a$.
2. Young forest tending. The pruning height of the young forest at 1-3 years old, do not exceed the 1/3 of the tree height; The intercropped wheat, vegetable or melons should be weeded by loosening the soil every year for 1-2 times to preserve soil moisture retention and reduce the water resource waste.
3. Prevention and control of diseases, pests such as mice: adopt integrated biological, chemical measures.
4. Forest thinning and clear felling for regeneration: conduct thinning (cut onetree for every two trees) when 4-5 years old, and clear felling for next rotation planting when 15-20 years old.
No energy and large machineries are used, so this technical pattern can be operated in long term.

Maintenance/recurrent inputs and costs per hm^2 per year

Inputs	Costs (US$)	% met by land user
Labour	60	100%
Equipment		
Materials		
- water fee; pest/disease control	30	33.3%
Agricultural		
TOTAL	90	77.8%

Remarks: Establishment activities contain labor for forestation of 60person day per ha (for planting and site preparation, US$4 /person day); equipment cost (bulldozer 24h, US$7.5/h; trucks 0.5d, US$70 /day; spade depreciation US$10); seedlings (8000 pieces, replanting at 20%, seedling of *Populus alba* cv. *Pyramidalis*, and *Populus alba* US$0.1/plant); facilities of channel and roadUS$30 .
Maintenance/recurrent activities: It contains Labor for tending maintaianece 15 person days for each hm^2. (US$4/person day); water fee US$10 (for government subsidized ecological water, US$0.0013 $/m^3$); and pest/disease control fee US$20.

Assessment

Acceptance/adoption

- All households accept this technology either actively or with the guidance of the government.
- Most households access this technology through project support; some households invest on their own funds to adopt the technology for afforestation.
- Government takes the responsibility for disseminating the technology. The forestry department is responsible for organizing technical training and for supervision, through convening site meetings, establishing demonstration plots as well as taking incentive measures. Incentive measures mean that the completed forestation project invested by the state, local government for the public benefit, is contracted free of charge to the households for management and profit making.
- In the future this technology will be continuously adopted. The farmer households accept the technology because they tangibly experienced the importance of ecological benefits and because of the direct and indirect profits from the technology application.

Benefits/costs according to land user	Benefits compared with costs	Short-term	Long-term
	establishment	positive	very positive
	maintenance/recurrent	positive	very positive

Impacts of the technology

Production and socio-economic benefits

+ + +	Improve per-unit production of the cropland
+ + +	Produce timber and add farmer income
+ +	Form good production and living environment

Production and socio-economic disadvantages

–	Have negative impact on neighboring crop

Socio-cultural benefits

+ + +	Activate the local people's environmental awareness to form good atmosphere of environmental protection

Socio-cultural disadvantages

	None

Ecological benefits

+ + +	Reduce wind speed and control wind erosion
+	Curb cropland alkilization
+	Add vegetation cover
+	Improve farmlamd micro cliamte and the land productivity

Ecological disadvantages

– –	Tree consumes water thus affect regional water balance
– –	Artificial ecosystem contains less species, food chain is simple, therefore is vulnerable to harmful species invasion
– –	It is biologically unstable because of pure forest

Off-site benefits

+ + +	Combat sand dust storm and improve ecological environment

Off-site disadvantages

	None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Reduce wind speed and control wind erosion and sand dust → Optimization of the design to improve protection role in winter	Too much pure forest → Establish mixed forest
Improvement of production environment and crop output → Reinforced maintenance and continuous technological extension	Negative impact of forest on crops → Root cutting and plant shade tolerant crops at the affected area.
Production of timber and firewood for better livelihood → Improvement of forest belt tending management level	

Key reference(s)

[1] Ci Longjun, Chen Zhongyuan, Liu Yuhua et al. Construction of shelterbelt protection forest system in Xinjiang. Urumqi: Xinjiang People's Press, 1980.
[2] Hou Ping. Rediscovery of shelter belt protection forest system construction in Xinjiang. Xinjiang Forestry, 2000 (4).
[3] Palihati. Strengthened appropriate technology extension to quicken shelter belt protection forest system construction in Xinjiang. Shelter Belt Forest Science And Technology, 1995 (1) .

Contact person

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Left: Compulsory forestation by the local people of Hetan County located at the southern edge of the Tarim Basin. Photo by Li Tipu
Right: Women of Hetan county participating in compulsory forestation Hetan County. Photo by Zhu Yuwei

Farmland Shelterbelt Network on Oasis

Hetan County of Xinjiang, China

Led by government, participated by the public and supported by national project funds, the "narrow belt and small grid" farmland shelterbelt network is established on oasis farmland

Adjacent to the southern brink of Taklimakan Desert, Hetan County is short of water resource and vegetations. So far Hetan has been the most severely desertified area in China. Oasis farmland shelterbelt network aims at increase of forest coverage, improvement of oasis ecological environment and farming condition, prevention of desert extension over the oasis, reduction of wind and sand disasters, maintaining oasis stability, safeguarding stable and high yield of crops and meeting local demand for timber and firewood.

Along with the implementation of the "Three-North" Shelterbelt Programme in 1978, a "narrow belt and small grid" model shelterbelt was carried out at large scale by local farmers under the leadership of Hetan Prefecture Government. By 1986, farmland shelterbelt network comprised 99.1% of total farmland acreage, thus making Hetan the first county to realize farmland shelterbelt networking in Xinjiang. During project implementation, the county forestry bureau designed the forest network plan on township basis by considering the factors of farmland, forest, irrigation, road and residential spots. County and township government organized and coordinated the social groups to participate in compulsory forestation. The forestry department is responsible for technical training, plantation quality supervision and acceptance checking. After forestation is completed, farmers are responsible for maintenance based on contract. The maintenance, including tending, thinning, regeneration and logging are managed on village basis. The regeneration felling is allowed only after approval by county forestry bureau. The project technology dissemination system was established at prefecture, county and township levels. The basic approach of technical dissemination is: experiments, demonstrations, trainings, farmer meetings as well as public media (radio and TV). The funds for establishment come from national finance (50% , including US$100/hm^2 provided by Three-North Shelterbelt Programme) and some other sources, such as national forestry engineering funds, poverty alleviation funds, relief for work, matching funds for farmland irrigation). Local governments often mobilize compulsory labours for construction projects. No or little cash input is available. It is a public welfare project that is implemented with governmental directives. The incentives for maintenance include issue of forest ownership certificate to the farmers, subsidies for purchasing irrigation water, free pest/disease control service etc. All income from forest product and by-product will be owned by farmers.

After the farmland shelterbelt network is established, the ecosystem deterioration trend can be reversed in Hetan, and local farmer's living standard can be improved. The technology extension also promotes local social and economic sustainable development.

Location: Hetan County located at the southern edge of Tarim Basin, Xinjiang
Land use: Farmlamd, orchard
Climate: Extremely arid
WOCAT database reference: QA
Related technology: Oasis Shelterbelt Network with Narrow-belt and Small-grid
Compiled by: Liu Kang, Liu Yuhua, Chen Qimin, Zhu Yuwei, Tai Yuren, Li Tipu, Xinjiang Branch of Chinese Academy of Forestry
Date: September, 2007

Editors' comments: At ecological fragile areas of serious harms from sand dust storm, the government took the lead to mobilize the whole social Strengthens to participate in forestation. Based on the established research organizations and the prefecture/county/town forestry bureaus and staff, the technology extension network was formed to promote construction of farmland forest protection network to effectively improve local agricultural production and human living environment. Now the farmland protection forest network is being widely expended in the project areas of the "Three-North" national shelter belt protection forest program.

Problem, objectives and constraints

Problem

- Limited government subsidy for the project area, lack of funds for establishment and heavy burden of farmer labour contribution.
- Compulsory labourers are not beneficiaries, so they are usually slack in working performance.
- Community farmers short of techniques of farmland shelterbelt and tending.
- Maintenance period is long, with low benefit at early stage that affects the farmers' enthusiasm in tending management.

Objectives

- Form effective technical extension mechanism.
- Raise the enthusiasm of community farmer willful participation.
- Prevent and control natural disasters and improve oasis' ecological condition.
- Raise crop production and ensure food security.
- Produce timber to promote farmer income and rural socio-economic development.

Constraints addressed

Major	Specification	Treatment
Shortage of water resource, outstanding conflicts of water use between crop farming and forestry	During drought year water is used for agriculture only, and no water can be allocated to forest, thus leading to forest trees die out.	Strengthen the management of water resources by arranging the ecological purpose irrigation.
Low water utilization rate	Traditional irrigation methods lead to water leaking, evaporation and serious seepage.	To apply the water-saving irrigation technology.
Major	**Specification**	**Treatment**
Forest land tenure not clarified in timely affecting young forest tending	Forestation project is organized by the government, and the land contracting households usually do not get the forest ownership right certificate in time, which affects young forest tending and intercropping.	Make clear the forest ownership in time.

Participation and decision making

Target groups


Decision maker


Planning staff


WSC experts


Land users


Teacher and students

Approach costs met by

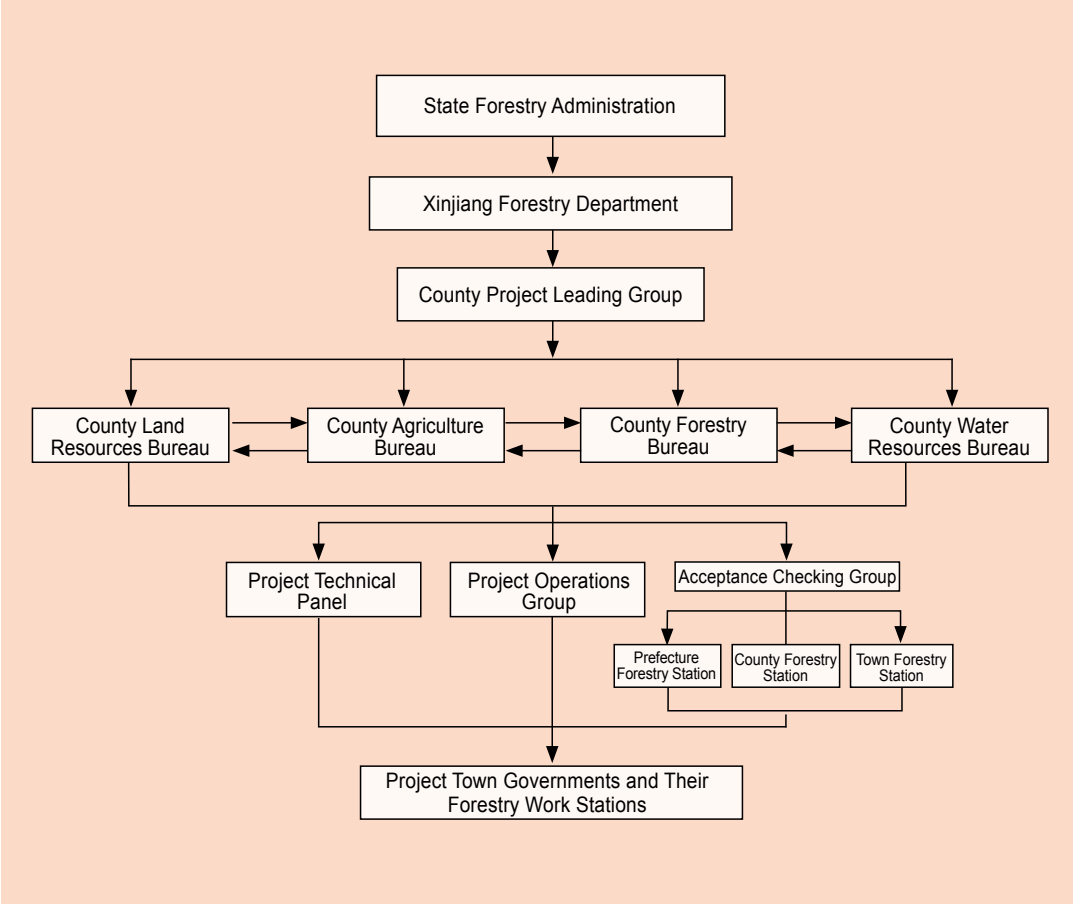
State	50%
Public compulsory labour	40%
Local government	5%
Land users (farmers)	5%
TOTAL	100%

Decisions on choice of the technology: Xinjiang autonomous region government and the forestry department promulgate the decision for implementation.
Decisions on method of implementing the technology: Prefecture and county government make decision of application.
Approach designed by: Forestry experts of the autonomous region, prefecture and county jointly make design.

Community involvement

Phase	Involvement	Activities
Initiation	Participation	Set up project leadership group and office; work out project regulations, determine annual work and finance plan; finalize the finances and seedlings; some farmers participate in seedling production.
Planning	Participation	Set up the land use planning group for landform mapping and formulation of land use plan. Community farmers offer planning suggestions.
Implementation	Active	Forestry department organize training, implementation and technical guidance; Farmers accept training. Communities and farmers offer compulsory labour for site preparation and planting.
Monitoring/evaluation	Participation	Establish 3-level system for quality inspection and evaluation. The township forestry work station conducts overall checking; the county forestry work station conducts sampling checking and the prefecture forestry work station does double checking. Communities and farmers offer collaborative support.
Research	Participation	The studies are undertaken on land uses planning, afforestation technology, ecological/economic/social benefits etc. Communities and farmers offer support to the research institutions.

Differences in participation of men and women: Male participants are mainly the main labourers.



Organogram

These projects of farmland shelterbelts network are mainly financed by State Forestry Administration.

Extension and promotion

Training: (1) Professional technician training. The training is done top-down for forestry department mainly by printed handouts; contents for training are mainly on setting out design, forestation and seedlings standards. (2) Training to farmers. The training has various forms, and its contents cover importance of farmland shelterbelt network, seedling production and afforestation techniques. The training effect to technical people is better than that to farmers.

Extension: In Xinjiang the key points of the technology are land planning, seedling cultivation and planting technique. The extension network of the Xinjiang Forestry Department with the lower level forestry organizations is established covering prefecture, county, township with clear work responsibilities.

Research: Research is undertaken by the Chinese Academy of Forestry Xinjiang Branch, and main contents are: (1) the relations between harm intensity of sand dust storm and the suitable specifications of shelterbelt network; (2) the relations between farmland shelterbelt structure, density and its functions of wind break and shifting sand fixation; (3)micro climate of shelterbelt and benefits of increased production and decreased disasters; (4) selection of species for the farmland shelterbelt, cultivation technique and pest/diseases control; (5) measures of mitigating negative impact on crop growth.

Importance of land use rights: Upon completion of shelterbelt, the forest is contracted to nearby farmers, who will have forest ownership and obligations of forest maintenance. This is helpful in raising the input by farmers for tending the forest land. The thinning and regeneration felling need approval by county forestry bureau in order to prevent illegal cutting and negative impact on function of shelterbelt.

Incentives

Labour: Local government mobilizes and uses compulsory labourers (farmers mainly).

Inputs: The state provides funds for seedling, forestation and pest/disease control, local government provides non-paid labourers.

Credit: No bank loan is applied for this project.

Support of local institutions: Due to serious shortage of input from the government, the support level to local organizations is limited, mainly to improve the quality of forestry technicians.

Long-term impact of incentives: Without national input, the local government is unable at all to undertake the establishment of shelterbelt network. The long term incentive has positive impact.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Typical weather survey of the growth season: air temperature, humidity, wind speed, evaporation etc. in the shelterbelt network.
Technical	Select forest representative belts of different management levels for measuring DBH, tree height, canopy size etc.
Socio-cultural	Questionnaire and visit interview to investigate whether and how the public is satisfactory to the ecological condition, living and production environment.
Economic/production	Monitor crop production and how it is affected by disastrous weather conditions, and the timber price tendency.
Area treated	The ecological condition and tendency.
No. of land users involved	Establish management archive system.
Management of approach	Advantages, weakness and efficiency of current management system, the satisfaction rate by the public.

Impacts of the approach

Changes as result of monitoring and evaluation: The extension method has not changed much compared with the past, because the extension relies on governmental instructions. Some large household contractors or enterprises, in case of water conservancy development (government permitted), applied for state seedling subsidy (US$100 /ha.) and raised the rest funds by themselves for establishment of shelterbelt network.

Improved soil and water management: Increase efficiently the soil water retention capacity and soil organic matter content; reduce harms caused by land salinization.

Adoption of the approach by other projects/land users: This method is applied extensively in other project area of the Three-North Shelterbelt Programme.

Sustainability: With proper governmental policy support and small amount of inputs for maintenance cost, farmers can adopt this method for long term.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Effective organizational work of the extension → Further raise the capability of the extensionists.	Short of construction funds, and local government and people have heavy burden → Make efforts to access national and international project financing.
All community participation → Conduct more trainings to raise technical level of communities and their environmental protection awareness.	Long maintenance period forms a burden to farmers → Establish ecological compensation mechanism by subsidizing the maintenance cost of the farmers.
Improve farmland ecological environment and raise land productivity → The supplemental shelterbelt adopts cash trees to raise the economic benefit of shelterbelt network.	

Key reference(s)

[1] Ci Longjun, Chen Zhongyuan, Liu Yuhua et al. Construction of shelterbelt protection forest system in Xinjiang. Urumqi: Xinjiang People's Press, 1980.
[2] Hou Ping. Rediscovery of shelter belt protection forest system construction in Xinjiang. Xinjiang Forestry, 2000 (4).
[3] Palihati. Strengthened appropriate technology extension to quicken shelter belt protection forest system construction in Xinjiang. Shelter Belt Forest Science And Technology, 1995 (1) .

Contact person

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Left: Stony sandy cropland. Photo by Wang Yan
Right: Corn planted in the stony sandy cropland. Photo by Wang Yan

Cultivation on Stony Sand Land

Jingtai County of Gansu Province, China

This is a tillage-free cultivation technology for arid area by building up an added mixed gravel earth layer on existing topsoil to contribute to site conservation, prevention of salinization, soil moisture retention and increase of soil temperature.

Sandy cropland is mainly concentrated in middle of Gansu Province, Lanzhou-centered arid and semi-arid areas in eastern Qinghai, and southeren Ningxia (small area). Yongdeng County and Gaolan County of Lanzhou City and Jingtai County of Baiyin City have concentrated distribution of sandy croplands. Sandy cropland created to adapt to low-rainfall saline arid lands. It uses a gravel mixture to cover the farmland to prevent soil wind/water erosion, mitigate salinization, reduce sandstorm, retain rainwater, diminish evaporation, increase soil moisture reserve, increase soil temperature to facilitate shooting and growth and increase temperature difference between day and night so as to improve crop yield and quality.

Key points of the technology: land slope should be less than 15o, fine sand and gravel (or pebble) are mixed at 7:3 or 5:5 ratio to cover the land in winter when the earth is frozen. The thickness is 8-10cm and 15,000-30,000kg of gravel is needed per hectare. Barren land should be leveled before coverage and the cultivated land requires tedding and application of basal manure of 2500-5000kg/hm^2 and leveling prior to coverage. Tillage seeding and hole fertilizing should apply to cereal crops to let the seeds scattered on top of the soil underneath the gravel mixture layer. Melon and vegetables should be spot-seeded in the holes dug before covering. Plough seeding and manure application in hole should be made in the sandy cropland, or chemical fertilizer solution may be used as dressing applied to the roots of plant. Tillage-free cultivation is implemented in the sandy cropland. Before harvest or seeding and after heavy rain, scarify the sand gravel layer transversely and longitudinally. When harvesting the plants, try to root out the plants without leaving residue stump. Sandy cropland in use for 40-60 years considered old Sandy cropland and irrigated Sandy cropland has only 5-6 years lifespan.

The sandy cropland totaled 1.0×10^{5}hm^2 for the whole country in 1980 and the area in Lanzhou reached its maximum in 1970s, as 5.57×10^{4}hm^2. Thereafter, with the construction of water conservancy works, the sandy cropland area stabilized at 4.5×10^4 hm^2. In 2004, the area Huanxiangshan in Zhongwei City of Ningxia developed a patch of sandy cropland up to 1.0×10^{4}hm^2 growing watermelon, the largest pollution-free watermelon production base in China. Lanzhou University and Lanzhou Agriculture Institute and Soil and Fertilizer Institute of Gansu Academy of Agricultural Sciences, Gansu Agriculture University and Gaolan County Agricultural Technology Station have conducted systematic researches on sandy cropland technology and accumulated substantial data included in the publication “Sandy cropland in Gansu” to provide technical support to sandy cropland technology dissemination and application.

Location: Jingtai County, Gansu Province
Technology area: 10km^2
SWC measure: Engineering measurer
Land use: Cropland
Climate: Arid
WOCAT database reference: QT
Related approach: Sandy Cropland Cultivation
Compiled by: Liu Hujun, Gansu Desert Control Research Institute
Date: August, 2007

Editors’ comments: Cover the sandy land with mixed gravel earth to prevent soil and water erosion and reduce incidence of sand dust storms. The technology is simple but with high economic value. The sandy cropland is located mainly in the arid, semi-arid areas around Lanzhou City of Gansu province, especially at Yongdeng County, Gaolan County and Baiyin City. In Huanxiang mountainous area of Zhongwei City, of Ningxia in 2004, a plantation of 10,000 hm^2. was developed on sandy land for sweet watermelon, which is now the largest pollution-free sweet watermelon production base in China.

Classification

Land use problems

The project demonstration area is located at semi-arid zone, with cropland located mainly at hillsides. Dryland agriculture thereby results easily in wind/water erosion and serious soil and water losses. The land fertility decline and reduced crop production reduce the income level.

Land use

Annual crops

Climate

Semi-arid

Degradation

Wind erosion

SWC measure

Mechnical measure

Technical function/impact

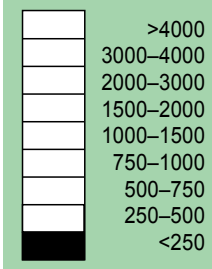
main: - add land cover to reduce wind erosion
- retain soil moisture
- improve soil temperature
- curb sand dust storm

secondary: - improve soil moisture condition for better crop growth
- maintain soil fertility and stabilize crop production

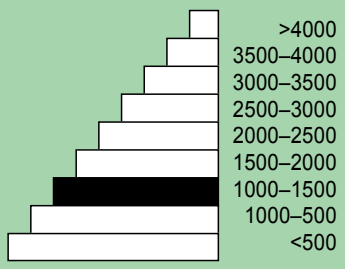
Environment

Natural Environment

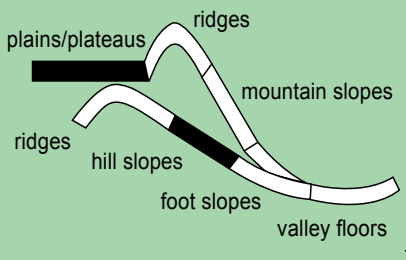
Average annual rainfall (mm)



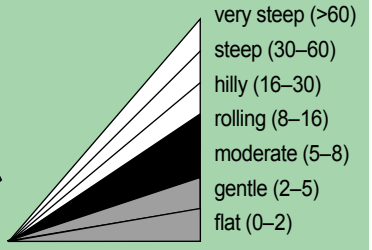
Altitude (m a.s.l.)



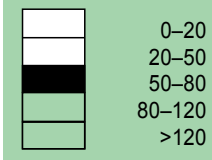
Landform



Slope (%)



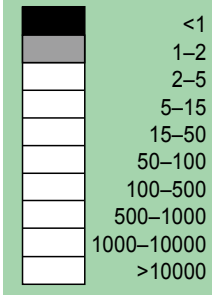
Soil depth (cm)



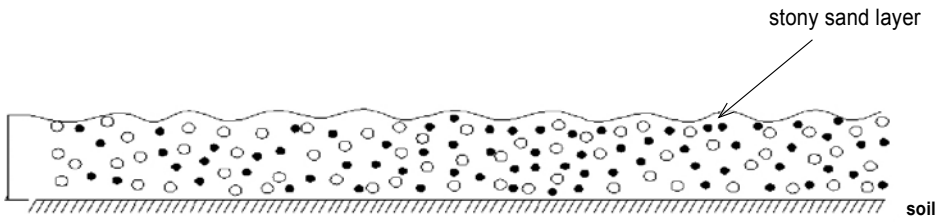
Growing season: 215 days in succession, from April to October
Soil fertility: low
Soil texture: coarse (sandy loam)
Surface stoniness: moderate(plenty of loose rock)
Topsoil organic matter: moderate (1%-3%) or low (<1%)
Soil drainage: good
Soil erodibility: very high

Human environment

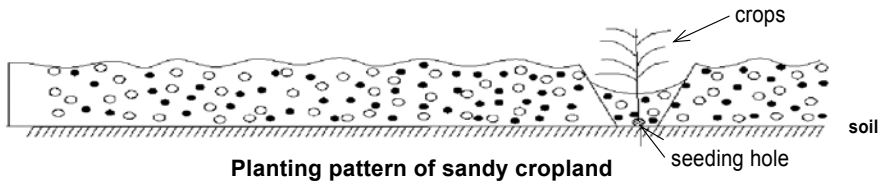
Mixed land per household (hm^2)



Land use rights: individual
Land ownership: state
Market orientation: mixed
Level of technical knowledge required: moderate to technical extensionists and low to land users
Importance of off-farm income: 10%-50% of total income



Layout of sandy cropland



Planting pattern of sandy cropland

Technical drawing

Based on conditions of climate, slope, soil and rock determine the suitable sand coverage thickness, cultivation time. The sand materials should be locally available.

Drawing by Guo Shujiang

Implementation activities, inputs and costs

Establishment activities

1. Animal power or machines can be used for site preparation in autumn.
2. Fertilizer application. Use human labor or machines, tools for application of manure following the site preparation.
3. Sand transport by machinery or manpower.
4. Sand covering in early winter.

Land leveling, sand coverage and needed sand quantity

Activity	Labor (day/mu)	Machine (day/mu)
Leveling	2	0.3
Sand covering	600	10
Seeding	4	0.5
Sand loosening	1	0.3

Establishment time: 2 years or 2 months.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
($3.0x10^4$kg earth coverage)		
Labour	63	15%
Equipment: samll tractors	42	10%
Materials: mixed gravel earth	250	60%
Agricultural: new crop varieties	21	5%
TOTAL	376	100%

Maintenance/recurrent activities

1. After the crop harvest, or before the seeding, or after the heacy rain, use sand harrow to lossen the sand layer in different directions, loosen the sand layer only if sand shovel is used. when harvesting the crops, uproot as far as possible not leaving crop residuals.
2. The sandy crop should be renewed at the latter stage of use,by removing seriously mixed sandy soil, replough, apply fertilizer and cover with sand. To reduce cost, whren applying sand for the second time, use sift to screen out the gravels (abandon only the mixture of sand and soil), then apply the fine sand and gravel that are transported to site before mixing them. The alternative is to apply another layer of sand on hte worn out sand rocky land, locally called “pileups”. Pileups have improved properties of sandy land but not as good as the replaced land because the soil fertility is not improved, and too thick sandy layer result in dropped soil layer temperature. Pileups are not recommended also because it means more difficulty, when you really replace it.

Maintenance/recurrent inputs and costs per hm^2 per year

Inputs	Costs (US$)	% met by land user
Labour	7.00	100%
Equipment		
Materials		
Agricultural		
TOTAL	7.00	100%

Remarks: 1US$= RMB 7.2 Yuan.

Assessment

Acceptance/adoption

Sandy land is a locally created crop cultivation technology that suits local natural conditions. With high inputs of establishment and encourage incentives 90% households are willing to accept it. Without incentives only the households in urgent need of it, about 30% of the households would adopt the technology in order to get higher profit.

The incentives include favorable policies, purchase order based agriculture and capital fund support. Because of the greater inputs of capital fund and labor, along with the advancement of dryland cultivation technology and drought-resistant crop breeding, the technology adoption may tend to decline. As a crop cultivation technology suitable to local natural conditions that has relatively steady and high economic benefit, once proper encouragement incentives are available, households would adopt it actively.

Benefits/costs according to land user

Obvious ecological and economic benefits. Land users' benefits assured.

