Yan River Basin, China

Study site details

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

Overview of scenarios

1. Baseline Scenario: PESERA baseline run
2. Technology Scenario: Bench terraces with loess soil wall (CHN51)
3. Technology Scenario: Checkdam for land (CHN52)
4. Technology Scenario: Year-after-year terraced land (CHN53)
5. Policy Scenario: Subsidizing terracing and checkdams (CHN51-53)
6. Adoption Scenario: Bench terraces with loess soil wall (CHN51), Checkdam for land (CHN52) and Year-after-year terraced land (CHN53)
7. Global Scenario: Food production
8. Global Scenario: Minimizing land degradation

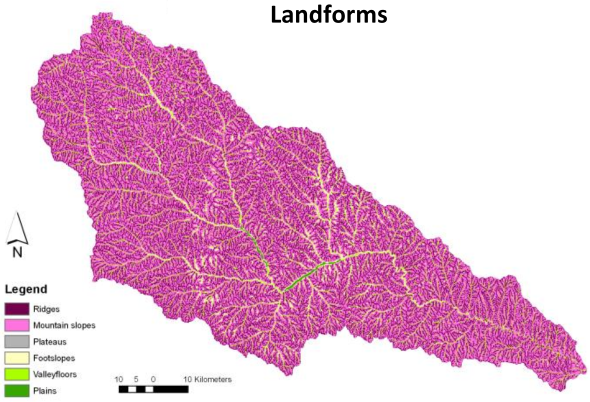
Yan River Basin, China

Baseline Scenario

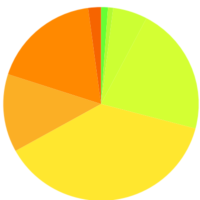
PESERA baseline run

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.

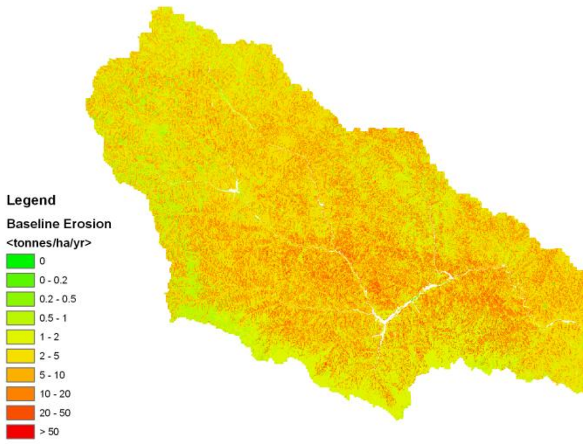
Landforms



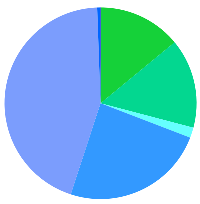
Soil erosion



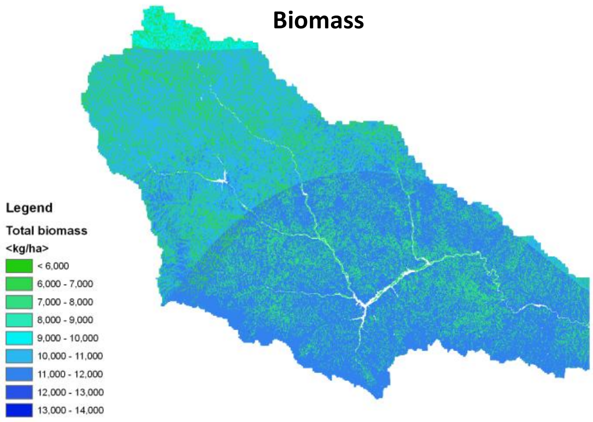
Soil erosion



Biomass production



Biomass



Yan River Basin, China

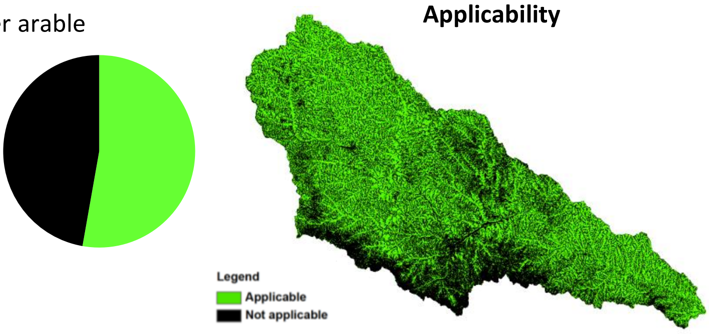
Technology Scenario:
Bench terraces with loess soil wall (CHN51)

- 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.

