Yan River Basin study site, China

Highlights of work carried out in the DESIRE Project
Based on work by the Chinese Academy of Sciences

The study site

The highly dissected Yan River catchment is a tributary to the Yellow River and originates from the Baiyu mountains on the Loess Plateau.

- **Coordinates:**
  Latitude: 36°23′—37°17′ N
  Longitude: 108°45′—110°28′ E
- **Size:** 7,678 km²
- **Altitude:** 495-1795 m
- **Precipitation:** 420-530 mm/year
- **Temperature:** 8.5°C – 11.4°C
- **Land use:** cropland, dam-land, paddy field, forest plantations, shrub, cash trees, orchards and grassland
- **Inhabitants:** 681,403 (1999)
- **Main degradation processes:** water erosion and sedimentation of reservoirs and riverbed
- **Major drivers of degradation:** global change; lack of resources for combating and monitoring land degradation

Location of the Yan River Basin

The Yan River is a primary tributary of the Yellow River, China. The average channel slope in the river basin is 3.26‰, and the area of whole basin is 7,687 km^2. The land is badly incised with a gully density of 2.1 to 4.6 $km \cdot km^{-2}$. Annual average sediment delivery: 43.6 M tons; annual runoff: 142.5 M m^3.

Yan River is a first class branch of the Yellow River. The Basin is 7,678 km^2 covered by loess with gully density (2.1 to 4.6 $km \bullet km^{-2}$). Dominated land use is dry farming land, and the vegetation is secondary forest in the southern part and forest-grass in the northern part. It is in arid and semi-arid region but about 70% or more rainfall is as strong storms. The mean annual runoff and sediment yield is 0.22 billion m^3 and 47.76 million tons respectively, and the sediment flow modulus accounting for 8,100 $t \bullet km^{-2} \bullet yr^{-1}$.

In the Yan River basin, on the loess plateau, it is soil erosion that is the predominant desertification process. The region is arid to semi-arid, with most of the precipitation in summer or early autumn.

Dry farming is the dominant land use, and the vegetation is secondary forest in the south, and forest and grass in the north. The major crops are winter wheat, maize, millet, buckwheat, potato, and many kinds of beans. Since the implementation of the "Grain for Green Policy" in 1998, thousands of ha of sloping crop land have been converted into forest and grassland. The local farmers can get annual subsidies, in the form of cash and cereals, from the central government.

Erosion patterns on the loess plateau, China © Wang Fei

Yan River, originating from Baiyu Mountains, Tianciwan Town, Jingbian county, Shaanxi Province, is a first class branch of Yellow River, China. It is located between 108°45′—110°28′ E and 36°23′—37°17′ N.The average channel slope is 3.26‰ and the area of whole basin is 7,678 km^2.

It is in hilly gully area of the Loess Plateau covered by loess. The landform is broken seriously. The gully density (the length of channel in one km^2) is amount to 2.1 to 4.6 $km \cdot km^{-2}$. Dominated land use is dry farming land, and the vegetation is secondary forest in the southern part and forest-grass in the northern part. The population in the area is 637234 in 1990 and 681403 in 1999.

The natural condition of Yan River Basin is poor. It is in arid and semi-arid region, the precipitation is low and the major rainfall (about 70%) is in the summer and early autumn as strong storm.

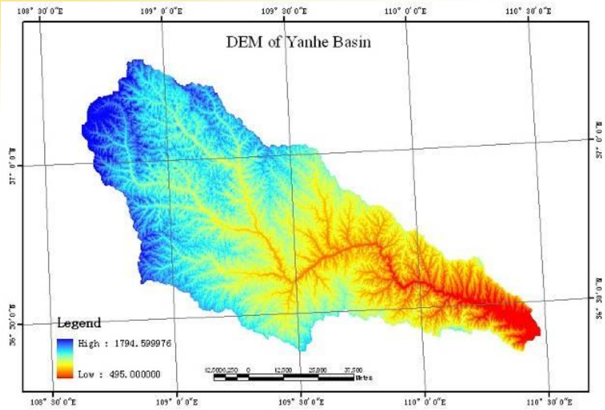
The soil erosion is very severe in this basin. The soil erosion area of Yan River Basin amounts to 4829.20 km2, about 62.90% of the whole basin. The average annual runoff is 0.22 billion m^3, and the runoff modulus accounting for 4,776.36 $m^3 \cdot km^{-2} \cdot yr^{-1}$. The average annual sediment flow is 4.776 million tons, and the sediment flow modulus accounting for 8,100 $t \cdot km^{-2} \cdot yr^{-1}$. The coarse sediment (sediment particle diameter not less than 0.05 mm) flow modulus is 2,430 $t \cdot km^{-2} \cdot yr^{-1}$ on the Ganguyi Hydrology Station.

The great soil erosion make the land infertile more and more, and the water loss also decrease the soil water available greatly that would induce lower yield of grain and biomass.

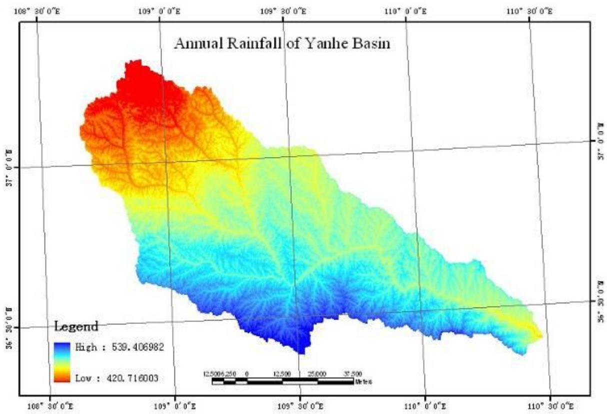
The sediment concentration of Yan River is very high. The data from Yan hydrology Station shows that the mean sediment concentration is 227227kg/m^3, and the highest one was 1300 kg/m3（June 17, 1963）. The sediment would silt in the reservoirs and riverbed of the down stream.

Bio-physical description

The geology in the Yan River Basin is quite simple (Sketch map 2). Most area is covered by Quaternary Loess (O_2). The main soils in the Yan River basin are Mian Soil and Heilu Soil (Local name). The Main soil is distributed on the slope, terrace, alluvial land and table land. The profile has no clear difference. The heilu soil is in the broken tableland area with clear layers. The soils here are easy to cultivate.



Map 1: DEM of Yan River Basin



Map 2: Annual precipitation map

The main vegetation systems include cropland, dam-land, paddy field, man-planting arbour forest, shrub, cash trees, orchards and grassland.

The orchard (left, apple) and sown grass (right)

Existing practices on land and resource uses

The main practices on land use include arable farming, cash crops, grass planting and vegetables. The main crops are winter wheat, maize, millet, buckwheat, potato, many kinds of beans like soybean and mung bean, rape, tobacco and so on . Since the implementation of "Grain for Green Policy" in 1998, there have been thousands ha of slope crop land changed into forest and grassland. The local farmers could get subsidies, such as cash and cereal, from central government annual. In the meantime, the grazing outside was forbidden in the whole area. The terrace, demland and alluvial land are the main cereal production area. The oil crops and cash crops in Yan River Basin are very limited because the exchange is not active all the time.

Existing practices on water resources

The irrigation in Yan River Basin is very limited because the growth period of crops is in the flood season and the cost of irrigation is very high. In the last ten years, there are some new practices of water saving irrigation, such as drip irrigation in orchards.

There are some reservoirs in the basin, such as Wangyao Reservoir in An'sai County, Shengli Reservoir and Suntai Reservoir in Yan'an city, to supply fresh water for the city. For the severe soil loss and sediment silt, the capacity of reservoirs decreased about 1.3% to 3.3% annually.

For the global change, the water resources decreased greatly. Compared to the average in 1960s, the annual precipitation in the 1970s, 1980s and 1990s in the basin, has respectively reduced by 10.5%, 11.7% and 14.0% and the annual water yield in the basin has separately reduced by 14.1%, 13.1% and 21.4%. It is a great challenge to combat the possible drought.