Benefits compared with costs	Short-term	Long-term
establishment	very positive	very positive
maintenance/recurrent	very positive	very positive

Impacts of the technology

Production and socio-economic benefits

+ + +	Improve crop production
+ +	Imporve farmer's income

Production and socio-economic disadvantages

	None

Socio-cultural benefits

+ +	Improve farmers' awareness of SWC

Socio-cultural disadvantages

	None

Ecological benefits

+ + +	Cover the ground surface to avoid wind erosion
+ + +	Curb the sand dust for better environmental protection
+ + +	Improve soil temperature

Ecological disadvantages

	None

Off-site benefits

+ + +	Reduce soil and water loss and sand dusty weather days

Off-site disadvantages

	None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Raise soil temperature and improve crop growth condition → Plant grain crop and cash crop.	Relatively low production level → Explore more effective dryland farming technology.
Prevention and control of soil and water loss and soil salinization → Adopt modern conservation cultivation technology.	The technology needs special seed sowing machines → Develop more adaptive facilities and equipment.

Key reference(s)

[1] Liu Xunhao. Agricultural science. Beijing: China Agricultural press.
[2] Wu Dakang, Feng Xihong. Q and A for the sweet watermelon cultivation technology on sandy land [M]. Ningxia people's press.
[3] Zhou Sunli, Zhao Ming, Cui Yuting. Conservation Farming and cropping technologies.
[4] Wu Junshan, Wu Yueshan, Jujube and melon intercropping technology on dry sandy land [J] Agricultural science and technology information. 2005(3).
[5] Ren Daoyi, Zhao Renfu, Zhai Hailiang. A prospective farmer-enriching ecological industry: study survey report ten 100000 mu Chinese datemelon intercropping orchid in Gaolan county.
[6] Tian Yuan, Li Xiaoling, Li Fengmin, Su Derong. Impact of collected rainwater irrigation on watermelon production and soil moisture Chinese desert, 2003(4).

Contact person

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Left: Sandy cropland. Photo by Liu Hujun
Right: Layer thickness built on the Sandy cropland. Photo by Liu Hujun

Sandy Cropland Cultivation

Jingtai County of Gansu Province, China

Sandy cropland is a farmland covered by sand and rock mixture. The technology is a tillage-free cultivation method to adapt to aridness and soil salinization. It is a soil and water conservation oriented technology to increase crop yield. Sandy cropland technology operations include plot selection, sand material screening, sand and rock mixing ratio, site preparation, crop selection, field operational management.

Early germination and short maturing duration: 3-5days earlier germination and 10days earlier in maturation for spring wheat; maturing date is advanced 17days for tomato, 14 days for Chinese cabbage, 47 days for spring cabbage. Sugar content in melons is remarkably increased fetching good taste; protein content is increased in wheat and higher flour yield obtained; cotton output is increased by 50%-80%; melon seeds output is increased by 2-4 times; cereal by 89.7% and thermophilic vegetables by 40%. Protein in spring wheat is increased by 21% and watermelon sugar is increased by 30%. Sandy cropland can reduce salt content of the 10mm top soil, with the salt content at 3.38% in the second year after the site is prepared and at 0.07% in twenty years.

Sandy cropland cultivation was originated in Lanzhou City of Gansu Province, thus it is called Lanzhou Sandy cropland or Gansu Sandy cropland, and the application started in early Qing Dynasty. Sandy cropland was first detailed in "Lanzhou Historical Exegesis"published in 1943. More explicit delineation was given by "General Record of Taosha County" (1930), indicating that farmers began using scientific method to lay coarse sand and pebbles on ground since Xianfeng Period in Qing Dynasty, no record regarding the origin, but it is said creation of Sandy cropland commenced in Kangxi Period or Jiaqing Period of Qing Dynasty according to folklore. In 1984, Li Fengzhi from Northwest University of Agriculture verified the discovery of astonishing Sandy cropland in central Gansu and Qinghai provinces originated in mid Ming Dynasty, about 400 or 500 years in history, instead of invention in Qing Dynasty approximately 200-300 years ago as literatures commonly suggest. Dissemination of Sandy cropland technology can reduce soil erosion and sandstorm. Sandy cropland operation can acquire high and stable yield, moreover, it allows improvement of quality of crops and melons. In addition, it is easy for dissemination and conducive to ecological protection and dryland cultivation. The technology dissemination has been implemented mainly by farmers, i.e. a scaling up of bottom-up. In recent years, the technology has been modified by Gansu Agriculture University. Sandy cropland technology extension requires substantial funds, manpower and machinery inputs. Farmers should be encouraged to expand the application areas to increase crop yield and product revenue.

Location: Jingtai County, Gansu Province
Land use: Cropland
Climate: Arid
WOCAT database reference: QA
Related technology: Cultivation on Stony Sand Land
Compiled by: Liu Hujun, Gansu Desert Control Research Institute
Date: August, 2007

Editors' comments: This is a technology of dryland farming to meet the needs of cultivation at arid salted barren land. The rainwater seeps easily the gravel that covered land, reduces soil evaporation while raising the moisture retention. With increased temperature, the technology promotes earlier crop seed germination for growth, and results in a temperature difference in day and at night, which is good to crop protection and quality; The technology also prevents soil wind/ water erosion and alleviates harms of land salinization, pests, disease and weeds. The Sandy cropland is geographically concentrated in central part of Gansu province, southern part of Ningxia, eastern part of Qinghai. In 2004, a plantation plot of 10,000 hm^2 was developed on sandy cropland for sweet watermelon planting. It is the largest pesticide-free sweet watermelon production base in China.

Problem, objectives and constraints

Problem

- Serious wind/water erosion and salinization in arid and semi-arid areas.
- Soil and waster losses and low land fertility result in reduction of production and income.
- Lack of technical extension service.
- Lack of financial support, so the technical improvement is slow.

Objectives

- Form effective farmer centered technical extension mechanism.
- Raise community awareness on ecological protection.
- Raise community participation level.
- Adopt sandy land cropping technology to reduce erosion, salinization and to protect farmland.
- Increase income, improve environmental environment, and improve people's living standard.

Constraints addressed

Major	Specification	Treatment
Economic aspect	High establishment cost but backward local economy and low investment ability of farmers.	Joint investment by the state (capital fund), local government (production raw materials such as the production tools) and farmers (paid labor).
Technical aspect	Farmers in lack of knowledge of establishing and managing sandy cropland.	Conduct training courses, organize farmers to visit the demonstration plots to lean the technology.
Minor	**Specification**	**Treatment**
Social aspect	Along with the development of market economy, the ecological protection sense of the farmers is weak, and their enthusiasm in conserving soil and water is low.	Strengthen farmers' learning capability to raise their consciousness of public benefit and environmental protection.

Participation and decision making

Target groups

Land users

Approach costs met by

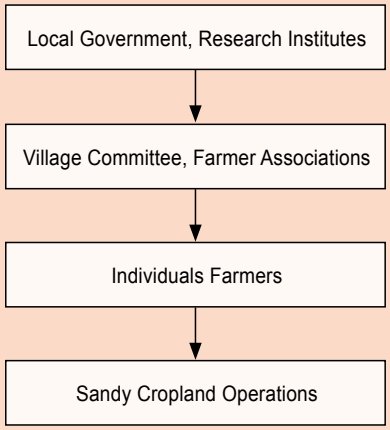
State	40%
Land user	30%
Labor for relief	30%
TOTAL	100%

Remarks: Adoption of the technology in Jingtai, Jingyuan counties of Gansu are to large extent land users' own behavior.
Decisions on choice of the technology: Land users.
Decisions on method of implementing the technology: Land users.
Approach designed by: Land users and technicians.

Community involvement

Phase	Involvement	Activities
Initiation	Self motivated	Prepare gravel, arrange land plot position, site preparation.
Planning	Interaction	Application area, land acreage, technical guidelines, crop type, farming machines and tools, incentive mechanism.
Implementation	Incentives/interaction/ self motivation	Transport gravel, fertilizer, apply fertilizer, laying out the gravel.
Monitoring/ evaluation	No participation	Sandy land quality, crop production, machine effectiveness.
Research	Interaction	Selection of crop, test of farming utilities, farming skills and techniques.

Differences in participation of men and women: Accomplished mainly by men.



Organogram

For organized technological application, the county forestry (agriculture) bureau and their higher level administration, the researchers, farmers, land users combined to form the project coordination and supervision committee that contain a leadership group comprising relevant governmental staff. The leadership group takes the responsibility for project implementation, including coordinating national and local financial support, raising finances, reasonable use of funds, field construction etc. With the organizational work of the leadership group, the research units, local governmental agriculture department and community farmer associations jointly implement the field operations. After project is completed, related experts and leaders are organized to make acceptance checking, after which the community farmer association shall carry out long term maintenance.

Extension and promotion

Training: By training sessions, site demonstrations etc, the training is conducted to include: selection of the candidate land, sandy gravel selection, sand and gravel mixing ratio, site preparation, field growth management, etc. This technology is an informal invention by locality, so farmers only would usually rely on their experience and feelings for implementation. The training allow farmers have rapid and accurate understanding of the technological points such as land making, sand sample, cropping as well as field growth operational management for higher benefit.

Extension: The extension is concerned with 3 linkages of technical research unit, technology extension unit and technology users. The farmers are the inventor and the users. Local agriculture extension station, technology extension unit and the researchers include Gansu agricultural university etc. The agricultural technical extension stations that connect both the researchers and users as the official technological functionary in China have usually higher responsibilities in popularizing and improving the technology.

Research: The researches started in 1960s, with the researchers of Lanzhou University, Lanzhou Institute of Agricultural Sciences, Gansu provincial agricultural university, Maolan County agricultural technology station; Gansu Academy of Agricultural Sciences. The current research organizations include mainly Gansu agricultural university, and Gansu provincial Academy of Agricultural Science. Research topics include site type and selection, sand sample, crop types, cropping machinery invention and innovation etc.

Importance of land use rights: The term of the present land use right is 50 years, which has no negative impact on technology adoption.

Incentives

Labour: Labour is offered by farmers as land users, without being paid.

Inputs: The implementation needs inputs of tractor, spade etc. which are supplied by farmers themselves.

Credit: Loan is not necessary.

Support of local institutions: The extension improved the technical strength and organizational ability of the local agricultural technology extension organizations. Project implementation by training and national/international interventions improved the capability of local agricultural and forestry sectors.

Long-term impact of incentives: None.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Site survey land slope gradient, soil fertility, sand stone purity, local precipitation, temperature and sunshine, growth issue etc.
Technical	iObserve and measure sand stone proportion, sand cover thickness, hardening level, cultivation condition and crop types.
Socio-cultural	Investigation interview to farmers on the knowledge of sandy land of the farmers.
Economic/production	Investigation of crop production and household income.
Area treated	Direct measurement of the treated acreage of Sandy cropland.
No. of land users involved	Investigation of the number of households that adopted the technology.
Management of approach	Governmental statistics regarding operating area and household number of sandy cropland, to guide related cropping production.

Impacts of the approach

Changes as result of monitoring and evaluation: No change.

Improved soil and water management: Conserve soil and water, improve soil moisture condition and temperature, and reduce soil evaporation and salinization.

Adoption of the approach by other projects/land users: All the semi-arid rainfed agricultural areas of other counties in central Gansu Province adopted this technology.

Sustainability: Land users without long term incentive and support will continue to use this technology.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Farmers motivate themselves using the technology → Strengthen technical extension by the government.	Initial investment is high → Increase financial support of the government.
No incentives → Enhance dryland farming technology development.	Farmers in lack of dryland farming technology → Conduct more training.
High farmer participation level → Continue encouraging farmers to make development by their own efforts.	

Key reference(s)

[1] Liu Xunhao. Agricultural science. Beijing: China Agricultural press.
[2] Wu Dakang, Feng Xihong. Q and A for the sweet watermelon cultivation technology on sandy land [M]. Ningxia people's press.
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Contact person(s)

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Left: Alkali suppression by biological measure at Hetao Iirrigatedion Plain. Photo by Wang Yan
Right: Drainage ditch dug for alkali removal at the Hetao Irrigation Plain. Photo by Wang Yan

Salinate Land Transformation

Urad Front Banner of Inner Mongolia, China

Dig alkali drainage ditches to allow remove salinity washing bythrough irrigation and plant salt tolerant plants species to improve soil quality.

The demonstration plot is located in Wulateqian Urad Front Banner in Hetao Irrigation Plain, Inner Mongolia. It is in the alluvial plain of Yellow River and the landscape landform is flat. Natural conditions feature abundant water, light and heat resources. and theIt region is an important agriculture area in China. The soil has suffered serious salinization due to dry climate, intense evaporation, drainage barrage, irrational irrigation and soil deterioration has become the top constraint to agricultural development.

Saline soil transformation in Hetao Irrigation Plain is an engineering and biological integrated technology aiming at reasonable utilization of water resource. By promoting smooth drainage and washing salinity by through irrigation, the technology tends to reduce surface salt accumulation to get rein in the occurrence of salinization. The biological measure is to plant saline tolerant trees for salt removal and saline content eradication with extended vegetation coverage. Biological and engineering combination is the best approach to transform saline soil by bringing salinization under control. This approach transform the large area alklinatealkalinity flat land with deep soil and fertility and applicable for machinery cultivation potentials into high quality farmland and forest land to make best use of their ecological and economic benefits. Main technical measures: (1) Dig drainage ditches – excavate a drainage ditch sized 30cm wide and 40cm deep by 5m spacing. Put water in to flood flush out the salt content once in hot period of summer and once in autumn with smooth drainage maintained. (2) Tree/ grass species selection –*Tamarix chinensis, Lycium Chinense, Radix Glycyrrhizae*, and other salt tolerant species for biological salt removal and soil modification. (3) Site preparation - dig holes in 1.5mx2m plant/row spacing along the ditch and specifications in every other row: 0.2m×0.3m and 0.4m×0.4m. (4) Planting – plant 2 year old *Tamarix chinensis and Lycium Chinense* seedlings. (5) Maintenance –intertillage weeding three to four times in May thru August. Apply 3000kg of farmyard manure in autumn.

The investment for establishment relevant to an investment of is RMB3300 Yuan/hm^2 and maintenance period of 4 years relevant towith an investment of RMB1125Yuan/hm^2-yr. Five years after the establishment, the production will reach 1500kg of *Lycium Chinense* for RMB12,000 Yuan an outstanding profit. In the meanwhile, the ties between internal and external factors of salinization process are cut off to make feasible the salinate soil control, conversion and utilization.

The technology has been successfully disseminated for 10,000hm^2 and the dissemination has immense significance for the grain production base sustainable development of Hetao Irrigation Plain.

Location: Urad Front Banner, Bayannzhuoer City, Inner Mongolia
Technology area: 1200km^2
SWC measure: Plant and engineering measures
Land use: Forest land
Climate: Semi-arid
WOCAT database reference: QT
Related approach: Mobilize Farmers to Implement Farmland Transformation
Compiled by: Li Jianmin, Forestry Survey team, Bayanzhuoer Bayannur City; Ya Jie, Inner Mongolia Forestry Survey and Design Institute
Date: August, 2007

Editors' comments: This technology is extracted from field practices of the farmers and technicians in the Hetao Irrigated Irrigation Plain farming areas. The practice for 20 years has proved that this technology simple, convenient and effective, so it deserves reference and extension.

Classification

Land use problems

Serious salinization of cropland making the cropping very difficult; barren soil and low land productivity.

Land use	Climate	Degradation	SWC measure	
				
Foest land: *Lycium chinense*	Semi-arid	Chemical degradation	Mechanical measure	Vegetation measure

Technical function/impact

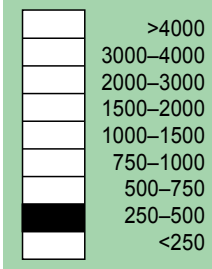
main: - leaching of the salt content
- reduce ground water level
- plants absorbing the salt
- improve the soil fertility

secondary: - add economic benefit to farmers

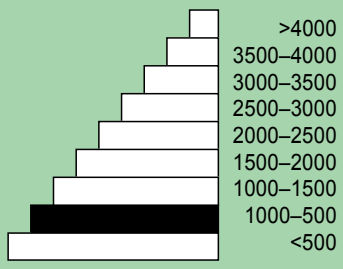
Environment

Natural Environment

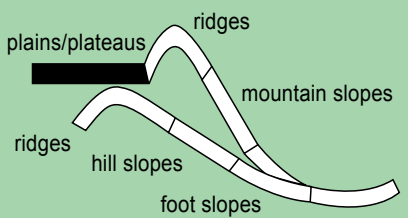
Average annual rainfall (mm)



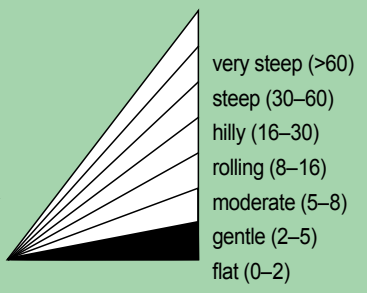
Altitude (m a.s.l.)



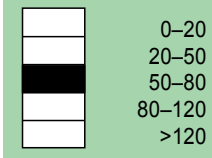
Landform



Slope (%)



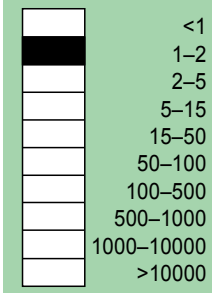
Soil depth (cm)



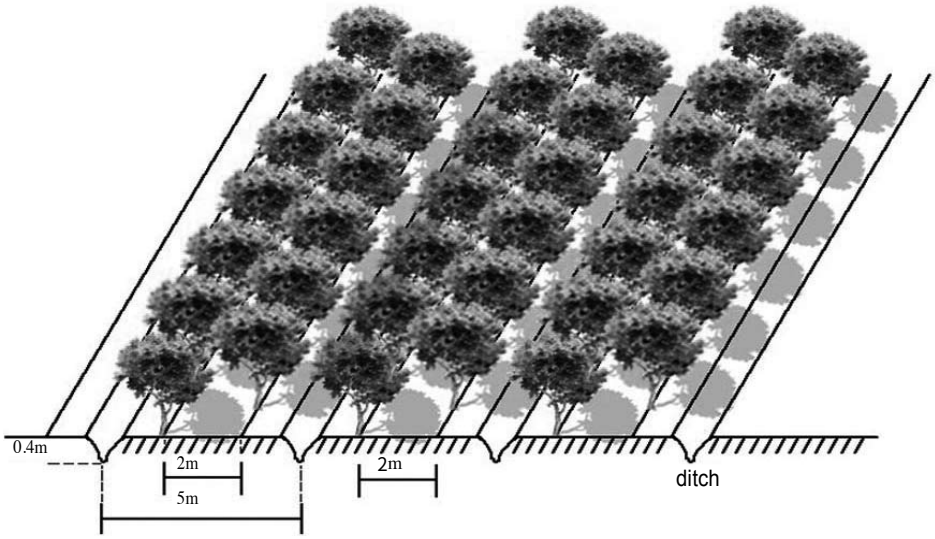
Growing season: 120 days
Soil fertility: low, and with high salt content
Soil texture: loam sandy
Surface stoniness: low
Topsoil organic matter: 1%-3%
Soil drainage: moderate
Soil erodibility: low

Human environment

Mixed land per household (hm^2)



Land use rights: individual
Land ownership: collective
Market orientation: for ecological restoration
Level of technical knowledge required: moderate to technical extensionists and land users
Importance of off-farm income: moderate ,10%-50% of total income



Model of saline removal through digging drainage ditch and water wash away in Hetao Irrigation Area

Technical drawing

1. Dig drainage ditch. One ditch for every 5 meters, ditch 30cm wide, 40cm deep.

2. Planting. site preparation is conducted along the drainage ditch, plantation spacing at 1.5m×2m, planting pit size 20cm×30cm.

Drawing by Li Minyu

Implementation activities, inputs and costs

Establishment activities

1. Construction of saline drainage ditch. Use mechanical means to dig drainage ditch at interval of 5m, the ditch is 30cm wide, 40cm deep, irrigate in hot summer and autumn respectively to wash away the salt. The drainage water flow should be kept un-blocked.
2. Plantation establishment. Select *Tamarix chinensis*, *Lycium Chinense* or other saline resistant tree species for forestation. Accomplish the site preparation in spring along the ditches. The forestation spacing at 1.5m×2m, planting pit is arranged every two rows at specifications of 0.2m×0.3m and 0.4m×0.4m. Immediately after site preparation, select seedling of *Tamarix chinensis, Ly-cium Chinense* of 2 years old for planting. Conduct soaked watering for one time after the planting. Cover with earth after the soaking to retain moisture.

Establishment time: 1 year.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
Labour	219.5	100%
Equipment		
- spade, tractor, ditch dig plough	18.3	0%
Equipment		
-seedlings, irrigation water	128.0	0%
Agricultural		
-fertilizer	36.8	100%
TOTAL	402.6	64%

Maintenance/recurrent activities

1. Conduct supplementary planting in spring of the following year.
2. Conduct weeding 3-4 times from May to August; apply barnyard manure of 3000kg/hm^2. in autumn.
3.Assign specialized people for tending maintenance to avoid damages from human or livestock.

Maintenance/recurrent inputs and costs per hm^2 per year

Inputs	Costs (US$)	% met by land user
Labour	91.5	100%
Equipment		
- sample, test instruments, spade etc.	18.3	0%
Equipment		
- medicine,test paper etc.	9.1	0%
Agricultural		
Fertilizer	18.3	100%
TOTAL	137.2	80%

Remarks: labor price at US$3.7/person day; seedlings at US$92/$hm^2$; water fee atUS$37/hm^2; exchange rate at the establishment: US$1= RMB8.2yuan.

Assessment

Acceptance/adoption

- With the current polices, most farmers accept the technology.
- Otherwise the farmers find it difficult to accept the technology.

Benefits/costs according to land user

The state government offer subsidy for land users to improve soil, so the land users are active in participation.

Benefits compared with costs	Short-term	Long-term
establishment	positive	neutral
maintenance/recurrent	positve	neutral

Impacts of the technology

Production and socio-economic benefits

+ + +	Improve soil and land productivity
+ +	Improve crop production and farmer income

Production and socio-economic disadvantages

	None

Socio-cultural benefits

+ +	Improve farmer's knowledge of soil improvement

Socio-cultural disadvantages

	None

Ecological benefits

+ + +	Reduced salt content of soil
+ +	Higher soil fertility
+ +	Higher vegeation cover

Ecological disadvantages

	None

Off-site benefits

+	Alleviate salinization of neighboring land

Off-site disadvantages

	None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Combination of biological measure and engineering measure, effective in alkaline removal → Further extension by standardizing technical operations.	Heavy labor demand → Adopt mechanization technology gradually.
Simple operating technology → Reduce the cost and raise benefit.	High water consumption → Optimization of irrigation, and adoption of soil covering measure to suppress the salt.

Key reference(s)

[1] State Forestry Administration. Forestry ecological improvement and the operational patterns. Beijing: China forestry publication house, 2000.
[2] Science and technology Department of State Forestry Administration. Collection of the prioritized national research achievements in the ninth five-year plan. Beijing: China forestry publication house, 2001.

Contact person(s)

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Left: *Tamarix chinensis* planted at the alkaline land at Hetao Irrigated Plain, Ningxia. Photo by Li Jianmin
Right: Trenches prepared for planting of alkaline resistant plants. Photo by Li Jianmin

Mobilize Farmers to Implement Farmland Transformation

Urad Front Banner of Inner Mongolia, China

Salinate farmland transformation is implemented by farmers with technical guidance of forestry administration and organization of the government.

Hetao Irrigation Plain, located in Bayannur City of Inner Mongolia, depends wholly on Yellow River water for farmland irrigation. Due to drainage stagnancy of the farmland for long term, saline content piled up, thus resulting in decline of crop production or even zero production. Soil salinization has become the most serious problem in agricultural production in Hetao region. It has seriously undermined local economic development.

In prevention and control of farmland salinization, local agriculture, forestry and water conservation departments and farmers have extracted through decade long practice the technology of alkali suppression by ditch flooding.

Before 2000, the technology was implemented through government mobilization and recommendation and funds raised by farmers themselves. Due to shortage of funds and poor organization, farmers' enthusiasm was passive and the project implementation was in a sluggish progress. With more than ten years efforts done, the technology dissemination covered only 4000hm^2. However, the implementation of the National Programme of Conversion of Farmland to Forest, started in 2000, offered an opportunity for the technical extension. According to the Programme, for every *mu* (measure unit in China, 1 hectare equals to 15 mu) of farmland converted to forest government provides to farmers 100kg of grain and RMB20 Yuan livelihood subsidies, and RMB50 Yuan for the seedling cost. Urad Front Banner government with the technical support of forestry bureau instructed the township government to organize farmers to implement the project using this technology. By far 5300hm^2 of land have been treated with the technology and remarkable results have been achieved.

Main dissemination steps are as follows: (1)In line with the tasks of the conversion of farmland to forest, the township government determines the land plots and households for the project implementation based on signed contract with the households. (2) Banner forestry bureau makes operation design and technical supervision. The bureau helps farmers to implement technology of alkali suppression and forestation. The labour input is provided by the contractors themselves and the cost of seedlings borne by the state. The water for irrigation will be dispatched by town-ship government. (3) Forest maintenance is the responsibility of the farmer contractors.

Conversion of farmland to forest policy has been recognized and supported by farmers, and the technology dissemination is carried out smoothly. However, the existing model has indicated shortcomings. For example, the water cost is soaring to make it hard for the township government to pay the bill, and poor economic benefits from the project have discouraged the activities of farmers.

Location: Urad Banner, Bayannur City, Inner Mongolia
Land area: 30 km^2
Land use: Forest
Climate: Semi-arid
WOCAT database reference: QA
Related technology: Salinate Land Transformation
Compiled by: Ya Jie, Inner Mongolia Forestry Survey and Design Institute; Li Jianmin, Forestry Survey team, Bayanzhuoer Bayannur City
Date: September, 2007

Editors' comments: The opportunity of implementing the key national programmes is an effective way of technical extension, and this technology is a successful example. However, with the changing conditions in the project areas, the government needs to adjust related policies to meet the local demands.

Problem, objectives and constraints

Problem

- Lack of effective extension organization.
- Households in lack of knowledge to combine engineering measures with biological measures to treat alkaline land.
- The cropland is salinized on expanding scale, causing significant reduction of cropland production, which seriously affected the development of local agriculture and local farmer's better-off process.

Objectives

- Form an effective technical extension mechanism.
- Raise community participation level.
- Reduce gradually the salt content in soil and improve agricultural production environment.
- Recover the productivity of land to guarantee local agricultural development and farmer income generation.

Constraints addressed

Major	Specification	Treatment
Financing	Short of capital fund.	Add local counterpart financing.
Technology	Farmer in need of alklinate land treatment technology.	The forestry department offers training and demonstration.
Minor	**Specification**	**Treatment**
Economic aspect	Forest/ grass is of low benefit, farmers income level is low.	Identify favored trees and grass.

Participation and decision making

Target groups


Land user


Planner


Decision maker

Approach costs met by

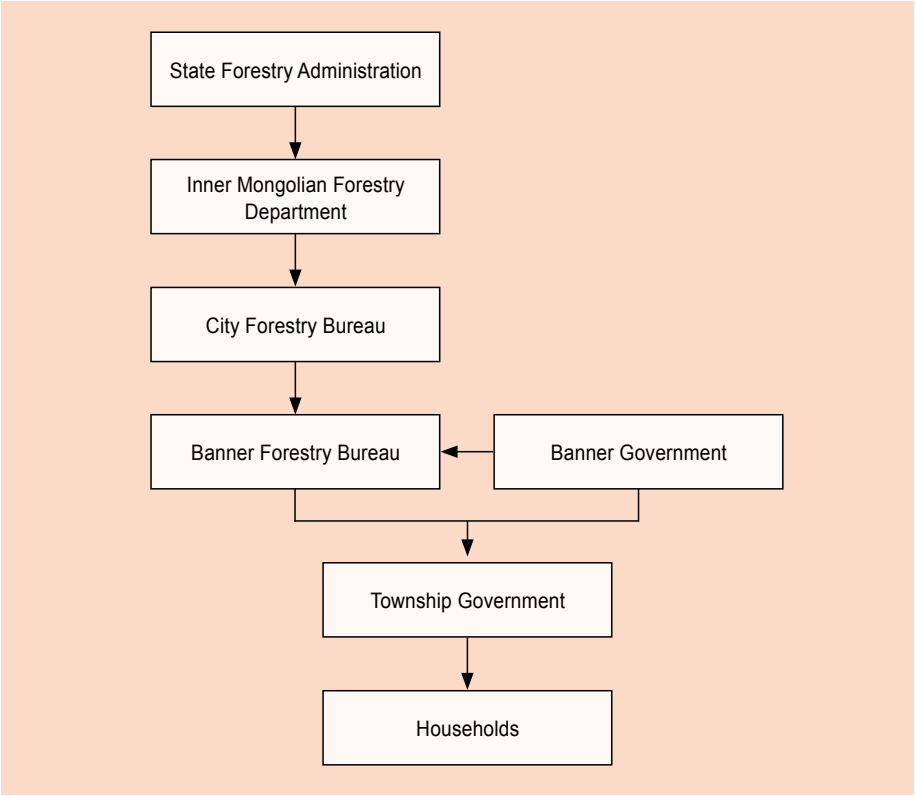
Land users	20%
State	80%
TOTAL	100%

Decisions on choice of the technology: Local households.
Decisions on method of implementing the technology: Banner government.
Approach designed by: Banner forestry experts.