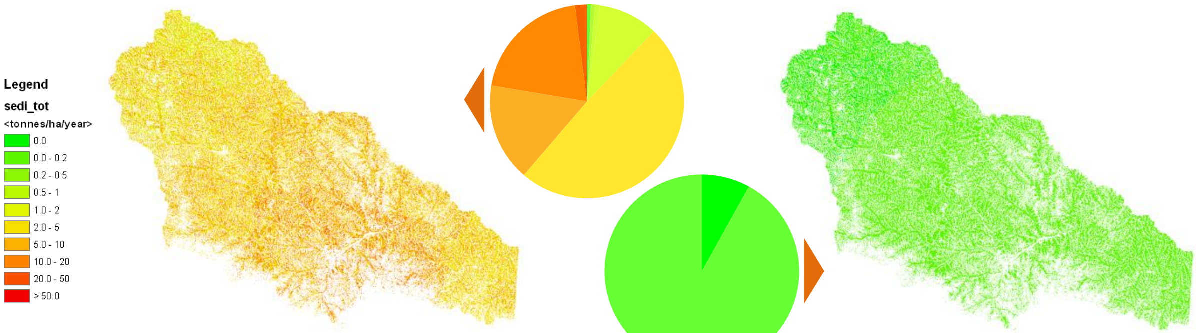
Applicability

- The technology is applicable on land under arable or tree crops on slopes higher than 2%.

Applicability

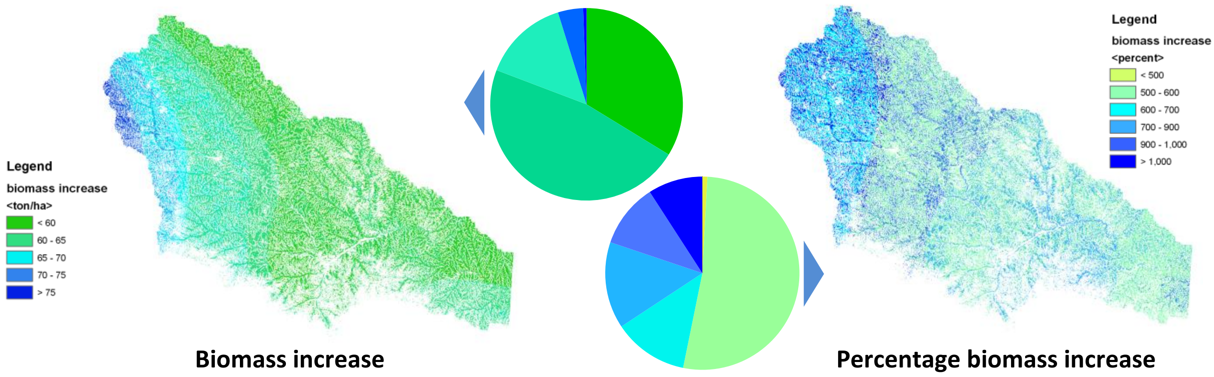


Biophysical impact: soil erosion



Without technology **With bench terraces**

Biophysical impact: increase in biomass

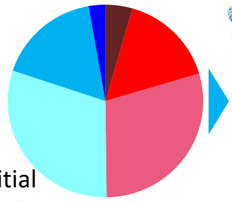


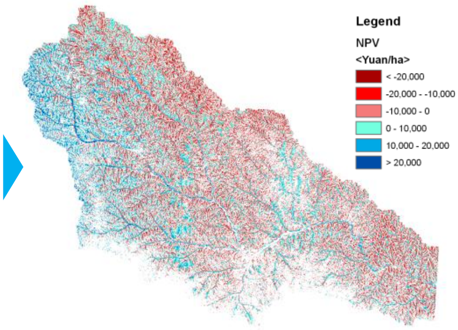
Biomass increase **Percentage biomass increase**

Economic viability

Further assumptions for financial analysis:

The cost of terracing varies with slope. On top of investment cost in terracing (range CNY 80 – 35,392 (i.e. €10 – 4,358) for slopes from 2 to 79% respectively; mean CNY 10,864 ± 4901 (i.e. €1338 ± €603)) tree planting costs of CNY 2,052 (€253) are accounted for. Annual maintenance costs are set at 14.5% of initial investment costs. Production costs for apple production (chemical inputs and labour) are CNY 9,664 (€1,190).





Net present value after 20 years

With these assumptions, bench terracing is profitable in slightly less than half of the applicable area. The western part of the study area (more productive) and the less steep slopes are the most viable areas. Despite the profitability, the fact that the payback period of the investment is long (close to 20 years) might deter land users from applying the technology.

