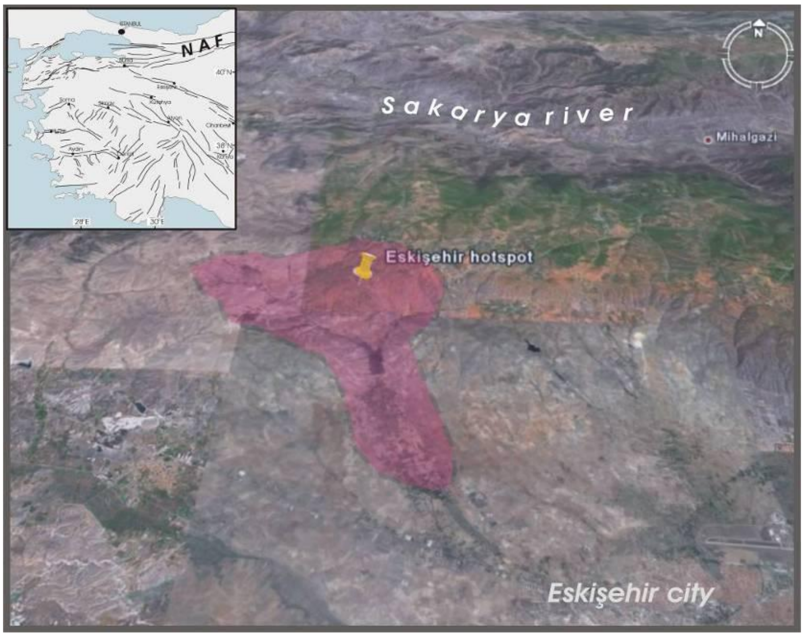
# Eskişehir, Turkey

**Highlights of work carried out in the DESIRE Project**
**Based on research at Eskisehir Osmangazi University, Turkey**

The Eskişehir study site is located in the western part of the central Anatolian Plateau, at its northern margin, and partially at the floor of a through-going depression, called the Eskişehir Basin.

- **Coordinates:**
  Latitude: 39°53'8"N
  Longitude: 30°16'12"E
- **Size:** 90 $km^2$
- **Altitude:** 819 – 1362 m
- **Precipitation:** 380 mm
- **Temperature:** generally below 0°C during winter and may exceed 40°C in summer days
- **Land use:** arable land (cereals, sugar beet, sunflower), pastures, forest
- **Inhabitants:** 3,040
- **Main degradation processes:** Water and wind erosion, droughts, urbanisation
- **Major drivers of degradation:** Inappropriate land management, urban expansion




***Study site location***

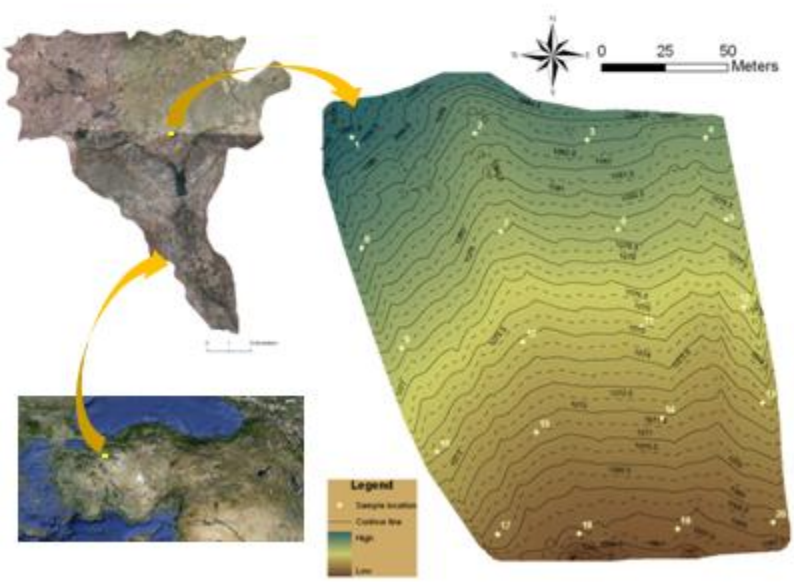
There are many challenges in the Eskisehir region. The growing city of Eskisehir is attracting new economic investment and agriculture is also expanding to support the needs of the population. Erosion by water, erosion by wind, salinisation and the effects of rapid urbanization are all seen in association with land degradation, in an area with sparse natural vegetation and a trend of climate change towards increasing aridity. Strategies for sustainable development need to find a balance among competing pressures. Crop rotation, mulching and tree planting may be used to improve soil fertility, drip irrigation will limit water loss, and terraces and check dams may reduce soil erosion and water loss.

Since the Eskişehir hotspot is situated in the mountainous northern part of the Eskisehir hotspot where slope gradients and precipitation are relatively high compared to elsewhere, basic goal here is to decrease water erosion. Due to the long-lasting nature of this problem together with non-existence of any previous prevention initiative, soil profiles are thin, stoniness is high and organic matter content is low. Dry-farming fields in vicinity are exhibiting severe rill erosion which has been facilitated by further wrong practices such as slope parallel and abnormally deep ploughing.