Community involvement

Phase	Involvement	Activities
Initiation	Interaction	Convene village meeting to discuss the necessity of the technology and organize related training to the farmers.
Planning	Interaction	Village heads, villagers and county technicians work together to finalize the project plot and location. County forestry and agricultural technical authorities formulate project technical plan and report to higher management for approval.
Implementation	Self motivation	County technicians deliver technical handbook to households, and go from village to village to offer supervision. Households in line with the training knowledge and the handbook conducted the field operations.
Monitoring/evaluation	Passive	Villagers carry out general measurement and note down the results, county technicians conduct regular measurements and analysis.
Research	Passive	Villagers offer observation data for statistical analysis by county technicians and submit it to higher research institutions for review.

Differences in participation of men and women: No difference.



Organogram

The conversion of farmland to forest program is a key national forestry pro-gram, organized and managed by the forestry department of different levels of the country.

Extension and promotion

Training: Training to farmer households is conducted in forms of lectures and site demonstrations, with topics of drainage ditch, planting and management of alkali resistant plants. The training effect is good.

Extension: The banner forestry work station takes the responsibility of technical extension, mainly by training sessions and household visits etc.

Research: The city forestry research institute carries out studies based on production demands, mainly on: impact of vegetation on the content of soil pH value, change of vegetation productivity.

Importance of land use rights: Farmers implement the project on their own land, so the land use right do not affect technology application.

Incentives

Labour: Households contribute non-paid labour inputs by themselves.

Inputs: Government provides seedlings and related technical service.

Credit: One household may access a micro credit of RMB3000-5000 Yuan, with the interest rate lower than normal commercial loan.

Support of local institutions: Technical application improved the reputation of forestry department, and helped to apply for implementation of other projects.

Long-term impact of incentives: Incentive mechanism has positive impact on the extension of the technology. Without above-mentioned encouragement measure, farmers find it hard to apply this technology.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Test paper and laboratory test, pH value.
Technical	Field measurement of underground water level.
Socio-cultural	Discussion meeting and questionnaire investigation, on farmers' knowledge regarding treating alkaline land with engineering and biological measures.
Economic/production	Calculate or estimate crop production and farmers' income.
Area treated	Investigate the extension area of the technology.
No. of land users involved	Investigate the number of households that adopt the technology.
Management of approach	Survey to the households and feedback regarding the technical application situation.

Impacts of the approach

Changes as result of monitoring and evaluation: Before the project implementation, the households adopted the technology independently without organization and technical support, so the extension is slow. The government and professionals organized and technically guided technology extension has higher efficiency and got support of the key government programmes.

Improved soil and water management: Affected by the extension of the technology, the local households started putting efforts on cropland irrigation drainage and they tended to adopt different salt-resistant crop rotations during their farming operations to avoid land salinization.

Adoption of the approach by other projects/land users: The technology has been extensively adopted in the Hetao Irrigated Plain in Ningxia.

Sustainability: Preferential polices motivate farmers and herdsmen in adopting the technology. Without long-term support policies, farmers find it hard to adopt the technology.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
High extension efficiency → Further improve the capability of governmental technical extension organizations.	Farmer participation level is low → Introduce participatory tool for use during period from design to implementation.
Easy-operating technology and low technical requirement to workers → To continuously extend the technology.	The establishment cost too high for the township government to cover → Improve the incentives and access multiple financing sources.
Explicit tenure relations, land use in form of contracting → Further improve the land contracting system.	

Key reference(s)

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[2] State forestry administration. Forestry ecological construction and the operational patterns. Beijing: China forestry publication house, 2000.

Contact person(s)

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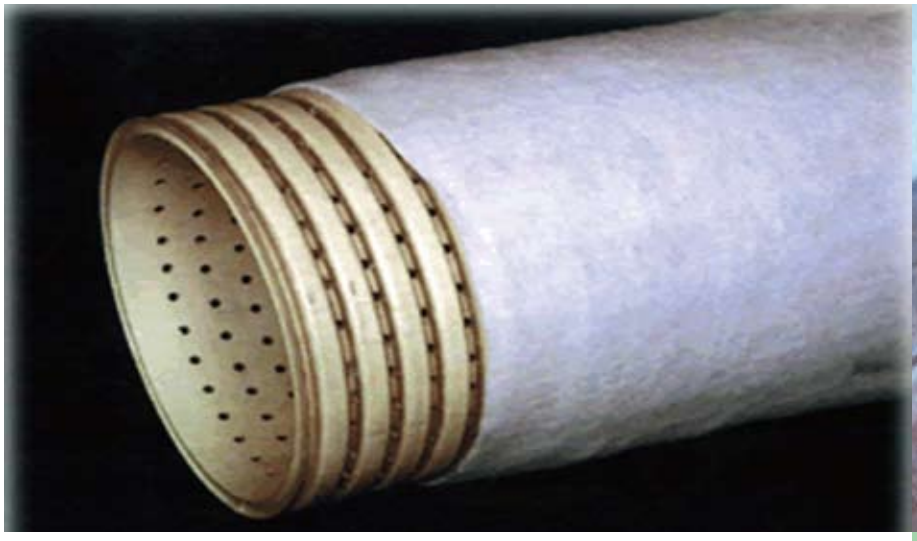


Left: Geo-textile wrapped corrugated drain pipe.
Right: Pipe layer trencher in operation.
Photos from http://www.iwicn.com/view.jsp?id=3311

Drainage by Hidden Pipe for Irrigated Farmland

Production and Construction Crops of Xinjiang, China

The engineering measure of laying filtration materials coated drainage pipe under the ground is adopted to control groundwater level in the extreme drought area and meanwhile to adjust soil moisture, improve soil property and control salinization.

Regiment 29, Division 14 of the Xinjiang Production and Construction Crops is located in southern foot of Tianshan Mountain and the piedmont plain northeast of Taklimakan Desert and down-stream of the alluvial fan. The location is in phreatic overflow zone where groundwater level is high, with mineralization reaching 30-50g/L and saline content ranging from 3% to 5%. Due to large area flooding operation to remove saline content without adequate experience and incom-plete irrigation facilities, severe salinization was caused in the area and 80000*mu* (1 hm^2 = 15 mu) farmland developed in 1951 was ruined in early 1960s. In 1962 the regiment established soil modi-fication experiment station by referring external experience, to build drainage facilities and strip fields, and thereby has successfully carried out saline flooding and rice cropping. At present, the site has become a nation-wide model of high quality and high efficiency agriculture.

Owing to flat landform and loose soil, open ditch drainage system can not last long. It usually lasts for three to four years before being abandoned. In comparison with open ditch drainage project, hidden pipe drainage system features small project volume, less land occupation and long service life so that it is popular with water conservation departments. In 1987, Regiment 29 introduced underground drain machinery and technology from the Netherlands under the World Bank loan project and successfully passed the trial operation.

Underground hidden pipe drainage facility is usually composed of suction pipe, water collection pipe, inspection wells and drainage control unit. In case if water accumulates at the low lands and cannot flow out by gravity, the pump station should be installed for operation. Hidden pipe drainage technology includes layout of pipelines, pipe fabrication, hidden pipe laying, pipe silt dredging. Underground drainage system pipelines should be laid along the long edge of farmland to replace the existing open ditch. All laid pipes deliver water to the open subsidiary channels or underground water collection pipes. There are inspection wells installed for certain distance along the pipeline and the drainage pipe is connected with water collection pipeline. The water collected flows to the open ditch and discharged to the external locality via branch pipelines. The underground pipes are supplied by professional manufacturers. The pipeline silt removal is done by special dredging machinery.

By adoption of hidden drainage system, no farmland is occupied and it provides ease in cultivation operations and ensure drainage depth and easy for maintenance management. But it requires great amount of initial lump sum investment

Location: Regiment 29, Division 2 of the Xinjiang Production and Construction Corps
Technology area: 43km^2
SWC measure: Water conservancy works
Land use: Irrigated agriculture
Climate: Extremely arid
WOCAT database reference: QT
Related approach: World Bank Project on Salinization Control by Hidden Pipe Drain
Compiled by: Tian Changyan, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Date: October, 2007

Editors' comments: The hidden pipe drain technology was used in Regiment 29, Division 2 of the Xinjiang Production Construction Corps, to deal with soil salinization and was proved to be effective. Now this technology has been extended in salinized irrigated areas in Ningxia, Gansu etc. The extension was supported by World Bank loan introduced. The technology meets the needs of improving the low-productivity alkalinized cropland and has bright application prospect.

Classification

Land use problems

High groundwater level and soil alkalinization.

Land use	Climate	Degradation	SWC measure
			
Annual crop: cotton, maize etc.	arid	Soil salinization	Engineering measure

Technical function/impact

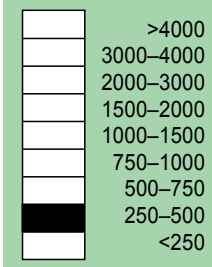
main: - control the groundwater level
- regulate soil moisture content
- improve the physical and chemical properties of the soil

secondary: - reduce land occupation
- facilitate farming operation
- facilitate maintenance

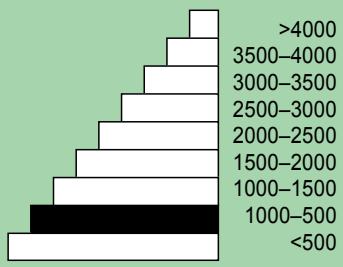
Environment

Natural Environment

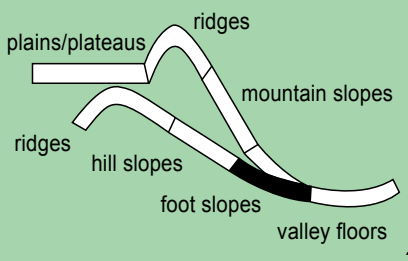
Average annual rainfall (mm)



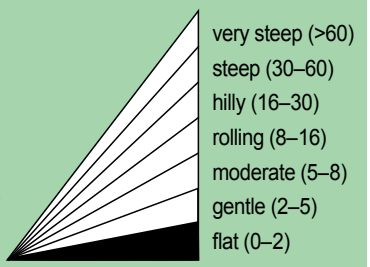
Altitude (m a.s.l.)



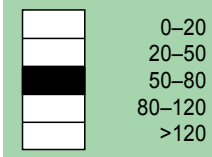
Landform



Slope (%)



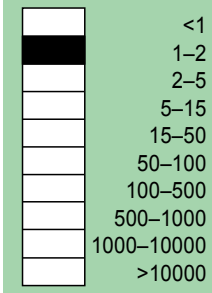
Soil depth (cm)



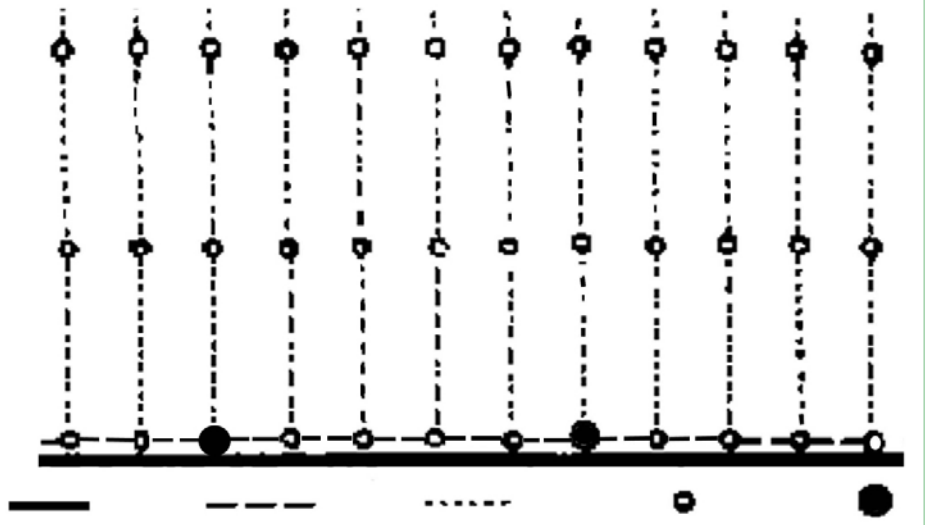
Growing season: 180 days in succession, from May to October
Soil fertility: low
Soil texture: moderate (loamy)
Surface stoniness: none
Topsoil organic matter: moderate (1%-3%)
Soil drainage: moderate
Soil erodibility: low

Human environment

Mixed land per household (hm^2)



Land use rights: individual
Land ownership: state or collective
Market orientation: for public use
Level of technical knowledge required: moderate to technical extensionists and land users
Importance of off-farm income: less than 10% of the total income.



Layout sketch of field hidden pipe dranage system

Technical drawing

The field underground drain pipe system consists of pump well, inspection well, field pipe, water collection pipe and subsidiary field ditches. The field pipe spacing is determined by the pipe burial depth, soil water-penetrating capability, and drain standards.

Drawing by Tian Changyan

Implementation activities, inputs and costs

Establishment activities

1. Hidden pipe line alignment.
2. Hidden pipe installation.
3. Inputs of the construction: machineries and fuel, pipe and filtering materials.

Establishment inputs and costs per hm²

Inputs	Costs (US$)	% met by land user
Technology and machineries	160	0%
Labor	200	100%
Pipes and filtering materials	80	0%
Fuels for machines	50	100%
accessory facility (monitor well)	110	100%
TOTAL	600	60 %

Maintenance/recurrent activities

1. Periodical maintenance repair to the installed hidden pipe facilities.
Conduct silt sluicing regularly to the pipes, twice a yeat.

Maintenance/recurrent inputs and costs per hm² per year

Inputs	Costs (US$)	% met by land user
Labor	40	100%
Equipment: machineries and fuel	10	100%
TOTAL	50	100 %

Remarks: Labor cost calculated based on the local standand.

Assessment

Acceptance/adoption

-. All farmer households accept this technology actively.
-. Most households suggest that government apply for loan investment for the construction.
-. Government takes the responsibility for extension through meetings, demonstrations and incentive measures etc.
-. The incentive measures refer to subsidy in kind of materials used for the project.

Benefits/costs according to land user

Benefits compared with costs	Short-term	Long-term
establishment	positive	positive
maintenance/recurrent	positive	positive

Impacts of the technology

Production and socio-economic benefits

+ + +	Contribute to cropland protection and maintain the farmland production safety
+ +	Improve land use efficiency for mechanized field operations
+	Raise crop produciton

Production and socio-economic disadvantages

− − −	High establishment cost

Socio-cultural benefits

+ +	Knowledge of drainage technology

Socio-cultural disadvantages

	None

Ecological benefits

+ + +	Prevent land salinization
+ +	Prevent flooding and waterlogging

Ecological disadvantages

	None

Off-site benefits

	None

Off-site disadvantages

	None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
One time investment for long benefit → Enlarge technical application area.	High initial one-time investment → Application for low-interest loan and mobilize financing from individuals and enterprises.
Economical land use → Pipe layout design suitable for local environmental features.	High consumption of building materials → More inputs for technology and studies for developing alternative materials.
Easy maintenance → Strengthen technical training to construction technicians and workers.	

Key reference(s)

[1] Wan Shenggan, Sha Jinxuan, Dong Feng etc. Application of key technologies of hidden pipe drainage in Yinbei irrigated farming area of Ningxia, water conservancy and hydropower technologies, 2002(33):57-59.
[2]Yang Yonggui. Some problems attentive for the hidden pipe drain project design. Ningxia agriculture college journal, 2003, 24(4):111-112.
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[4] Liu Ziyi. Applications of the hidden pipe drain technology at inland arid areas of Xinjiang. Water Conservancy and Micro Hydropower, 1994(7):9-12.
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Contact person(s)

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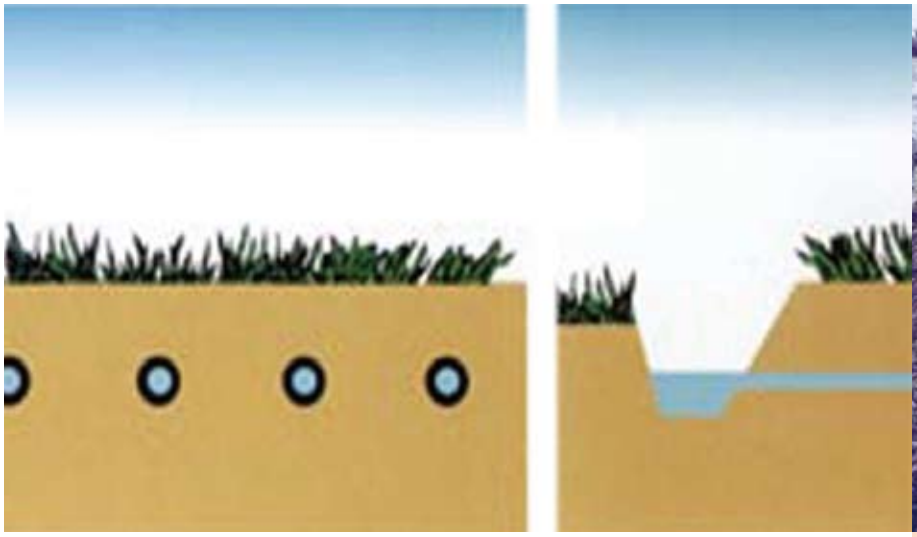


Left: Profile sketch of hidden pipe drain. Photo from http://www.cnhydro.com/hc/picture/gcyy/pages/31_psd.htm
Right: Hidden pipe drain in installation. Photo from http://www.iwicn.com/view.jsp?id=3311

World Bank Project on Salinization Control by Hidden Pipe Drain

Production and Construction Crops of Xinjiang, China

To reduce groundwater level in farmlands, control and prevent secondary salinization, hidden pipe drain technology is carried out through World Bank loan project in line with national farmland protection policy.

The farmlands of Regiment 29, Division 2, the Xinjiang Production and Construction Crops practiced totally irrigated cropland production. Under the impact of climate, landform, topography and hydrological conditions, soil has high saline content. Due to the flooding irrigation method used in the past and aging of irrigation facilities constructed in 1950s, soil salinization has become so serious that the farmlands were under threat. Control and prevention of secondary soil salinization and effective utilization of cultivated land resource require introduction and construction of new irrigation and drainage system. Open ditch drainage was used for combating salinization by local residents; however, its function would fail in three to four years after construction owing to loose soil and flattened landscape. In the meanwhile, open ditch occupied a great deal of lands and restricted mechanic operation and maintenance, so that earth salinization remained unsolved.

Under the support by scientific and technological committee of Xinjiang Production and Construction Crops, Regiment No. 29 carried out an experiment of hidden pipe drain during 1985-1990 and proved its feasibility and rationality as well as positive effect in salinization control and management safety of cultivated land.

In 1985, Regiment 29 started the trial operation of underground drain piping system made up of corrugated tubes. Since 1987, the regiment introduced hidden pipe drain technology and corrugated tube production line from the Netherlands within framework of the World Bank loan project. By 1994, there were 783km long hidden pipeline laid to control drainage of 4300hm^2. The hidden pipe drain features small project volume, less land occupation, long service life and satisfactory effect in control over salinization and soil modification. However, it requires huge lump sum funds, so that its dissemination is restricted.

This technology has been well developed in other provinces of China. To suit hidden pipe drain technology development, China has developed large, medium and small ditch excavator and pipe laying machines, plastic corrugated tube, cement tube, tile tube and relevant construction machineries to furnish convenient condition for mechanic operation.

Location: Regiment No. 29, Agriculture Division No2 of the Xinjiang Construction Corps
Technology area: 43km^2
Land use: Cropland
Climate: Extremely arid
Continental climate: Warm temperate zone
WOCAT database reference: QA
Related technology: Drainage by Hidden Pipe for Irrigated Farmland
Compiled by: Tian Changyan, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Date: November, 2007

Editors' comments: The technology extension was dominated by the government with finances of World Bank loan and in forms of tests, demonstrations and technical training sessions. The technology has been proved very effective in prevention of waterlogging, soil salinization. It is a very suitable technology for dissemination in the arid areas with serious salinization in western China.

Problem, objectives and constraints

Problem

- High groundwater level.
- Serious soil salinization.
- Low land productivity.
- Lack of professional knowledge.

Objectives

- Control groundwater level.
- Improve the physical and chemical properties of soil.
- Raise land productivity.
- Protect the cropland.

Constraints addressed

Major	Specification	Treatment
Financial aspect	The technology application needs high one-time invest ment, farmers in lack of capital fund.	Government provides financial support.
Knowledge and technology	Lack of establishment technology and maintenance knowledge.	Organize technical demonstrations and training.

Participation and decision making

Target groups

Water resour- ce expert

Local govern- ment

Approach costs met by

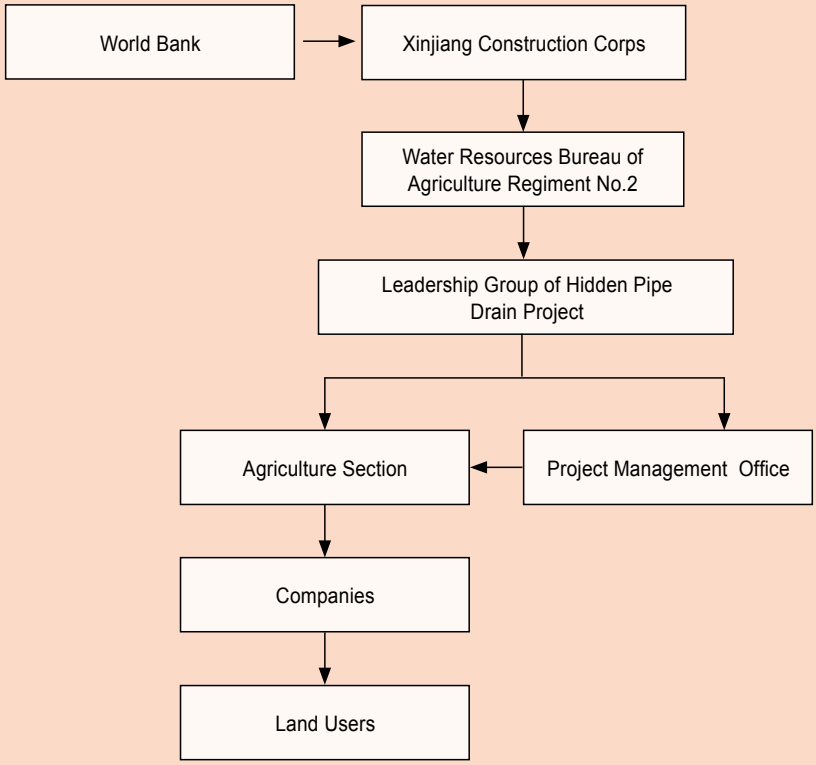
World Bank loan	40%
Raised by farmers	60%
TOTAL	100%

Decisions on choice of the technology: Local government.
Decisions on method of implementing the technology: Local government.
Approach designed by: Local water conservancy experts.

Community involvement

Phase	Involvement	Activities
Initiation	Active	Organized meetings, household interview visits.
Planning	Active	Participate in surveys.
Implementation	Active	Labor input.
Monitoring/evaluation	Active	Active collaboration with related staff.
Research	Active	Participate in related experiments, tests.

Differences in participation of men and women: Strong labor required, so more male labor is used.



Organogram

The hidden pipe drain project was mainly financed by the World Bank loan.

Extension and promotion

Training: Training is conducted in forms of study tours, lectures, brochures, on-the-spot demonstrations etc, with topics of alignment of hidden pipes, pipe installation, pipe silt sluicing etc. The training effect to technicians is better.

Extension: Technical extension is undertaken by the water resources bureau and the agricultural technical extension stations, in forms of meetings, household visits, on-the-spot lecturing etc.

Research: Researches of ecological, economic and social benefits of hidden pipe drain system is carried out by the science and technology committee of the division. The beneficiary households attend the related surveys by offering relevant information regarding operation and maintenance of the pipes.

Importance of land use rights: The land is state owned, but contracted for paid use by households; At the same time, the farmland is concentrated on large scale, so easier for unified programming and management.

Incentives

Labour: Farmers provide labor contribution as part of project investment.

Inputs: Pipe installation machineries, pipe material, filtration materials, wrapping materials are financed by World Bank loan, other material and transport expenses are covered by households.

Credit: World Bank loan.

Support of local institutions: The capacity building of the local water resources bureau is strengthened. The technology application has promoted application for more projects, which contribute to improve local water conservancy and soil improvement.

Long-term impact of incentives: The technology application project plays a long term positive role.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Site surveys: soil moisture and salt content, groundwater level.
Technical	Measurement and calculation: determination of pipe diameter, slope gradient, filter material water-penetration capability and stability.
Socio-cultural	Visit survey: technical level of agriculture management; acceptance level of new technologies.
Economic/production	Interview visits: crop production, income level.
Area treated	Statistical work: cropland area, pipeline length.
No. of land users involved	Statistical work: population, number of households.
Management of approach	Survey and report to management: pipe operation and maintenance.

Impacts of the approach

Changes as result of monitoring and evaluation: Following the adoption of the hidden pipe drain technology, the conditions regarding field groundwater level, soil water content, soil salt content were improved to certain extent, and the crop production was increased by 15% in average.

Improved soil and water management: The technology can effectively reduce groundwater level, regulate soil moisture, improve soil physical and chemical properties, transforming seriously salinized low production cropland into high yielding cropland.

Adoption of the approach by other projects/land users: the technology has been extended to areas with serious salinization in Ningxia, Gansu etc., but not in institutionalized manner.

Sustainability: If there is no project support, the technology application will be limited.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
One time investment for long time benefit → Application for project support.	High one-time investment for establishment → Application for low-interest loan and attraction of financing from individuals or enterprises.
Economical land use → Layout design of underground drain piping suitable for regional environmental features.	High consumption of building materials → Reinforced input in technology for development of new materials.
Cropland has been protected → Extend the hidden pipe drain technology.	High technical requirement for implementation → Strengthen training of technical designers and implementation workers.

Key reference(s)

[1] Wan Shenggan, Sha Jinxuan, Dong Feng etc. Application of key technologies of hidden pipe drainage in Yinbei irrigated farming area of Ningxia, water conservancy and hydropower technologies, 2002(33):57-59.
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[5] Jing Qinghua, Liu Xuejun. Performance monitoring of the hidden pipe drain project in Yinbei irrigated farming area of Ningxia, Irrigation and Drainage Journal, 2005, 24(1):45-49.

Contact person(s)

Tian Changyan, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences

Left: Mulched drip irrigation for planted cotton. Photo by Wang Yan
Right: Mulched drip irrigation for the *Populus alba* cv. Pyramidalis plantation. Photo by Liu Duohong

Mulched Drip Irrigation

Production and Construction Crops of Xinjiang, China

Use plastic film mulching and under-film drip irrigation to the plantation of dates, apricot and other cash crop species to overcome sandlot water leakage and for the purposes of water conservation, increased forestation survival rate, prevention of wind harm, sand fixation in areas near Taklimakan Desert.

The demonstration plot is located in the south brink of Taklimakan Desert, where wind, desert, saline soil and drought are natural harmful factors to local economic development. The soil is mainly sandy one suffering from severe sandification. Regiment No.224 of Division No. 14 of Xinjiang Production and Construction Crops despite of the harsh natural conditions and the economic constrains has persis-tently engaged in environmental protection and sandification control by establishment of shelterbelt and economic forest, and great ecological and economic benefit has emerged.

Application of this technology can increase forest survival rate to produce significant benefits. Once forestation survival rate is higher than 85% and water saving comes to more than 40%. The water consumption for irrigation per mu is controlled within 450 cubic meters. Crop production is increased, with 200kg/mu production for Chinese dates (fresh).