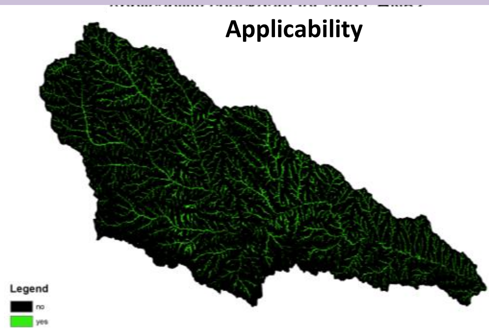
Yan River Basin, China

Technology Scenario:
Checkdam for land (CHN52)

- It is assumed that maize is grown. A harvest index (HI), set at 0.4, was used and multiplied with the difference in maximum vegetation
- Maize price of CNY 1.57/kg (€0.19) is used
- A 10% discount rate and an economic life of 20 years were assumed
- Because construction of dams takes more than one year, the gross difference in output can be expected from year 2 onwards
- For further details see under viability below

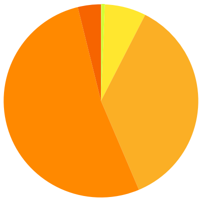
Applicability

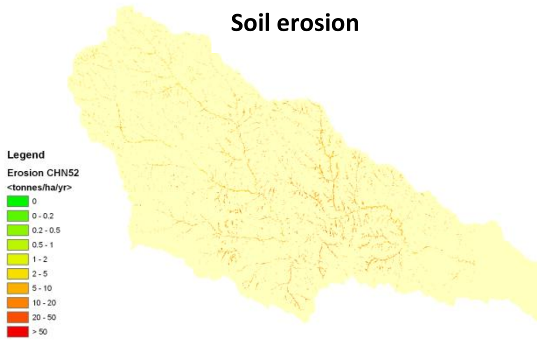
- The technology is only applicable in valley bottoms with slopes lower than 20%, which restricts it to 9% of the area.



Biophysical impact: reduction of erosion

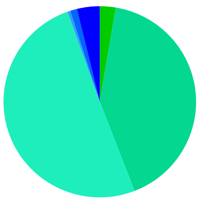
- Soil erosion after implementation of check-dams for land is still high; this is due to the assumption of a maize crop being grown. A reduction of between 3-5% relative to maize under baseline conditions is obtained. However, the technology i to harvest the soil lost upstream to create new land; hence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

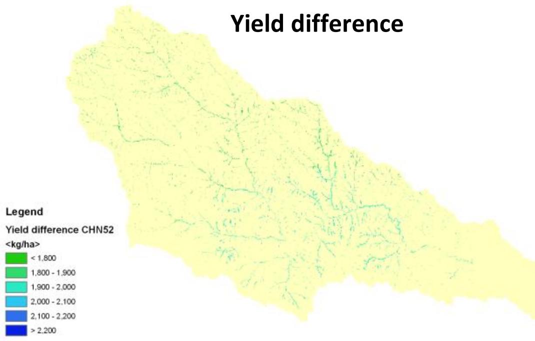




Biophysical impact: increase in yield

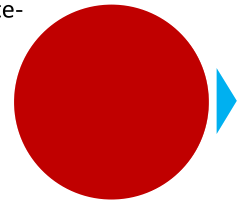
- The technology leads to substantial yield increases throughout the applicability area. Maize yields increase by 65-89% relative to maize grown under baseline conditions.

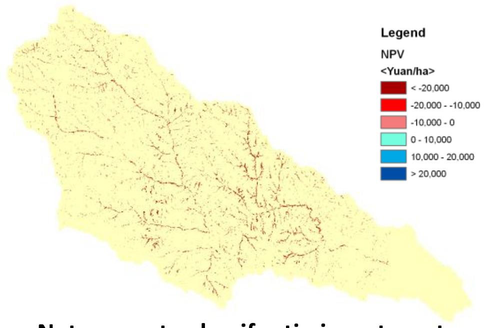




Economic viability

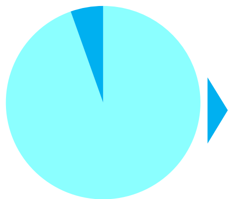
If it is assumed that each check-dam implemented results in a 1 hectare of improved cropping land, the technology is too expensive. Investment costs amount to CNY 40,495 (€4,993) and maintenance costs to CNY 900 (€111) per year.

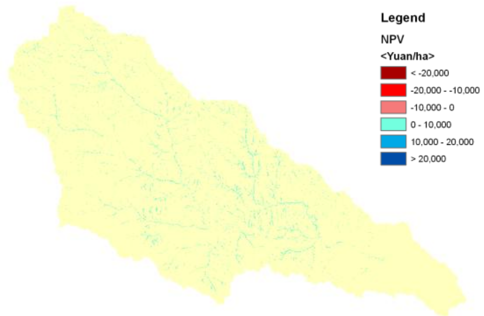




Net present value if ratio investment: improved cropping land 1:1

If 1 ha of treated land leads to 3 ha land with improved yield, the analyses reverts to a 100% profitable outcome.