Existing uses of Forest resources

Most of the forest resources are ecological use in the Yan River Basin. There are 66242 ha, accounting for 8.63%. The areas of man-planting arbour forest, shrub and cash trees are 119864, 90874 and 40915 ha respectively, accounting for 15.61%, 11.84% and 5.33% respectively.

The forest is distributed in the south part of the basin with thin topsoil. The species of secondary forest are Sophora and Chinese pine. In the local site, the forest is in the valley with more soil moisture. After the "Grain for Green Policy", more and more forest were fostered on the steep slope.

Some other policies to protect forest, such as Natural Forest Protection Project, have also played a great role in the sustainable forest development.

Strengths of existing land use practices

The soil and water conservation could decrease the soil and runoff erosion to improve the soil properties. The yield of terrace and dam land is much higher and stable than that of the slope cropland. The yield of terrace, dam land and paddy field is 1752 kg/ha, 5181 kg/ha and 6060 kg/ha respectively.

Weaknesses of existing land use practices

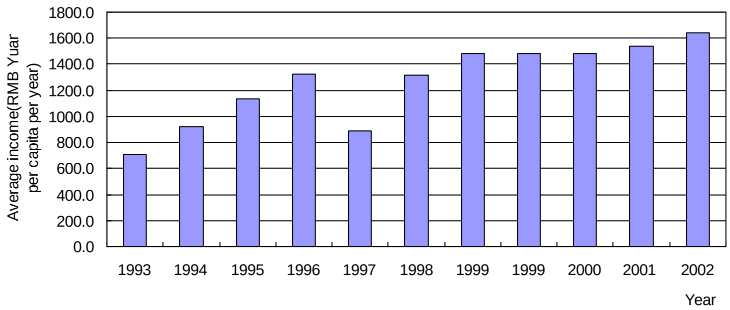
The most unsustainable practice in the Yan River Basin is the forest that could consume the soil moisture fast. There are many old and small trees in the Loess Plateau. The productivity of forest is very low but the effective soil moisture is nearly use up. It is quite difficult to judge how to improve the vegetation.

The dry land farming on the slope land could increase the soil loss, but many local farmers would like to use it for the possible yield if there is enough rainfall. Although the Grain for Green Policy has already changed many slope croplands into forest and grassland, the slope cropland is widely cultivated in great area without subsidies. The plastic film could increase the yield and income normally, but it is too expensive in the Yan River Basin if we use thicker film that could recycle and reuse. The thin plastic film has already destroyed the soil structure.

Major degradation issues due to the use of natural resources? (e.g. erosion, soil fertility decline, salinisation, pollution, water quality or quantity decline, biodiversity). The major degradation issue in the Yan River Basin are soil erosion that could not only induce the on-site soil fertility decline but pollute the water resources of the downstream rivers. The sediment delivery would silt in the reservoirs and the riverbed. The runoff to flush 1 ton of the sediment into the sea is amount to 60 m^3 in the Yellow Rive. It will make the water shortage worse.

Level and source(s) of income main stakeholder groups (income from the resource base vs. income from off-farm labour or from family members in city or abroad)

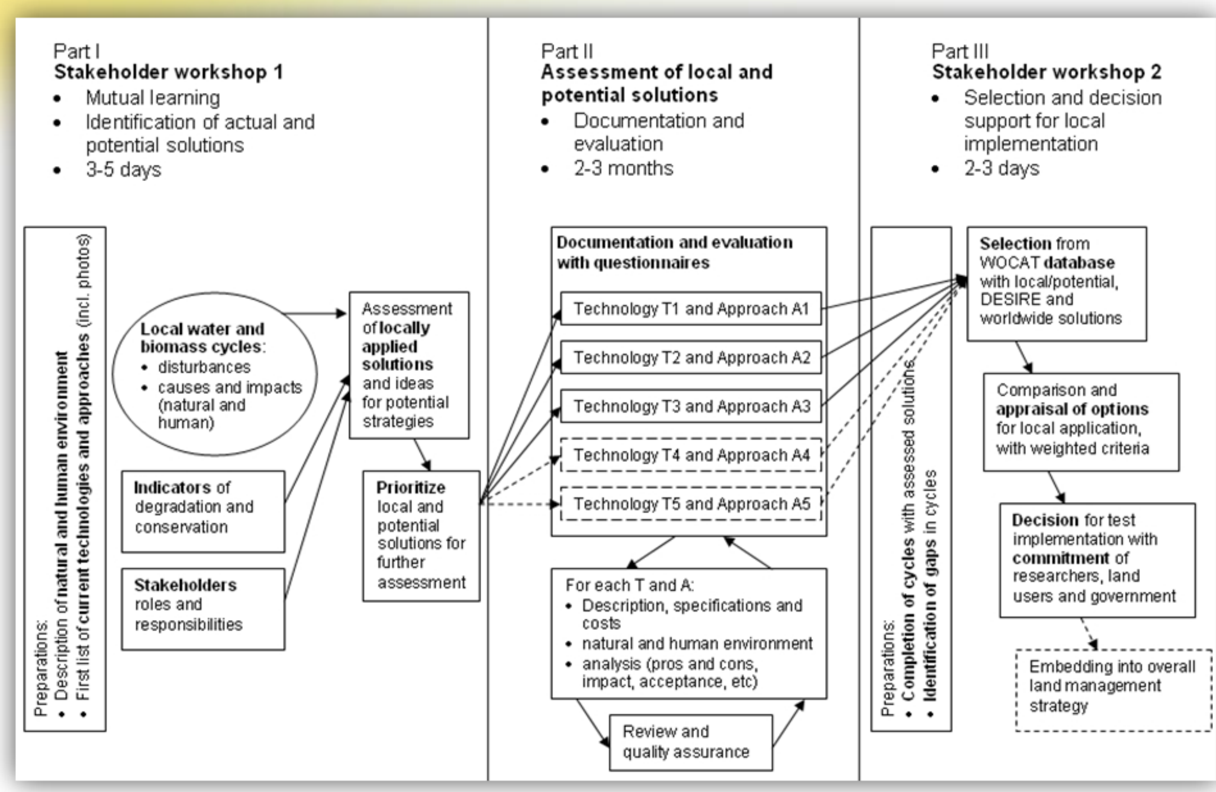
The average income of local farmers 465, 1044, 1270 and 1277 RMB Yuan per capita in 1990, 1995, 2000 and 2002 respectively in Baota County. More and more income of farmers is coming from sub-industry and service, such as transportation, construction, business. The average income is 225 RMB Yuan, 786 RMB Yuan, 855 RMB Yuan and 987 RMB Yuan in 1990, 1995, 2000 and 2002 respectively.



The net income change of Baota County

The income of local farmers is very low from the land. In Baota County, the net income increased slowly from 703 RMB Yuan per capita in 1993 to 1640 RMB Yuan per capita.

Workshops for researchers and stakeholders to select sustainable land management technologies



Researchers talked with local people and policy makers, and together they decided on the best options for sustainable land use. In the DESIRE Project the three Parts to WOCAT methodology were developed as outlined above. This provides decision support for choosing technologies suited to the local environment that includes social, cultural and economic factors as well as physical science.

In every DESIRE study site researchers and stakeholders held two workshops to arrive at their selection of approaches and technologies. At the first workshop stakeholders learned about how degradation happens, and how to avoid it.

Meetings of researchers with stakeholders were used to help break the cycle of desertification. Together they discussed and tried out suggestions to find the best ways of reducing the incidence and impact of land degradation while addressing goals for sustainability.