Main technical steps: (1) In the outskirt of Pimo ecological demonstrative district, shelterbelt forest is lined up against the prevailing wind direction (westward and northward) at the width of 116m and in parallel with the prevailing wind at the width of 50m. (2) Inside the shelterbelts, “narrow belt and small grid” strip croplands are configured with standard strip land shelter forest established. The orchard grid may be configured per 250mx125m pattern and the main shelterbelt is arranged in 15-20 width perpendicular to the prevailing wind. The belts in parallel to the prevailing wind are configured in 10-15m wide in 5-8 rows. (3) Make full use of outstanding light and thermal resources at the project site to select good suitable horticulture species characterized by “being famous, special, superior and new”. In the meanwhile, grass should be planted under the forest and intercropping is maximized to add vegetation coverage for wind prevention, desert fixation, control of soil erosion, soil fertility improvement and fodder pro-duction. (4) Water conservancy facilities are constructed alongside the project implementation. Drip irrigation for orchard trees is set in 0.5m drip hole spacing, with the 16 mm inner diameter drip tubes, and a noz-zle rated flow at 2.8L/h (10m pumping head as rated pressure), and working head ranges from 8 to 20m. The tubing is of inbedded design. The rated irrigation for young fruit trees is 4.73 cubic meters/mu and irrigation cycle is 3days. During full fruiting season the rate is adjusted to 18.31 cubic meters/mu and the cycle is 3.5 days.

Location: Regiment 224, Moyu County, Hetan Prefecture, Xinjiang
Technology area: 6667km^2
SWC measure: Horticulture, engineering and management
Land use: Forest
Climate: Arid
WOCAT database reference: QT
Related approach: Mulched Drip Irrigation for High Efficiency Horticulture
Compiled by: Wang Dongjian, Chen Qiling, Liu Duo-hong, the Forestry and Horticulture Institute, Xinjiang Agriculture Reclamation Academy
Date: October, 2007

Editors’ comments: This technology has been widely adopted in Hetan prefecture of Xinjiang, playing signifi-cant role in improving the local ecological condition.

Classification

Land use problems

The local soil is sandy loamy soil that is seriously affected by wind, salinization, drought etc.

Land use | **Climate** | **Degradation** | **SWC measure**





Forest land | Arid | Wind erosion | Biological measure | Management measure

Technical function/impact

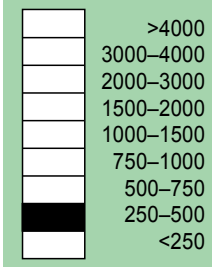
main: - improve water utilization efficiency
- fix drifting sand
- improve economic output
- reduce wind speed

secondary: - add vegetation cover

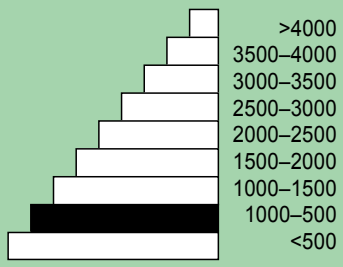
Environment

Natural Environment

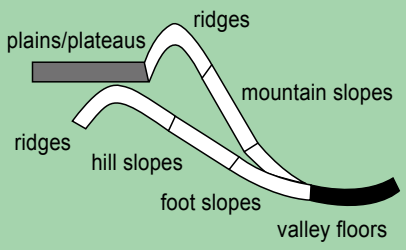
Average annual rainfall (mm)



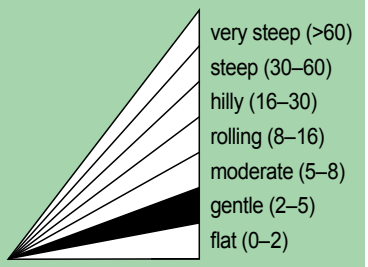
Altitude (m a.s.l.)



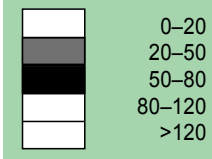
Landform



Slope (%)



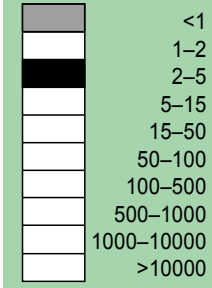
Soil depth (cm)



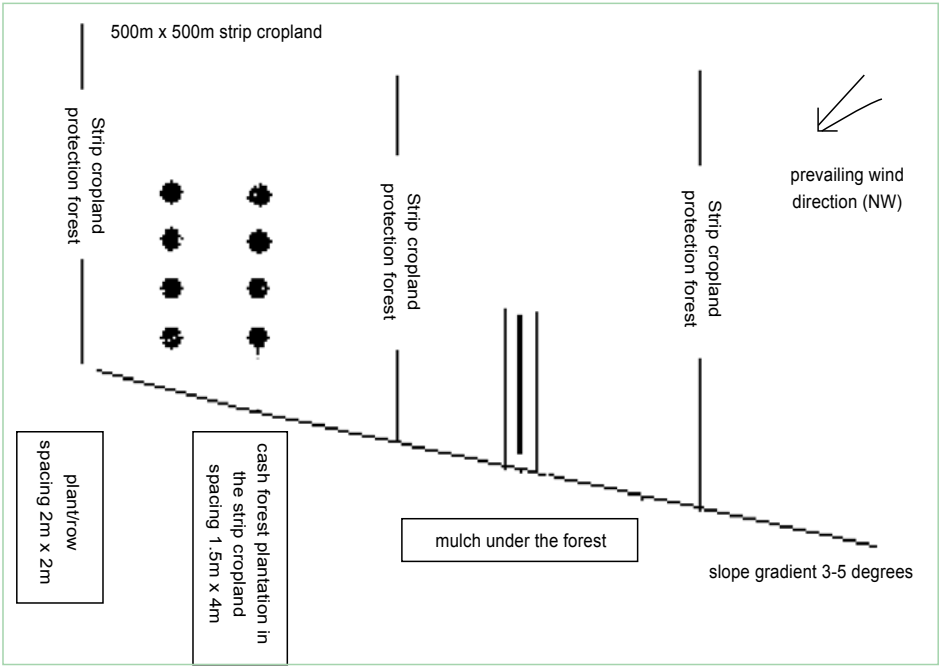
Growing season: 173 days in succession, from April to October
Soil fertility: very low
Soil texture: coarse (sandy)
Surface stoniness: none
Topsoil organic matter: moderate(1%-3%)
Soil drainage: moderate
Soil erodibility: very high

Human environment

Mixed land per household (hm^2)



Land use rights: individual
Land ownership: state
Market orientation: commercial
Level of technical knowledge required: high for field operation and for land users
Importance of off-farm income: less than 10% of the total income



Technical drawing

Spacing: cash trees are planted at spacing of 1.5m×4m inside the strip field;

Forest belt width: shelterbelt is 10 meters in 5 rows, planted around the strip field;

Slope gradien: 3-5 degrees;

Strip field size: 500m×500m;

Dominant wind direction: northwest wind.

Drawing by Chen Qiling

Implementation activities, inputs and costs

Establishment activities:

1. site preparation.
2. installation of the drip irrigation equipment.
3. planting of the seedlings.
4. establishment of the mulch.

Gravity drip irrigation is adopted, with equipment of material transportation vehicles, drip irrigation facilities, planting tools etc. for use during the implementation.

Establishment inputs and costs per hm²

Inputs	Costs (US$)	% met by land user
Labor	181	100%
Equipment	396	
- tractor, spade		0%
Materials	1319	
- drip irrigation equipment, plastic film		0%
Agricultural	723	
- seeds, fertilizers etc.		0%
TOTAL	2619	7%

Maintenance/recurrent activities

1. Shelterbelt forest tending management.
2. Orchard tree pruning, water and fertilizer management.
3. Irrigation system maintainence.

Gravity drip irrigation is adopted, with equipment of material transportation vehicles, drip irrigation facilities, planting tools etc. for use during the implementation.

Maintenance/recurrent inputs and costs per hm² per year

Inputs	Costs (US$)	% met by land user
Labor	34	100%
Equipment	11	0%
Materials	27	0%
Agricultural	141	100%
TOTAL	213	16%

Remarks: Input cost based on prevailing prices of the year 2003, calculated according to the actually happened or needed sums of labor, materials etc. US$1=RMB 8.3 Yuan.

Assessment

Acceptance/adoption

- All the households accepted the technology. With the corps military administration system, the water saving technology is heartedly accepted by the local residents.
- Half of the farmer households adopted the technology. Due to the aridness, the local water resource is very limited, so the water saving technology was appreciated.
- Incentives of subsidy, tax reduction, labor devotion etc. were adopted. Farmers accept the technology because of its effectiveness in water saving and alleviating the labor burden. Without these incentive measures, they had to seek other similar advanced technology.

Benefits/costs according to land user

Benefits compared with costs	Short-term	Long-term
establishment	neutral	neutral
maintenance/recurrent	very positive	very positive

Impacts of the technology

Production and socio-economic benefits

+ + +	Save water use by 40%
+ + +	Improve labor productivity and add staff income
+ + +	Solved the bottleneck problem of agricultural development in arid areas

Production and socio-economic disadvantages

– –	Relatively high initial investment
– –	White pollution

Socio-cultural benefits

+ + +	Promote people's water saving awareness and improve agricultural produciton level

Socio-cultural disadvantages

	None

Ecological benefits

+ + +	100,000 mu Gobi desert transformed into high quality orchard
+ + +	Reduction of disastrous weather days
+ +	Ecological plants were recovered
+ +	Living environment improved

Ecological disadvantages

	None

Off-site benefits

+	Disastrous weather days decreased

Off-site disadvantages

	None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Raise water retention capacty and economical water use → Adopt drip irrigation and mulching technologies.	Low mechanization level → Reinforce related researches.
Prevent soil sandification and fix shifting sand → Improve shelter protection forest network, use plastic film mulch to prevent site sand winnowing.	The technical operations cause white pollution → Vigorous studies in recovering the plastic.

Key reference(s)

[1] Ma Fuyu, Yang Jianrong, Zheng Xurong etc. Water saving agriculture development in Xinjiang. Xinjiang agricultural reclamation science and technology (supplementary edition), 2001.
[2] Shi Min, Song Jihui, Li Fang. Wide mulched, drip irrigated cotton cultivation technical guidelines. Xinjiang agriculture reclamation science and technology(supplementary edition), 2001.

Contact person

Wang Dongjian, Chen Qiling, the Forestry and Horticulture Institute, Xinjiang Agriculture Reclamation Academy. Tel: 0993-2553836, Email: Cql619@chinaacc.com

Left: Technicians demonstrating the mulched drip irrigation technology. Photo by Liu Duo-hong
Right: Mechanized plastic film mulching. Photo by Liu Duohong

Mulched Drip Irrigation for High Efficiency Horticulture

Production and Construction Corps of Xinjiang, China

In ecological-economic orchard development, mulched drip irrigation measures are taken to increase water utilization efficiency and forestation survival rate.

Hetan of Xinjiang is a county suffering from severe drought, short of water resource, and deteriorating natural environment. The traditional irrigation has low water utilization rate, and successful ecological-economic orchard project depends largely on water use efficiency. Drip irrigation technology can save water and plastic film mulching can conserve water to reduce water loss.

The technology is adopted to coincide with the strategic targets of changing the ecological condition of Hetan, increasing its technical level in desertification control, upgrading the local ecological industry development capacity and achieving ecological and economic benefits. It is also essential in enhancing the corps economic strength, maintaining social stability in Xinjiang and Hetan and promoting regional economic and social development.

This technology dissemination relies on the mandated implementation of administrative directives, with infrastructure funded from national treasury and bank loans. Farmers provide labor service to the project. The technology has been rapidly scaled up since the project launched in 2003.

The project implementation is funded by the state with counterpart funds provided by the corps. Financial support from the banks is obtained. So far RMB1 billion has be used for the implementation, in which 520 million Yuan of the water conservancy funds of the Ministry of Water Resources, 50 million of the Ministry of Agriculture, and 400 million by Development Bank and Italian Government. The unit cost is about RMB2000 per mu including expenditures on the ground and underground.

Stringent project management methods are adopted for project implementation. Tendering is carried out to ensure the success of construction. Upon completion, the project sites are contracted to individual households for operation under strict four-uniform policies, i.e. uniform land contracting, uniform production operation, uniform material supply and uniform product purchase.

Ancillary technical measures include dryland area drip irrigation technology, Chinese date dwarfing dense plantation technique, pollution-free cultivation technology, etc. These technologies can help increase production and assist the implementation of the mulched drip irrigation technology. In slack season technical training is conducted to farmers to increase their capability and awareness of the advanced technologies.

Location: Division No.224, Moyu county of Hetan Prefecture, Xinjiang
Land use: Forest land
Climate: Extremely arid
WOCAT database reference: QA
Related technology: Mulched Drip Irrigation
Compiled by: Wang Dongjian, Chen Qiling, Liu Duo-hong, the Forestry and Horticulture Institute, Xinjiang Agriculture Reclamation Academy
Date: October, 2007

Editors' comments: This technology has been widely adopted in Hetan prefecture of Xinjiang, playing significant role in improving the local ecological environment.

Problem, objectives and constraints

Problem

- Efficacy of the administrative orders. Extension of this technology mainly depend on the administrative means, i.e. unified planning and management is adopted to disseminate the technology.
- The inputs of early stage are costly. Governmental fund or bank loan are used to guarantee rapid technology extension.
- Limited water resources. Drip irrigation with mulch technologies can save and retain water, which will facilitate planting ecological-economic plantations on extended scale.
- Fix sand. During the establishment stage, the sand dust winnow, so the mulch technology plays the role of sand fixation.

Objectives

- Higher technical application rate,100% application of new technology
- Water saving. With this technology, 300 cubic meters water is saved per mu.
- Raise the survival rate. Due to the sand-fixing, moisture-retaining roles, the forestation survival rate is raised from original 50% to more than 85%.

Constraints addressed

Major	Specification	Treatment
Fund aspect	With the poverty and backwardness in Hetan Prefecture, lack of fund for technology implementation is a problem.	Apply for national project support or seek -support of related department.
Expertis	Located at remote place with unfavorable natural environmental, shortage of technical talent is another major problem.	Have more local talent trained and establish preferential policies to introduce talent.

Participation and decision making

Target groups


Land user


Decision maker

Approach costs met by

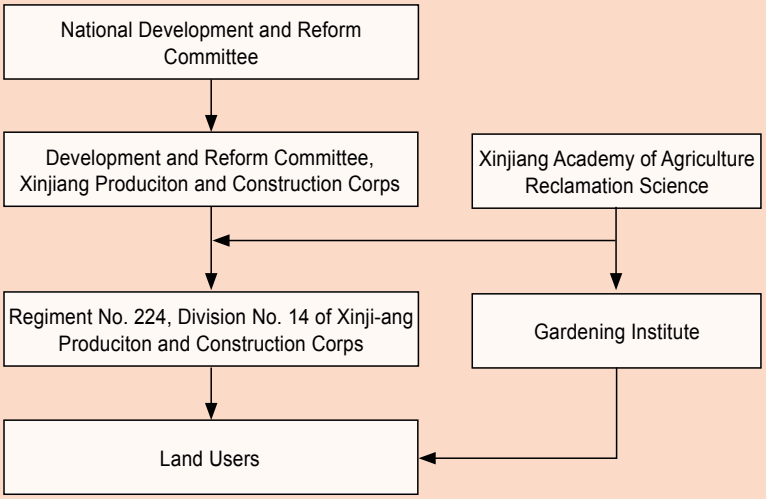
State financing	60%
Bank loan	40%
TOTAL	100%

Decisions on choice of the technology: The technology application was initiated by local agricultural bureau, improved and extracted by Xinjiang Land Reclamation Science Academy
Decisions on method of implementing the technology: Forestry experts and local technicians decide the technical route for the technology implementation.
Approach designed by: Mainly by experts of the Gardening Institute of Xinjiang Land Reclamation Science Academy.

Community involvement

Phase	Involvement	Activities
Initiation	No participation	
Planning	No participation	
Implementation	Interaction	Participated in the construction work of establishing mulch, forestation, installing pipelines.
Monitoring/evaluation	Passive	Feel passively the implementation outcomes and environmental changes.
Research	No participation	

Differences in participation of men and women: No difference.



Organogram

The National Development and Reform Committee (NDRC) allocates fund to finance the technology application with counterpart fund provided by DRC of Corps. The project design is made by Xinjiang Academy of Agriculture Reclamation Science, implemented by Regiment No. 224, Division No. 14. Checking acceptance was conducted by the Development and Reform Committee of the Corps, and Agriculture Bureau of the Corps when the project was completed.

Extension and promotion

Training: The training topics is the mulched drip irrigation technical application; the training forms are technical lectures, site agricultural meetings etc. The training effect to farming workers is better than the temporarily hired laborers.

Extension: : Training, site demonstration teaching, site actual operations etc. make the land users apply the technology correctly on their contracted land.

Research: The researches on cultivation technology, water and fertilizer management measures etc., are conducted mainly by Xinjiang Land Reclamation Science Academy.

Importance of land use rights: Land use right is contracted to farm workers, who are crucial for the technology implementation.

Incentives

Labour: Labour is devoted jointly by the Division Farm and farm workers. Piecework system is adopted for wage payment.

Inputs: Inputs include seed, seedlings and drip irrigation tube as well as tractors and spades etc. mostly provided by the Division Farm, and partially by farm workers.

Credit: Financed by foreign government loan at lower interest rate than the normal commercial loan.

Support of local institutions: Local government supports the project by policies and guidance, and in forms of providing advanced capital fund, demonstration, tax weaving and subsidy.

Long-term impact of incentives: The technology raised farm workers' awareness of technical application, and pushed the local technical extension progress.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	The factors of light, heat, water etc. And disastrous weather (through local meteorological stations).
Technical	Water saving rate, forestation survival rate, technical adoption rate, technical application accuracy (site investigation in autumn every year).
Socio-cultural	Improvement of people's awareness in saving water (by knowledge education and lecture sessions).
Economic/production	Unit area production, merchandising rate and staff average income (by data from the statistical department).
Area treated	Site survey and mapping.
No. of land users involved	Investigation and statistical work.
Management of approach	Implement management of militarized institutions with division, company, platoon, squad and group.

Impacts of the approach

Changes as result of monitoring and evaluation: No change.

Improved soil and water management: Yes, great improvement.

Adoption of the approach by other projects/land users: Yes.

Sustainability: Without long term support the land users will continue using this technology.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Rapid extension speed → Rely on administrative means guarantee the efficiency.	High inputs of establishment at early stage → Adopted Corps Division unified efforts for resolution.
Short construction time → High requirements to materials supply, manpower and technology.	Complicated operating procedures, so it is more difficult to learn the technology → Reinforce training to technical implementation level of the technicians and farmer workers.
High operational requirements in managing the ecological and economic forest → Only high profit can guarantee effective operation of the system.	

Key reference(s)

[1] Ma Fuyu, Yang Jianrong, Zheng Xurong etc. Water saving agriculture development in Xinjiang. Xinjiang agricultural reclamation science and technology (supplementary edition), 2001.

[2] Shi Min, Song Jihui, Li Fang. Wide mulched, drip irrigated cotton cultivation technical guidelines. Xinjiang agriculture reclamation science and technology(supplementary edition), 2001.

Contact person(s)

Wang Dongjian, Chen Qiling, the Forestry and Horticulture Institute, Xinjiang Agriculture Reclamation Academy. Tel: 0993-2553836. Email: Cql619@chinaacc.com

Left: Water cellars solving the drinking water problem of the farmer communities. Photo by Wang Yaolin.
Right: Water cellars used for water-saving irrigation. Photo by Chen Zhengbin.

Rainwater Cellars

Dingxi City of Gansu Province, China

Use courtyard, roof, road surface, slope, etc. as catchments to collect rainwater for underground water storage to future supply of cropland irrigation as well as the drinking water for human and livestock.

The demonstration site is located in mid Gansu, semi-arid gully area of the Loess Plateau, where either surface or groundwater is in great shortage. The annual precipitation is around 380mm with 60% concentrated in July, August and September in storm form. Low productivity of land and shortage of water for mankind and animal leads to poverty. Since 1980s the government has organized local people in mid Gansu to explore the utilization of water cellar to achieve coincided precipitation, i.e. collecting rainwater to solve water shortage and development dryland crops cultivation.

Water cellar is used mainly for interception of rainwater to supply water for human and livestock as well as irrigation of crops. The cellar is comprised of the cellar body and ancillary facilities, including catchments area, delivery facility (ditch, silt tank, stain interception grate, inlet pipe, cellar opening and irrigation equipment). In general, water cellar is designed to 20-30m^3 in capacity. The catchment should be chosen at hillside, road surface, courtyard, roofing, greenhouse roof, etc. For the location selection, considerations should to given to site landform and geological conditions and not in proximity to ditch or trench banks, large tree stumps but close to farmland to maximize the possibility of self-flowing irrigation. In consideration of drinking water safety, the cellar should be built far from livestock sheds and toilet to prevent contamination. Silt tank is 2-3m wide, 1m deep and 2-3m away from cellar opening, and higher than water cellar inlet. Dirt interception grate should be installed 0.5m higher than the base of the silt tank pond and upstream of the inlet. The platform of the water cellar should be 0.3-0.5m high above ground. In Anding, the concrete cement sphere type water cellar is more often adopted, with the cellar vault/wall of 10cm and base of 20cm thick. At the demonstration site, the inner wall used to be lined with red puddle as an old fashion but now in concrete cement for base and lined with cement and mortar. The water for irrigation does not need special treatment, but drinking water does. Irrigation is done by pumping for watering by ditches flowing to the farmland, hole watering or drip irrigation.

Since mid 1990s, the water cellar has expanded gradually. The 1-2-1 rainwater collection project (each household has 1 catchment, 2 water cellars and 1 patch of courtyard cashcrop forest) has played significant role in the technology dissemination and poverty alleviation. Since 2000, water cellar function has been further extended toward multifunction for livestock raising, farmland/forest land irrigation and so forth, and greater economic and social benefits are captured by its combination with greenhouse development. Plastic film greenhouse roof was used as the catchment and two water cellars (30 cubic meters capacity for each) were set for each greenhouse. In combination with other technologies of mulched ditch irrigation or drip irrigation, water resource utilization has been tremendously increased. The technology has thereby triggered industrial restructuring as outstanding pilot sites for high benefit agricultural development.

Location: Anding District of Dingxi City, gansu Province
Technology area: 3638.7km^2
SWC measure: Engineering
Land use: Farmland
Climate: Semi-arid
WOCAT database reference: QT
Related approach: Rainwater Cellars
Compiled by: Wang Yaolin, GEF/OP12 Project Management Office, Gansu Sand Control Research Institute; Chen Zhengbin, Forestry Bureau of Anding District, Dingxi City
Date: September, 2007

Editors' comments: The water cellars for rainwater collection and water-saving irrigation at semiarid and semi-humid arid areas of Gansu Province have demonstrated tremendous role in solving the problems of human/livestock drinking water supply, developing dryland agriculture, soil and water conservation, ecological recovery etc. Now the water cellar technology application is developing rapidly in the arid and water deficient areas of Shaanxi, Shanxi, Inner Mongolia, Ningxia etc.

Classification

Land use problems

Low precipitation, deficient groundwater, arid and short of water supply; rainfall in form of storms to form runoff arousing serious soil and water erosion; low and unstable land productivity because of aridness and soil infertility.

Land use	Climate	Degradation	SWC measure
			
Wheat,maize, and potato	Semi-arid	Water erosion	Mechanical measure

Technical function/impact

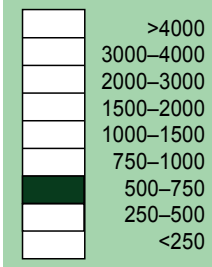
main: - intercept the runoff
- solve the drinking water problem for humans and livestock
- serve supplementary irrigation of the cropland

secondary: - promote the development of dryland agriculture
- improve the local villagers' living standard

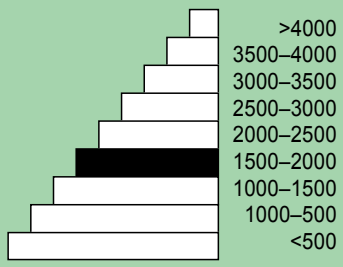
Environment

Natural Environment

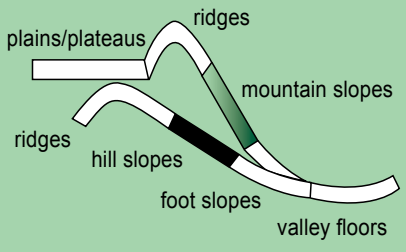
Average annual rainfall (mm)



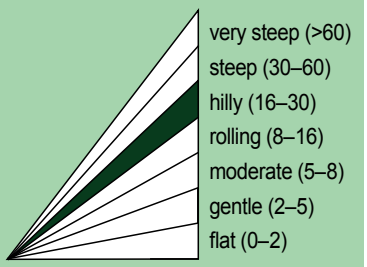
Altitude (m a.s.l.)



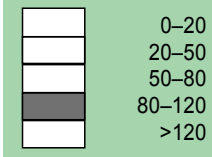
Landform



Slope (%)



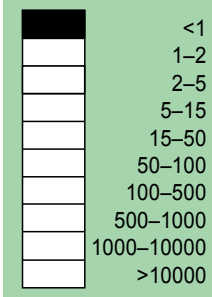
Soil depth (cm)



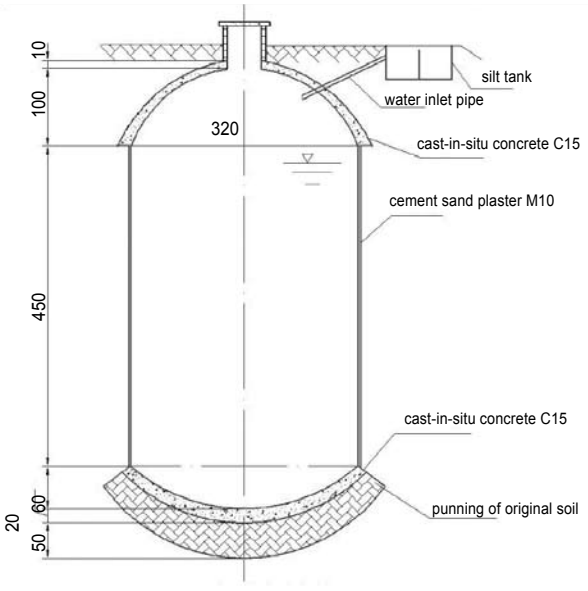
Growing season: 140 days in succession, from May to October
Soil fertility: low
Soil texture: thin (clay)
Surface stoniness: none
Topsoil organic matter: moderate (1%-3%)
Soil drainage: moderate
Soil erodibility: high

Human environment

Mixed land per household (hm^2)



Land use rights: individual
Land ownership: state or collective
Market orientation: mixed, for self use or for selling
Level of technical knowledge required: moderate to technical extensionists and land users
Importance of off-farm income: 10%-50% of total income



Profile of a 40 cubic meters cement-shell water cellar

Technical drawing

Structure of the cylinder type water cellar (40m^3).

Notes:

1. specifications in cm
2. dry unit weight of rammed lime earth for the cellar base no less than 1.65g/cm^3
3. cellar top and base built with concrete cement of 150#

Implementation activities, inputs and costs

Establishment activities

1. Identification of cellar location, by considering the geological condition such as easier water collection.
2. Construction of water cellar capping. Dig the earth into an arch shape pile, and conduct lining with concrete cement, steel bar, sand, gravel by reserving the cellar opening about 70-80cm in diameter.
3. Dig the earth downward from the cellar opening according to the designed depth and width.
4. Building the cellar body. Use concrete cement and sand for lining of thickness about 15cm.
5. Building of cellar base. Use cement, sand and steel bar for lining of the thickness about 20cm.
6. Antiseepage treatment. Use sanded cement grout at the ratio 1:2 for treatment of cellar inner wall and footwall.
7. Construction of the cellar platform. Build cellar platform with bricks, cement and sand. Cover the opening with a cellar cover.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
Labor	140	100%
Steel bar (20kg)	26.7	100%
Sand，gravel (7m^3)	33.3	100%
Concrete cement (1ton)	40	0%
Bricks (200 pieces)	5.3	100%
Transportation	26.7	100%
TOTAL	272	85%

Maintenance/recurrent activities

1. Clear the water channel prior to rainfall. Close the water inlets immediately once the cellar is full to avoid collapse due to water overburdening the seepage protection.
2. Dredge regularly the sediments of the cellar.
3. Disinfect the stored rainwater if for drinking water of human or livestock.