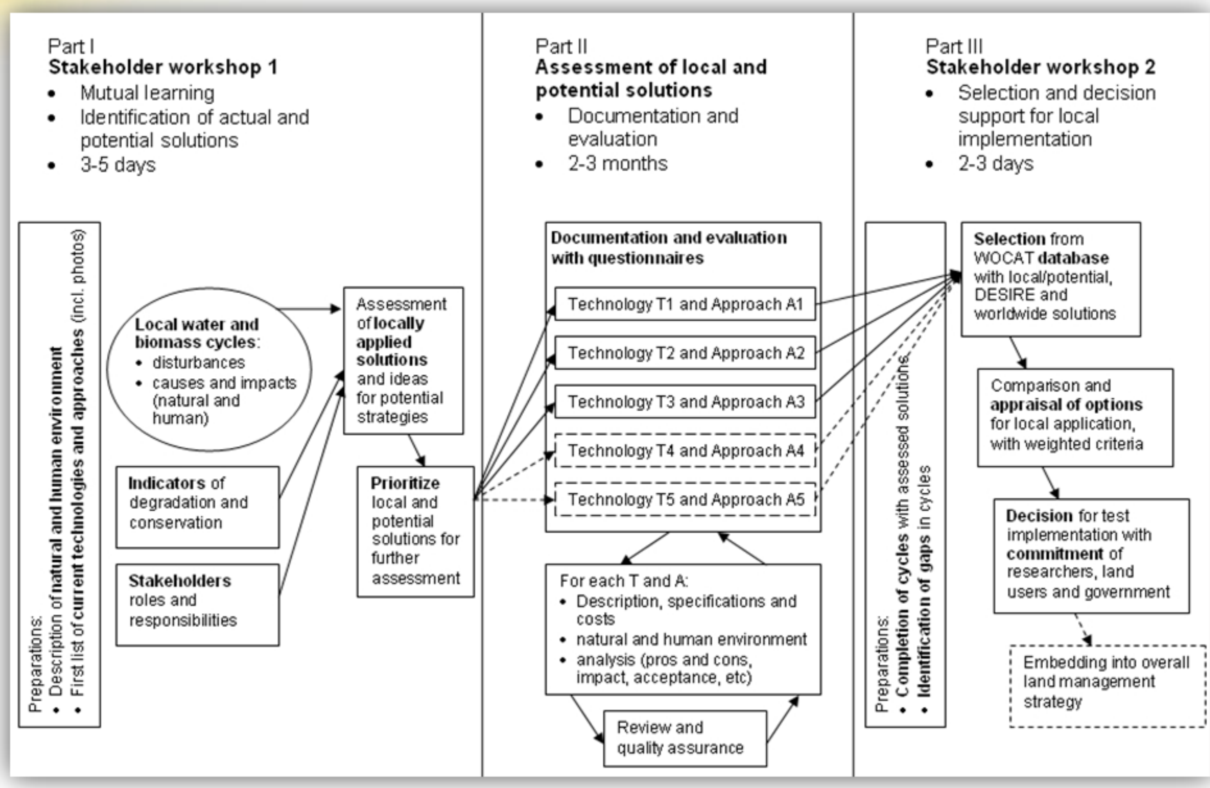
Rill erosion in vicinity of the trial field, N. Eskişehir.

The implementation field is divided into 3 parts, one is non-technology (control parcel), i.e. downslope ploughing and others are contour ploughing and contour ploughed terracing.
Terracing (also called fencing) consists of wooden stakes of 150 cm high inserted into ground and woven by tiny branches in between. Part of the soil from the upslope of the fence is piled up to support stakes and prevent run-off over the fence. Contour ploughing (including tillage) is applied in the western parcel of about 50 m long. Contours here are NE-running.

Since the area is situated in the mountainous northern part of the Eskisehir hotspot where slope gradients (% 10) and precipitation (400 mm/yr) are relatively high compared to elsewhere, our basic goal here will be decreasing water erosion. Due to the long-lasting nature of this problem together with non-existence of any previous prevention initiative, soil profiles are thin, stoniness is high and organic matter content is low. Dry-farming fields in vicinity are exhibiting severe rill erosion which has been facilitated by further wrong practices such as slope parallel and abnormally deep ploughing.



**Workshops for researchers and stakeholders to select sustainable land management technologies**

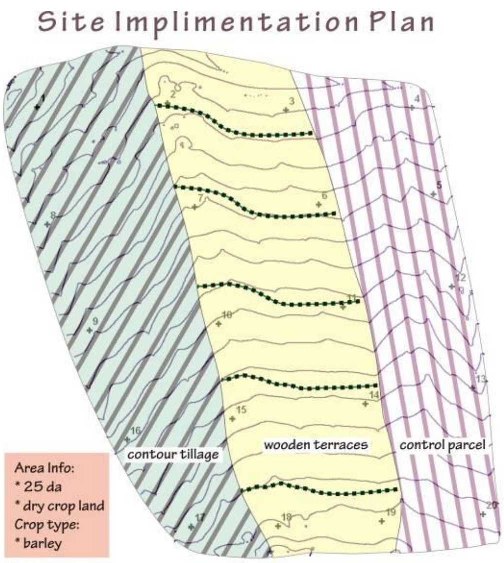



Researchers talked with local people and policy makers, and together they decided on the best options for sustainable land use. In the DESIRE Project the three Parts to WOCAT methodology were developed as outlined above. This provides decision support for choosing technologies suited to the local environment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

**Two technologies were implemented in the SIP area due to outcomes of stakeholder meetings ;**

1. **Contour tillage**
2. **Wooden terraces with soil bunds**




**Monioring**

- Regular soil surface assessment
- Crop charectaristics
- Malch cover fraction
- Erosion features

Repeated soil moisture, EC and temperature measurements

- Empty sediment tank measurements
- Malch cover fraction
- Agronomic measurements
- Yield assessment

The first DESIRE workshops resulted in choosing two technologies to prevent water erosion in the Eskişehir study site. These (wooden terraces and contour tillage) were applied and monitored for two years and the results were evaluated in a final workshop held in June 2011 in Eskişehir. According to the voting results, stakeholders selected wooden terraces mostly due to economic advantages. They thought that this strategy increases crop yield, decreases risk of production though it has a significant cost of installation. Generally speaking, the terracing technology was considered superior in terms of socio-economic and ecological regards too. Contour tillage is still a significant option to them with very low installation cost and relatively good crop yield and conservation characteristics.

The basic obstacle against adoption has been economic and demographic (decreasing welfare and emptying of rural settlements due to migration).