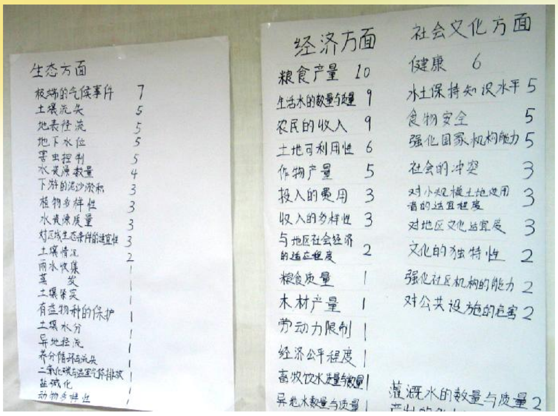
Step 1 Impact chains

1st: Land degradation and desertification – existing and potential prevention and conservation strategies June 2-5, 2008

Step 2 Selected options and necessary adaptations

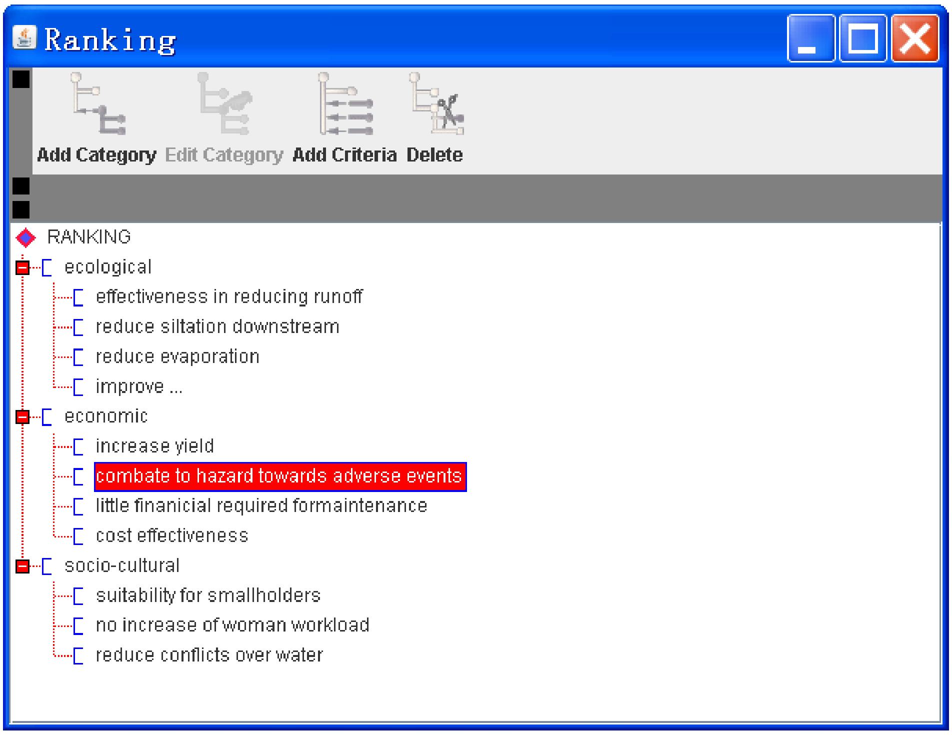
Option	Level bench Terrace	Reforestation
Photo		
Option	Check dam land	Level groove on the slope
Photo		
Option	Fish-scale pits	Mulching
Photo		

Step 3 stakeholders' Influence analysis Step 3 Evaluation Criteria



Step 4 Scoring of options made by different groups Step 4 Applied Tech and approaches selection

Step 5 Ranking criteria



Step 6 Analysis and interpretation


Result: Final Run
Polar View
Ascending
Sort by: Maximum
RANKING
ecological
economic
socio-cultu
Glue
0.0
0.25
0.5
0.75
1.0
Level bench Terrace
Check damland
Reforestation
Level groove on the slope
Mulching
Fish-scale pits


Result: Final Run
Polar View
Ascending
Sort by: Maximum
RANKING
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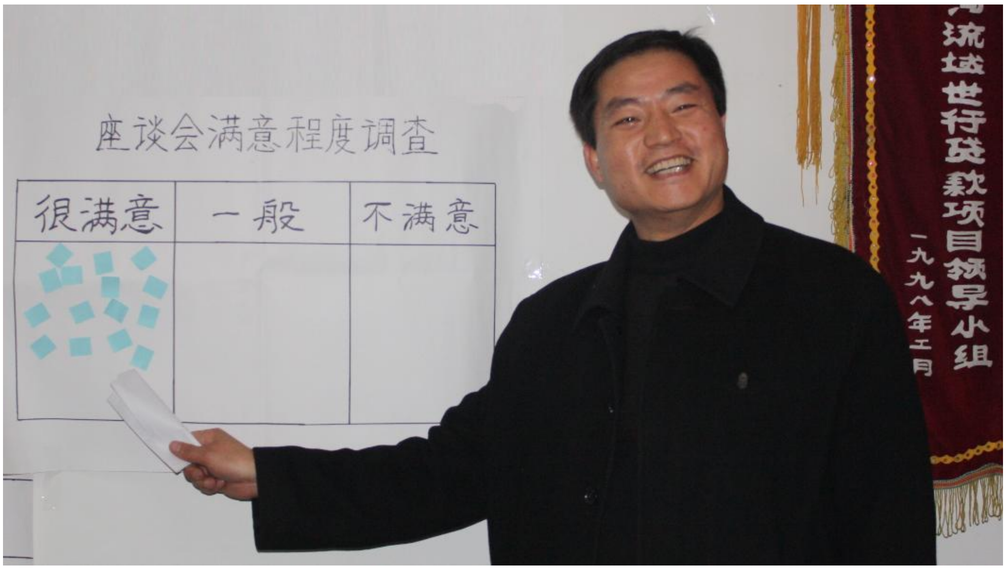
0.75
1.0
Reforestation
Level bench Terrace
Mulching
Level groove on the slope
Fish-scale pits
Check damland

Step 7 Prioritisation of options

Step 8 Embedding into strategy

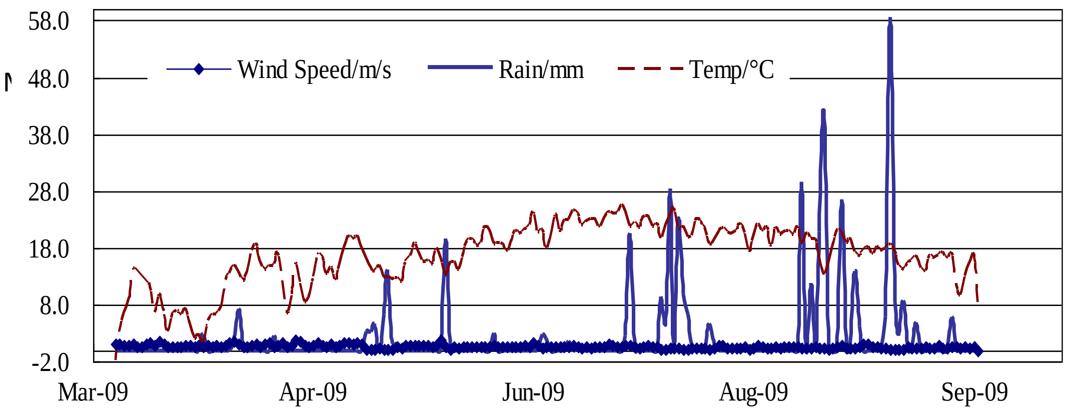


Researchers and stakeholders work together

Scientists, local experts and managers, local farmers are involved in the monitoring. The local farmers can protect the equipments and plots well in Miaowan Watershed. To confirm the integrated impacts of different technologies and land use on natural resources; To test and explain the benefits of selected technologies from WOCAT-DESIRE process; To show the differences of technologies for the local farmers; and To find something new, interesting and possible that has not been mentioned in the concern stages of DESIRE all the time.

Monitoring 1: Climate and Weather Conditions

Two set of automatic weather stations (HOBO) are set up in Miaowan, Zhenwudong Town, Ansai country and Kelaigou Village, Liulin Town, Baota County. The result of precipitation, temperature, wind speed would be used in the soil moisture change and soil erosion evaluation.