Maintenance/recurrent inputs and costs per hm^2 per year

Inputs	Costs (US$)	% met by land user
Labor	23.3	100%
Equipment		
Materials		
Other	2.67	100%
TOTAL	25.97	100%

Remarks: Labor calculated at the local prevailing price of 2007 of 35RMB Yuan per person day. Exchange rate: US$1=RMB 7.5 Yuan.

Assessment

Acceptance/adoption

- All farmer households accept the technology actively.
- Most household adopted the technology through project support while other households invested by themselves for the construction.
- Government takes the responsibility for extension, through convening meetings, demonstrations as well as incentive measures etc.
- The incentive measure is in form of subsidy of construction materials.

Benefits/costs according to land user

Benefits compared with costs	Short-term	Long-term
establishment	negative	positive
maintenance/recurrent	positive	positive

Impacts of the technology

Production and socio-economic benefits

+ + +	Solve the human and living stock drinking water problem
+ + +	Improve crop production
+ + +	Improve rainwater utilization rate

Production and socio-economic disadvantages

–	Short term economic burden

Socio-cultural benefits

+ +	Add knowledge of soil and water conservation and agriculture
+ +	Improve capacity building of the communities

Socio-cultural disadvantages

	None

Ecological benefits

+ + +	Intercept runoff and conserve soil and water
+ + +	Improve moisture and nutrient condition of the soil

Ecological disadvantages

	None

Off-site benefits

+ +	Reduce silt inflow of the downstream

Off-site disadvantages

–	Runoff decease of the downstream

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Intercept and retain runoff and reduce soil and water losses → Continuous extension for wider coverage.	High initial establishment cost → Seek more project support.
Supplementary irrigation to the cropland for higher production → Integrate with conservation farming for more extensive benefits.	

Key reference(s)

Wang Lin. Water cellar Construction technology for rainwater collection and water-saving irrigation in the mountainous areas. Gansu water conservancy and hydro power technology, 2002, 38(4).

Contact person(s)

Wang Yaolin, GEF/OP12 Project Management Office, Gansu Sand Control Research Institute. Tel: 0931-8412816. Email: wangylgs@126.com

Left: rainwater catchment experiment. Photo by Wang Yaolin
Right: rainwater cellar used for cropland irrigation. Photo by Wang Yaolin

Rainwater Cellars

Dingxi City of Gansu Province, China

Government takes the lead and propelled by project, the rainwater collection for irrigation technology scales up by demonstration.

Dingxi County of Gansu Province is short of water resource. There is an old saying “It’s hard to exchange a cup of water for a cup of oil in Anding of Dingxi”. During drought years, drinking water became a crisis and people had to walk dozens of miles to get water. With no self-relief capacity the local people live a hard life. To resolve water shortage, the most realistic method is to tap into the potential of local precipitation.

Under the support of Gansu provincial government, researches on rainwater collection were conducted during period from 1988 to 1992 and water cellar technology was proven technically and economically feasible with its functions in preventing erosion, developing arid cropland and ecosystem recovery.

In 1994, the government disseminated water cellar technology in the northwestern part of the county covering 14 townships and 4376 households. After completion, the drinking water supply problem was mitigated for 22,000 people and 8700 animals. In 1995, a severe drought hit Gansu and provincial government immediately initiated “1-2-1” rainwater Collection Project, under which the government supplied cement and the local people provided sand/stone and labor to build water cellars. According to this project each household should build one water catchment with an area of100m2 made by concrete cement and two water cellars and one backyard cash-crop forest. By the end of 2000, total of 57800 households involved in the project to provide drinking water to 60,900 people and 333,900 heads of livestock. In addition, dryland farming has seen great development. Since 1996, water cellar technology has been diversified and evolved. The water collection fields has extended from roof and courtyard to road surface, ditch, hillside, land brink, etc and the application has been widened to scale livestock farming, spot watering and conservation irrigation of farmland based on the achievement of “1-2-1” rainwater collection project. Moreover, water cellar technology has been gradually combined with greenhouse production, tourism agriculture, etc to form a development model integrating rainwater conservation irrigation, dryland farming and improved livelihood standard.

The dissemination approaches include trial operation, demonstration, training, household visit for publicity, media (TV), technical handouts, posters. The key organizer of the extension is the water resources bureau of Anding District as well as the township government. They called villager meetings to determine the supportive policies for the farmers who were about to build the water cellars. The farmers hired technical workers to construct the water cellars. Farmers may be voluntary promoters of the technology by spreading the advantages of water cellars. The government provided each household with one ton of cement free of charge (about RMB300) with the remainder of other materials, labor and shipping cost covered by the farmers. The locals have realized the importance of the project so some have built water cellars at their own cost. In 2007, donations for water cellar construction reached Anding and were allocated in kind (one ton cement) to the farmers through the resolution passed at village meeting on a case by case basis.

Location: Anding District of Dingxi City, Gansu Province
Land use: Engineering
Climate: Semi-arid
WOCAT database reference: QA
Related technology: Rainwater Cellars
Compiled by: Wang Yaolin, GEF/OP12 Project Management Office, Gansu Sand Control Research Institute; Chen Zhengbin, Forestry Bureau of Anding District, Dingxi City
Date: September, 2007

Editors’ comments: rainwater cellar technology is extended by the government through project incentives and in forms of demonstrations, training etc. This technology is one major measure for the arid and water deficient areas to solve the problems of drinking water, soil and water losses, poverty and agricultural development. As a very suitable technology in the arid areas, it has been widely extended in the dry mountainous areas in northwestern China.

Problem, objectives and constraints

Problem

- Lack of effective grass-roots organization.
- Backward economy and lack funds.
- Farmers in lack of the knowledge of water cellar establishment and management.
- Short of drinking water for human and domestic animals.

Objectives

- Establish a extension mechanism that promotes sustainable development and involves farmers participation.
- Improve the farmers' knowledge about rainwater utilization.
- Strengthen farmer participation and their confidence in overcoming difficulties.
- Solve drinking water problem.
- Eliminate poverty.

Constraints addressed

Major	Specification	Treatment
Fund shortage	Farmers cannot afford water cellar construction.	Governmental financial assistance, social public assistance.
Knowledge/technology shortage	Short of knowledge of rainwater high efficiency utilization and related agricultureal technology.	Demonstration and training.

Participation and decision making

Target groups


Decision maker


Land user


SWC expert

Approach costs met by

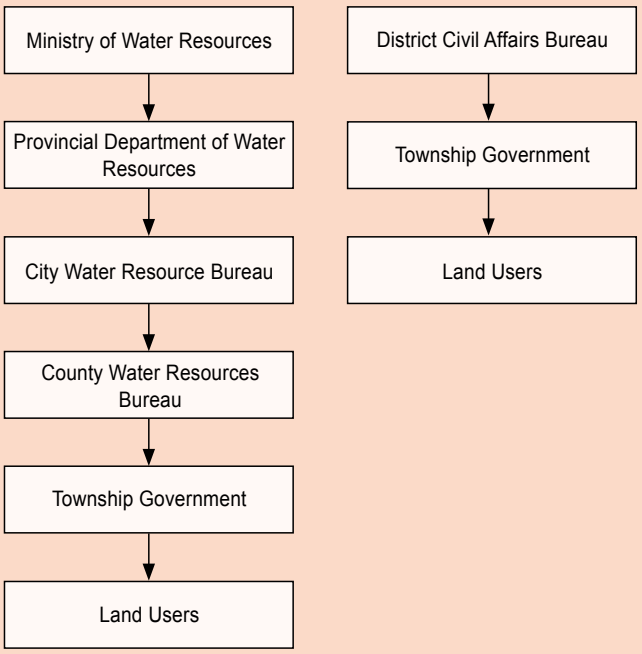
Government	15%
Local funds	85%
TOTAL	100%

Decisions on choice of the technology: Land users and decision makers.
Decisions on method of implementing the technology: Land users or village leaders decide to build water cellars.
Approach designed by: National and local SWC experts.

Community involvement

Phase	Involvement	Activities
Initiation	Active	Meetings, household visits.
Planning	Active	Participate in the survey and site location arrangement.
Implementation	Active	Labor input for technological implementation.
Monitoring/evaluation	Active	Observation, collaboration with the survey of the technicians.
Research	Active	Participate in the surveys.

Differences in participation of men and women: Strong labor is required, so undertaken mainly by male laborers.



Organogram

Most of the water cellar projects are financed by the projects of Ministry of Water Resources, with a small amount by public donations.

Extension and promotion

Training: The training is conducted in the forms of meetings, lectures, publicity brochures, site demonstrations. The contents are: water cellar building and management, irrigation etc. The training effect to farmers is satisfactory.

Extension: Extension work is undertaken by county water resources bureau and the agricultural technical extension station, and in the forms of meetings, publicity into households, site explanations etc.

Research: The research is conducted by provincial level researchers on the ecological, economic, social benefits of the water cellars, mainly.

Importance of land use rights: The land use right belongs to land users, and land use right does not affect technology implementation.

Incentives

Labour: Labor force is not paid.

Inputs: Concrete cement supplied free of charge by project or government, and all other materials and related traffic expenses covered by land users.

Credit: Credits are sometimes used, with interest rate similar with that of commercial loan.

Support of local institutions: The technology application strengthened the capacity building of the local water resources departments. Application of the technology helped other projects related to water conservancy and poverty reduction.

Long-term impact of incentives: The long-term impact of incentive is positive.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Site survey on water storage.
Technical	Site measure of irrigated area.
Socio-cultural	Interview visit, improvement of farmers' knowledge and technology.
Economic/production	Crop production, income, by site visits.
Area treated	Survey and calculate the number of villagers that adopt the technology.
No. of land users involved	Survey the number of households that adopt the technology.
Management of approach	Township government conducts survey annually about water cellar use conditions and report to the higher level.

Impacts of the approach

Changes as result of monitoring and evaluation: The technology itself has not evolved from sole water cellar development to an assembled technology with others. The financial resources o support water cellars have been changed from sole government to social funds, moreover, the farmers would actively asks for building water cellars.

Improved soil and water management: The technology intercepts runoffs, solves deficiency of water resources, and raises land productivity.

Adoption of the approach by other projects/land users: It has been adopted extensively by neighboring provinces. Chinese Women's Federation has initiated the public welfare program named "Mother's Water Cellar" in northern China.

Sustainability: Insufficient project financial aid will affect the technology application.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Solve the problems of aridness and drinking water for human and livestock → Continued project support.	High investment for technology adoption → Use of micro-credits, optimized use of farming technology for high benefit agriculture.
Strong extension mechanism → Further strengthen the role of technical extension organizations.	Weak monitoring and evaluation → Establish participatory monitoring and evaluation mechanism.
Improve farmer's life → Develop dryland agriculture industry.	

Key reference(s)

Shang Xinming et al. Rainwater collection and utilization and the rural economic development in central Gansu province. Arid Area Agricultural Studies, 1999, 17(2).

Contact person(s)

Wang Yaolin, GEF/OP12 Project Management Office, Gansu Sand Control Research Institute

Left: Hole-digging at the rooting of Haloxylon ammodendron for inoculation of Cistanche deserticola. Photo by Tian Yongzhen
Right: Cistanche deserticola growth from the root of Haloxylon ammodendron. Photo by Tian Yongzhen

Artificial Inoculation of *Cistanche deserticola* to *Haloxylon ammodendron*

Alashan League of Inner Mongolia, China

Inoculation of *Cistanche* deserticola to the roots of *Haloxylon* ammodendron to cultivate *Cistanche deserticola* product.

Alashan League is located in the arid highland Gobi desert of western China, with 850-1500m in elevation, 7.4-8.8℃ annual mean temperature, 40-200mm annual precipitation, 2600-3800mm of annual evaporation; soil types are of sierozems, grey-brown desert soil and aeolian soil. Desert plants *Reaumuria trigyna* Maxim, *Zygophyllum xanthoxylum, Sorbaria sorbifolia, Artemisia, Haloxylon ammodendron, Calligonum,* etc. sparsely dominate the vegetation. The local economy largely relies on traditional livestock grazing with low returns, and the local people live a hard life. Overgrazing places a big pressure on ecosystems. Therefore, replacing the low-return singular economic production pattern with multiple sustainable development patterns is a priority.

Cistanche deserticola is a parasitical plant to *haloxylon ammodendron* roots and a valuable Chinese medicinal herb. With the development and utilization of *Cistanche deserticola* health keeping products, the supply falls behind the ever-increasing market demand. *Cistanche deserticola* grows naturally in disperse manner and harvesting the wild plant is hard and will cause soil and water losses. Artificial plantation not only can develop *Cistanche deserticola* business to meet the demand for herb market, but also promote ecological balance by rejuvenating *Haloxylon ammodendron* stands.

Focal points of the technology: (1) soak Grade I or II *Cistanche deserticola* seeds in 500ppm ABT 3 rooting powder for 30min and use nutrition induction method for inoculation; (2) carry out inoculation in April and May. Dig a hole of the size 60cm in length, 30cm in width and 50cm in depth about 50-60cm away from the *Haloxylon ammodendron* trunk, and apply 1kg fermented humus manure and 10-15kg water for each hole. Identify healthy capillary roots and place 5-10 *Cistanche deserticola* seeds in its proximity and backfill the soil; and (3) harvest *Cistanche deserticola* in three years by using non-metal tools for excavation. In digging operation, keep the inoculation parasitic plate intact and replace it to roots in a slightly deeper location and then cover with soil.

The technology resolved the basic technical issues in the inoculation especially by using innovative nutrient induction inoculation method for increased operational success. Alashan is a suitable region for growth of *Haloxylon ammodendron* which has a wide natural distribution. There are also planted *Haloxylon ammodendron* and areas suitable for more plantations, making the region good for *Haloxylon ammodendron* and *Cistanche deserticola* development. The technology dissemination has high importance to increasing the technological level of key forestry programs such as the conversion of cultivated land conversion forest, restructuring local industrial of agriculture and animal husbandry, and promoting local economic development, and resource development and management.

Location: Alashan league, Inner Mongolia
Technology area: 1500km^2
SWC measure: Agronomy /vegetation
Land use: Forest
Climate: Arid
WOCAT database reference: QT
Related approach: *Cistanche deserticola* Inoculation Extension Supported by Research
Compiled by: Tian Yongzhen, Alashan LeagueForestry Research Institute, Inner Mongolia; Tianlü, Inner Mongolia Forestry Monitering and Design Academy
Date: August, 2007

Editors' comments: The technology of *Cistanche deserticola* inoculation in arid desert area has been a successful model. It is an advanced, mature and easily operable technology with leading technological level in China. With its features of being simple and labor saving, it is suitable for large-scale application. Dissemination of this technology will have high significance for the well-being of local farmers, herdsmen and forestry staff as well as the ecological protection.

Classification

Land use problems

Low vegetation cover, severe wind erosion, barren soil, aridness, fragile ecological condition.

Land use	Climate	Degradation	SWC measure
			
Forest land	Arid	Wind erosion	Biological measure

Technical function/impact

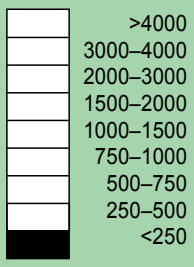
main: - promote industrial restructuring and desert industry development
- contribute to environmental protection by restoring vegetation in desert areas

secondary: - increase farmer's income

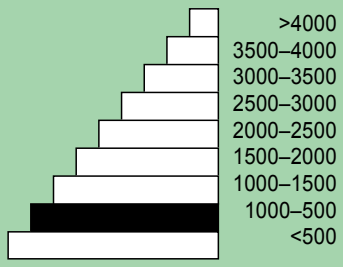
Environment

Natural Environment

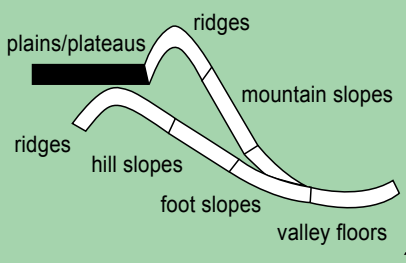
Average annual rainfall (mm)



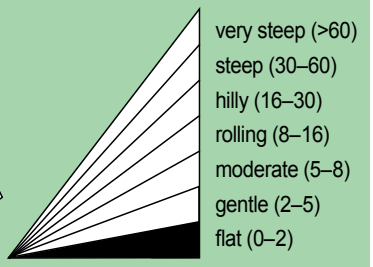
Altitude (m a.s.l.)



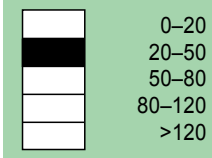
Landform



Slope (%)



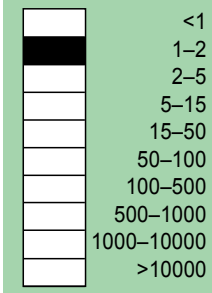
Soil depth (cm)



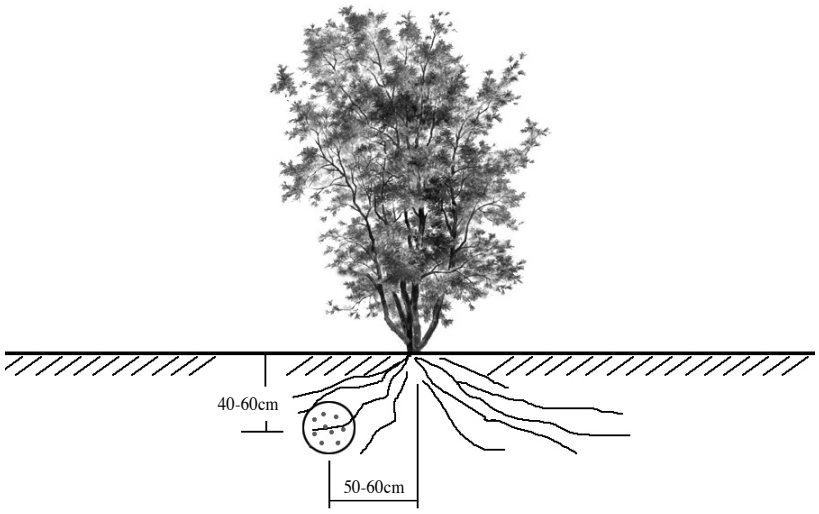
Growing season: 180 days in succession, from April to September
Soil fertility: very low
Soil texture: coarse (sandy)
Surface stoniness: moderate
Topsoil organic matter: moderate(1%-3%)
Soil drainage: moderate
Soil erodibility: high

Human environment

Mixed land per household (hm^2)



Land use rights: collective
Land ownership: state
Market orientation: mixed
Level of technical knowledge required: moderate to technical extensionists and low to the land user
Importance of off-farm income: less than 10% of the total income



Cistanche deserticola inoculated to Haloxylon ammodendron

Technical drawing

Dig a hole of 20-30cm in diameter, 40-60cm in depth, and 50-60 cm away from the *Cistanche deserticola* truck for inoculation. The inoculation time is from April to May. For each *Cistanche deserticola plant*, one or two holes can be made for inoculaiotn. For each inoculation hole, apply 1 kg fully fermented organic fertilizer, and 10-15 kg water.

Drawing by Li Minyu

Implementation activities, inputs and costs

Establishment activities

1. Use Grade I, II seeds of *Cistanche deserticola*, and soak in 500mg/L ABT(3)rooting power for 30 minutes. Nutrient induciton incoculaiton method is adopted.
2. The inoculation is conducted 50-60 cm away from the truck of *Haloxylon ammodendron*, and at 40-60 cm depth, from April to May.

Establishemnt time: 3 years.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
Labor	54.9	100%
Equipment		
- tractor, water trasnport vehicles	18.3	0%
Materials		
- *cistanche deserticola* seeds, culture solution etc.	18.3	0%
Agricultural		
- pesticide, fertilizer	18.3	0%
TOTAL	109.8	50%

Maintenance/recurrent activities

1. Specialized staff for maintainance tending against livestock browsing and human damage.
2. Prevention and conrol of pests and diseases.

Maintenance/recurrent inputs and costs per hm^2 per year

Inputs	Costs (US$)	% met by land user
Labor	3.7	100%
Equipment		
Moter vihile	1.8	100%
Materials		
- fuel, maintainence etc	1.2	100%
Agricultural	6.7	100%
TOTAL	13.4	100%

Remarks: annual maintainence cost at US$1463.4 (for 400hm^2.); exchange rate US$1=RMB8.2yuan.

Assessment

Acceptance/adoption

Benefits/costs according to land user

During the project implementation, the contracting arrangement is adopted by linking the contractor's income with the project operational benefit, which significantly motivated the enthusiasm of the land managers.

Benefits compared with costs	Short-term	Long-term
establishment	neutral	very positive
maintenance/recurrent	very positive	very positive

Impacts of the technology

Production and socio-economic benefits

+++ High benefit/cost ratio, short income generation cycle (harvest starts in 3 yrs after inoculation), high profitability

++ Contribute to the poverty alleviation of the locality

++ Contribute to industrial restructuring of the local agriculture and animal husbandry

Production and socio-economic disadvantages

None

Socio-cultural benefits

++ Promote institutional capability building

++ Extend scientific knowledge and improve local people's technological level

Socio-cultural disadvantages

None

Ecological benefits

++ Effectively promote the rejuvenation of the natural *Haloxylon ammodendron* stands and expansion of forest plantation

++ Combat sandification for improved regional ecological condition

Ecological disadvantages

−− The inoculation and harvest digging lead to some vegetation loss and soil and water erosion

− Result in some nutrient loss and therefore low growth to the parental plants of *Haloxylon ammodendron*

Off-site benefits

\+ Promote the development of the neighboring and related desert industries

Off-site disadvantages

None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Simple inoculation operation for easy grasp of the technology→ Gradually develop mechanized operation.	Pit digging leading to tosoil and water erosion→ Timely backfilling of the soil and spraying of water on earth surface.
Saved use of seeds and high success rate of inoculation→ Improve the genetic quality through genetic improvement efforts.	Nutrient loss and therefore low growth to the parental plants of Haloxylon ammodendron → Adequate nutrient supplementation.

Key reference(s)

[1] Alashan Forestry Research Institute of Inner Mongolia. Key and supplemental technology researches on *Cistanche deserticola* inoculation. Collections of Inner Mongolia Forestry Research Accomplishments in Science and Technology (2001-2005). 2006.64-66.

[2] Alashan Forestry Research Institute of Inner Mongolia. Inoculation technology of *Cistanche deserticola* to *Haloxylon ammodendron* (Internal Information), 2007.

Contact person(s)

Tianlü, Inner Mongolia Forestry Survey and Planning Institute. Tel: 86-471-5953487. Email: tianlv001@sina.com

Left: Natural *Haloxylon ammodendron*.stnad. Photo by Tian Yongzhen
Right: *Cistanche deserticola* growth by the inoculation method. Photo by Tian Yongzhen

Cistanche deserticola Inoculation Extension Supported by Research

Alashan League of Inner Mongolia, China

Based on research accomplishments, artificial inoculation of *Cistanche deserticola* technology is demonstrated and extended to promote the development of desert vegetation protection and desert industry.

Located in the desert of western Inner Mongolia, Alashan League has limited plant species and low vegetation cover. *Haloxylon ammodendron* is one of the few species with wider distribution in the region. *Cistanche deserticola* is a parasitical plant to *Haloxylon ammodendron* roots and a valuable medicinal herb with healing and health keeping functions and a high economic value. Due to the succulent tissues, high active ingredient content for better curative effect, the local plant is famous at home and abroad and development of its production is an effective approach to improve local ecological condition and relieve the residents from poverty. At present, *Cistanche deserticola* is mainly produced under natural condition which is not able to meet the market demand owing to the restrictions of slow growth, disperse distribution and inconvenient traffic condition. In addition, the harvesting operation of wild *Cistanche deserticola* leads to destruction to surface soil and local ecosystem.

In 2003, Alashan Science and Technology Bureau and the Forestry Bureau jointly approved the research project of artificial *Cistanche deserticola* inoculation. Alashan League Forest Research Institute undertook the research with objectives of exploring scientific and practical integrative *Cistanche deserticola* inoculation technologies for high yield and large-scale plantation across the League to meet market demand and reduce the wild excavation destruction to natural vegetation.

The research lasted for three years focusing on *Cistanche deserticola* seed quality, origins of various stands, inoculation depth, chemical treatment of seed, and inoculation timing and density, to form a set of artificial inoculation technical measures and modulated planting technologies suitable for dissemination in the league. In particular, the nutrition induction method is innovatively adopted in *Cistanche deserticol*a inoculation to enable great success rate of the inoculation operations.

Alanshan Science and Technology Bureau commanded the research in 2005 to conclude that research result was at the leading edge nationwide. Since 2006 the technology has been piloted in Alashanzuo Banner and Alashanyou Banner, and also applied to over 350hm^2 *Haloxylon ammodendron* stand in the sand control station with satisfactory results. The technology is highly viewed and actively adopted by the local residents. Alashan League administration takes *Cistanche deserticola* proucts development as an important industry and has disseminated artificial *Haloxylon ammodendron* inoculation technology with preferential policies made to better the locality and protect the environment. It is believed that the technology will be rapidly extended in near future.

Location: Alashan league, Inner Mongolia
Land use: Shrub forest
Climate: Arid
WOCAT database reference: QA
Related technology: Artificial Inoculation of Cistanche deserticola to *Haloxylon ammodendron*
Compiled by: Tian Yongzhen, Alashan LeagueForestry Research Institute, Inner Mongolia; Tianlü, Inner Mongolia Forestry Monitering and Design Academy
Date: September, 2007

0Editors' comments: This technology has been extended over 350 hm^2. in the whole Alashan League. Increase of extended area of the technology shall contribute more to the protection and expansion of the *Haloxylon ammodendron* shrubland area, improving the technological level of the forestry programs such as the conversion of cultivated land forest program, industrial restructuring of farming and animal husbandry, developing desert industry by relying on local resource advantages, promoting local economic development, promoting desert area environmental protection.

Problem, objectives and constraints

Problem

- Local residents lack inoculation knowledge of *Cistanche deserticola.*
- Communities lack effective organizational system for technological extension.

Objectives

- For an extension that integrates research and production.
- Protect natural vegetation in desert area and improve ecological condition.
- Raise farmer and herdsman's capability in inoculation of *cistanche deserticola.*
- Increase the comprehensive processing capability of *cistanche deserticola* to promote the development of desert industry.

Constraints addressed

Major	Specification	Treatment
Technical	Local participants of the project are mainly herdsman who are inhabited to traditional grazing life and slow in accepting newly developed industries.	Reinforce promotion and encouragement; carry out training of farmers and herdsman, and adopt market measures for guidance.
Minor	**Specification**	**Treatment**
Social	Most of the natural *Haloxylon ammodendron* stands grow in remote areas with inconvenient traffic conditions, restricting the artificial inoculation and harvests.	Scientifically select the demonstration sites; establish *Haloxylon ammodendron* stands at sites with better traffic conditions.

Participation and decision making

Target groups


Planner


Decision maker


Land user

Approach costs met by

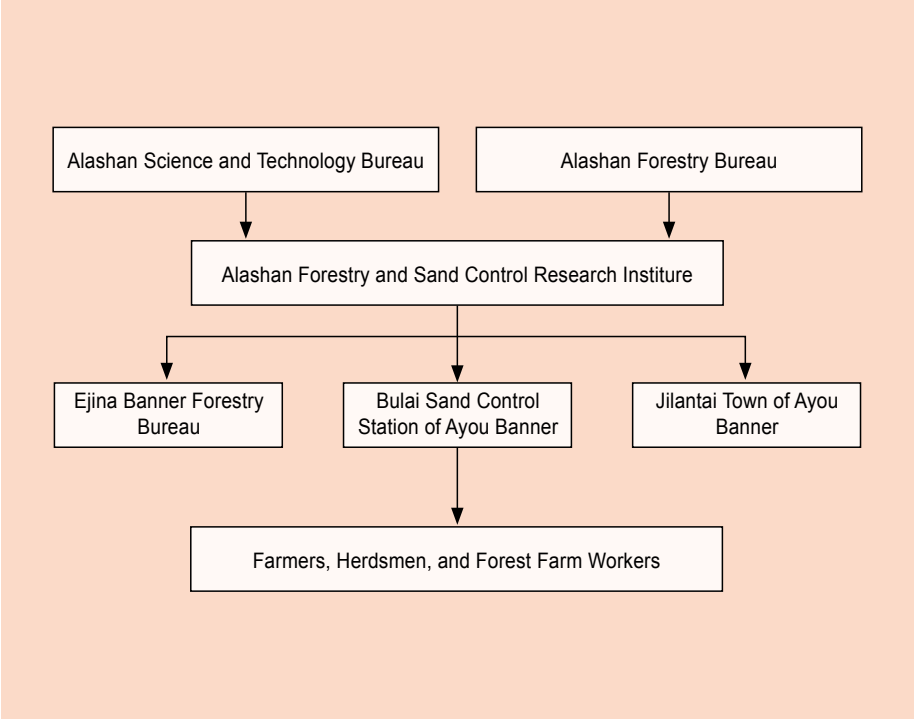
Government	50%
Land users	50%
TOTAL	100%

Decisions on choice of the technology: Land users.
Decisions on method of implementing the technology: Jointly by You Banner Forestry Bureau of Alashan League and land users.
Approach designed by: Alashan League Forestry Research Institute.