Net present value if ratio investment: improved cropping land 1:3

It is hence important to study each location where the technology would be implemented to assess expected costs and benefits in a feasibility study. Off-site impacts have not been valued but would, if sedimentation is the main concern, be very positive.

Yan River Basin, China

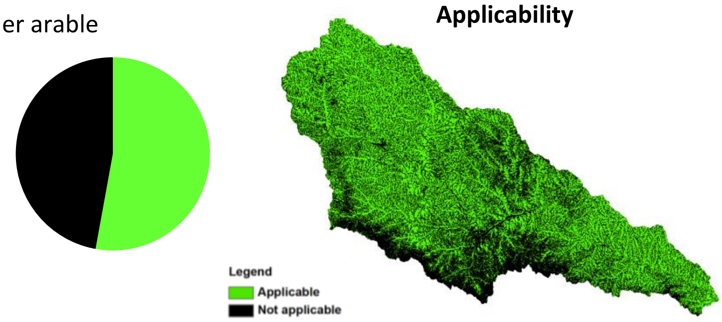
Technology Scenario:
Year-after-year terraced land (CHN53)

- 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.

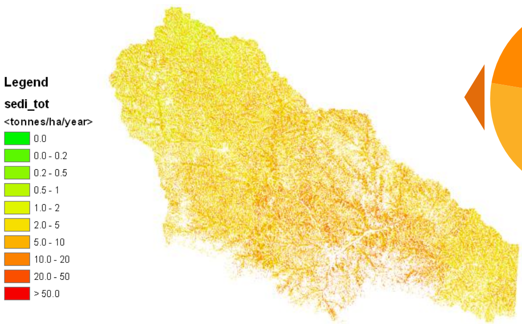
Applicability

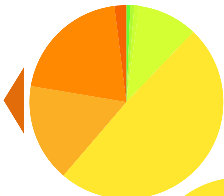
- The technology is applicable on land under arable or tree crops on slopes higher than 2%.

Applicability

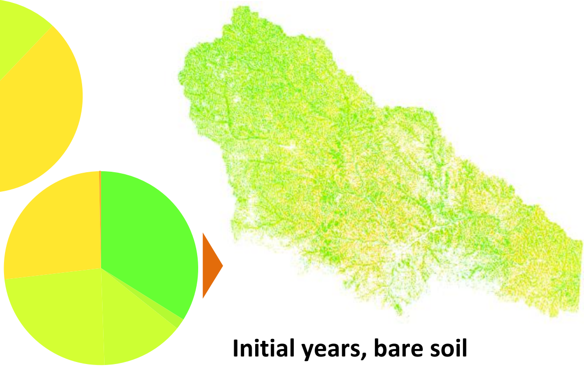


Biophysical impact: soil erosion



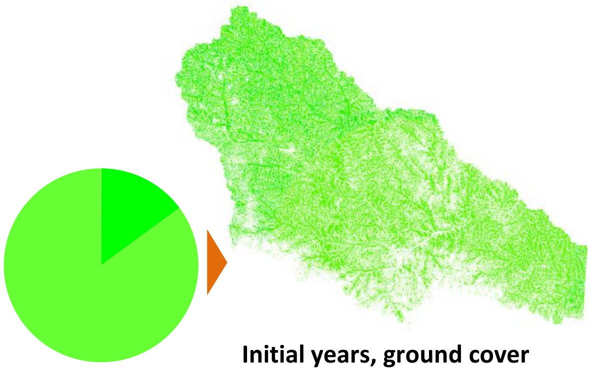


Without technology



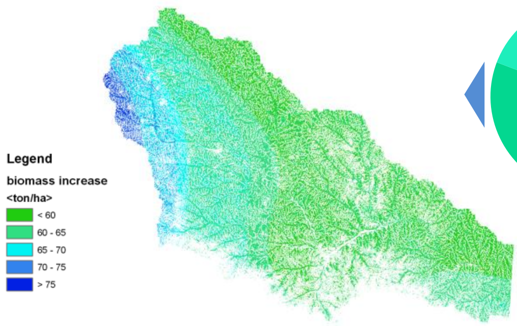
Initial years, bare soil

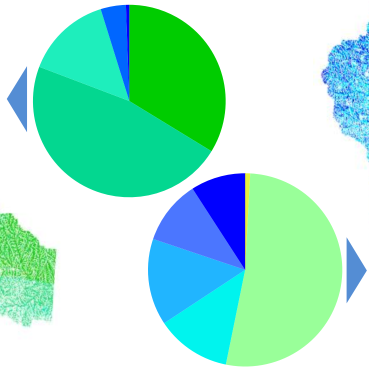
On year after year terraced land, it matters how ground cover is managed in apple orchards – especially in the initial years. If the ground is kept bare, soil loss is greatly reduced but on average still amounts to 1.26 ton/ha/year. If the ground is kept covered, e.g. through vegetated strips or mulch,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