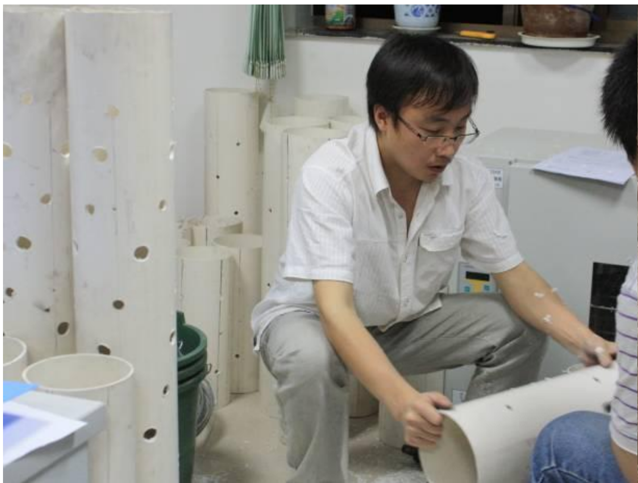
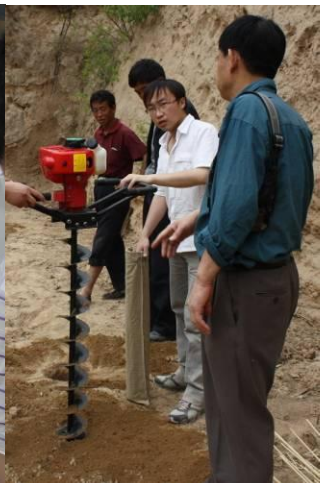


Monitoring 2: New Soil Erosion Plots

Building erosion plots on the slope of orchard in Miaowan village (2 gradients ,13 and 29), 5 meters long, three treatments (natural slope without coverage, contour tillage and contour with mulching, two times) 。Some soil erosion tests with simulating rainfall finished.

Monitoring 3: Small Rainfall Harvesting

For improvement of dry and high climate change trends, small rainfall harvesting for deeper infiltration with plastic film in Miaowan Village are set and monitor the soil moisture and its impact on apple yield.



Monitoring 4: Soil Moisture of Different Land Use

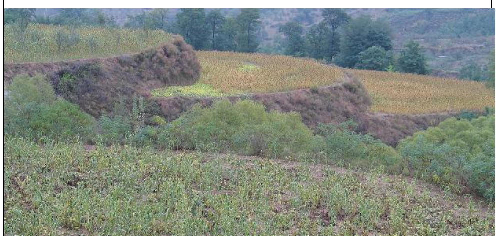
The cropland, orchards, grassland, shrub and forestry on different slopes or terraces are measured every two weeks with local farmers.

Monitoring 5: Crop and Livelihood Monitoring

WB4-5 Workshop Report in Ansai County, the Loess Plateau

Technology trials

There were 6 options, level bench Terrace, reforestation, check dam land, level groove on the slope, fish-scale pits, mulching, being widely used in this region, and were selected and agreed upon by the stakeholders as the options in WB3. There were 3 strategies were test in WB4 and the relative information is shown in table below including of brief description of the technologies (Dot), the nature of the desertification problems that need to be tackled in the study area (Dp) with accompanying photo and a short description of the results of remediation strategies (Dor).

Level bench Terrace 	Dot: a kind of construction to make small flats on the slopes that could increase the infiltration of rainfall and the yield of crops. Dp: the soil erosion and water loss in this region is very severe and induce land degradation and lower output. Dor: - according to the survey in 2009, terrace (4500 kg/ha,maize; 3200 kg/ha, millet), slope cropland (maize 1100 kg/ha, millet 1200 kg/ha) - according to the simulating rainfall and small plots: no erosion terrace and 4800 t/km^2 on the slope of 20 degree with rainfall intensity (55 mm/hr) in 30 minters
Check dam land	Dot: a kind of construction (check dam) on the downstream of

	gullies to silt the sediment from the upper streams induced by erosion on the slopes and gullies. After a certain time, the area in front of the dam would be check dam land with sufficient water and fertile soil for crops. Dp: to reduce the sediment delivery to the river from gullies, mitigate the gully erosion that would make the landform much broken. Dor: - according to the survey in 2009, terrace (7800 kg/ha, maize), slope cropland (maize 1100 kg/ha, millet 1200 kg/ha) - no erosion normally.
Reforestation 	Dot: a kind of vegetation measure to increase the land cover by crone and residues to reduce the rainfall erosion energy and increase the infiltration of rainfall. Dp: the soil erosion and water loss in this region is very severe and induce land degradation and also induce the land broken. Dor: - according to the simulating rainfall and small plots: soil erosion rate with grass (70% of coverage) being 2400 t/km2 and 4800 t/km^2 on the slope of 20 degree with rainfall intensity (55 mm/hr) in 30 minters

Priority Remediation Technologies

The workshop was held with 2 sessions. The first session was held in the afternoon, June 22, 2011 with local farmers, and 6 village heads and 2 farmers from Zhenwudong Town, Ansai County, Yan'an City participated. These 2 farmers also do monitoring of soil erosion and soil water and economic survey.

The second half is with policymakers at the county level in the norning, June 23, 2011. The 5 person below could participate the relative consultation meeting or planning directly.

Mr. Su Wenlin, Deputy Director, Ansai Senior Association of Sciences (this association was founded by the former officials and local experts of Ansai County and almost all of them with plentiful local knowledge and experiences both in practices and management)

Mr. Xue Shengming, Deputy Director of Ansai Bureau of Water Resurces (bureau for the soil and water conservation planning and implementation of projects, and water supply and resources protection).

Mr. Bai Sunbao, Assistant of "Grain for Grain Project" Office of Ansai County

Mr. Wu Ping, Assistant of Ansai Bureau of Forestry (bureau for forestry management, protection of natural forests, the forest right of local farmers)

Mr. Xue Wei, Deputy-Director of Yan River Management Office, Ansai Branch (integrated river basin management office, normally concerning of all aspects of natural condition, policies and coordinating the different departments)

The result of ranking showed that terrace, reforestation and check dam land have relative high ranks in ecological, economic and socio-cultural aspects.

Ecological:

Economic:

Socio-cultural:

Priority remediation technologie(s) selected in WB3 workshop were check dam for land, reforestation and terrace based on the analysis and interpretation process.

Outcomes of discussion at the workshop

The three strategies were also the most important ones in this region because their integrated benefits in ecological, economic and socio-cultural aspects. The survey and monitoring results also showed that they are good options. The additional criteria used to evaluate the strategies are the return of these strategies but the criteria are not very clear. For check dam for land, the new technology developed to build check dam land since the beginning of building of check dam. The flat land in the valley can be used soon after the building and will not waiting for the siltation of dam for 10 years or longer.

There are many terraces abandoned in Ansai County because they are far away from the villages and the net income is very low, especially when considering the value of labour. For the reforestation, it could save time and get some subsidies from government. Some participants also suggested how to improve the management of low-yielded forest there.

The main soil and water conservation technologies are grass-planting, reforestation, terraces and check dams to prevent the soil erosion on the slope and the sediment being delivered into the main stream of Yan River and the Yellow River finally.

The monitoring items include soil moisture and soil erosion, and crop yield and health parameters. Weather variables are measured at an Auto-weather Station set on the roof of one family.

The area of cropland on the steep slope is very small since the implementation of Grain for Green Project in 1999, so we cancelled the monitoring even the main soil erosion is from the steep cropland.

The mean annual precipitations and evaporation are 560 mm and 1600 mm in this watershed. The precipitation varies greatly among different years and within each season and more than 60% precipitation is in flood season from June to September. The rain storms occurring mainly in summer can induce intensive soil and water loss on the slope that makes the unstable yield even to with no economic return some time.

The monitoring in Kelaigou Watershed is mainly for the increasing water availability for maize using terrace and check-dam land.

TRIAL LAYOUT

(a) 4 kinds of land, terrace, reforestation land, grassland and orchard on the steep slope (sparse) to south, all around 20 degree gradients, the soil moisture will be measured 3 times (Before planting in April normally, mid-August and after harvesting in October); soil erosion with rainfall simulator, 2 storm intensity and 2 rainfall period (30 minters and 60 minters) , double duplications. The simulator and total sediment was dried and weighed.

(b) 3 kinds of land, terrace, slope cropland (maize, millet) and check dam land (maize), survey the yields.

(c) The water is the limitation factor in this region. We set terrace and check-dam to test the soil water and yield comparing with those crops on the slope. The auto weather station was set up in this watershed. The metrological data, soil moisture, yield, soil erosion, input and output of agriculture were monitored, but some foundational items were not tested this time.