**Feedback from participants**

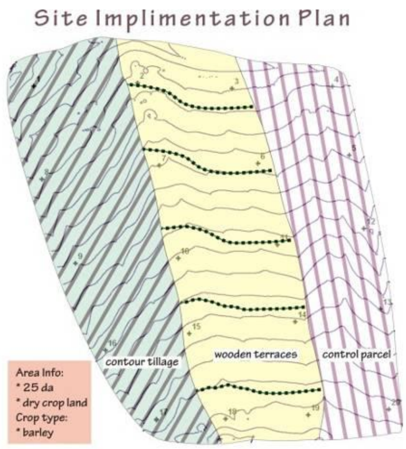
All –inclusive nature of DESIRE project is considered very useful  but time-consuming. Determining the future steps of the project with stakeholder discussions is particularly encouraging for farmers. More budget and involvement  of farmers into experimental phase of project would increase the chance of adoption of strategies.

## TERRACING & CONTOUR TILLAGE

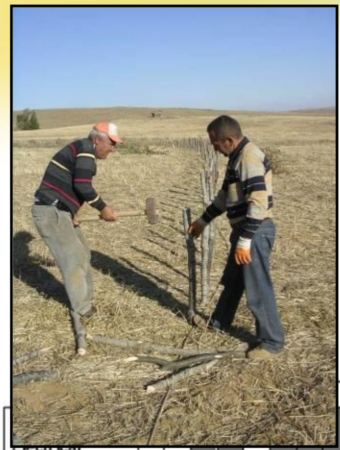
The hill slope areas near Eskisehir suffer from soil erosion.  The area is semi -arid, soils are shallow, stony and organic matter content is low. Land use is rainfed wheat with occasional fallow periods. Late spring and early summer rainfalls are particularly erosive. Experiments were carried out that interrupt the runoff and help increase infiltration and thereby increasing soil moisture storage. The overall objective is to decrease surface runoff and to reduce soil losses.

### THE EXPERIMENT: TERRACING AND COUNTOUR TILLAGES

Two technologies (contour ploughing and terracing) were investigated for water retention and crop growth against the conventional cultivation practice during the period December 2009 and July 2011.




Terracing in this context means that shallow levees were made along the contour lines (dashed lines in the drawing to the left). Poles are hammered on top and branches are woven between them This potentially stops the sediment and slows down runoff and when left continuously, a sloping terrace would eventually form. The tillage between these fences is along the contours. The left hand plot was done with contour ploughing only. The right hand plot uses the conventional tillage along the slope as it gives the longest seed lines.

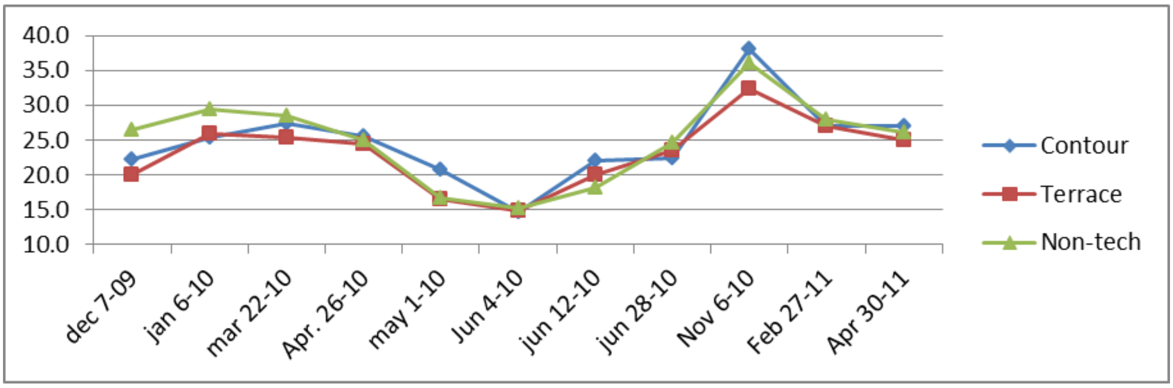


Soil parameters such as moisture content and electrical conductivity were measured regularly with a portable TDR at pre-defined locations (12 per plot), apart from germination rate and crop yield observations (see table below). Germination rate is determined by counting the individual sprouts in $m^2$ once within January in the early sprouting period. Crop yield assessment was made during the harvest at the end of growing season.

| |
|---|
| conductivity |
| Temperature |
| Germination rate |
| Crop yield |
| Expenses |
| Incomes |

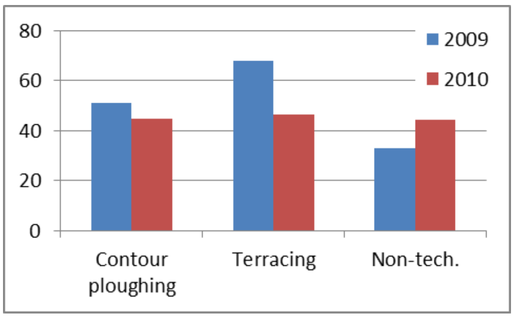
## RESULTS

The result shows that the water content (WC) of the soils vary seasonally. During the monitoring period (Nov 2009 – June 2011) contour tillage technology results in a slightly higher WC (Figure below). Terracing gives second best results though non-technology area exhibit higher WC in the winter months. The differences might also be caused by soil variation. In any case, the differences are not significant, certainly not in a sense of crop water availability.




*Average moisture content (12 measurementsper moment per treatment) during the experiment.*

It appears that during the first year, seed germination rate was the highest in the terraced plot as compared to contour and conventional tillage, while in the second year these differences were not observed. This shows that inter-annual variability is sometimes large and not all effects should be contributed to the technology.




*Germination rate winter Barley in January in sprouts/$m^2$*

Finally, crop yield in the terrace and contour tillage plots is increased by 2-3 times. While this can be explained by a better germination in 2009, there is no clear explanation for 2010. There might be moisture differences deeper in the soil that are not detected.

During the two years there were no direct erosion events on the plots, However a neighbouring unprotected field showed heavy rills which were seen on the experimental slope.