Community involvement

Phase	Phase	Activity
Initiation	Passive	Been informed of the project and attend the related mobilization meeting.
Planning	Passive	Participate in the planning and opinions soliciting.
Implementation	Active	Participate in the operations of inoculation and maintenance tending etc.
Monitoring/evaluation	Interactive	Soil sampling, survey of the *Cistanche deserticola* production.
Research	Not involved	

Differences in participation of men and women: No difference.



Organogram

Project's research is financed and approved by the league's Science and Technology Bureau and implemented by Forestry and Sand Control Research Institure;Project extension is organized by the league's Forestry Bureau and implemented by banner forestry departments and the town forestry stations.

Extension and promotion

Training: The training topic is the artificial inoculation technology of *Cistanche deserticola*; 120 person times of forest farm workers, farmers and herdsman were trained; and the training is in forms of lectures in combination with on-site supervision.

Extension: The Forestry Bureau of the League is responsible for the organization of the extension with technical support from the league's Forestry Research Institute. The extension is conducted in forms of lectures, and site demonstrations, etc. The training is done firstly to the sand control station staff and some herdsmen. The trainees have now grasped this technology. Now the extension area of the inoculation has reached to 330 hm^2.

Research: The research is mainly conducted by the league's Forestry Research Institute, with the sand control station staff providing some observation data.

Importance of land use rights: The project is implemented on the land user's own land, so the land tenure does not affect the technological extension.

Incentive mechanism

Labour: Labour is not paid, the government offer technical service free of charge.

Inputs: *Cistanche deserticola* seed is supplied by governmental seed stations while the costs of tractors and water transport vehicles etc. are covered by the contractors.

Credit: Micro credit of RMB1000-2000 Yuan per household with subsidized interest is available.

Support of local institutions: The application of technology improved the recognition, identification, and the influence of the local forestry research and extension organizations, and helped the above organizations accessing more project fund.

Long-term impact of incentives: Incentives (by project or subsidy) have obvious effect on the technological extension and *Cistanche deserticola* business development. With further technical extension and increased benefits, the land users shall still adopt the technology without incentives.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Measure the annual growth conditions of *Haloxylon ammodendron* include tree height, crown size.
Technical	Inventory the inoculation success rate, and annual productivity of *Cistanche deserticola*
Socio-cultural	questionnaire investigation on the attitude and acceptance of farmers and herdsmen toward the technology.
Economic/production	Inventory and calculation of *Cistanche deserticola* production and the comparative economic benefits.
Area treated	Survey the implementation area and changes of land use types.
No. of land users involved	Sample survey the number of land users concerned and the structural change.
Management of approach	The Science and Technology Bureau and the Forestry Bureau of Alashan League monitor the view to the technology and the extension area.

Impacts of the approach

Changes as result of monitoring and evaluation: The extension which is not in preliminary stage is organized by forestry management department with technical guidance of the forestry technical institutions.

Improved soil and water management: The technology helps using the groundwater resource more efficiently. Through the planting of *Haloxylon ammodendron*, drift sand is fixed and soil quality is improved.

Adoption of the approach by other projects/land users: The farmers and herdsmen involved in the project adopt this technology.

Sustainability: Because of the satisfactory ecological and economic benefits, the technology will be adopted in long-term.

Concluding statements

Strengthens and → how to sustain/improve*	Weaknesses and → how to overcome
Research and extension are integrated → Further reform the current extension mechanism.	Low community participation level → Introduce community participation tools.
Integration with industrial development → Enhance processing and enterprise cultivation for sustainable development.	

Key reference(s)

[1] Alashan Forestry Research Institute of Inner Mongolia. Key and supplemental technology researches on *Cistanche deserticola* inoculation. Collections of Inner Mongolia Forestry Research Accomplishments in Science and Technology (2001-2005). 2006.64-66.

[2] Alashan Forestry Research Institute of Inner Mongolia. Inoculation technology of *Cistanche deserticola* to *Haloxylon ammodendron* (Internal Information), 2007.

Contact person(s)

Tianlü, Inner Mongolia Forestry Survey and Planning. Tel: 86-471-5953487. Email: tianlv001@sina.com

Left: *Salix psammophila* plantation as industrial raw material forest. Photo by Ma Jian
Right: *Salix psammophila* plantation following the coppice harvest. Photo by Ma Jian

Integrated Development of *Salix Psammophila*

Ejin Horo Banner of Inner Mongolia, China

Plant *Salix psammophila* for wind breaking and sand fixation and meanwhile for the coppice harvest every three years for processing of wood based panel or for use as animal feedstock and fuel.

The project site is in the outskirt of Mu Us Desert and Kubuqi Desert, Erdos, Inner Mongolia, where fixed and semi-fixed sand dunes prevail. It is in semi-arid climate of temperate zone, with 350mm annual precipitation. There is relatively rich ground water. The soil types include aeolian soil, saline soil, and meadow soil, etc. Vegetation includes *Agriophyllum squarrosum*, *Artemisia sphaerocephala* Krasch, Artemisia *Ordosica, Caragana*, and *Salix psammophila*, etc.

Soil sandification has taken place in different degrees owing to human and natural factors to result in wind erosion, sand invasion on grassland/farmland, and worsened production and living conditions.

The project is aimed at developing *Salix psammophila* plantations for artificial board industry with active participation of farmers in planting to push forward the local ecological construction and economic development.

Main technical procedures: (1) Planting of cuttings – select sites inter–dune lowland and plain sandy lands, etc., for planting ofcuttings, in two-row belts at 1m row spacing and 0.5m plant spacing. Cuttings of 50cm long are planted in spring or autumn. The planting is done immediately after the pit is ready (care should be taken not setting the cutting upside down). Use the wet sand from the second pit to fill the first one, and so forth, and compress the soil firmly in layers, use the wet sand from the third pit to fill the second hole and tread soil firm, repeat above steps. The cuttage should be put in soil to level with the ground surface, or 3-5cm underground if the sand moisture is insufficient or in autumn. (2) Tending management – water the planted cuttings four times in the first year if possible, and three times a year thereafter. Weeding and soil loosening should be done for three times a year with adequate water and fertilizer supply. Supplementary planting should be conducted on sites with survival rate less than 90%, or sites with high survival but uneven growth or deaths in blocks. (3) Coppicing – cut the growth from the trunk in the fourth year, and thereafter, coppicing harvest should be made every three years. The operation should be done in every other belt to maintain adequate vegetation cover.

The project has produced multiple benefits. For the past decade, *Salix psammophila* planting area has increased by 10% per annum and the area has reached 600000ha at present. Most of the forests were raised by farmers and enterprises on their own wishes, bring remarkable economic benefit to local farmers. Each year the factories spend RMB33 million yuan to purchase *Salix psammophila* from farmers and the latter receive RMB470 yuan for for each hectare of trees sold harvested. The project has benefited 300000 farmers and about 10000 households out of poverty. In addition, surplus labors were employed on the project.

Location: Ejin Horo Banner, Inner Mongolia
Technology area: 600km^2
SWC measure: Vegetation
Land use: Grazing and other
Climate: Semi-arid
WOCAT database reference: QT
Related approach: *Salix Psammophila* Enterprise Development to Facilitate Ecological Construction
Compiled by: Tian Lü, Inner Mongolia Forestry Survey and Design Institute
Date: August, 2007

Editors' comments: Now this technology has been extended allsidedly in Erdos city of Inner Mongolia with good enterprise revenues and household income addition. This economy benefit and ecological benefit combined technology can be extended in the wide sandy area suitable for Salix psammophila growth.

Classification

Land use problems

Low ground vegetation cover and severe wind erosion; barren soil and low land productivity; some plantations with low benefits

Land use	Climate	Degradation	SWC measure
			
Forest	Semi-arid	Wind erosion	Biological measure

Technical function/impact

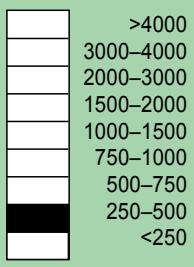
main: - increased vegetation cover to reduce wind erosion
- increased income to farmers and herdsmen
- inccreased sales of the enterprise

secondary: - improve soil fertility
- creat employment opportunities

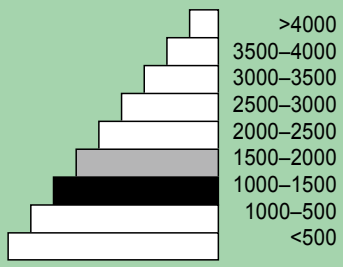
Environment

Natural Environment

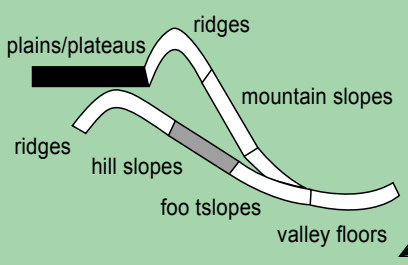
Average annual rainfall (mm)



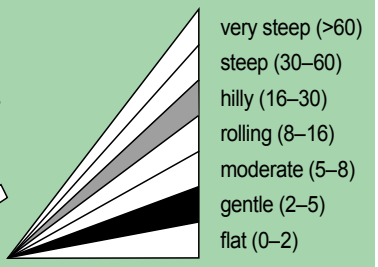
Altitude (m a.s.l.)



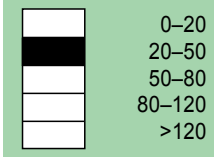
Landform



Slope (%)



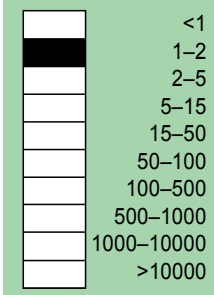
Soil depth (cm)



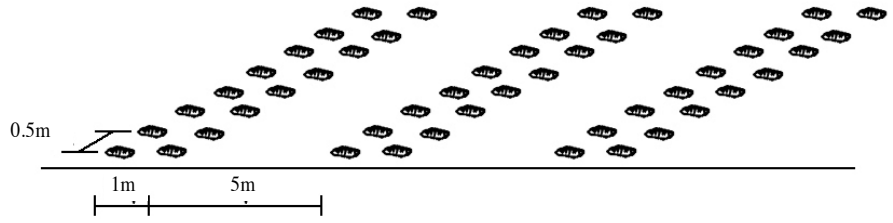
Growing season: 150 days in succession
Soil fertility: low
Soil texture: coarse sandy
Surface stoniness: plentiful loose rock and gravel
Topsoil organic matter: 0.1%-2.96%
Soil drainage: moderate
Soil erodibility: moderate

Human environment

Mixed land per household (hm^2)



Land use rights: collectives or individuals
Land ownership: the state or collectives
Market orientation: mixed
Level of technical knowledge required: moderate to technical extensionists and land users
Importance of off-farm income: 10%-50% of total income



Salix psammophila plantation lavout

Technical drawing

Cuttings of 50cm length are planted in belts on inter-dune lowland, plain sandy lands etc.

Select sites of inter-dune lowlands, plain sandy lands, etc., for planting of cuttings, in two-row belts at 1m row spacing and 0.5m plant spacing. Cutting length 50 cm. First coppice harvest in the fourth year after planting, and thereafter once every three years to every alternate belt. The harvest biomass is sent to wood based panel factory for processing procures of crushing, sieving, gluing, and extrusion forming for finished products.

Drawing by Li Minyu

Implementation activities, inputs and costs

Establishment activities

1. *Salix psammophila* vegetative reproduction. Cuttings of 50cm length are planted in two-row belts on lowland between dunes, plain sandy lands, etc., at 1m row spacing and 0.5m plant spacing. Planting time in spring or autumn. The planting depth is to the cutting length. In case of low soil moisture or planting in autumn, top end of the cuttings is to be at 3-5 cm below the gound surface.
2. Tending. Irrigate the planting pit four times in the first year when possible and three times a year thereafter to saturation.
3. Coppice harvest. Cut the growth from the plant stock in the fourth year, and then once every three years. The coppice harvest should be done to every alternate belts to maintain adequate vegetation cover.

Establishment inputs and costs per hm²

Inputs	Costs (US$)	% met by land user
Labor	54.9	100%
Equipment		
- tractor, water transport vehicles	18.3	100%
Materials		
- seedlings	36.6	100%
Agricultural		
TOTAL	109.8	100%

Maintenance/recurrent activities

1. Coppice harvest starts in the fourth year after planting, to be made from beginning of winter season to beginning of soil thawing of the following year.
2. Pest and disease prevention and control.
3. Assign special manpower for protection against the livestock browsing and human.

Maintenance/recurrent inputs and costs per hm² per year

Inputs	Costs (US$)	% met by land user
Labor	73.2	100%
Equipment		
- tractor, coppice harvester	36.6	100%
Materials		
- seedlings, pesticide	9.1	100%
Agricultural		
TOTAL	118.9	100%

Remarks:labor price at US$3.7/person day, exchange rate at the time of establishment: US$1=RMB8.2yuan.

Assessment

Acceptance/adoption

- With the growth of economic benefit of planting *Salix psammophila* year by year, farmers and herdsmen become more enthusiastic in developing plantations. Most householders hold positive attitude to the technology.
- Drops of sales of the enterprises and lower income can turn the attitude of farmers and herdsmen to negative toward the technology.

Benefits/costs according to land user

Benefits compared with costs	Short-term	Long-term
establishment	positive	very positive
maintenance/recurrent	positive	very positive

Impacts of the technology

Production and socio-economic benefits

+ + +	Promotion of local ecological construciton
+ + +	Added revenue to the local government
+	Positiverole in local agriculture and animal husbandry industrial restructuring

Production and socio-economic disadvantages

	None

Socio-cultural benefits

+ + +	Improved theknowledge level and capability of local farmers and herdsmen in ecological protection

Socio-cultural disadvantages

	None

Ecological benefits

+ + +	Fixing of large areas of sand dunes
+ + +	Increased forest cover
+ +	Inproved ecologicla condition

Ecological disadvantages

–	Slight reduction of ecological benefit and environmental pollution

Off-site benefits

+ +	Farmers and herdsmen in neighboring area are motivated for *Salix psammophila* planting

Off-site disadvantages

	None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Fixing of dunes and improvement of environment → To further expand the plantation.	Wastes from the processing → To set up sewage processing system, and use residues for edible fugus or organic fertilizer development for circular economy.
Promotion of economic developemnt→ To further enhance the development.	

Key reference(s)

[1] Liu Shu. Brief study of sand industry. Beijing: China Environmental Science Press, 2001.
[2] Yang Junping. The role of forestry science and technology in ecological construction. Hohhot: Inner Mongolia Autonomous Region. Inner Mongolia University Press, 2004: 253-258.

Contact person(s)

Tian Lü, Inner Mongolia Forestry Survey and Design Institute. Tel: 86-471-5953487. Email: tianlv001@sina.com

Left: Coppice harvest of *Salix psammophila.*
Right: Wood composite panel made of *Salix psammophila.*
Photo by Ma Jian

Salix Psammophila Enterprise Development to Facilitate Ecological Construction

Ejin Horo Banner of Inner Mongolia ,China

Increase market demand via enterprising to push *Salix psammophila* plantation and realize win-win of ecological and economic development.

Salix psammophila is a common shrub growing in desert and distributed in Mu Us Desert and Kubuqi Desert in Erdos Municipal, Inner Mongolia. It features high survival rate, fast growth and tolerance to desert environment. Coppicing (cut off the aboveground shoots at ground level) for every 2-3 years is required to promote flourishing growth and avoid plant death. The plant can be used for weaving crafts and as forages and fuel, so it is an important production and living material. In recent years it has been used for producing particle board, medium and high density board, fiber board, etc., with remarkable economic benefits.

Local farmers traditionally used *Salix psammophila* for fuel, and plantation of *Salix psammophila* hardly led to income, making the enthusiasm and progress of *Salix psammophila* plantation very low and resulting in withering of plantations due to lack of timely coppicing. In 1989, the first particle board factory of 5000 cubic meters/a production capacity was set up in Erdos using *Salix psammophila* as raw materail, and 8500t of produce was consumed by the factory the same year. Thereafter, *Salix psammophila* enterprise was swiftly developed into a local industry, and in 2006, there were eight factories producing particle board with a total capacity of 200,000m^3 and requiring nearly 330,000t/a of *Salix psammophila* for producing RMB200 million yuan of the product value and RMB35 million yuan of profit. Farmers' enthusiasm was reactivated in wake of the large demand for the raw material, and many factories established their own *Salix psammophila* plantation bases. Such joint efforts have enabled *Salix psammophila* plantation area to grow at a rate of 10% per annum in the past decade to reach a total area of 600,000hm^2 today.

The *Salix psammophila* utilization project in Erdos has been carried out with governmental support, market orientation, and economic stimulation. Government finance with discounted or low interest loan enterprises helped with building or expanding the factories. The forestry administration was in charge of uniform planning of the raw material production base with the planting funded by the farmers and forest farm owners. The forest administration also provided the production data to the enterprises who then determine market price according to the production and planting cost and organize the board production.

As proven in years of practice, *Salix psammophila* enterprise development for board production triggered the ecological construction. The technology application by project contributes to side by side ecological and economic improvement, increased participation of farmers in expanding plantation, and additional income.

Location: Ejin Horo Banner, Inner Mongolia
Land use: Forest
Climate: Semi-arid
WOCAT database reference: QA
Related technology: Integrated Development of *Salix psammophila*
Compiled by: Tian Lü, Inner Mongolia Forestry Survey and Design Institute
Date: August, 2007

Editors' comments: This project is implemented with governmental support, on market operation basis, and as an economic growth stimulator for local development. It has been proved a feasible technology contributive to enterprise revenues, household income increase. With the economic and ecological benefits of the technology, it is in vigorously extension in Erdos city and the prospect is promising.

Problem, objectives and constraints

Problem

- Lack of macro guidance for coppice harvest, leading to excessive or insufficient production.
- Lack of other plants in *salix psammophila* stands, so the ecological effect is low.
- Farmers and herdsmen lack the knowledge and technology on *salix psammophila* planting, ecological protection, and processing, etc.

Objectives

- Form effective investment and extension mechanism.
- Raise community's awareness in ecological protection.
- Improve the coordination efficiency between communities and enterprises.

Constraints addressed

Major	Specification	Treatment
Technical	Lack of effective machinery for coppice harvest.	Innovate the coppice harvest machinery.
Social	Low knowledge level and poor skills of the labourers.	Expertise formation by training and incentives.
Minor	**Specification**	**Treatment**
Low developemnt strength	Sole product of wood based panel, no development yet for paper carton, edible fungus etc.	Policy guidance and financial support.

Participation and decision making

Target groups


Decison maker


Land user


Planner

Approach costs met by

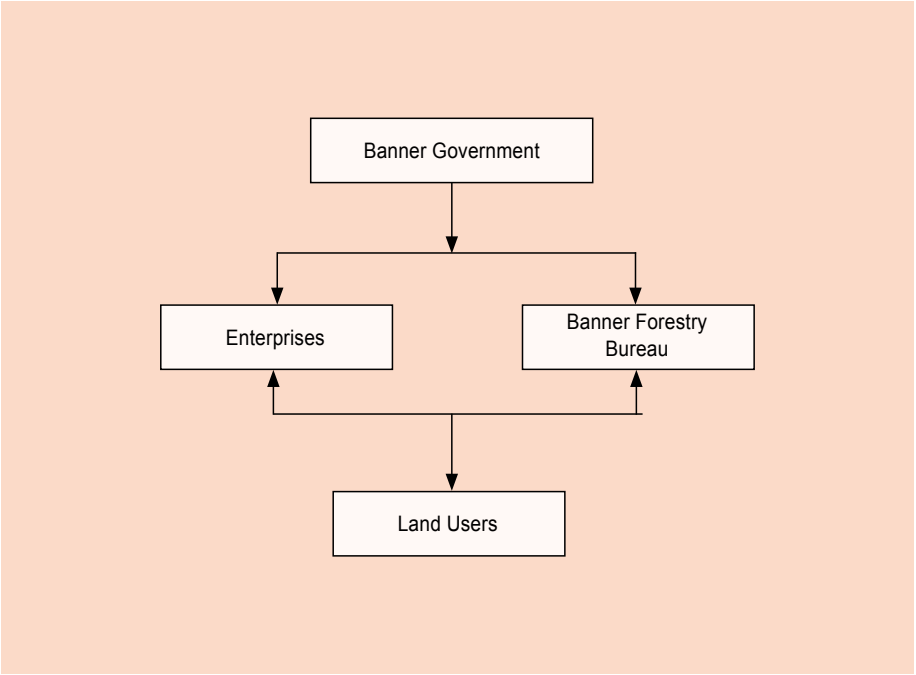
Households	100%
TOTAL	100%

Decisions on choice of the technology: Farmers and herdsmen.
Decisions on method of implementing the technology: Farmers and herdsmen.
Approach designed by: Forest experts of the banner.

Community involvement

Phase	Phase	Activity
Initiation	Passive	Provide usable land and sign contract on *Salix psammophila* plantation.
Planning	Passive	Participate in the planning process, arrange the planting sites.
Implementation	Positive	*Salix psammophila* planting, tending, coppice harvest, and transportation.
Monitoring/evaluation	No participation	
Research	No participation	

Differences in participation of men and women: The difference in the role of men and women is not significant for the implementation.



Organogram

The project is supported by the government and implemented on market operations by the enterprises and local farmers and herdsmen.

Extension and promotion

Training: Banner and town forestry station technicians offered training of *Salix psammophila* planting and coppicing to farmers and herdsmen in the forms of distributing handouts and site demonstration, with satisfactory results.

Extension: Government supports the growth of processing enterprises, and recommend to villagers for *Salix psammophila* planting, while the town forestry station technical staff take the responsibility on technological extension.

Research: Enterprises increased their economic efficiency through the technical innovation in raising raw material utilization, Erdos City Forestry Research Institute conducted studies on optimal planting density of *Salix psammophila* and growth for improved production, which have promoted the development of the project.

Importance of land use rights: The sandy soil wasteland ownership rights and use rights belong to state or collectives. The government offers preferential policy for enterprises to establish raw material production bases. The role of land rights is positive. Farmers and herdsmen who develop the plantations on their own land are not affected by the land tenure issues.

Incentive

Labour: Farmers and herdsmen resolve labor input by themselves while the enterprises that operate the raw material forest bases either employ labor or contract the production to individuals.

Inputs: For those land units incorporated into national priority projects, seedlings are provided free of charge. For other plots, the land users arrange their own inputs.

Credit: The bank offers loans at discounted or lower interest rate to the processing enterprise establishment, and micro credit to households that plant *Salix psammophila.*

Support of local institutions: Application of technology has enlarged forest area, increased the workload of local forestry department, and improved the recognition of the related organizations.

Long-term impact of incentives: In long term point of view, incentives play a positive role on adoption of the technology.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	The sand dust weather days, sand dune shift speed, and temperature, etc; by actual measurement.
Technical	Vegetation cover, cost, planting area; by actual measurement.
Socio-cultural	Questionnaire survey regarding the improved awareness/knowledge of households on Salix psammophila plantation and ecological protection.
Economic/production	Estimation and calculation of the economic profit of households through planting.
Area treated	Investigate the treated acreage and change of the land types.
No. of land users involved	Sample survey and site investigation on changes of land users and the structure.
Management of approach	Monitoring and evaluation on regular basis.

Impacts of the approach

Changes as result of monitoring and evaluation: The technology extension was initially conducted by the government and the enterprise and households were passive in participation. Now the enterprises and households are actively enlarging the production scale with the macro control of the government.

Improved soil and water management: Stabilize sand ground, reduce the wind erosion of sandified land; vegetation retains the runoff.

Adoption of the approach by other projects/land users: To mobilize the participation of many other farmers and herdsmen.

Sustainability: To form positive benefit-driven mechanism. With incentives the technology will be adopted continuously.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Salix psammophila planting and processing lead to positive economic and ecological development → Deepen the processing for value addition.	Temporarily negative ecological impact and low level of environmental pollution → Reinforce sites and timing of coppice harvest; enterprise adopt environmental protection measures.
Ecological protection and resource development are inter promoted → More efforts in optimizing the business chain.	

Key reference(s)

[1] Liu Shu. Brief study of sand industry. Beijing: China Environmental Science Press, 2001.
[2] Yang Junping. The role of forestry science and technology in ecological construction. Hohhot: Inner Mongolia Autonomous Region. Inner Mongolia University Press, 2004: 253-258.

Contact person(s)

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Left: Front side of solar stove. Photo by You Luqing
Right: Back side of solar stove. Photo by You Luqing

Solar Stove Development

Gonghe County of Qinghai Province, China

The parabolic reflector spotlight principle is used to reflect sunlight into the focus to heat food or water.

Shazhu Township of Gonghe County, Qinghai Province was chosen as the pilot site for solar stove demonstration project. The site is 35km west of the county seat, located in arid and semi-arid desert plain. The climate features intense sunshine, low average temperature, large temperature difference between day and night, dry and low rainfall, 2.5°C annual mean temperature, 2772.2h annual sunlight, 100 days frost-free period, 250-400mm annual precipitation concentrated in June thru September, 1778mmin annual evaporation, 50.4 days of annual windy days concentrated in February thru May when northwest wind is prevailing. The average elevation is 2880m in the region where the farmers engage in agriculture and livestock production with per-capita income of RMB1500 Yuan.

Dissemination of solar stove technology in the region is intended to help solve the shortage of firewood and straw as fuels while reducing pressure on vegetation and diminishing vegetation destruction in order to protect environment, promote livestock development and control soil degradation.

Solar stove is a kitchenware utilizing solar energy – renewable, environmental-friendly, pollution free, low cost, ease in operation and maintenance, safe and convenient in use, saving of firewood, etc. Adjust the solar unit aiming at the sun and the focus on the stove when sunlight is available. To increase utilization efficiency of solar stove, extension of improved solar stoves should be promoted that contained advantages of easier handling, flexible adjustment and updated technologies of hot water storage, autotracking technologies to increase the duration of operation in accordance with weather forecast.

Since 2005 when the solar stove began to be disseminated in the demonstration area, 150 units of solar stoves have been installed making up 28% of total households in the demonstration vilage. To accelerate the dissemination pace, the province provided poverty alleviation funds to support the project. The cost is RMB140 Yuan and about RMB20 Yuan for maintenance during five years. One solar stove can save 500kg firewood/straw per year or equivalent to about RMB500 Yuan. It takes 15% of fuels used for cooking of the household.

Location: Shazhuyu Town, Gonghe County, Qinghai
Technology area: 20000 hm^2
SWC measure: Mechanical measure
Land use: Others
Climate: Semi-arid and arid
WOCAT database reference: QT
Related approach: Solar Stove for Rural Communities
Compiled by: Zhang Peng, Qinghai Provincial Forestry Bureau
Date: September, 2007

Editors' comments: Solar stove is a type of cooking utility using solar energy, having the characteristics of no pollution, low price, easy operation and maintenance. It is safe and convenient, can save firewood. In the project areas 150 units of solar stoves are used to solve or alleviate the fuel shortage problem in farming or pastoral areas. Solar stoves play a role in saving firewood or straw, reducing pressure on vegetation, and protecting ecological environment.