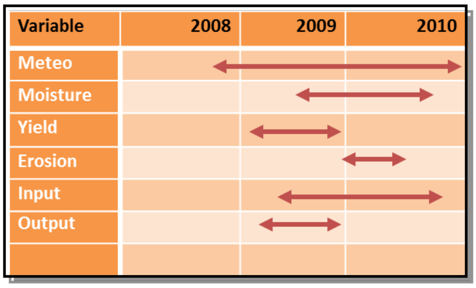
Technologies

KELAIGOU: CHECKDAM AND TERRACES

On the Loess plateau area in the Yan river basin in China, severe soil erosion is common. This results in deep gully and badland formation on the steeper slopes. To rehabilitate gullies, check dams have been constructed. These limit runoff and sediment delivery downstream and increase water availability for maize. The slopes can be stabilized with terrace constructions. Because of annual rainfall fluctuates between 400 and 1100 mm (average 560 mm), water can be a limiting factor in this region. Soil water conditions are monitored and compared to crops on the slopes, as well as runoff and erosion under different land uses. The erosion is especially important downstream while the conservation measures are tought to be important on site (because of soil moisture increase).

THE EXPERIMENT: CHECKDAMS FOR WATER HARVESTING

Check dams were constructed in an area covering 6.27 ha in the Mazhuang watershed, Basota country, Yan basin, Yan'an which is located in the Loess plateau (top left photo). In the same catchment 18,2 ha are under bench terraces (middle phoyo). The experiment is to see the effect of check dams and terraces on soil moisture, soil erosion and surface runoff. This area was compared with sloping cropland (24.5 ha, bottom photo). Surface runoff was assessed with a rainfall simulator with a rain intensity of 55 mm/hr. Data was gathered using 2 rainfall events



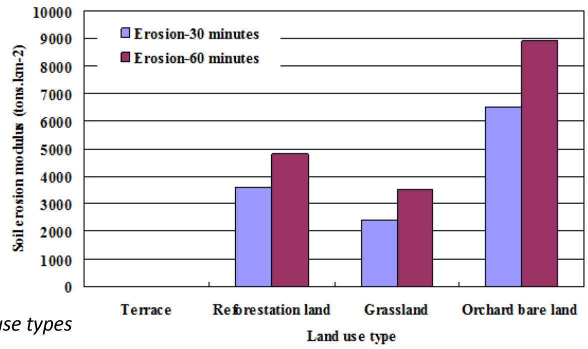
lasting 30 and 60 minutes.

Soil moisture was measured 3 times (before planting field crops in April, mid-august and after harvesting in October). Experiment started in 2009 and data for 2 years are available. The auto weather station was set up in this watershed. The metrological data, soil moisture, yield, soil erosion, input and output of agriculture were monitored.

RESULTS

The results indicated an increase of soil moisture because the runoff from the up-stream area is detained by the check dams. This also results in minimizing soil losses from the fields. The result is based on 2010. The orchard with a bare soil shows twice as much soil erosion as the experiments under forest and on grass land. Terraces and check dams have of course no runoff because of the flat slope.

Total cost involved in the cultivation in check dam land and on terraces is higher because there is simply more surface to plant (see Table below). But the net income is also higher on the flatter areas because of better yields in all the 3 land use types: the yield of check-dam land, terrace, slope crop land is 7800, 4500, 2400 kg per hectare respectively.



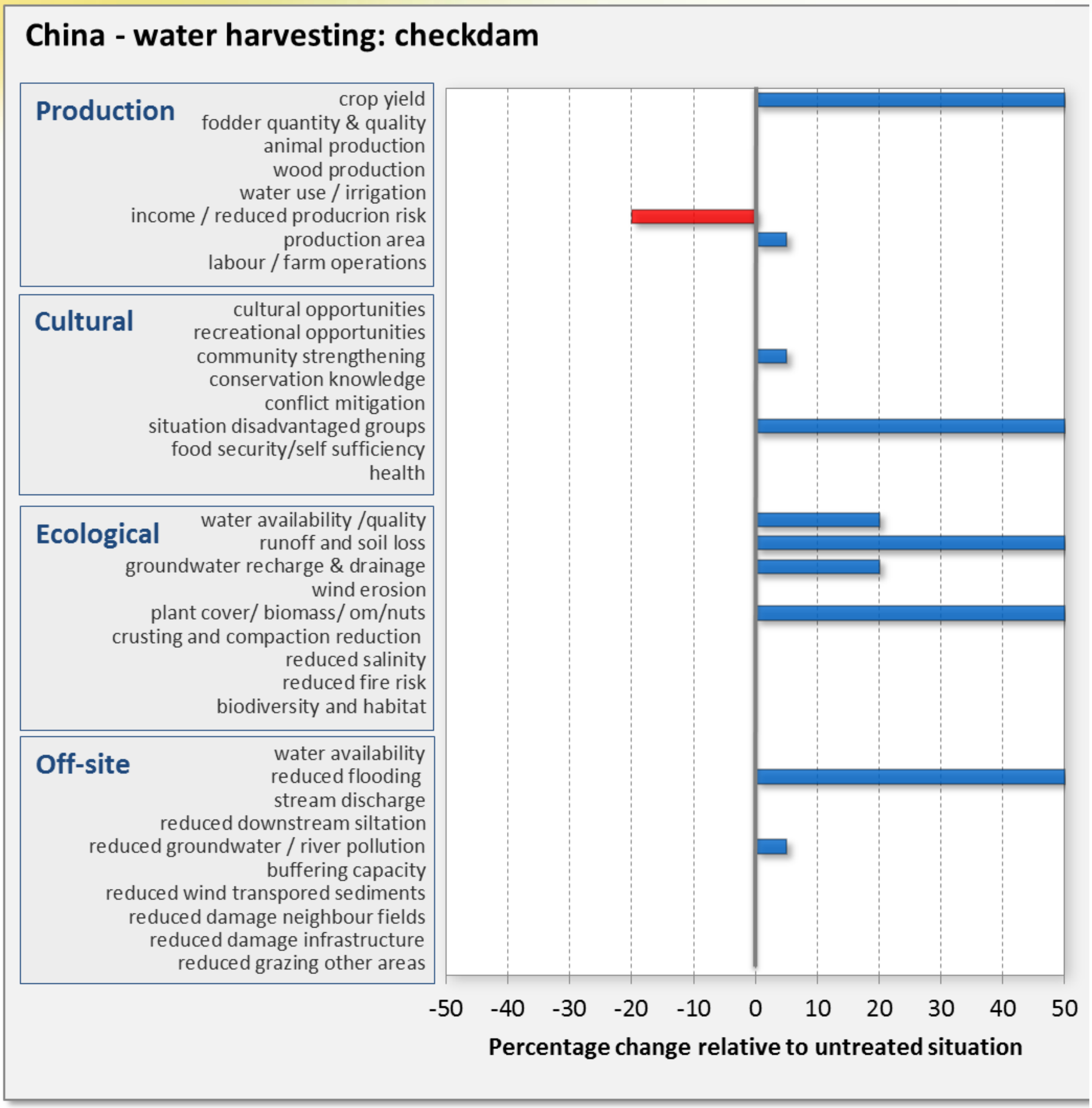
Soil loss in ton/km² under various land use types