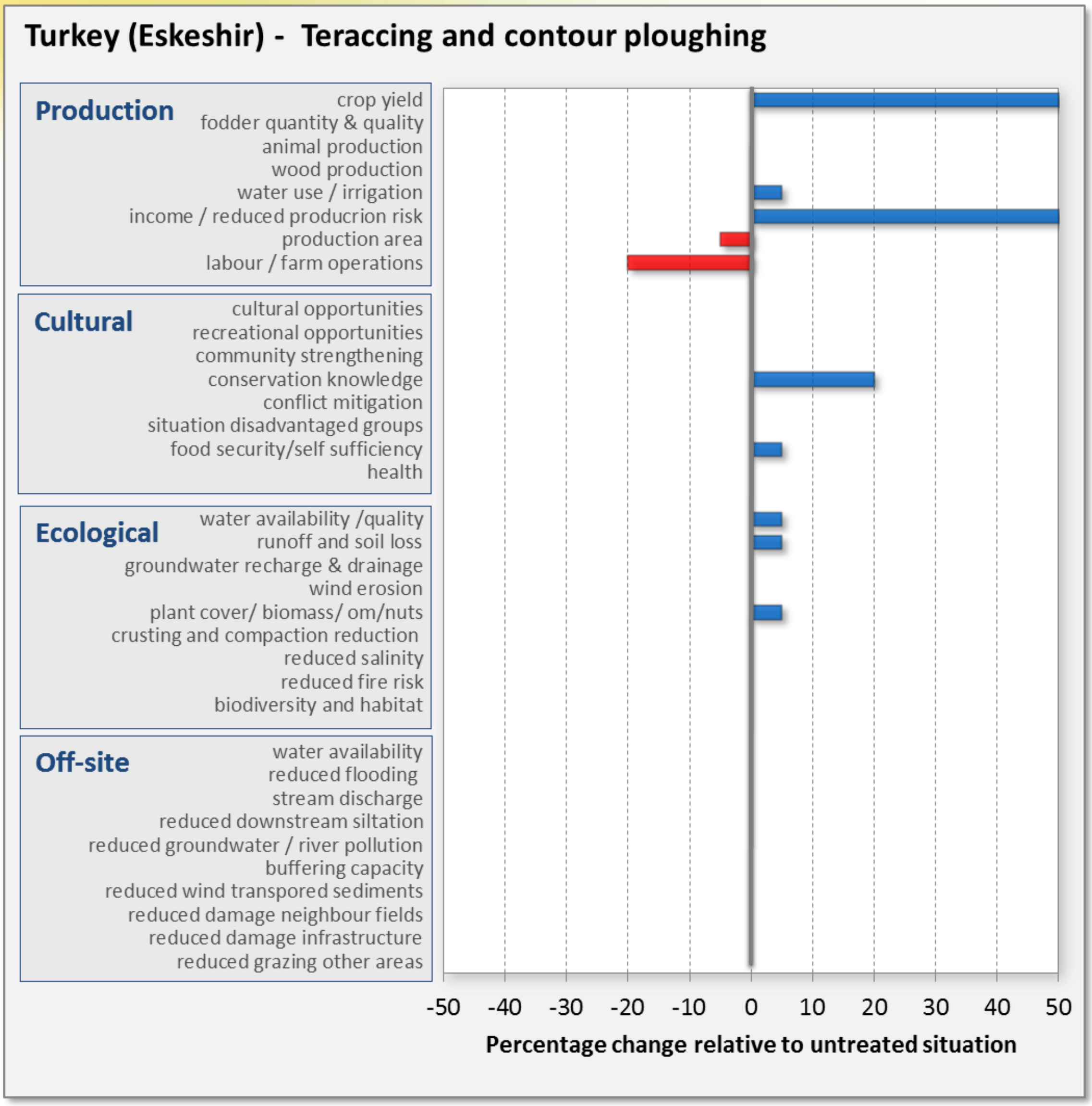
| Harvest / collection date | technology | Area (ha) | Crop type | Quantity (kg/ha) | Income (per ha) | Quantity (kg/ha) | Income (per ha) |
|---|---|---|---|---|---|---|---|
| | | | | 2009 | | 2010 | |
| 07-07-10 | Terrace | 1.15 | barley-grain | 1652 | 634 | 1304 | 501 |
| 07-07-10 | Terrace | 1.15 | straw | 609 | 61 | 635 | 63 |
| 07-07-10 | Terrace Total | | | | *(293)* **695** | | *(512)* **564** |
| 07-07-10 | Contour tillage | 0.82 | barley-grain | 756 | 290 | 1829 | 702 |
| 07-07-10 | Contour tillage | 0.82 | straw | 366 | 37 | 762 | 77 |
| 07-07-10 | Contour tillage Total | | | | *(293)* **327** | | *(574)* **779** |
| 07-07-10 | Control | 0.8 | barley-grain | 375 | 144 | 313 | 120 |
| 07-07-10 | Control | 0.8 | straw | 188 | 19 | 313 | 31 |
| 07-07-10 | Control Total | | | | *(271)* **163** | | *(558)* **151** |

*Summary of yields in kg/ha, expenses (between brackets) and income for the two years. Monetary unit is Turkish Lyra. Note that there is an initial expense to create the levees of 2170 TL.*

## 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.

NOTE: the evaluation outcome was nearly the same for both technologies. The only difference is that for contour ploughing alone the negative judgment of farm operations is less severe. Creating and maintaining the levees is considerable more effort than the tradional tillage.




## STAKEHOLDER OPINIONS

The stakeholders meeting showed the importance of bringing solutions to this degradation trend which threats both the environment and the farmers' income. The farmers experience shows that barley is the most appropriate crop for the terrace and the contour ploughing technologies. Stakeholders were passively involved in the construction of wooden terraces as observer. In the last harvesting season, stakeholders visited mutually the implementation area and discussed the technologies. By using their own experiences they found that barley crop in terraced and contour ploughed spots are more robust compared to control parcel. Stakeholders mostly think that due to low rainfall rates throughout the growing season 2009 and lack of fallow in our application radically decreased the effectiveness of the technologies applied. In a wider sense they believe that the population is becoming older due to intense migration of young people to big cities for economic reasons, which puts an extra stress on implementing technologies at a larger scale.

