Sand-dune based greenhouses

Land degradation results from a combination of inappropriate and over-use of the soil, and of over-grazing, in an attempt to produce more than the site can produce in a sustainable way. By introducing alternative crops, particularly cash crops, or other methods of generating income that provide incentives for the further stabilization of unproductive land, the reliance on unsustainable practices can be reduced. To try and respond to this challenge, the Project has elaborated on the idea of integrating greenhouses for cash-crop production into the sand-dunes, using the sand-dune as a protection against wind and cold. The main cash-crop is grapes, but others crops may also be approprate.

If dunes can be made productive in this way, farmers would become motivated to invest in dune-fixation.

Achievements by the Project:

- ✓ New varieties of high-quality grapes were successfully introduced and a reproduction base developed
- ✓ Six different types of dune-based greenhouses designed, built and in operation.

The work with sand-dune based greenhouses was started by the Project in 1997.

Sand dune-based greenhouse are oriented to the South and have a sand-dune of certain height as its back wall and sidewalls. The main characteristics are:

- ✓ It takes advantage of the existing miro-topographic features, and has a potential for sand-stabilization.
- ✓ the space available inside is 20%-50% larger compared to a conventional greenhouse and its heat accumulating capacity is big enough to keep temperatures up and relative humidity down
- ✓ it has socio-economic potential.

Sand dune-based greenhouses are built at the leeward side of unstable mobile or semi-mobile sand dunes. In order to avoid that the greenhouse is covered in a short time by the moving sands, stabilization must be undertaken, both through mechanical means as well as through biological means. Shrubs and herbs with high economic value are favoured, including species such as *Prunus sibirica, Amorpha fruticosa, Astragalus adsurgens* and alfafa.

In order to grow grapes in a satisfying way, soil improvement is needed. The greenhouse should be complemented by animal husbandry capable of providing manure for the needed soil improvement. Crop farming inside the greenhouse increases the economic output on the usable area. Green folder with high protein content can be planted in the space between rows of individuals and around the greenhouse.

Sandy dune-based greenhouse increases manyfold the production capacity of what otherwise would be a baren area, and promote sand-fixation and greening. It could contribute to maintaining the stability of rural communities, vertically integrating and intensifying local production systems, and increasing the level of use of technology in other production systems.

Types of greenhouses used for comparative research

Sand dune-based greenhouse should be oriented to the South and have a sand-dune of sufficient height as its back wall and sidewalls, to protect the greenhouse from the dominant

North-Western winds. Six types have been build and compared. All greenhouses have the following dimensions: the back wall is about is 3.2m-3.4m heigh, the width from South to North is 6.5m-7.0m, and from East to West it should not measure less than 35m. Orientation should be E-W, with 5° deviation to the South.

The roof- and other structures for all the types are made of wood.

All types require a relatively flat and stable or semi-stable sandy land, protected by shelterbelts.

1. Brickwall backed greenhouse with wooden roof framework

This type of greenhouse has to the back and at both sides a double brick wall, separated by a space that is filled up with sawdust and dry leaves. This is similar to the traditional kind of greenhouse usually built beyond 43° N latitude in China.

2. Dune-backed greenhouse, interior dune-slope stabilised with brick-grid

The interior dune-slope is lowered to an angle of 30-40°, and stabilised with a grid made-up of side-turned bricks. The spaces inside the brick grid may be used for cultiviation of vegetables and flowers with low height, increasing the out-put and diversity of production from the greenhouse.

3. Dune-backed greenhouse, interior dune-slope stabilised with fence

When tree and grass roots are holding the sand dune slope together, but nor enough, to prevent the dune from collapsing and the sand flowing downwards in the greenhouse, a 1.0m heigh fence, made of poles and intertwined branches is established at the foot of the dune. In this way the slope above the fence becomes stable and may serve as back wall for the greenhouse.

Measures to deviate the water flowing down the slope are needed and grasses and shrubs should be planted to further stabilise the back slope.

4. Dune-backed greenhouse, interior dune-slope stabilised with wickerwork

When the sand dune is not high enough, it may be raised employing, a wall formed by wickerwork of willow branches may be used, that is filled up from behind with leaves and saw dust as isolation against the cold.

This type of greenhouse has the potential for wide-spread use for the excellent heat saving effect of its back wall and the stable structure with the willow fence.

5. Slope without treatment

When tree and grass roots are holding together the sand dune slope thoroughly, and where the slope is steep and high, the sand dune may serve as back wall without further treatment.

Measures to deviate the water flowing down the slope are needed and grasses and shrubs should be planted to further stabilise the back slope.

6. Model B: Slope without treatment

On less stable big dunes, with less inclined slopes, the natural shape can also be used, increasing the constructin costs. This type of greenhouse is very stable, and the space of its back wall is available.