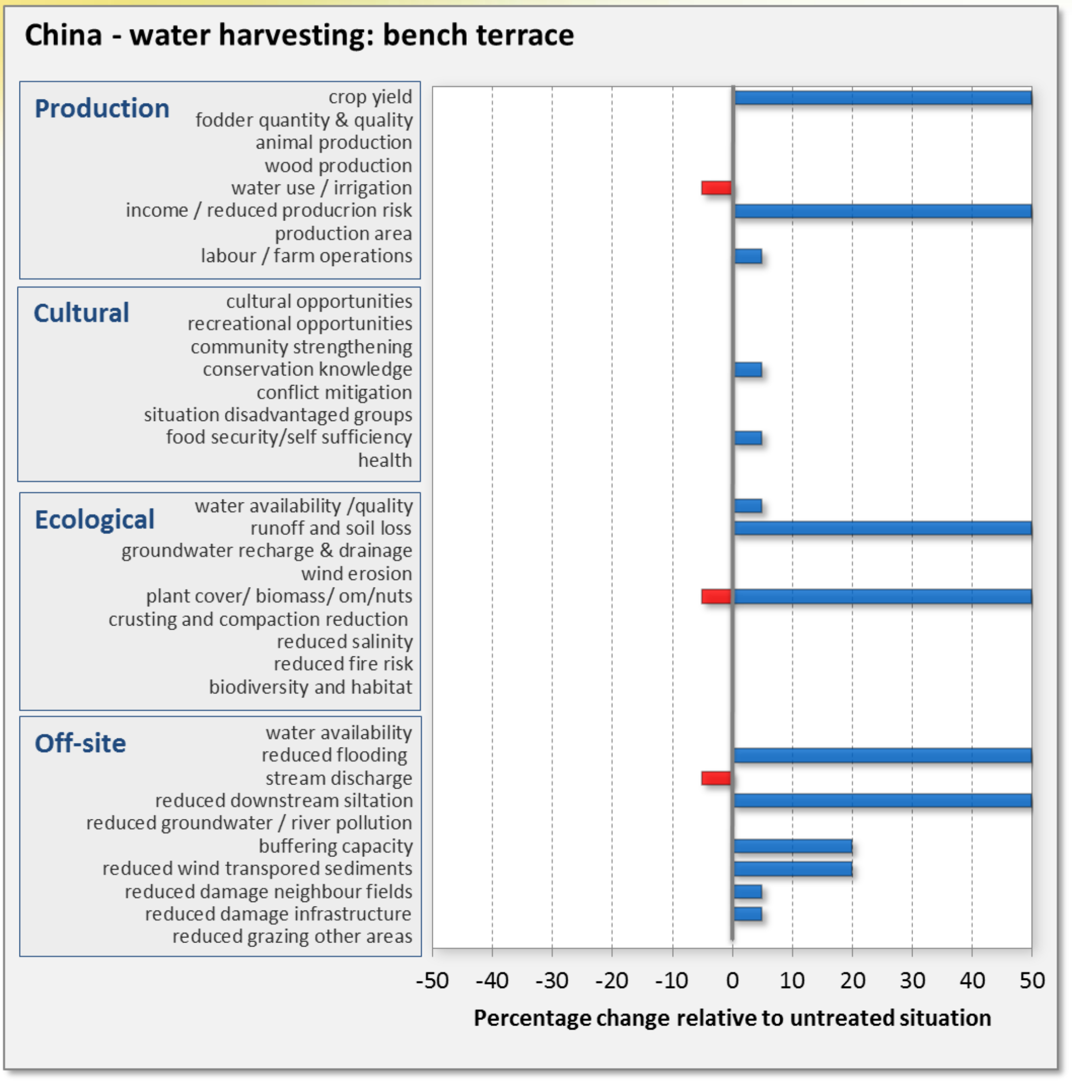
Land use	Seeds	Chemical Materials*	Tillage And planting	Direct input	Labor	Labor cost	Total Input Including Labor	Yield	Value	Net income without labor	Net income with labor
	Yuan	Yuan	Yuan	Yuan	Day	Yuan	Yuan	kg	Yuan	Yuan	Yuan
	a	b	c	d=a+b+c	e	f=e*50**	g=d+f	h	v=h*1.85***	v-d	v-g
Check-dam land	525	4575	525	**5625**	105	5250	**10875**	7800	14430	**8805**	**3555**
Terrace	420	2700	525	**3645**	90	4500	**8145**	4500	8325	**4680**	**180**
Slope Crop land	300	1800	525	**2625**	75	3750	**6375**	2400	4440	**1815**	**-1935**

** Chemical Materials: fertilizer, pesticides and herbicide; ** Price of corn: 1.85 Yuan RMB per kg; *** Price of labor days: 50 Yuan*

EVALUATION

The results are evaluated from a production, socio-cultural and economic point of view. The bars express the estimated or measured percentage of change with respect to the reference situation. This change can be positive (blue) or negative (red). Note that this evaluation is based on the experiments, on the long term experience of the coordinating team in this area and on consultations with the farmers.


China - water harvesting: checkdam
Production
crop yield
fodder quantity & quality
animal production
wood production
water use / irrigation
income / reduced producrion risk
production area
labour / farm operations
Cultural
cultural opportunities
recreational opportunities
community strengthening
conservation knowledge
conflict mitigation
situation disadvantaged groups
food security/self sufficiency
health
Ecological
water availability /quality
runoff and soil loss
groundwater recharge & drainage
wind erosion
plant cover/ biomass/ om/nuts
crusting and compaction reduction
reduced salinity
reduced fire risk
biodiversity and habitat
Off-site
water availability
reduced flooding
stream discharge
reduced downstream siltation
reduced groundwater / river pollution
buffering capacity
reduced wind transpored sediments
reduced damage neighbour fields
reduced damage infrastructure
reduced grazing other areas
-50 -40 -30 -20 -10 0 10 20 30 40 50
Percentage change relative to untreated situation



STAKEHOLDER OPINIONS

The stakeholders here include local farmers, village head Soil and Water Conservation Bureau and Agriculture Bureau of Baota County. Farmers have clear planting plans with simple crops such as maize, millets, potatoes and beans. They have a desire to improve the income of the land and they think the soil and water conservation is a very good approach to improve the agricultural conditions. Since the yield of slope land, terrace and check-dam are higher, they would like the local government to invest more to build high quality land.

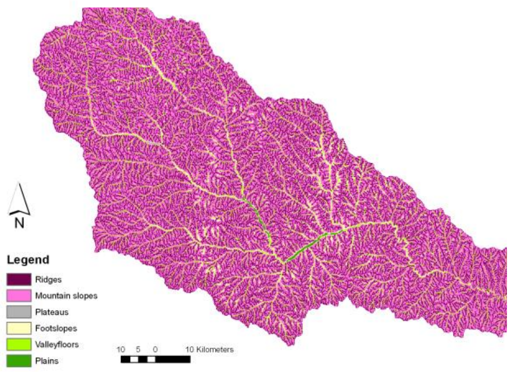
Scenario analysis

Baseline Scenario

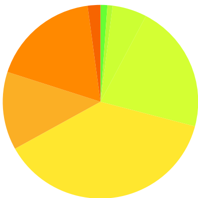
PESERA baseline run

The erosion and biomass baseline maps represent a variety of land uses. Although erosion rates are clearly high in many parts of the study area, the pattern is patchy. Biomass production shows a pattern of climatic conditions but is also patchy reflecting differences in land use types.