Classification

Land use problems

Land use | **Climate** | **Degradation** | **SWC measure**

Agriculture, forestry, animal husbandery | Agriculture, animal husbandery | Arid | Semi-arid | Wind erosion | Vegetation destruction | Water erosion | Management measure | Biological measure

Technical function/impact

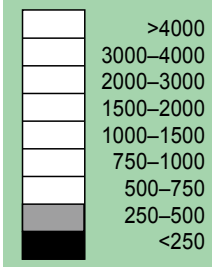
main: - using solar energy to resolve energy insufficiency and alleviate vegetation destruction

secondary: - indirectly protect vegetation, prevent sand storms and soil and water loss

Environment

Natural Environment

Average annual rainfall (mm)



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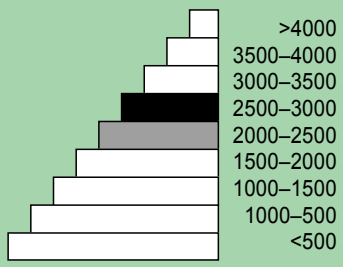
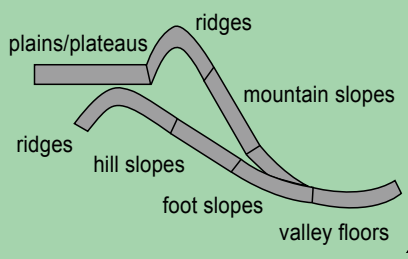
3000–4000
2000–3000
1500–2000
1000–1500
750–1000
500–750
250–500
<250

Altitude (m a.s.l.)



>4000
3500–4000
3000–3500
2500–3000
2000–2500
1500–2000
1000–1500
1000–500
<500

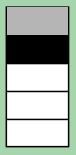
Landform



Slope (%)

very steep (>60)
steep (30–60)
hilly (16–30)
rolling (8–16)
moderate (5–8)
gentle (2–5)
flat (0–2)

Soil depth (cm)

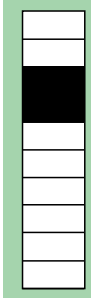


0–20
20–50
50–80
80–120
>120

Growing season: 120 days in succession, from may to September
Soil fertility: moderate
Soil texture: fine (clay)
Surface stoniness: moderate
Topsoil organic matter: moderate (1%-3%)
Soil drainage: moderate
Soil erodibility: moderate

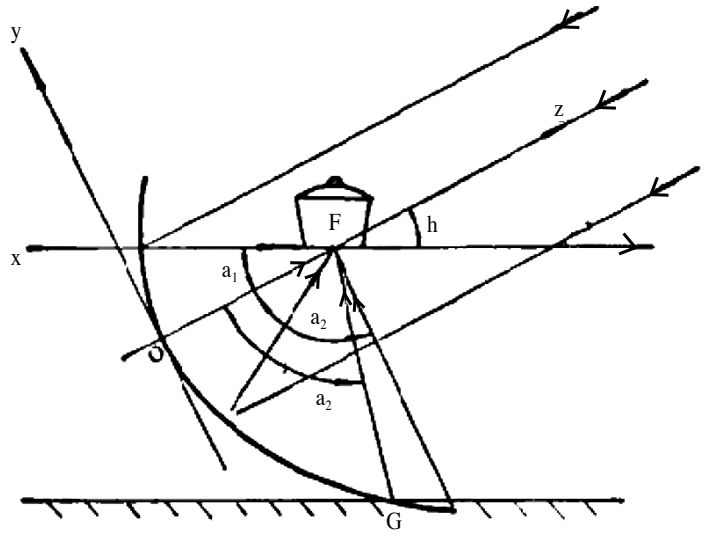
Human environment

Mixed land per household (hm^2)



<1
1–2
2–5
5–15
15–50
50–100
100–500
500–1000
1000–10000
>10000

Land use rights: state or collective
Land ownership: state or collective
Market orientation: mixed
Level of technical knowledge required: moderate to extensionists and the land users
Importance of off-farm income: 10%-50% of the total income



Technical drawing

h= solar altitude(25-90 degrees adjustable);

Y axis = direction of the altitude angle;

X axis = horizontal direction;

Z axis = primary axis direction of paraboloid of revolution.

Drawing by Zhang Peng

Implementation activities, inputs and costs

Establishment activities

1. Installation of the equipment.
2. Operation. At the sunshine time, turn the condenser (pot cover in nickname) to the solar direction by adjusting the spot on the stove or other objects to be heated.

Establishment inputs and costs per hm²

Inputs	Costs (US$)	% met by land user
Labour	4.00	100%
Equipment		
- solar energy stove	18.50	0%
Materials		
- iron stand	2.50	0 %
Agricultural		
TOTAL	25.00	16.6%

Maintenance/recurrent activities

1. Solar stove maintainence repair.
2. The product lifetime is 15 years.

Maintenance/recurrent inputs and costs per hm² per year

Inputs	Costs (US$)	% met by land user
Labour	4.00	100%
Equipment		
Materials		
- steel	2.50	%
Agricultural		
TOTAL	6.50	61.5%

Remarks:the selling price of one solar stove is US$21(RMB 160.00Yuan), annual maintainence cost is US$2.50(RMB 19.00Yuan): Exchange rate:US$1 = RMB 7.60Yuan.

Assessment

Acceptance/adoption

Benefits/costs according to land user

Benefits compared with costs	Short-term	Long-term
establishment	positive	positive
maintenance/recurrent	positive	positive

Impacts of the technology

Production and socio-economic benefits

+++ Save fuel

++ Save cooking time

++ Save expenditure

Production and socio-economic disadvantages

None

Socio-cultural benefits

+ Add knowledge of clean energy utilization

+ Improve the hygiene level of the rural area

Socio-cultural disadvantages

None

Ecological benefits

+++ Reduce the destruction to vegetation

++ Improve ecological environmental

Ecological disadvantages

None

Off-site benefits

++ Improve the ecological conditions of surrounding area

Off-site disadvantages

None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Convenient, easy and simple operation, low price, safe in use → Training of farmers on how to use correctly.	Weather condition has influence on use → Conduct researches on energy storage and automatic tracking technologies.
Energy saving, clean and free of pollution → Extension to more users and areas.	
Save firewood and straw, protect vegetation and environment.	

Key reference(s)

[1] Nearly twenty percent of farmers and herdsmen households in Qinghai province have used condensed splar stove, Solar Stove Home.
[2] Technological progress and application of solar stoves in China. Chinese Solar Stove.
[3] Demonstration site of desertification control in Shazhuyu, Gonghe County, Qinghai Province. GEF/OP12 project proposal for Gonghe County land degradation control.

Contact person(s)

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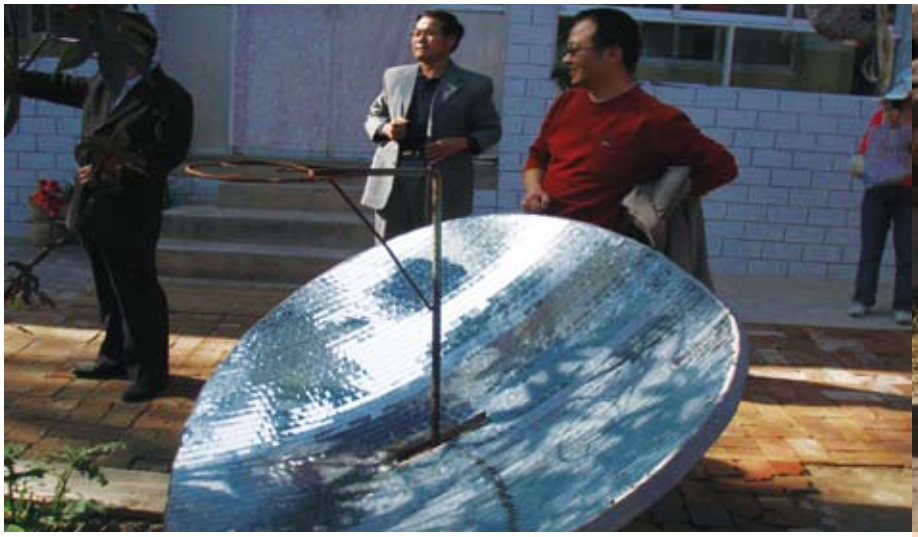


Left: Technicians giving introduction on the use of the solar stove. Photo by Zhang Peng
Right: Using the solar stove for heating water. Photo by Zhang Peng

Solar Stove for Rural Communities

Gonghe County of Qinghai Province, China

Solar stove uses solar energy for cooking, featuring environmental-friendly, zero pollution, low cost, easy operation and maintenance, safe and convenient use, saving firewood, etc. To operate the stove, adjust condenser aiming at the sun with the spot on stove or other objects to be heated.

Qinghai has high elevation, with intense and long sunshine to suit dissemination of the technology to compensate for the shortage of fuel in the countryside, effectively reduce the labor in wood/grass cutting and vegetation destruction, protect environment and promote soil degradation control. Therefore the technology has significant ecological and social benefits.

Restrictions in use: it can only be operated when sunlight is available; operation requires manual adjustment of aim from time to time (lack of sunlight auto-tracking technology application) resulting in an operative time efficiency about 40%.

Solar stove dissemination is financed by the government with labor input by farmers and herdsmen. International financial aid is utilized as an effective incentive for implementation. Publicity and demonstration were conducted to attract more families to use solar stove. Farmers are the users and beneficiaries so that training to them on operation and maintenance should be conducted.

In 2005, the solar stove dissemination started and so far 150 units have been in operation representing 28% of total demonstration households. Satisfactory results have been achieved. At present, Qinghai provincial government provides special financial support to the dissemination of solar stove extension so the technology application has a bright prospect.

Location: Shazhuyu pilot of Gonghe County, Qinghai Province
Land use: Others
Climate: Arid and semi-arid
WOCAT database reference: QA
Related technology: Solar Stove Development
Compiled by: Zhang Peng, Qinghai Provincial Forestry Bureau
Date: September, 2007

Editors' comments: Solar energy stove as a renewable energy utilization form has characteristics of pollution free, convenient use, energy saving, and simple maintenance. It changes the traditional energy consumption structure of the farming and grazing areas by saving firewood to contribute to protecting vegetation and curbing land degradation. With the support of government and cofinancing, the technology has been extended in the project area with good socioeconomic effect.

Problem, objectives and constraints

Problem

- Lack of fuel and firewood cutting damage vegetations in the rural area.
- Serious soil and water erosion.
- Topsoil losses.
- Decline of soil fertility.

Objectives

- Form the technology dissemination mechanism that integrates related organizations.
- Carry out environmental awareness education and raise community participation level.
- Develop technical training to raise the community's capability in ecological protection.
- Use alternative energy to solve the rural fuel insufficiency problem and to alleviate the pressure to environment.
- Protect and increase vegetation cover and improve ecological condition.

Constraints addressed

Major	Specification	Treatment
Economic	Farmer households are poor and short of funds.	Government provides financial support with counterpart funds from households. Access to international assistance.
Technical	The technology is not mature. Most solar stoves are artificially operated unable of tracking automatically the sun. Weather condition may also affect the use efficiency.	Research and developemnt to resolve the technical problems and reduce the cost.

Participation and decision making

Target groups


Decision maker


Planner


Land user

Approach costs met by

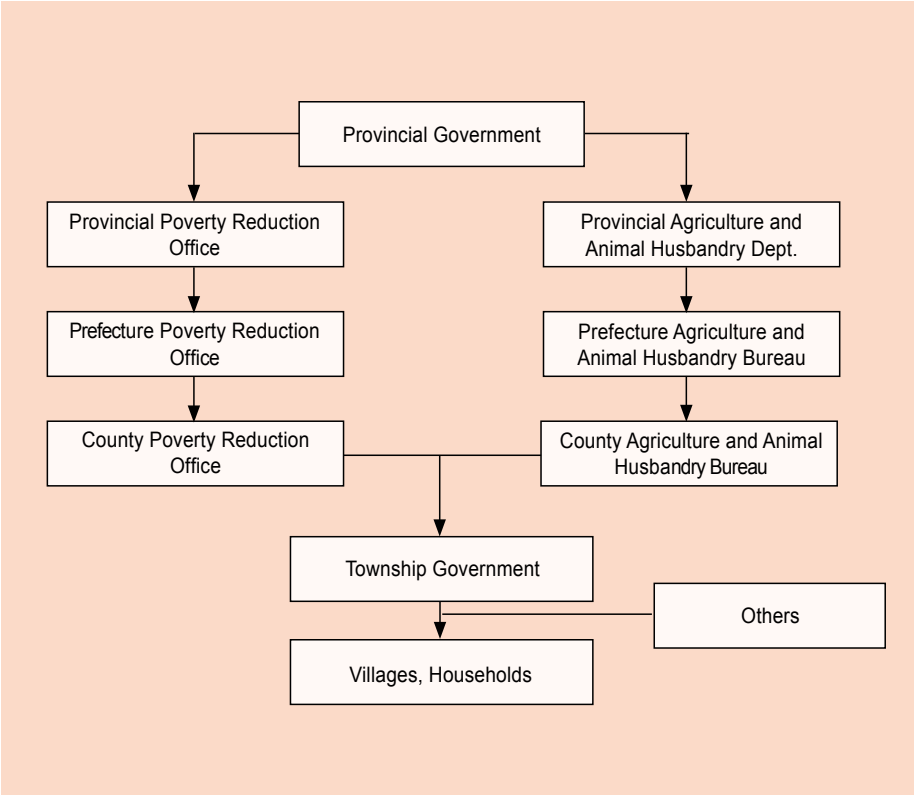
Government	90%
Household	10%
TOTAL	100%

Decisions on choice of the technology: Experts of rural new energy use/ecological protection experts /project implementation organizer/ government poverty reduction office.
Decisions on method of implementing the technology: Government poverty reduction office/project implementation organizer.
Approach designed by: National and international experts / relevant technical organizers.

Community involvement

Phase	Phase	Activity
Initiation	Active	Accept education of solar energy technology.
Planning	Interaction	The participatory planning on solar stove extension.
Implementation	Active	Use and disseminate solar stoves.
Monitoring/evaluation	Interaction	Monitoring and evaluation of the solar stove application.
Research	No participation	

Differences in participation of men and women: Women are main users of the solar stoves.



Organogram

1. The project decisions are made by governmental departments, and implemented by the poverty reduction office, agriculture and animal husbandry bureaus etc

2. The "other" refers to project sponsors other than those initiated by the government.

Extension and promotion

Training: The training includes solar stove installation, operation and maintenance is conducted in form of site demonstration; The effect of training to households especially the training to woman is acceptable.

Extension: Adopt participation method for government, individuals and social public to co-finance the extension of solar stove technology for restructuring the rural energy utilization, saving firewood, protecting vegetation and preventing land degradation.

Research: Undertaken by the solar research institutions and on the topics of solar stove automatic tracking, energy storage, new building materials, raising utilization efficiency etc.

Importance of land use rights: The implementation is not related with land use right.

Incentive

Labour: The labor of transportation of solar stove is solved by farmer households.

Inputs: Expenditures of training, solar stove are covered by government, project finances etc while the transportation and maintenance costs by the farmer users.

Credit: None.

Support of local institutions: Application of the technology changes the villager's energy consumption manner, with decreased expenditure and increased income. Therefore it is helpful for poverty reduction and environmental protection. The extension also promoted the capacity building of local forestry organizations.

Long-term impact of incentives: The above-mentioned incentives activated villagers in actively accepting the technology.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Site measure the light application time and illumination intensity.
Technical	Hours of soalr stove use (the use rate). Estimate the quantity of firewood saving.
Socio-cultural	Survey the villagers' acceptance to the technology and comments from women.
Economic/production	Calculate the economic value equivalent to standard coal.
Area treated	Survey the number of household users.
No. of land users involved	
Management of approach	Survey regularly the household users, monitor and evaluate their feedback information.

Impacts of the approach

Changes as result of monitoring and evaluation: Adopt the participatory type and not the administrative type of extension approach.

Improved soil and water management: Investigate the conditions of vegetation cover increase, soil and water erosion reduction in the technology application areas.

Adoption of the approach by other projects/land users: The technology has also been adopted in other areas and other projects.

Sustainability: The investment of the technology is low and the technical operation is easy, so farmers will adopt the technology without long-term incentive support.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome*
The top-down extension is effective → Raise the capacity of the govern-mental organization.	Backward economy affect the extension speed → Strengthen project support.
Farmers extend the technology among themselves by observation and visits → Enhance the training and extension.	Sole financing channel for the technology → Form cofinancing arrangement of government, individuals and international donors.
Farmers are benefited by reduced expenditure in energy → Use mean-while other clean energy forms.	

Key reference(s)

[1] Nearly twenty percent of farmers and herdsmen households in Qinghai province have used condensed splar stove, Solar Stove Home.
[2] Technological progress and application of solar stoves in China. Chinese Solar Stove.
[3] Demonstration site of desertification control in Shazhuyu, Gonghe County, Qinghai Province. GEF/OP12 project proposal for Gonghe County land degradation control.

Contact person(s)

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Left: Large-scale wind power station
Right: Wind-powered water pumping in a shift grazing area. Photo by Ding Yong

Rural Wind Power Utilization

Inner Mongolia, China

Use mechanical facilities to convert the wind energy into electricity in farming/grazing areas with rich wind resources for energy supply to the production and living of local farmers and herdsmen.

Inner Mongolia is located between 38°-53°N and 96°-126°E, with prevailing westerlies of the Northern Hemisphere and temperate continental monsoon climate. Affected by the Siberia cold air current and Mongolian highland cyclonic activity, the region is rich in wind resources. Usable wind energy area makes up 80% of the whole region, with average wind velocity of 1.8-5.5 m/second, annual effective density of wind energy 150-200W/m^2, the annual accumulation of wind velocity of 3-20 m/second reaches 4000-5000 hour, and annual longest continuous unusable wind velocity is less than 100 hours. With the large usable area, broad distribution, high stability, good continuity, etc., wind energy development in Inner Mongolia will not only solve the electricity shortage problem but also reduce firewood collection to protect the natural environment.

Wind energy is a kinetic energy resulting from the air movement of the earth surface from the place with high pressure to the place with low pressure. The wind-power generator is the machinery that transforms wind energy into electrical energy. Wind turbine is the major part that is made of the blade and hub. The blade driven by the airflow produces aerodynamics converting wind energy into mechanic energy that goes through gearbox to increase speed to drive generator for transformation of electrical energy. Theoretically, about 60% wind energy can be converted into mechanic energy, and the efficiency of wind turbine for a modern wind-power generator can reach 40%.

Technical procedures: (1) Identification of the location: no obstacles, good wind condition, hard earth, and as nearby as possible to the residential area. (2) To consider the farmer and herdsmen's elec-tricity use needs to determine the capacity of the generator. (3) To use 100-200W power-storage battery. (4) To use DC-AC converter; this should be 10%-20% higher in power than the wind-power generator. (5) Indoor component installation. The layout should be reasonable; the power control unit, DC-AC converter should be put at a location of easier observation; Storage battery should be put in a safe place. (6) Maintenance: to carry out lubrication maintenance every three months. Install protection facilities around the generator; check the tower regularly for tightness of the ropes. Maintenance and use of the storage battery.

About RMB 2000-3000 Yuan should be invested for the wind-power generator. The rural house-holds shall cover the cost with the help of governmental subsidy. Wind energy technology solved the electricity supply problem in remote areas by alleviating energy pressure and improving the living and production conditions of the local people.

Location: Inner Mongolia
Technology area: Farming area wind power electricity
SWC measure:
Land use: Grazing etc.
Climate: Arid, semi-arid
WOCAT database reference: QT
Related approach: Wind Energy Utilization In Rural Area
Compiled by: Liu Qingquan, Inner Mongolia Forestry Research Institute
Date: October, 2007

Editors' comments: Wind-power generation has its obvious advantages compared with routine power generation technologies: energy-saving bringing the power industry to the track of sustainable development. Wind-power generation promotes the economic development of remote areas. With the national preferential policies in renewable energy development, the wind-power generation industry in Inner Mongolia has bright prospects.

Classification

Land use problems

Dry and short of water; Land degradation, sandification.

Land use | **Climate** | **Degradation** | **SWC measure**




Grazing | Arid | Semi-arid | Vegetation degradation

Technical function/impact

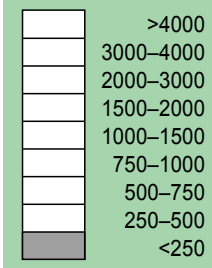
main: - supply production/living energy and reduce damages to vegetation
- convert wind energy to electrical energy and to make agricultural production more environmental friendly

secondary: - contribute to development of ethnic-inhabited areas and improve local living standard
- optimize energy structure for sustainable energy development

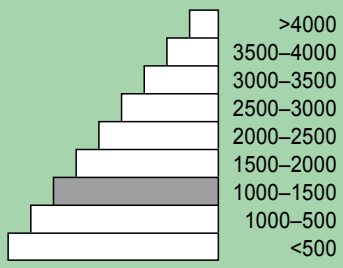
Environment

Natural Environment

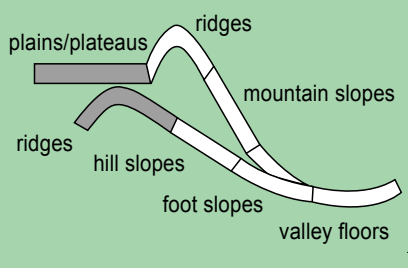
Average annual rainfall (mm)



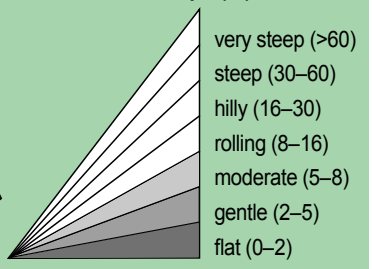
Altitude (m a.s.l.)



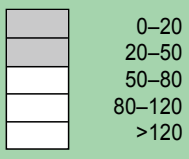
Landform



Slope (%)



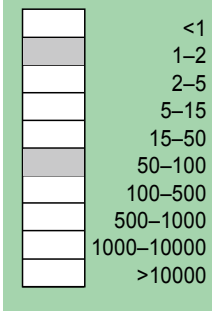
Soil depth (cm)



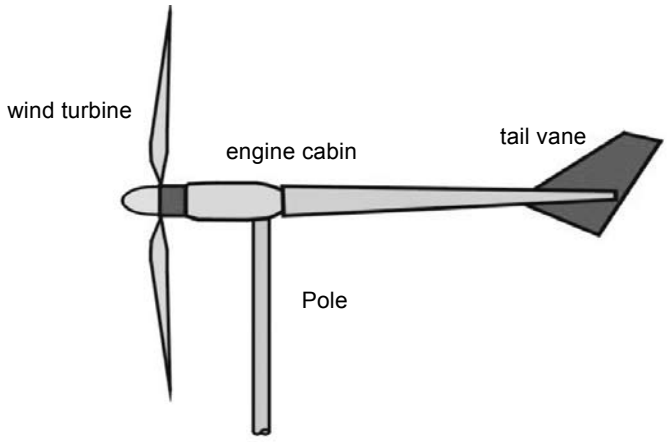
Growing season: 150 days, from May to September
Soil fertility: moderate
Soil texture: medium
Surface stoniness: none
Topsoil organic matter: low
Soil drainage: good
Soil erodibility: high

Human environment

Mixed land per household (hm^2)



Land use rights: individuals
Land ownership: collectives
Market orientation: self-sufficiency
Level of technical knowledge required: moderate for technical extension staff, low for land users
Importance of off-farm income: less than 10% of the total income



Technical drawing

Small wind power generator is usually composed of wind turbine, engine cabin, tail vane and pole.

Drawing by Liu Qingquan

Implementation activities, inputs and costs

Establishment activities:

1. Identification of the outdoor installation location. Basic conditions: no obstacles around, good windy condition, hard earth quality. If these conditions fit, the location should be as close as it is to the user to save on cable wire.
2. Determine the capacity of the generator according to the need of the household.
3. Use 100-200W storage battery.
4. Use DC-AC converter; this should be 10%-20% higher in power than the wind power generator.
5. Indoor component installation. The layout should be reasonable; The power control unit, DC-AC converter should be put at a location of easier observation; storage battery should be placed in a safe place.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
Labour	15	100%
Equipment: electricity generator, storage battery, power module etc.	312.5	8%
TOTAL	327.5	12.2%

Maintenance/recurrent activities

1. Pay adequate attention to the operation condition of generator system, and carry out timely adjustment or maintenance when discovering abnormal sounds and violent vibra-tions. Carry out lubrication maintenance every three months.
2. Intall collision protection facility around the generator to prevent against livestock. The tower should be inspected regularly to for tightness of the ropes. At the softer earth locations, wood or cement stake can be buried into ground for consolidation.
3. Maintenance and use of the storage battery. Maintain clean surface of the storage battery by regular checking to prevent external short circuit; keep the air hole of the charging cover unblocked; Avoid use of storage battery in high temperature conditions; Check regularly the liquid level of storage battery.

Maintenance/recurrent inputs and costs per hm^2 per year

Inputs	Costs (US$)	% met by land user
Labour	18.75	100%
TOTAL	18.75	100%

Remarks: Exchange rate at the establishment time: US$1=RMB 8 yuan.

Assessment

Acceptance/adoption

- Farmer/herdsman households accept this technology actively, and most farmers and herdsmen benefited from the technology.
- Farmer/herdsman households invested by themselves for construction, with subsidy support from the government.
- Farmers and herdsmen, by using the technology, have fulfilled their basic household need in electricity, and promoted their production, therefore they are very much willing to use the technology continuously.

Benefits/costs according to land user

Benefits compared with costs	Short-term	Long-term
establishment	slightly negative	positive
maintenance/recurrent	positive	positive

Impacts of the technology

Production and socio-economic benefits

+ + +	Alliviate electricty use pressure of local farmers and herdsmen
+ + +	Increase energy application rate

Production and socio-economic disadvantages

−	Add economic burben in short-term

Socio-cultural benefits

+ + +	Acquire knowledge on wind power use

Socio-cultural disadvantages

	None

Ecological benefits

+ + +	Reduce damages to vegetation
+ +	Improve environment

Ecological disadvantages

	None

Off-site benefits

+ +	Strengthen communication of remote area with the outside

Off-site disadvantages

	None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Solve the electricity supply problem to remotely locatedfarmers and herdsman → To reinforce re-search and demonstration.	Heavy earlier stage input → To continue with the governmental economic support policy.
No pollution and environmental protection effect → To make further efforts in technological extension.	Poor reliability and stability and short life-span of the light duty windpower generator → To introduce new technology to raise product stability and reliability.
Full use of natural resources and protection of vegetation for improved environment → To make further efforts in technological extension.	Incomplete after sale maintenance service system → To make more efforts to establish sound service system.

Key reference(s)

[1] Hou Guoqing. Wind-power generation and the prospect in Inner Mongolia. Electricity Power Survey and Design. 2004, 9(3): 77-80.
[2] Cai Jingyu. Inner Mongolia wind energy resource analysis and evaluation. International Electric Power for China. 2004, 8(3): 36-37.

Contact person(s)

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Left: Light duty wind-power generation system installed for herdsman household. Photo by Liu Qingquan
Right: Water pumping at a grazing area by wind power. Photo by Liu Qingquan

Wind Energy Utilization In Rural Area

Inner Mongolia, China

Installation and use of the light duty wind-power generator around the houses of farmers/herdsmen in remote areas to meet their daily demand of electricity; surplus powers are stored in batteries to guarantee electricity supply at times of windless weather conditions.

Wind energy has advantages of abundant supplies, wide distribution, and free of pollution. It is a renewable energy that uses no fuels and solar radiation, and produces no air pollution. Appropriate use of wind energy reduces environmental pollution and ecological destruction, and alleviates power shortage by taking advantage of rich wind energy resource. Inner Mongolia Autonomous Region has rich resource of wind energy. Development of wind energy technology is an important channel to solve the problem of electricity shortage of the remotely distributed agricultural and livestock breeding areas.

In the extension of the wind energy use technology, the Energy Office of the Agriculture and Animal Husbandry Department of Inner Mongolia Autonomous Region has the unified responsibility of organization, propaganda and answering queries, and instructs prefecture and county's agriculture and animal husbandry departments and town administration on planning and implementation. Specialized staff are arranged to offer guidance on system installation and technical service. In 1986, the regional administration of Inner Mongolia promulgated preferential policies of wind energy development and use by subsidized wind power generation. For each 100W capacity wind-power generation system, the government provides a subsidy of RMB200 Yuan. The policy promoted the application of wind energy technology in the whole region.