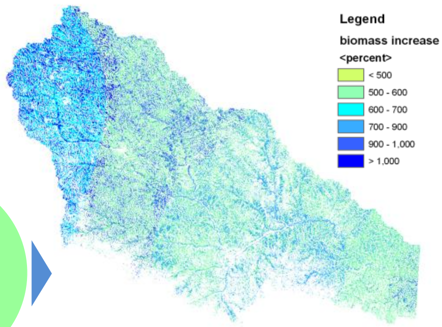


Initial years, ground cover

Biophysical impact: increase in biomass







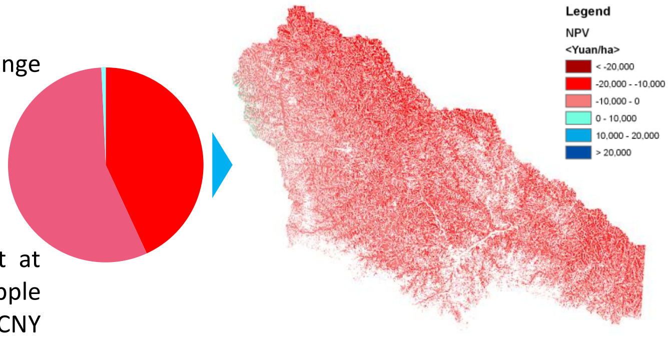
Biomass increase

Percentage biomass increase

Economic viability

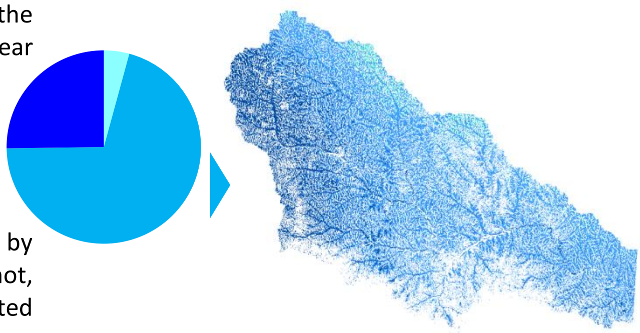
Further assumptions for financial analysis:

The cost of terracing varies with slope; costs range from CNY 30 –13,129 (i.e. €4 – 1,617) for slopes from 2 to 79% (mean CNY 4,019 ± 1,805 (i.e. €495 ± 222)), and are spread out equally over five years. In addition, tree planting costs of CNY 2,052 (€253) are taken into account. Annual maintenance costs are set at 6.7% of investment costs. Production costs for apple production (chemical inputs and labour) are CNY 9,664 (€1,190).



Net present value after 10 years

With these assumptions, in a tiny part of the applicable area (extreme west) year-after-year terracing is profitable after 10 years. This is in the extreme western part of the study area. When we extend the analysis to 20 years, the profitability map swaps completely, with the most profitable zones in the west and in the less steep valley floors. Yield levels are not influenced by the fact whether a ground cover is maintained or not, and are moreover in agreement with those predicted under bench terracing.