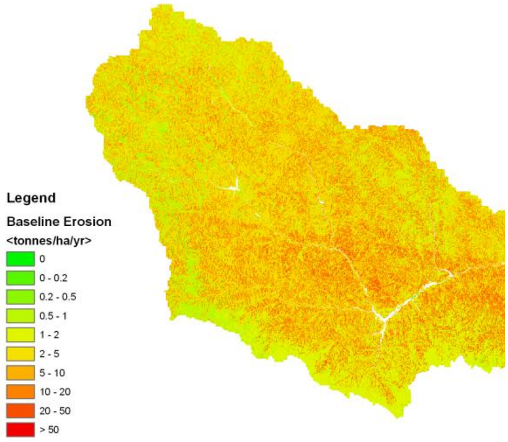
Landforms



Soil erosion



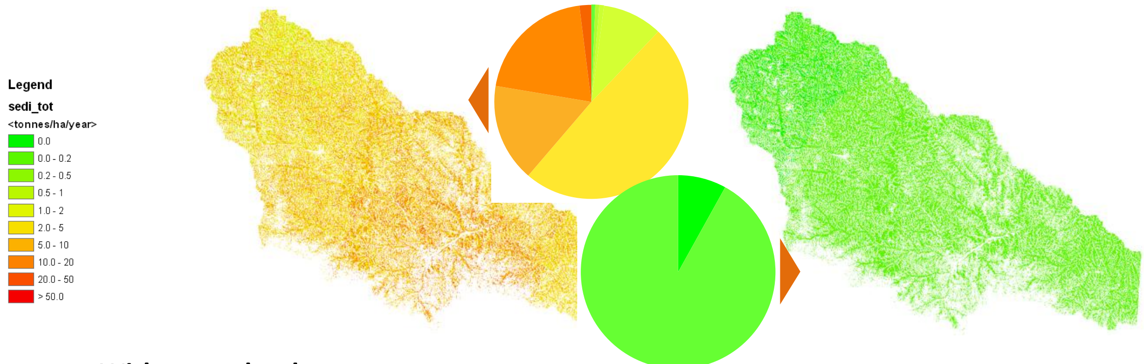
Soil erosion



Technology Scenario: Bench terraces with loess soil wall

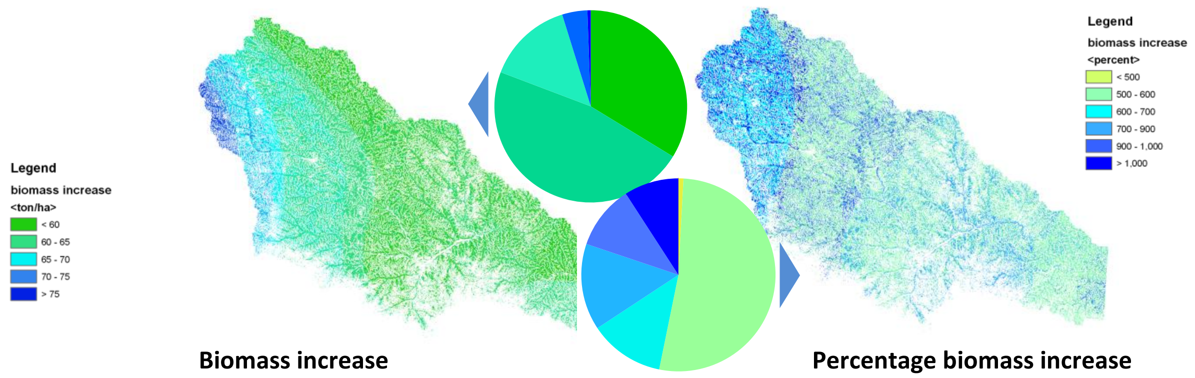
- It is assumed that apples are grown on terraces. A harvest to total tree biomass index of 0.19 is used based on secondary data
- Without case is unproductive as cereal cropping on slopes is indicated to make a loss
- Apple price of CNY 1.5/kg (€0.18) is used
- A 10% discount rate and an economic life of 20 years were assumed
- Apples produce 25% in year 4, 50% in Y5, 75% in Y6 and achieve full production in Y7.
- Further cost details under viability below.

Biophysical impact: soil erosion



Without technology **With bench terraces**

Biophysical impact: increase in biomass

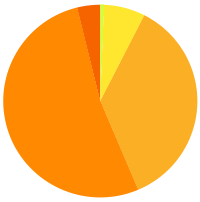


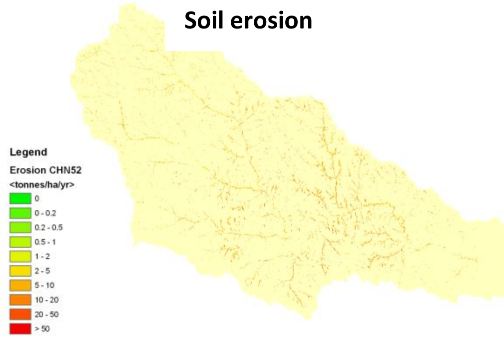
Biomass increase **Percentage biomass increase**

Technology Scenario: Checkdam for land

Biophysical impact: reduction of erosion

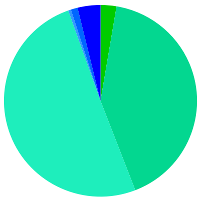
- Soil erosion after implementation of check-dams for land is still high; this is due to the assumption of a maize crop being grown. A reduction of between 3-5% relative to maize under baseline conditions is obtained. However, the technology is intended to harvest the soil lost upstream to create new land; hence the net effect downstream will be significant (this could not be modelled).

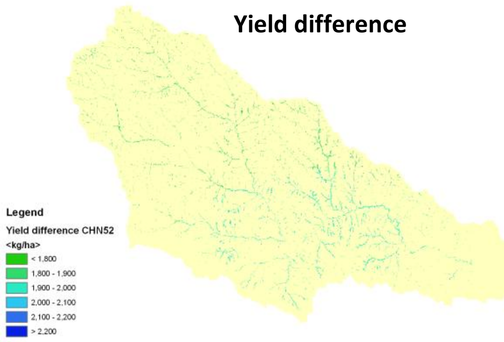




Biophysical impact: increase in yield

- The technology leads to substantial yield increases throughout the applicability area. Maize yields increase by 65-89% relative to maize grown under baseline conditions.



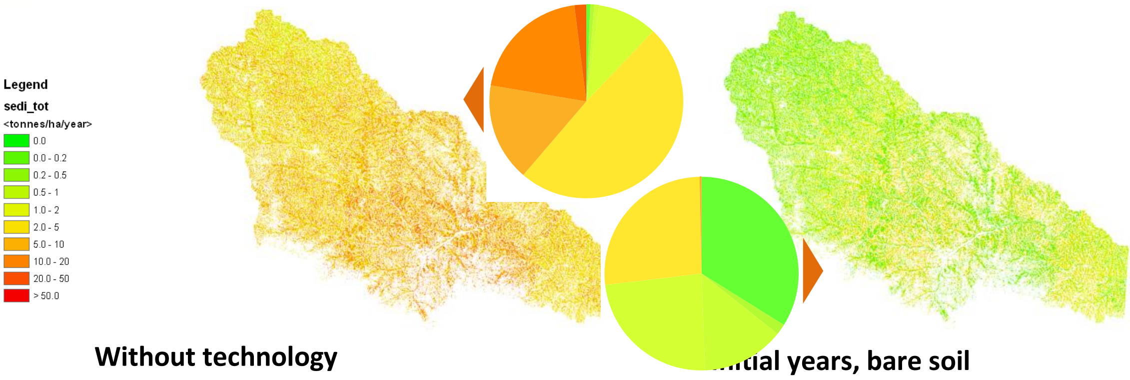


Technology Scenario: Year-after-year terraced land

- It is assumed that apples are grown on terraces. A harvest to total tree biomass index of 0.19 is used based on secondary data
- Without case is unproductive as cereal cropping on slopes is indicated to make a loss
- Apple price of CNY 1.5/kg (€0.18) is used
- A 10% discount rate is assumed, with terraces gradually constructed over 5 years.
- Apples produce 25% in year 4, 50% in Y5, 75% in Y6 and achieve full production in Y7.

- Further cost details under viability below.

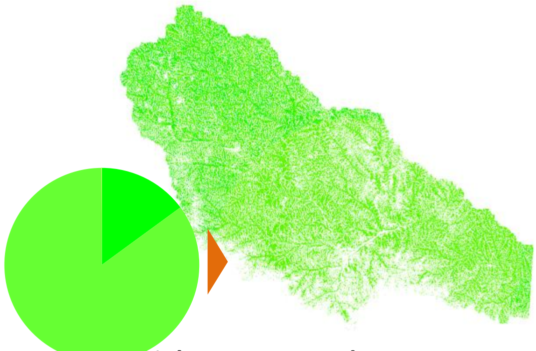
Biophysical impact: soil erosion



Without technology

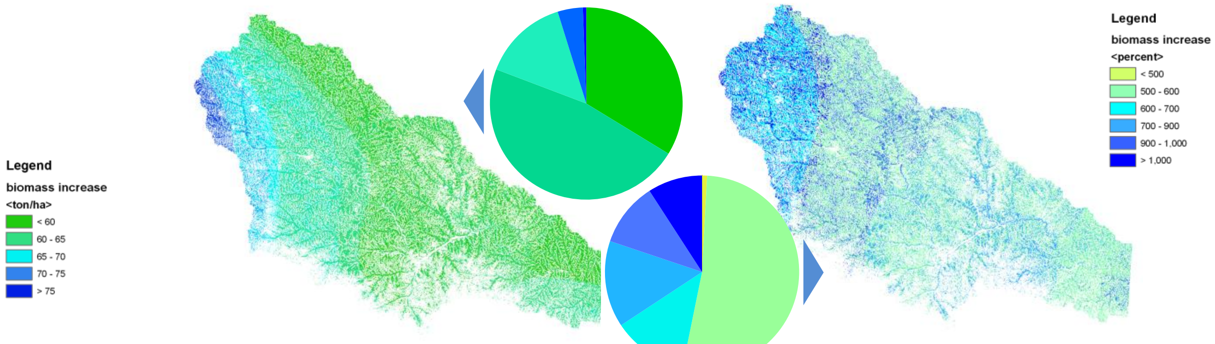
Initial years, bare soil

On year after year terraced land, it matters how ground cover is managed in apple orchards – especially in the initial years. If the ground is kept bare, soil loss is greatly reduced but on average still amounts to 1.26 ton/ha/year. If the ground is kept covered, e.g. through vegetated strips or mulch, the average soil loss drops to only 0.02 ton/ha/year. The latter is comparable in performance to bench terraces (CHN51).