Ziziphus (chinese dates) or other crops may be cultivated in the flat area to the back of the sand-dune slope greenhouses, increasing the productivity. These fruit trees which can not be cultivated in the open field or the early-ripening ones as well as the over winter strawberry can be cultivated in the space.

7. Tunnel-shaped greenhouse, without back-wall

The tunnel-shaped polyhouse is a greenhouse based on wooden framework without walls. The establishment of this greenhouse differs from the traditional polyhouse in that it is built for fruit tree cultivation, being taller and needing more building materials and of higher quality, making it more expensive. However, as the space inside it is much bigger, the cultivated fruit trees and other cash crops can fully develop, and output is much higher than that of a traditional greenhouse.
Its dimensions are 12 m wide, 2.5 m high by 35 m long.

Based on four years' observation and practice types 1, 2, 4, 6 are more suitable, either for reasons of stability, ease of construction and costs.

Temperature control inside the greenhouse

The vegetation and the shelterbelt protection around the greenhouse are crucial for the heat saving and for the protection against the wind. The temperature changes inside the greenhouse are very complicated. On a clear day with sunshine, the maximum temperature inside the greenhouse may reach 45°C for a long time, and even applying ventilation, it will remain well above 30°C. However, temperatures between daytime and night are very different.

Irrigation

Drip irrigation is the most appropriate type, as it allows saving water and application of fertilizer in an efficicient way.

Soil improvement

In the poor sandy soils of the dunes, soil improvement beomes extremely important for grape cultiviation. After four year's trial and practice, it has been determined that best results are

obtained when the soil improvement is carried out in a ditch, with a dimension of 1 m wide by 1 m deep. Topsoil and soil from deeper layers are separated during digging.

A layer of 20 cm thick of straw is laid on the bottom of the ditch. This layer is covered with topsoil, and finally with the remainig soil to refill the ditch. Fertilizer with trace-elements should be added; yearly, additional manure, nitrogen, phosphorus, potassium and other micro-elements should be provided. The soil improvement for vegetable production is done in much the same, but to a depth of 0.5 m instead of 1 m.

Costs

The wooden-framework sand dune-based greenhouse is made up of wood, bamboo plank and some supplementary materials. The building materials and their costs are listed in the following table.

Table 7.4.1 : Cost of building materials used in the construction of dune slope backed greenhouse (Naiman)
(per mu)

Materials	**Cost**
Wood and bamboo	5893
Plastic film	1890
Nails and wire	1550
Straw mats	2236
Total	11569

Labour costs for the construction of this greenhouse type are 4950 RMB, and for the soil improvement 4000 RMB.

The mud wall-based greenhouse is the greenhouse with mud wall at the back. Its building materials and cost are listed in the following table.

Table 7.4.2 : Cost of building materials used in the construction of traditional mud-wall backed greenhouse
(per mu)

Materials	**Cost**
Wood and bamboo	8314
Plastic film	1650
Nails and wire	1300
Straw mats	2236
Total	13500

Labour cost for the construction of this greenhouse type are 5610 RMB, and for soil improvement 3000 RMB. As this greenhouse is generally located on better quality soils, costs for soil improvement are less, but a land lease of about 2250 RMB per mu and for a 10-year period should be calculated.

It is easily concluded that though the sand dune-based greenhouse is cheaper to build compared to the mud wall backed greenhouse, the soil improvement costs are higher, because the inherent lack of fertility of soils on shifting dunes. Therefore, the total costs of the two are nearly the same.

For comparisson, costs for a brick-walled greenhouse are at least 30,000 RMB per mu.

Table 7.4.3 : Cost of building materials used for the construction of tunnel shaped greenhouse

Materials	**Cost**
Wood and bamboo	3155
Plastic film, cloth	1650
Nails and wire	1088
Total	5893

Labour cost for the construction of this type of greenhouse are about 1000 RMB, and soil improvement costs around 4000 RMB.

Income generation

Comparison of the input and output of sandy dune-based greenhouse, sandy polyhouse and traditional polyhouse, as well as the net income of grape cultivation inside them are listed in the following table:

Table 7.4.4 : Comparison of output and income for different types of greenhouses

Type of facility	Varieties	Initial invest-ment	Yearly reproduction cost (RMB)	Output (RMB)				Net income(RMB)			
				1st year	2nd year	3rd year	4th year	1st year	2nd year	3rd year	4th year
Sand dune-based greenhouse	Early-ripening	20500	5000	500	1000	2000	2000	-2050	2950	12950	12950
Sand dune-based greenhouse	Late-ripening	20500	5000	300	800	1500	2000	-3450	2550	10950	16950
Tunnel shaped greenhouse on sand-sheet area	Late-ripening	6500	4250	300	800	1500	2000	-1900	3100	10100	15100
Traditional greenhouse, mud-wall backed	Early-ripening	24500	5000	500	1000	2000	2000	-2450	2550	12550	12550
Traditional greenhouse, mud-wall backed	Late-ripening	24500	5000	300	800	1500	2000	-3850	2150	10550	16550
Traditional tunnel-shaped greenhouse on productive land	Late-ripening	6500	4250	300	800	1500	2000	-1900	3100	10100	15100