Net present value after 20 years

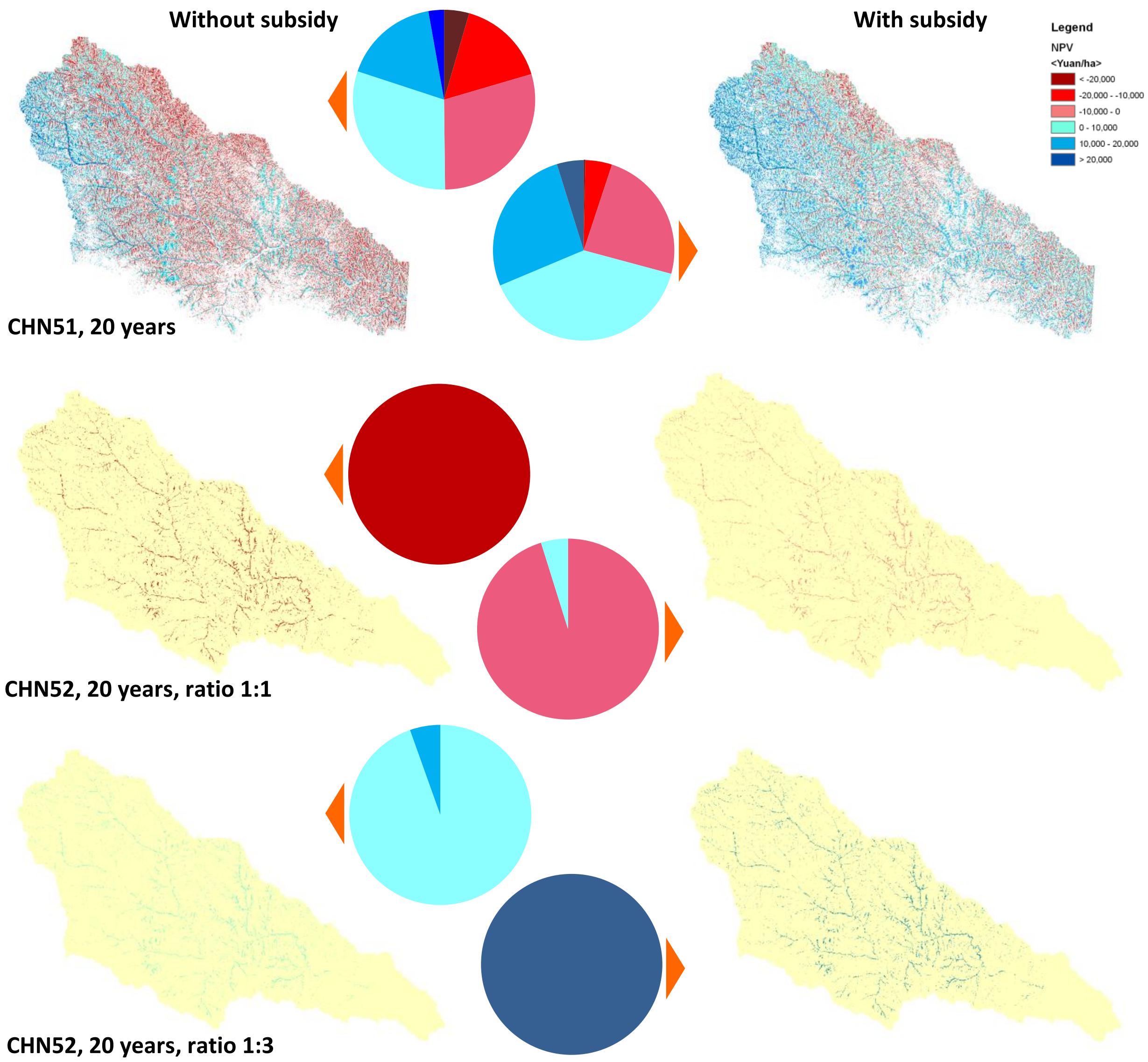
Yan River Basin, China

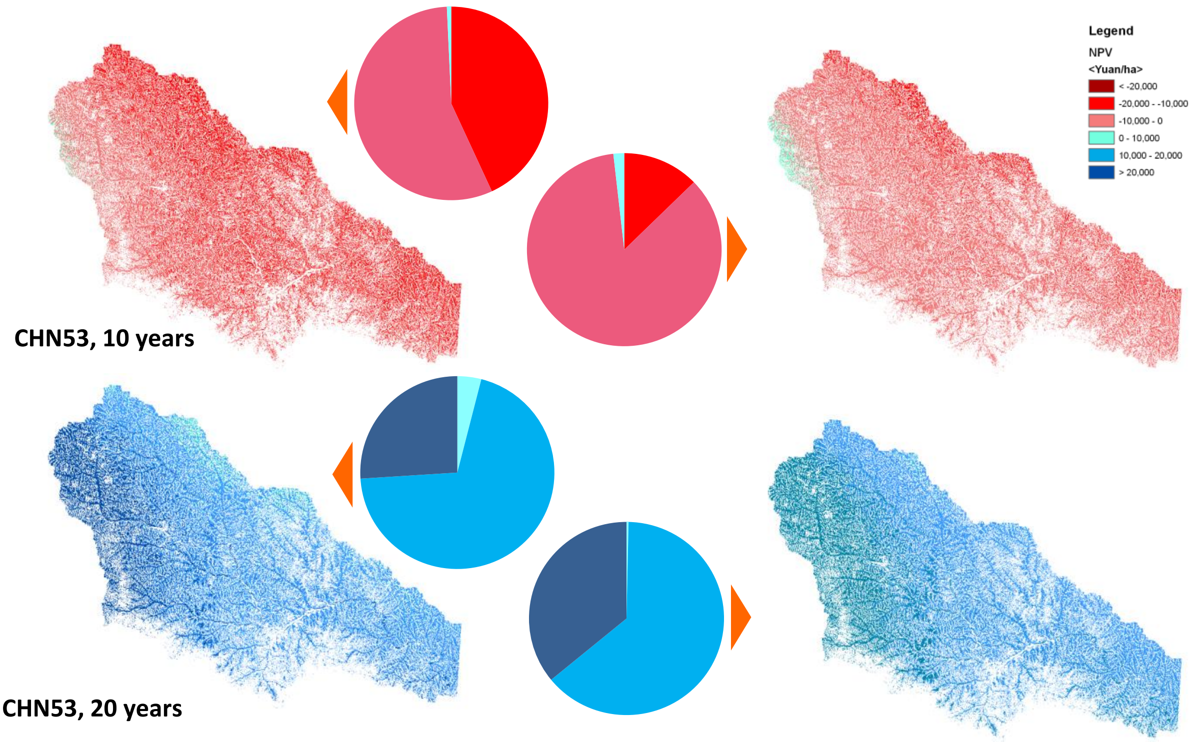
Policy Scenario:
Subsidising terracing and checkdams (CHN51-53)