Initial years, ground cover

Biophysical impact: increase in biomass



Biomass increase

Percentage biomass increase

Policy Scenario: Subsidising terracing and checkdams

At a time horizon of 10 years, none of the technologies is profitable and even after 20 years bench terraces are not financially attractive. Land users are unlikely to wait longer for benefits to accrue. Hence costs of the technology need to be reduced. This is possible through a subsidy, which could e.g. be part of a payment for ecosystem services scheme as there are significant downstream effects: reducing sedimentation and flood risk in the Yellow River basin. In this scenario a cost reduction equal to 50% of the investment costs is explored.

Conclusions

The terrace and check-dam land are good technologies to reduce the soil and water loss in the research site. It could increasing the water availability for maize through reduce runoff and evaporation from land surface. The check-dam land could use the water from upstream or moisture of former years that improve the soil condition.

The technologies could be used in other area of the Loess Plateau. The high quality wide terraces is necessary for planting with machineries. The check-dam should be designed and built according the present condition of less erosion and longer time to form the land.
The land area for each person is very limited in Yan'an City. The local people can get some cereal and food from the land, and it is nearly impossible ti improve the livelihood and economic condition.

Experimental plots to measure soil erosion have been set up on the slope of an orchard in Miaowan village under different treatments: natural slope without vegetation cover, contour tillage and contour tillage with mulching. Plastic film is being used to assist harvesting of rain water and promote deeper infiltration of soil water. Other strategies include building of bench terraces and reforestation.

Soil erosion on the loess sediments is the prevailing desertification problem, and every year about 0.01 to 2 cm topsoil is washed away. New ways to prevent soil erosion and improve soil stability and fertility will be investigated.

Terrace and check-dam land could increasing the water availability for maize through reduce runoff and evaporation from land surface and using water from upstream or moisture of former years. They could be extended to the similar area of the Loess Plateau.

Combatting erosion is possible in many ways and especially interesting tomitigate problems downstream. Measures that drastically improve the onsite circumstances, such as terracces and checkdams are interesting because they xcreate flat land with favourable conditions. This is shown by substantially incerased yields. In fact rainfed agriculture with staple food crops on slopes is hardly profitable because of the low yields.

However constructing and maintaining check dams and terraces is expensive. Since Cropland is in short supply (0.1 ha per capita) it is impossible for most people to do this themselves. Therefore they are interested but also regard is as something unobtainable. Many farmers find an income in other types of work such as road and building construction.

- Baseline simulations show a mixed picture of soil erosion in the Yan River Basin area: roughly equal parts of the area experience soil erosion rates below 1 ton/ha/yr, between 2 and 5 ton/ha/yr and over 5 ton/ha/yr.
- Six options were prioritised by scientists and local stakeholders to control soil erosion: level bench terraces; reforestation; checkdams; level groove on the slope; fish-scale pits; and mulching. Three technologies were tested: level bench terraces (CHN51), checkdams (CHN52) and reforestation. Reforestation was not modelled but replaced by year-after-year terraced land (CHN53). The technology scenarios show that both terracing technologies can drastically reduce erosion rates; this was confirmed in field rainfall simulation experiments. Checkdams are less effective in reducing runoff within the field but capture sediments in-stream to build up terrace land. The downstream effects will thus still be significant. Maize on checkdam land yielded 70-90% higher yields than in baseline situation according to PESERA simulations. The difference observed in field experiments was higher (7-fold). Biomass on terraces increased spectacularly but with and without situations cannot really be compared as arable land is converted to apple orchards. Being structural soil conservation measures, investment costs are high. Least costly is year-after-year terraced land, which moreover has the advantage of gradual investment requirements. But as apple trees need to grow to maturity before they start producing, there is a time lag which means the pay-back period for terracing occurs only after a minimum of 10 years, but typically in the range of 20 years. For checkdams the amount of land that can be gained is an important variable requiring local, site-specific planning. If a ratio of 1:3 is assumed, the technology is profitable over a period of 20 years.
- In the workshop to evaluate monitoring and modelling results, stakeholders reaffirmed their priority interest in checkdams. Low maintenance costs and high productivity were important factors in justifying their choice. Terraces were not very popular due to low productivity (of maize) and long gap before trees become productive (apples).
- A policy scenario reducing investment costs by 50% for all technologies did not make a large difference in potential uptake (based on profitability) of checkdams and year-after-year terraced land. However, level bench terraces become of interest in an additional 21% of the applicable area. Such a subsidy would reduce soil erosion in the incremental area by on average 5.6 ton/ha/yr, and at a cost of CNY 3**,808/ton (€470)**. Such subsidies do however not make a notable difference in bridging the production gap: after 10 years in most of the cases the technology is not yet profitable. Subsidies might be justified when considering downstream benefits of reduced flooding and sedimentation. These effects were not included in the analysis.
- The adoption scenario summarises the above: the technologies tested are together applicable in 53% of the study area. Without policies, year-after-year terraced land is the most profitable technology, with checkdams surpassing profits in isolated locations in a reduced number of cases. With subsidies, the relative profitability of bench terraces and checkdams improves but substitutes land where year-after-year terraced land would be most beneficial. There is thus no change in the total area of land that would be attractive for technology implementation.
- The global scenarios show that the technology can achieve very significant yield increases and erosion reductions in the vast majority of the applicability area. The investment costs to achieve this are moderately low, at €78/ton food produced and €212/ton soil conserved. Per area unit, investment costs are nevertheless substantial. Food production is however fresh weight apples, which cannot be directly compared to indicator values based on grain production.

- The technologies considered are very effective to conserve soil and water. In the case of checkdams for land, productivity increases are instant and might justify the high investment costs. However, local feasibility studies need to be conducted on a case-by-case basis. For terracing, the cost is high in relation to the benefits, which, in the case of apple production, leave an important unproductive gap period. As it takes longer than 10 years to see a return on investment, the technology might be of less interest. Under climate change, the relative performance of all technologies considered will improve. However, the downstream impacts should be included in the assessment of large scale introduction of terracing and checkdams.

Leading Scientist:
Prof. Li Rui, Dr. Wang Fei
Institute of Soil and Water Conservation, Chinese Academy of Sciences, Ministry of Water Resources
26, Xinong Road, Yangling 712100
Shaanxi, China

Fax: +86 29 8701 2210
wafe@ms.iswc.ac.cn

➜ Contact address: ALTERRA, Soil Science Centre/ Coen Ritsema, P.O. Box 47, 6700 AA Wageningen, The Netherlands
Phone: +31 317 48 65 17
Fax: +31 317 41 90 00

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Head of Unit *Pierre Mathy*, Project officer *Maria Yeroyanni*

During the period January 2007- January 2012, this work was carried out by:
Associate Professor Dr. Wang Fei
Professor Li Rui
Professor Dr.Jiao Juying
Associate Professor Dr. Jiao Feng
Associate Professor Dr. Wen Zhongming
Professor Dr.Chen Yunming
Professor Dr.Yang Qinke
Associate Professor Ms. Liang Wei
Professor Dr.Mu Xingmin
Technican Mr. Cao Qing Yu
Dr. Gao Peng
Dr. Xie Hongxia
Technican Mr. Zhang Wenshuai

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