By the end of 2004, 158,000 sets of light duty wind-power generation systems were installed in Inner Mongolia Autonomous Region and helped solving the daily electricity supply problem of 150,000 remote households. Wind power has also been used in water lifting for irrigation of pastures and drinking demands of humans or animals. Extension of wind energy technology offers good economic benefits and considerable ecological and social benefits.

Location: Inner Mongolia
Land use: Others
Climate: Arid and Sami-arid
WOCAT database reference: QA
Related technology: Rural Wind Power Utilization
Compiled by: Liu Qingquan, Inner Mongolia Forestry Research Institute
Date: October, 2007

Editors' comments: Inner Mongolia Autonomous Region is a major agricultural and livestock production base in China, and has 70% of its population distributed in rural and pasture areas. Due to remoteness and inconvenient traffic conditions, some of the rural households do not have access to electricity grid, which has restricted the development of local socio-economy. The promulgation of supportive policies for the development of wind energy resources by the provincial administration of Inner Mongolia since 1986 has accelerated the extension of wind-power generation technology in rural households and helped to improve the living standard of the local people.

Problem, objectives and constraints

Problem

- Although the economic conditions of farmers and herdsmen have been improved in recent years, they generally find the wind power generator expensive.
- Without further technological development, the reliability, stability and life-span of light duty generator system are proven poor, and the quality and life-span of the storage battery fall behind the demand of wind energy development.
- The project area is wide but with sparsely distributed population, and the after-sale maintenance service for the local communities is not satisfactory.

Objectives

- Improve the ecological condition.
- Raise the community's awareness in ecological protection.
- Enhance community participation and continuously implement economic incentive policies.
- Make more vigorous efforts on development of the light duty wind-power generator to meet the demand of basic household electricity supply of the farmers and herdsmen in remote areas; to actively and steadily develop light and medium duty independently operated wind-power generators and diversified energy sources to serve small scale production uses.

Constraints addressed

Major	Specification	Treatment
Economic	Farmers and herdsmen can not afford the high investment on wind-power generator, which is at about RMB 2000-3000 Yuan/set.	To further strengthen the economic incentive support policy.
Technical	The reliability, stability and life-span of the current light duty generator system are poor so that its production is only sufficient for meeting the basic daily demand but not for running large numbers of home electric appliances.	To reinforce technological transfer to improve product stability and reliability.
Minor	**Specification**	**Treatment**
Incomplete maintenance service network	The area is broad with sparsely distributed population, making he after-sale maintenance service difficult and unsatisfactory.	To reinforce technical extension and maintenance service system.

Participation and decision making

Target groups

Land user

Decision maker

Approach costs met by

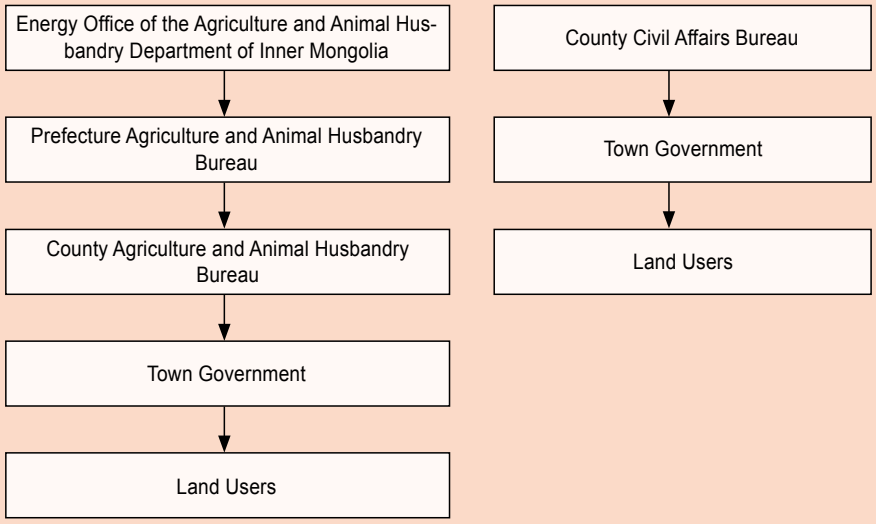
Household user	90%-95%
Government subsidy	5%-10%
TOTAL	100%

Decisions on choice of the technology: Local government, the farmers and herdsmen.
Decisions on method of implementing the technology: Technical specialists, the farmers and herdsmen.
Approach designed by: Local government, the technical specialists, farmers and herdsmen.

Community involvement

Phase	Involvement	Activities
Initiation	Active	Farmers and herdsmen are required to be acknowledged with the functions, advantages of the wind-power energy use.
Planning	Active	Farmers and herdsmen actively make recommendations to government for the making of improved in centive policies.
Implementation	Spontaneous	Farmers and herdsmen spontaneously purchase and install wind-power generation system.
Monitoring/evaluation	Active	Farmers and herdsmen actively contribute to technological survey on operational conditions.
Research		

Differences in participation of men and women: The implementation is carried mainly by male labors including purchasing, transportation, installation, maintenance of the wind-power generator and related materials.



Organogram

The costs for purchasing wind-power generator system for farmers and herdsmen are subsidized by government or covered by household users themselves except the few occasions of public donations.

Drawing by Liu Qingquan

Extension and promotion

Training: The installation and operation of wind-power generation system is relatively simple so usually special training is not necessary. Surveys indicate that farmers and herdsmen have been actively adopting the technology.

Extension: Town administration and the agriculture and animal husbandry departments of counties/prefectures conducted publicity to let farmers and herdsmen understand the advantages and operational methods of wind-power generator units as well as the related incentive policies and key technical details for their acceptance.

Research: Town administration and administrations of counties/prefectures conducted research on independently operated wind-power generator systems and multiple-energy complementary systems, raised product reliability and stability by means of technology introduction, and improved the technical operational methods to make the products more practical by soliciting farmers and herdsmen's opinions.

Importance of land use rights: The land belongs to land users, and land rights do not affect technology adoption.

Incentive mechanism

Labour: It is simple installation and operation, so the farmers and herdsmen adopt installed the system with their own labor inputs.

Inputs: Government subsidizes the household purchase according to actual local conditions. Inner Mongolia Autonomous Region stipulates that for each 100W-capacity wind-power generator system, the government provides a subsidy of RMB200 Yuan.

Credit: Loan is not used.

Support of local institutions: Apart from the above mentioned governmental subsidy to extend the use of new energies, the government supports research on technology development. Extension organizations have been established in 56 banners/counties with overhead financed by the government.

Long-term impact of incentives: Incentives have positive role in long-term. Without subsidies, farmers and herdsmen will still use this technology because it helps raising their living standard.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	On-site measurement of the wind velocity.
Technical	On-site measurement of the generation capacity.
Socio-cultural	Interview visits to farmers and herdsmen on operation and maintenance conditions.
Economic/production	Types of compatible electrical appliances.
Area treated	Inventory on numbers of household users.
No. of land users involved	Survey of the household users.
Management of approach	Local government obtain statistical data, determine the subsidy amount.

Impacts of the approach

Changes as result of monitoring and evaluation: Governmental support and recognition of farmers and herdsmen lead to widespread application of the technology. With improved sense in environmental protection, farmers and herdsmen would ask for updated technology and equipment including using wind energy resource.

Improved soil and water management: The technology is implemented by rural or pastoral households without obvious impact on the soil and water management.

Adoption of the approach by other projects/land users: The technology is simple so it is accepted very easily.

Sustainability: Without long-term incentive support, the land users will still use the technology.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Legislation promoted the technology application → To further improve the extension system.	High inputs of earlier stage → To continue the economic incentive support policy.
Subsidy incentives raise the adoption enthusiasm of the farmers and herdsmen → To further expand extension and application.	Incomplete maintenance service system → To make vigorous efforts in establishing sound community based service system.
Meet the basic need of electricity by householders → To further expand dissemination and application of the technology.	

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[1] Hou Guoqing. Wind-power generation and the prospect in Inner Mongolia. Electricity Power Survey and Design. 2004,9(3):77-80.
[2] Cai Jingyu. Inner Mongolia wind energy resource analysis and evaluation. International Electric Power for China.2004, 8(30:36-37.

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Left: The main part of the digester under construction. Photo by Wang Yaolin
Right: The gas produced is used for indoor lighting (the gadget on wall is for desulphurization). Photo by Wang Yaolin

Biogas Digester

Jingyuan County of Gansu Province, China

By established facilities and use organic matter of animal manure, human waste, plant straw for anaerobic fermentation to produce inflammable biogas for uses of lighting, cooking with the residue liquid and dreg for high quality organic fertilizer.

The demonstration site is located at Jingyuan County of central Gansu Province, an arid county with annual rainfall 240 mm for rainfed agriculture. The vegetation cover of the county is 5.6% and the water and soil erosion affected area is 5359 square kilometers or 92.2% of total land area. The fragile ecological and serious land degradation made the locality a very poor place, short of fuel. Poverty and ecological degradation has formed a vicious circle. Energy scarcity problem that needs to be solved urgently is also a cutting point for curbing land degradation. Since 2000, with the support of relevant departments, biogas production technology has been introduced and extended in Jingyuan County. Due to its multiple functions in kitchen, toilet, animal house etc., it has obvious social, ecological and economic benefits. The technology is easy and the maintenance is simple, so the extension is quick.

The construction procedures: location identification, digester type selection (e.g. rotational-flowed digester), elevation determination, earthwork, and construction of digester base, digester wall, feed and discharge chutes, proof seal layer and digester cover etc..

The operational management: pH value kept at 6.8-7.5; digester fermentation temperature maintained over 10 degrees Celsius; Replace desulfurizer every three months, stir frequently to ferment raw material, inspect often to ensure no leakage in the cover, pipeline etc.; frequent work in feeding and discharging, control the density of liquid material.

The functions of biogas digesters: (1) Ecologically, the use of biogas can reduce vegetation damage, prevent land degradation. A biogas digester with capacity of 10 m^3 can economize 2 tons of firewood every year, which is equivalent to the annual increment of 3.5 mu firewood forest; The dregs and residue liquid are organic fertilizers, the liquid can also be used for treatment of plant diseases and pests. (2) Social benefit. The biogas digester may offer over 70% clean energy of the household while reducing the consumption of the conventional energies of firewood and coal. The life quality, sanitary condition are improved and the working burden of women is alleviated. The use of biogas digester promotes social progress by raising the awareness of science and technology of the farmers to promote the construction of new socialist countryside. (3) Economically the biogas will increase the income of farmers. It can cut down the expenditure by 1500 Yuan for one year. Biogas use can promote livestock development and as an environmental-friendly agriculture development model.

Location: Jingyuan County of Gansu Province (the loess plateau)
Technology area: 5809.4km^2
SWC measure: Engineering
Land use: Farmland/other
Climate: Arid
WOCAT database reference: QT
Related approach: Rural Biogas Development – One Digester with Three Facilities
Compiled by: Wang Yaolin, GEF/OP12 Project Management Office, Gansu Sand Control Research Institute; Chang Qing, Foreign Funded Ecological Project Office, Jingyuan County, Gansu
Date: Revised on September 2007

Editors' comments: The technology of biogas digester is a mature one, and now widely adopted in rural areas of China. It has special importance for arid, ecologically fragile counties such as Jingyuan. It is playing increasingly important role in rural life. Now most farmers have realized its advantages and the enthusiasm of application is high. However, the initial relatively higher investment restricts technological extension larger scope.

Classification

Land use problems

Low vegetation cover, wind erosion, water erosion, barren soil, arid climate, fragile ecological condition.

Land use


Annual crops | Forest

Climate

Arid

Degradation


Water erosion | Wind erosion

SWC measure

Mechanical measures

Technical function/impact

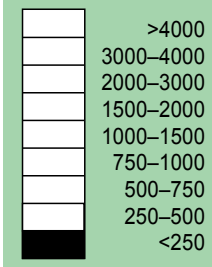
main: - protect vegetation
- reduce water erosion
- prevent wind erosion

secondary: - improve soil
- develop environmental friendly agriculture
- reduce emission of co_2
- increase income

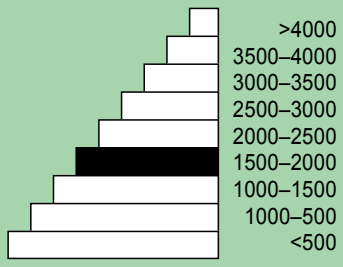
Environment

Natural Environment

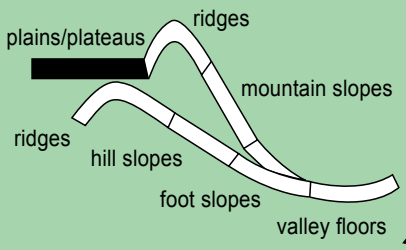
Average annual rainfall (mm)



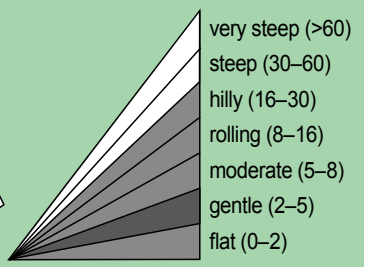
Altitude (m a.s.l.)



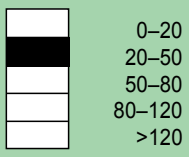
Landform



Slope (%)



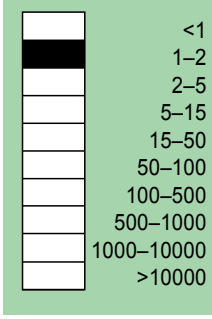
Soil depth (cm)



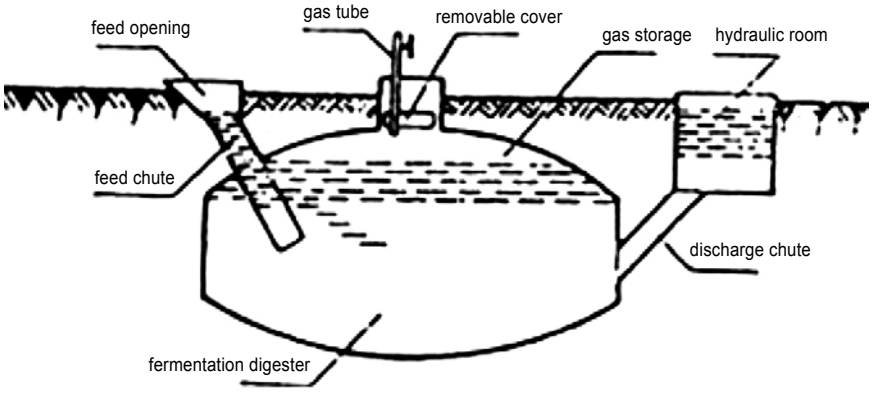
Growing season: 180 days in succession, from April to September
Soil fertility: moderate
Soil texture: moderate (loamy)
Surface stoniness: none
Topsoil organic matter: moderate (<1%)
Soil drainage: good
Soil erodibility: high

Human environment

Mixed land per household (hm^2)



Land use rights: individual
Land ownership: collectives
Market orientation: self use
Level of technical knowledge required: high to technical extensionists and high to land users
Importance of off-farm income: 10%-50% of total income



Technical drawing

Rural home use hydraulic cylinder-type hydraulic biogas digester

Discharge chute is connected with the toilet and animal houses, the digester should not be higher than the toilet, animal houses, and nearby residential houses.

For ordinary uses, the inner diameter of the digester is 2.7m. digester height 1m; low-spherical digester cover vector height: 54cm; low-spherical digester base vector height: 34cm; hydraulic pressure room: 1.2m long, 1.0m wide.

Implementation activities, inputs and costs

1. Planning: Make efforts to make digester functional 4 in 1, I.E digester, toilet, animal house and kitchen. In general, the household used of biogas digester is 8-12 m^3.
2. Location selection (leeward and not facing the sun), about 25m away to the kitchen.
3. Elevation determination to guarantee smooth inflow of the manure of the humans and livestock.
4. Get the raw materials ready.
5. Alignment and start the earthwork.
6. Construct the main digester including the proof seal, cover plate, feed chute, and discharge chute. Establish 2- 3 m^3. space for fertilizer storage that is linked with discharge chute to facilitate the discharge.
7. Install kitchen range with affiliated utilities.
8. input the inoculum and raw material of manure etc. for fermentation.

Establishment inputs and costs per hm^2

Inputs	Costs (US$)	% met by land user
Materials,cement, sand, cooker etc.	267	%
Labour	40	100%
Other: transport fee	40	100%
TOTAL	347	23%

1. Check to see whether the gas production is normal.
2. Check to identify any possible leakage of gas.
3. Check to see whether feeding is needed.
4. Check the use of desulfurizer.
5. Safety checking.

The checking is done for every 6 days.

Maintenance/recurrent inputs and costs per hm^2 per year

Inputs	Costs (US$)	% met by land user
Labour	80	100%
TOTAL	80	100%

Remarks: labor price calculated at RMB40 Yuan/day,equipment at permanent use cost, material cost is estimated; other costs by contracted annual maintenance.

Assessment

Acceptance/adoption

- Farmers accept the technology actively, with now more than 6000 household users in each township and 5% of the total households of the county total.
- By the demonstration role of the project, more and more householders recognized the advantages of biogas digesters. Some households are building biogas digesters by themselves.
- The incentives are mainly in form of supply of materials free of charge.

Benefits/costs according to land user

Benefits compared with costs	Short-term	Long-term
establishment	negative	positive
maintenance/recurrent	positve	positve

Impacts of the technology

Production and socio-economic benefits

+ + +	Save energies of coal, firewood etc
+ + +	Improve living environemtn
+ +	Add income
+ + +	Promote development of environmental friendly agriculture

Production and socio-economic disadvantages

	None

Socio-cultural benefits

+ + +	Improve knowledge level and technology dissemination
+ + +	Alliviate women's labor burden

Socio-cultural disadvantages

	None

Ecological benefits

+ + +	Protect vegetation and add vegetation cover
+ + +	Prevent water erosion and wind erosion
+ +	Improve soil
+ +	Reduce emission of CO_2

Ecological disadvantages

	None

Off-site benefits

+ +	Reduce sand dust weather days of the surrounding areas
+ +	Reduce silt downstream inflow of the Yellow River

Off-site disadvantages

	None

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Protect vegetation → Obtain more support from society for further biogas digester extension.	High initial investment → Get more project support.
Prevent soil and water erosion → Strengthen demonstration and inte-grate with conservation agriculture.	Low gas production → Strengthen training for correct operation.
Economical use of energy → Launch more projects for extension.	Biogas can be dangerous→ Strengthen training.
Serve the development of organic agriculture → Reinforce research and demonstration.	

Key reference(s)

Zhou Mengjin. Methane production and utilization technology. Beijing: China Agricultural University Press, 1999.

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Left: Biogas digester under construction. Photo by Chang Qing
Right: Biogas used for cooking. Photo by Wang Yaolin

Rural Biogas Development – One Digester with Three Facilities

Jingyuan County of Gansu Province, China

A campaign of "One digester with three facilities", launched by government and promoted by demonstration, is going on Jingyuan County of Gansu Province. This campaign is aimed to improve biogas digester and three facilities used in kitchen, animal house and toilet.

The demonstration project is located in Jingyuan County of Gansu Province. Historically, Jingyuan is a naturally harsh region, where shortage of "three materials" (materials for fuel, fodder and building) are felt. Furthermore, ecological degradation has led to poverty of rural community. In 1970s government encourage people to use biogas digesters, and in 1980s government called people to use firewood saving stoves and solar cookers, which to a certain extent alleviated the rural shortage of fuel material. However, due to financial and technical constraints the biogas application had a very limited progress.

In May 1979 National Biogas Application Conference was convened. After this conference a Biogas Office was set up in Jingyuan County dealing with promotion of biogas technology. During period of tenth Five-year Plan entire Gansu Province implemented a pilot village programme entitled "Ecological Homestead and Enriching People", sponsored by the Ministry of Agriculture, in addition to the National Programme of Conversion of Farmland to Forest and Programme of Poverty Reduction. Some farmers spontaneously made investment to build biogas digesters. Since 2003 government has launched a series of programmes, including programme of rural biogas digesters (financed by treasure bonds) and large/medium-sized biogas engineering programme (financed by Ministry of Agriculture). Powered by these programmes, more households were using biogas, and the scope of use was expanded to cover integrated uses in addition to lighting, cooking and boiling etc. In 2003, Jingyuan county had 121 certified biogas workers, and over 2100 sets of biogas digesters, including 1200 sets with advanced technology (lateral hydraulic automatic rotational-flowed digester). Four pilot villages were arranged. At present total of 6000 households are using biogas in the county.

The technology extension of biogas digesters is made mainly through project demonstration under the leadership of the county energy office. The extension approaches are: training, village meetings, on-the-spot explanations, handouts distribution. Trainees are the rural biogas technicians, administration staff as well as the farmers. Generally speaking, the village meeting is convened firstly for farmers to discuss and decide who should be financed by the project for biogas digester construction. In course of the publicity and construction, the county energy office staffs are responsible for answering the inquiries. The project or government will supply the building materials while farmers are responsible for transportation and labor input. The household who uses "one digester with three facilities" has a advanced digester with features of simple structure, reasonable layout and convenient operation. It also features more automatic operation, high gas production, easy cleaning and environment friendly.

Location: Jingyuan County, Gansu Province
Land use: Farmland/other
Climate: Arid
WOCAT database reference: QA
Related technology: Biogas Digester
Compiled by: Wang Yaolin, GEF/OP12 Project Management Office, Gansu Sand Control Research Institute; Chang Qing, Foreign Funded Ecological Project Office, Jingyuan County, Gansu
Date: Revised on September 2007

Editors' comments: The technology of "one digester with three facilities is project initiated by government, but now it is spontaneously adopted in rural communities. With increased number of users, this technology will play an important role in protection and restoration of degraded environment, reduction of poverty and development of new village. It is a practical and reliable method of solving rural energy problem. This technology has ahuge potential, but it needs financial and technical support from government.

Problem, objectives and constraints

Problem

- Community lacks funds for biogas digester construction.
- Community lacks biogas knowledge.
- Community lacks effective organization.
- Households lack fuel.
- Farmers extremely poor.
- Arid climate, low rainfall, low land productivity.

Objectives

- Establish effective extension mechanism.
- Raise community participation capability.
- Alleviate soil erosion.
- Provide energy to rural area to meet daily needs.
- Improve rural living environment.

Constraints addressed

Major	Specification	Treatment
Low knowledge level	Some farmers feel difficult to learn and accept new technology, and can not manage and operate the biogas facilities correctly.	Increase training intensity.
Short of fund	Current technological application is supported by project. Those areas without project are difficult to adopt it because of high initial investment.	Seek more social support and governmental special finances.
Minor	**Specification**	**Treatment**
Natural factor	Low temperature in late fall, early spring and winter has an influence on biogas output.	To keep biogas digester warm by combining animal breeding in warm house.

Participation and decision making

Target groups


Land user


Decision maker


Planner

Approach costs met by

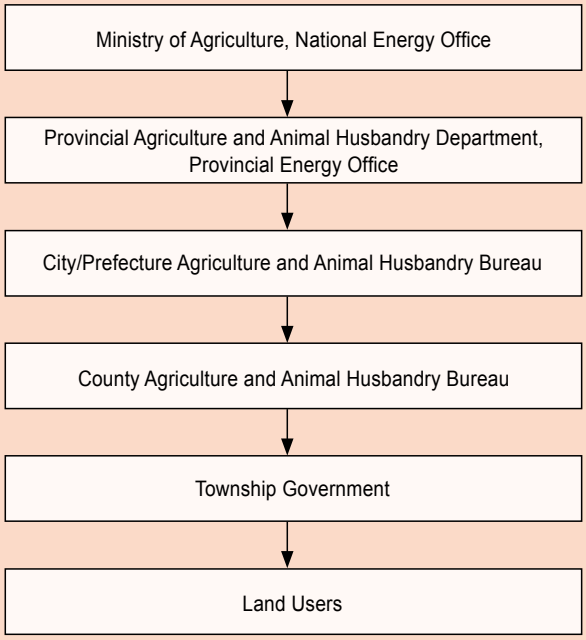
households	23%
Project finance	77%
TOTAL(2600 RMB Yuan)	100%

Decisions on choice of the technology: Land users and the government.
Decisions on method of implementing the technology: Government and farmers.
Approach designed by: Local experts.

Community involvement

Phase	Phase	Phase
Initiation	Passive	The departments at levels of Province, prefecture and county conduct surveys, convene meetings, carry out publicity to let villagers aware of the purpose of project.
Planning	Active	Villagers have consultations with design staff/technicians.
Implementation	Self mobilization	Farmers contribute labor and participate in the construction work.
Monitoring/evaluation	Active	Related departments explain the purpose of monitoring to the villagers and en-courage them to participate in monitoring recording and reporting.
Research	Active	Join In the digester construction and analysis of socio-economic effect during process of intro duction and research of new technologies.

Differences in participation of men and women: Male labor participate in the main part of physical work, including material purchasing, transportation and recruitment of technicians etc..



Organogram

Projects related with the technologies of "one digester with three facilities" are financed by the National Energy Office, and affairs related to international support will be dealt with by provinces and counties.

Extension and promotion

Training: The contents of training are: biogas digester construction, operation, maintenance and the use of dregs and residue liquid. The training forms are: demonstrations, meetings, wall newspaper, household visits and brochure distribution. Training is conducted mainly by county-level technicians. The training plays an extremely important role in technological application and improved knowledge of farmers.

Extension: The extension is organized by County Energy Office with collaboration efforts by the township government. The extension forms include demonstration, on-the-spot explanation, interviews etc. Some farmers with good cultural education can easily accept new things. They can scale up the technology through visits, discussion meetings to other householders. The extension has positive influence to both the extensionists and farmers.

Research: Research work has been mainly conducted at national and provincial levels, with little participation by farmers.

Importance of land use rights: Biogas digester is normally located in or around the home courtyard, so land use right does not affect the technology application.

Incentive mechanism

Labour: In process of the biogas digester construction, the labor is not paid, while the technical service employed should be paid by the project.

Inputs: Building material such as cement, brick, plastic pipe etc., are wholly or partially financed by the project while working tools such as shovels, tractor and pickaxe is supplied by farmer households.

Credit: : None.

Support of local institutions: Energy Office is established at the county level responsible for training and the extension and applying for assistance of biogas digester project support from country government or relevant international organizations.

Long-term impact of incentives: With the support of projects, the application scope of the technology is expanding quickly, some households of better economic condition are raising fund by themselves to construct biogas digesters. Without the support of projects, extension and application of the technology will shrink.

Monitoring and evaluation

Monitored aspects	Methods and indicators
Bio-physical	Field vegetation cover, ratio change of coal consumption and firewood consumption, the temperature inside the digester. By site observations and tests.
Technical	Gas production is obtained by observations and tests.
Socio-cultural	Survey the knowledge level of farmers on biogas and their understanding of organic agriculture.
Economic/production	Income and crops production.
Area treated	The entire county.
No. of land users involved	Annual survey of the number of adoption household of the biogas digesters.
Management of approach	Observe and record household biogas users, along with introduction, inputs and integrated development (planting, aquaculture etc.) of new technologies.

Impacts of the approach

Changes as result of monitoring and evaluation: At the beginning, the extension was done by efforts of government cadres to mobilizing the farmers. Now it is the government-project- farmer integrated extension pattern. Most farmers now has strong wishes to build biogas digesters and the biogas digester has evolved from single energy use to the present pattern of "Four-in-one" to cover organic agriculture development, aquaculture etc. and the users are extended from farmer household to governmental and social institutions, enterprises, schools etc..

Improved soil and water management: Protect vegetation and curb degradation of the ecosystem; the dregs and the residue liquid as fertilizer can help increase soil organic matter, produce green food and improve rural environment.

Adoption of the approach by other projects/land users: The technology has been adopted in the county as well as the surrounding areas.

Sustainability: The sustainability will be higher if project support or other external fund sources are available.

Concluding statements

Strengthens and → how to sustain/improve	Weaknesses and → how to overcome
Governmental extension combined with farmer spontaneous adoption of the technology → Reinforce propaganda, training.	Relatively complicated technology → Reinforce training and propaganda.
Increase capability and knowledge level of farmers → Access more projects to cover more biogas users.	The inputs are higher → Obtain more external support.
Add income → Reinforce integrated development.	
Promote organic agriculture → Further develop the uses of residues.	

Key reference(s)

Wang Xiaohua etc. Impact of rural household biogas consumption and economic behavior, College of Technology, Nanjing Agricultural University, 2005.

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