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.

50%

Profitability:





Cost-effectiveness indicators:

- A reduction in investment costs of 50% is especially important for bench terraces, which then become profitable in 71% of the applicable area (up from 50%), based on the net present value after 20 years.
- This will result in an average reduction of erosion of 6.56 ton/ha/year.
- In total, an annual reduction of 505,428 tonnes of eroded soil can be expected.
- If the cost reduction would be in the form of a subsidy, the total cost would be CNY 1,925 million (€237 million), including those areas where bench terraces would already be feasible but not considering subsidies for year-after-year terraced land and checkdams for land.
- Hence a cost-effectiveness of CNY 3,808/ton (€470) of soil conserved.

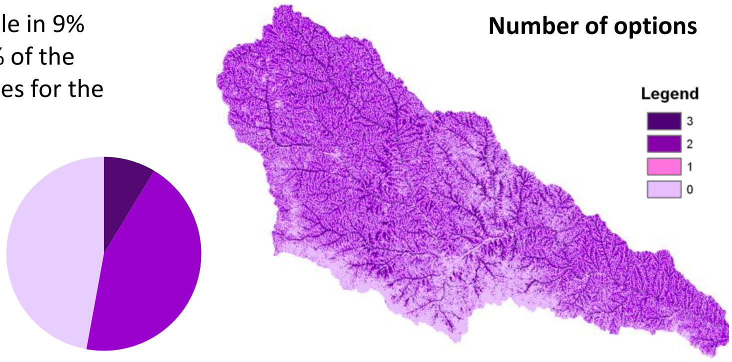
Yan River Basin, China

Adoption Scenario:
Bench terraces with loess soil wall (CHN51), Checkdam for land (CHN52) and Year-after-year terraced land (CHN53)

An adoption scenario considers the simulated technologies (if more than one) in conjunction and assumes that the most profitable option has the highest potential for uptake by land users. In order to make the net present value of different options comparable, the same time horizon is applied to the analysis. For Yan River Basin, bench terraces (CHN51), checkdams for land (CHN52) and year-after-year terraced land (CHN53) are considered. All three options are compared for a 20 year time horizon, according to specifications in the technology scenarios. For checkdams, a ratio of treated to conserved area of 1:3 is assumed.

Mitigation options

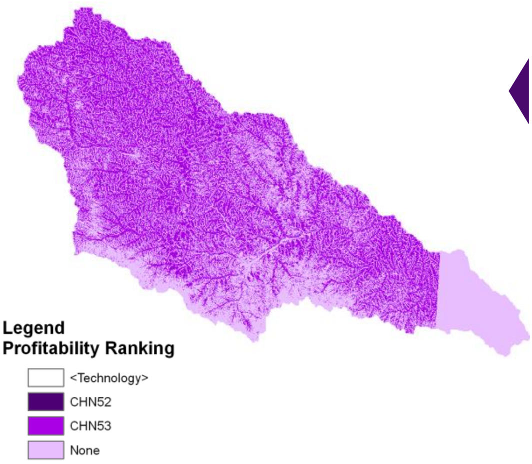
- The three mitigation options are all applicable in 9% of the area; two options are available in 44% of the area; and there are no applicable technologies for the remaining 47% of the area.