Terracing involves additional costs and possibly loss of some land whereas contour ploughing can be widely applied without much effort. Also it is seen as a slight loss of land. The field however has to be wide enough because contour ploughing might create many short tracks and turns of a tractor,

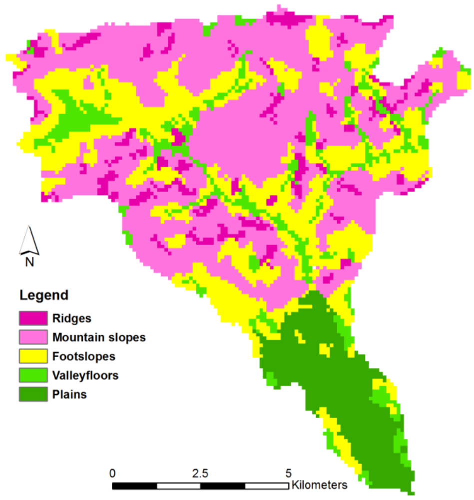
which causes a yield loss. Generally it needs only cost for fuel use which is similar to traditional ploughing. However some training is needed for implementing in steeper slopes. Also smaller tractors with more manoeuvre capability will be better in cultivating terraced land.

## Baseline Scenario

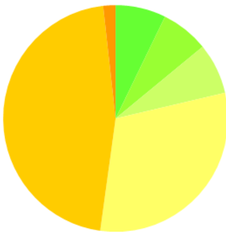
### PESERA baseline run

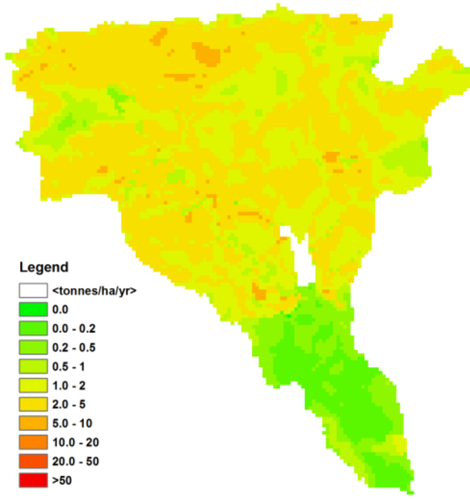
The baseline run clearly shows distinct erosion rates for two areas: the mountain slopes and the plains. Several valleyfloors also have low erosion rates. Roughly 80% of the area has simulated erosion rates of over 1 ton/ha/yr, but only a very small area experiences erosion rates of over 10 ton/ha/yr. Biomass production output shows a clear cut difference between dryland farming (mostly 500-1000 kg/ha) and irrigated farming (typically larger than 3500 kg/ha). Pastures occupy the intermediate ranges.

**Landforms**

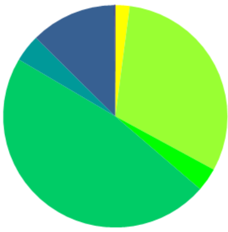


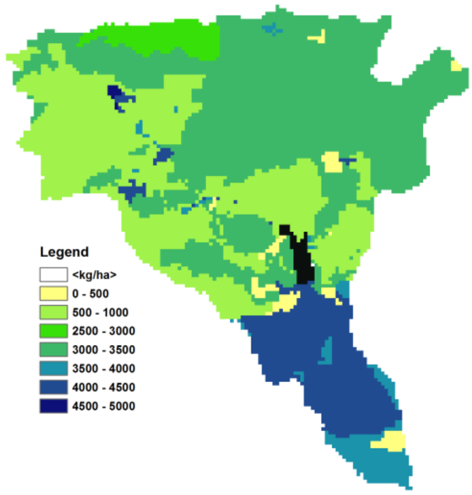

### Soil erosion





## Biomass production





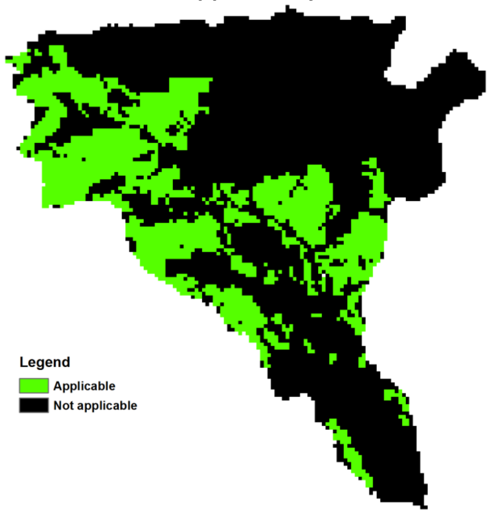

## Technology Scenario:
Contour ploughing

- Total operation costs under different practices:
  - traditional ploughing 286 TRY/ha (€216)
  - contour ploughing 286 TRY/ha (€216)
- The above operation costs include renting of equipment to implement each practice
- A harvest index for grains of 45% of total biomass was assumed
- NPV was calculated on 20 year period basis at 10% discount rate
- The price of grains is 0.384 TRY/kg (€0.16)

## Applicability

- The technology is applicable on arable land with slopes between 2 and 35% (not in plains and valley floors).