Notes:

1. The early-ripening grape varieties sell at 10.00 RMB per kg, and the late-ripening ones sell at 12.00 RMB per kg.
2. The initial investment is for the purchase of building materials, frost-protection and so on; the yearly reproduction cost includes the cost of seedlings, production materials (including plastic film – PVC type: 1 year duration; PE plastic lasts 2 years, but less transparent), labour costs and some other costs.
3. The net income simply refers to the fruit-selling income, the income obtained from inter-cropping and its by-product are not included.
4. It is assumed that the greenhouses have a usefull lifespan of 10 years.

Table 7.4.5 : Benefits from inter-cropped vegetables in grape cultivation

Type of facility	Varieties intercropped with vegetables	Intercropping benefits (RMB)				
		1st year	2nd year	3rd year	4th year	5th year
Sand dune-based greenhouse	Early-ripening	3000	2000	2000	2000	2000
Sand dune-based greenhouse	Late-ripening	3000	2000	2000	2000	2000
Sandy polyhouse	Late-ripening	2000	1500	1500	1500	1500
Traditional greenhouse	Early-ripening	3000	2000	2000	2000	2000
Traditional greenhouse	Late-ripening	3000	2000	2000	2000	2000
Traditional polyhouse	Late-ripening	2000	1500	1500	1500	1500

Table 7.4.6 : Net income of vegetable production (without grapes) in greenhouses

Type of greenhouse	Initial investment (RMB)	Yearly reproduction cost (RMB)	Net yearly income (RMB)
Sand dune-based greenhouse	20500	5000	8950-10950
Sandy polyhouse	6500	4250	2150-3650
Traditional greenhouse	24500	5000	4550-12950
Traditional polyhouse	6500	4250	2250-3750

Note: Yearly greenhouse production output for one bed (1m x 5m long) is 120-200 RMB per year, and for the tunnel-shaped greenhouse it is 55-90 RMB for one bed per year.

The above analysis shows that the input and net income of the sand dune-based greenhouse is similar to that of the traditional mud-walled backed greenhouse. The cost return period of both is about 4 years, and the steady yearly output lasts over 10 years. However, there are some unique qualities the sand dune-based greenhouse has in favour over the traditional one:

- it takes the advantages of the micro-topography features of the region.

- the available space inside the greenhouse is 20%-50% larger compared to a traditional greenhouse, and its heat accumulation effect is higher

- it intensifies production on otherwise barren land

- it provides opportunities of cash-crop production and associated income generation in rural areas, mainly near population centers.

Introduction of superior grape varieties

Ten grape varieties have been introduced from the U.S.A: Red Globe, Riber, Thompson Seedless, Flame Seedless, Ruby Seedless, Christmas Rose, Queen, Exotic, Centennial Seedless, Jinxi Seedless.

Six domestic outstanding grape varieties were also tried-out: Xiangfei, Jingya, Jingxiu, Lizhamate, 87-1 and Black Banana, introduced to the local region in 1998.

Research on adapted grape cultivation techniques in greenhouse

The grape varieties introduced from U.S.A are mostly the late-ripening varieties, not suitable for open field cultivation; the domestic varieties are early-ripening varieties, cultivation techniques of the latter for sandy soils are not yet well enough developed.

Five early-ripening varieties (Xiangfei, Jingya, Jingxiu, Centennial Seedless, 87-1) and 7 late-ripening ones (Red Globe, Riber, Thompson Seedless, Flame Seedless, Ruby Seedless, Christamas Rose and Exotic) were selected.

Adapted grape cultivation techniques have been improved for each. The Red Globe variety has been the most succesfull among the varieties tried out.

Demonstration and popularization

From 1998, demonstrations have been set up in Naiman and in the outskirt of Tongliao City (traditional vegetable greenhouse and polyhouse). This technique is gradually being accepted by the progressive minded among the local farmers. Over the recent 3 years, over 500 people have received training and more than 1,000 people have paid a visit to the demonstration sites.

Limiting factors for grape development

After four years of trials and practice, it has become clear that the main problem for further development of the grape cultivation in sandy-dune greenhouses is the requiered soil improvement, for the following reasons:

- the initial investment for soil improvement is high, the time of its effect relatively short, and often it is observed that the improvement has not been good enough
- the soil nutrition supplements make up a high percentage of annual working costs (labour and fertilizers)
- it is not easy to keep the soil nutrition in balance, due to leaching out of moisture and fertilizer in the sandy soils