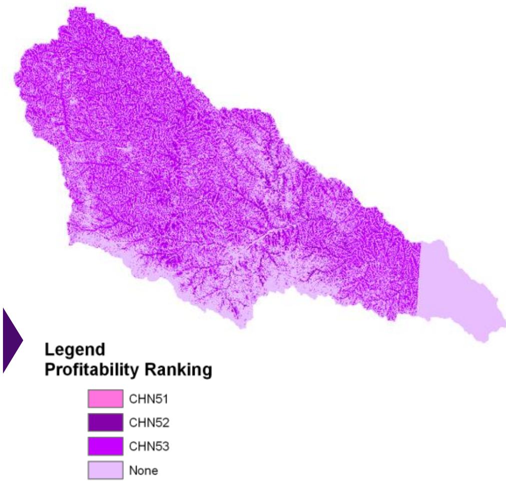


Adoption of most profitable technology

Without policies

With policies





Yan River Basin, China

Global Scenario:
Food production

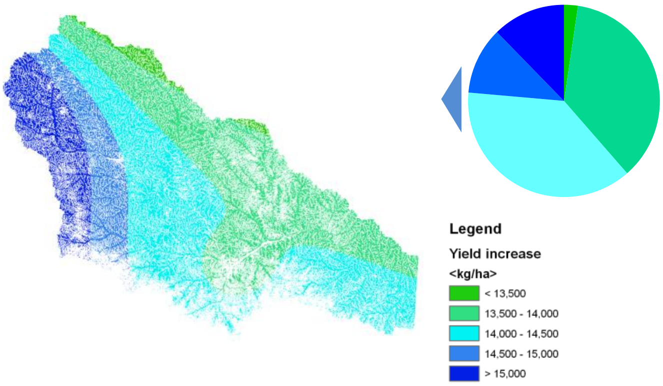
The food production scenario selects the technology with the highest agricultural productivity (biomass) for each cell where a higher productivity than in the baseline scenario is achieved. The implementation costs for the total study area are calculated and cost-productivity relations assessed. To facilitate comparison between different study sites, all costs are expressed in Euro.

+14,272 kg/ha*

+7,821 kg/inhabitant

Scope for increased production

Yield increase



Biophysical impact: yield increase

- Yield increase in 100 % of applicable area
- Average absolute yield increase: 14,272 kg/ha
- Average yield increase: na

Economic indicators

Average costs:

- Investment cost: €1,109/ha
- Unitary cost year 7: €78/ton**
- Unitary cost lifetime: €5/ton

Aggregate indicators:

- Study site: €414 million
- Augmented annual production: 5,329,250 ton
- Augmented total production: 82,603,375 ton

*Note: this yield increase is for fresh weight apples
**Note: year 7 is the first year when full production is reached

Yan River Basin, China

Global Scenario:
Minimizing land degradation

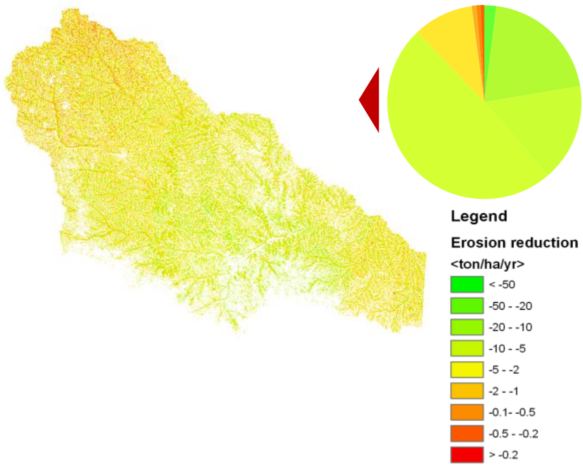
The minimizing land degradation scenario selects the technology with the highest mitigating effect on land degradation or none if the baseline situation demonstrates the lowest rate of land degradation. The implementation costs for the total study area are calculated and cost-productivity relations assessed. To facilitate comparison between different study sites, all costs are expressed in Euro.

-6.32 ton soil/ha

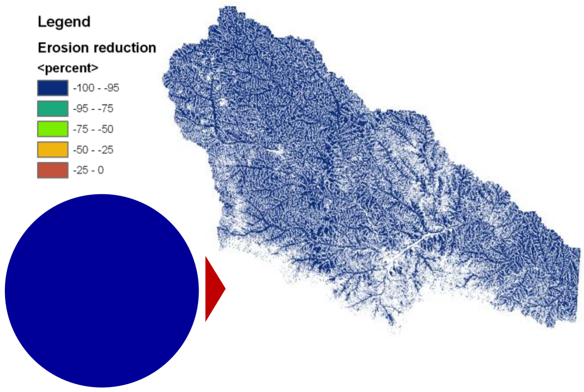
€212/ton soil

Scope for reduced erosion

Reduction of erosion (negative values)



Percentage of erosion reduction (negative values)



Biophysical impact: erosion reduction

- Reduction of erosion in 100 % of applicable area
- Average absolute erosion reduction: 6.32 tonnes/ha/yr
- Average percent erosion reduction: 99.9 %

Economic indicators

Average costs:
- Investment cost: €1338/ha
- Unitary cost year 1: €212/ton soil
- Unitary cost lifetime: €11/ton soil

Aggregate indicators:
- Study site: €500 million
- Aggregate annual erosion reduction: 2.36 million ton
- Total erosion reduction: 47.2 million ton

Yan River Basin, China

Concluding remarks

- 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/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 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.