**Applicability**

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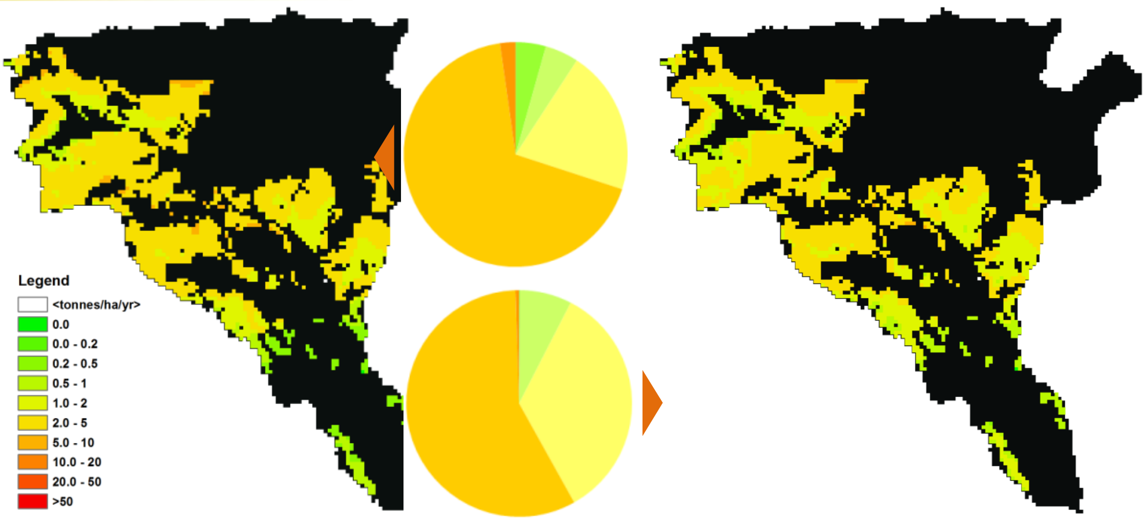
## Biophysical impact: soil erosion



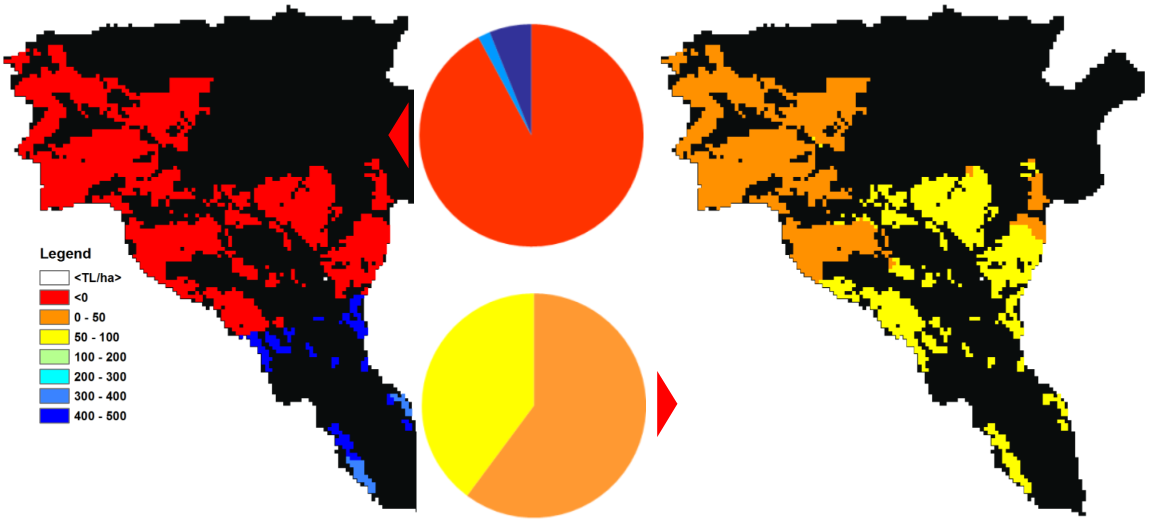

Under traditional ploughing

Under contour ploughing

## Economic viability

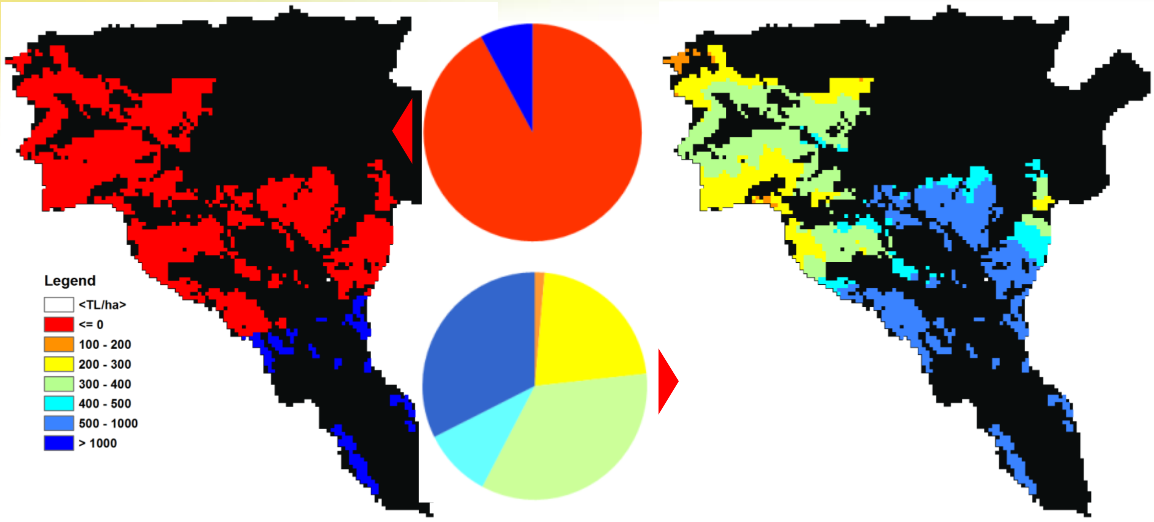
Net profit under traditional ploughing

Net profit under contour ploughing




NPV under traditional ploughing

NPV under contour ploughing




- Contour ploughing is profitable as it does not require extra costs but increases production.
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## Technology Scenario:

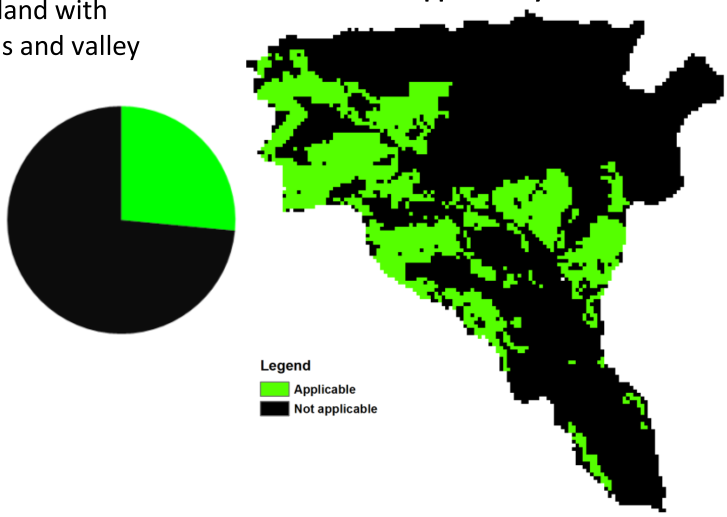
## Woven fence and contour ploughing

- Total operation costs under different practices:
  - traditional ploughing 286 TRY/ha (€216)
  - woven fence and contour ploughing 286 TRY/ha (€216with an initial investment cost of 2500 TRY/ha (€1014 – first year only), annual maintenance cost of 5% of investment cost
- The above operation costs include renting of equipment to implement each practice
- A harvest index for grains of 45% of total biomass was assumed
- The life of the technology is 20 years.
- The price of grains is 0.384 TRY/kg (€0.16)
- 10% discount rate was used for calculating NPV

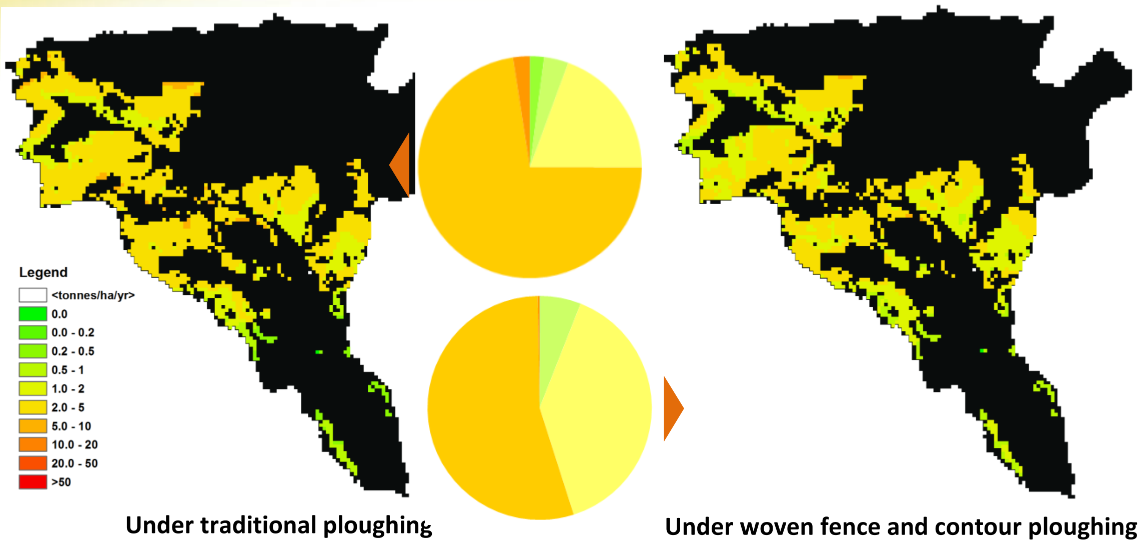
## Applicability

- The technology is applicable on arable land with slopes between 3 and 35% (not in plains and valley floors).

**Applicability**



## Biophysical impact: soil erosion



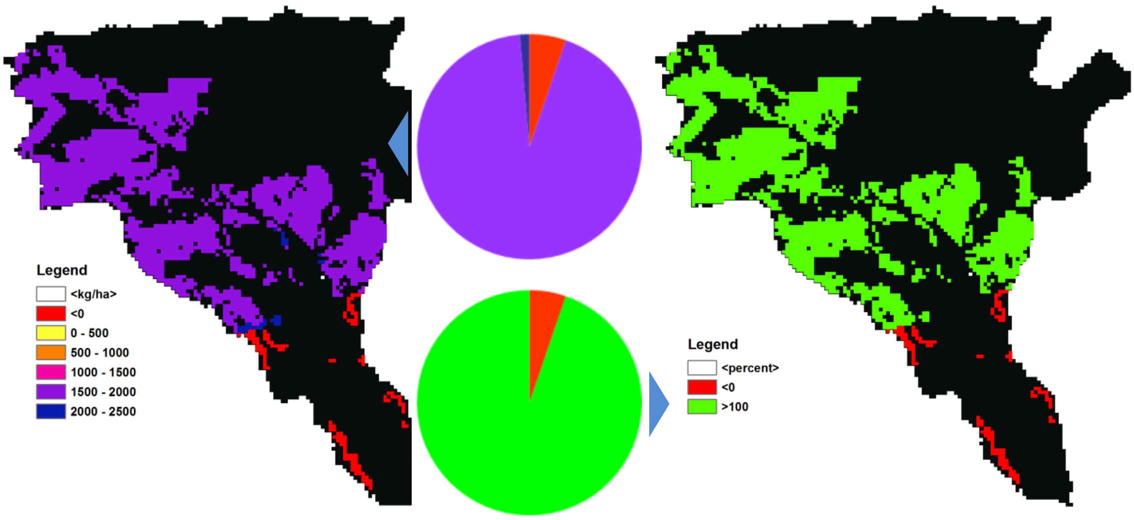

Under traditional ploughing

Under woven fence and contour ploughing

## Biophysical impact: change in biomass

Biomass change

Percentage biomass change




The technology has, according to the model simulations, the potential to double yields across much of the applicability area. Nevertheless, the net present value of woven fences and contour ploughing is negative due to the substantial initial investment costs. Under these circumstances, the technology is unlikely to be adopted unless policy incentives reduce the initial costs. Also, the technology has been assumed to require annual maintenance costs equal to 5% of the investment costs. Productivity increases are such that these can be easily covered. A third observation which can be made is that traditional ploughing also shows negative returns in most of the area considered. This could indicate that farmers accept lower return to labour than the opportunity cost used in the simulations.

Due to a high investment cost for building the woven fence, without external financial incentive in all parts of the study area widespread adoption of the technology is very unlikely. In this scenario the effects of a subsidy equal to 50% of the investment costs on profitability of the technology and the potential for mitigating land degradation were explored. The introduction of 50% subsidy would not have significant impact as the proportion of the study area with negative economic gain remains the same with and without the subsidy. The technology was ranked first in the stakeholder evaluation based on its performance in the experiment, which is also supported by model output. However, the investment costs were in the experimental case not borne by the land user, and as such it could have been assumed by the participants that these would be subsidised. This scenario shows that such subsidies would be required to stimulate adoption, as even a 50% reduction in investment cost does not justify the investment. An additional question would be if such high rates of subsidies would still be cost-effective in reducing environmental degradation.

## Conclusions

Contour ploughing and terracing seems to have a slight increase in top soil moisture due to reduced runoff but this depends on the seasonal rainfall. The technology helps in improving soil condition and crop growth as well as increased yield benefits. The yields over two years were much higher in the experiments than in the control plot, even while the rainfall was very different between the years. Regarding relatively smaller costs involved in contour ploughing, the technology is applicable in wider hill slope areas of semi-arid Central Anatolia. The levees with fences were considered less advantageous because of initial costs and loss of agricultural area, for little gain. Main bottleneck for the easy application of technologies seems sociological (lack of enough young farmers) and economic (prices etc.) rather than scientific.

This experimental season was generally suitable for trial except for the lack of fallow. This caused significant decrease in productivity due to limited water content of the soil. But the present data allow us a comparison of technology efficiencies.

▸Two technologies applied caused better soil and crop growth parameters as well as increased yield benefits. It is suggested that terracing increased water content of soil by decreasing runoff distance. Results showed that contour ploughing is also effective in similar way.

▸ Regarding relatively smaller costs of terracing, and particularly the contour ploughing, increase in productivity is very high. For this reason, these technologies are applicable in wider hillslope areas of semi-arid Central Anatolia.

▸ Main bottleneck in front of easy application of technologies seems sociological (lack of enough young farmers) and economic (prices etc.) rather than scientific.

- Baseline simulations show that the study site experiences considerable erosion, especially in the sloping areas; roughly 80% of the area has erosion rates of over 1 ton/ha/yr, although only a very small area experiences erosion rates of over 10 ton/ha/yr.
- The technologies simulated are the technologies for which field experiments were conducted. These technologies were further specifications of remediation options selected by scientists and local stakeholders to address water erosion problems. The technology scenario shows that contour ploughing (ETH43) goes some way in reducing the area with erosion rates greater than 2 ton/ha/yr from about 70 to 60% of the applicable area. More impressive is its effect on biomass production, generating a more than 100% increase in about 90% of the applicable area. The technology requires no additional costs, and is thus profitable everywhere where it increases productivity. This only excludes some productive low-lying areas. Similarly, woven fences with contour ploughing (KEN05) have a more

notable effect on production than on reduction of erosion. On both criteria, KEN05 outperforms ETH43. Despite of this, application of the woven fences is not economically viable under the assumptions made.

- Evaluating the results in a workshop, stakeholders preferred woven fences over contour ploughing. They did so based on the experimental results, which showed superior performance of the woven fences. There was also concern that contour ploughing would not be effective under high intensity rainfall. The modelling results support the idea that contour ploughing is not very effective in areas with high erosion rates. They acknowledged the investment costs of woven fences, but do not seem to have internalised these to their decision-making perspective – perhaps assuming that this would be subsidised as was the case for the experiment. The statement that incentives would stimulate adoption could imply however that land users are aware of the fact that profitability is an issue.
- A policy scenario subsidising investment costs of woven fences by 50% sorted no effect on its profitability. It could be that labour opportunity costs were too high (i.e. farmers may accept return to labour lower than the going wage rate). Given the vicinity of Eskişehir city this is probably not a very significant factor. High levels of subsidy would be difficult to justify on cost-effectiveness criteria.
- The global scenarios show that the technologies can achieve yield increases and erosion reductions across virtually their entire applicability areas. Yield increases are impressive, at 200% overall and for woven fences in most of the area (i.e. a tripling of yields), and still 120% on average for contour ploughing. Overall, erosion can be reduced by up to 25%, however contour ploughing only delivers reductions of over 15% in about 40% of its applicability area. The average yield increase is 788 kg/ha/yr and the average erosion reduction 0.6 ton/ha/yr, at a cost of €1293 and €1648/ton food product and soil respectively.
- Based on the analyses and perspectives, contour ploughing can easily be adopted but could entail some level of risk in high erosion risk areas and under high intensity events. The effects of woven fences with contour ploughing are clearly demonstrated, but their implementation is not recommended based on economic analysis. A case for subsidies should establish the level of off-site benefits to be obtained.

Leading Scientist:

Assoc. Prof. Faruk Ocakoglu
Eskişehir Osmangazi University
Meşelik Kampüsü
26480 Eskişehir
Turkey
Fax: +90 222 239 36 13
focak@ogu.edu.tr

➜ 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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**During the period January 2007- January 2012, this work was carried out by:**
Assoc. Prof. Faruk Ocakoglu

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