# Sehoul, Morocco

## Study site details

The Sehoul Plateau is located between the highway from Rabat to Fes in the north, and the Grou River in the south. It is a part of the old Atlantic Meseta.

- **Coordinates:**
  Latitude: 33°54’ N
  Longitude: 6°38’ W
- **Size:** 397 km²
- **Altitude:** 45 – 359 m
- **Precipitation:** 450 mm
- **Temperature:** na
- **Land use:** arable land, forest, shrubland
- **Inhabitants:** 19,706 (2004)
- **Main degradation processes:** water erosion
- **Major drivers of degradation:** inadequate land management, land use change, groundwater overexploitation

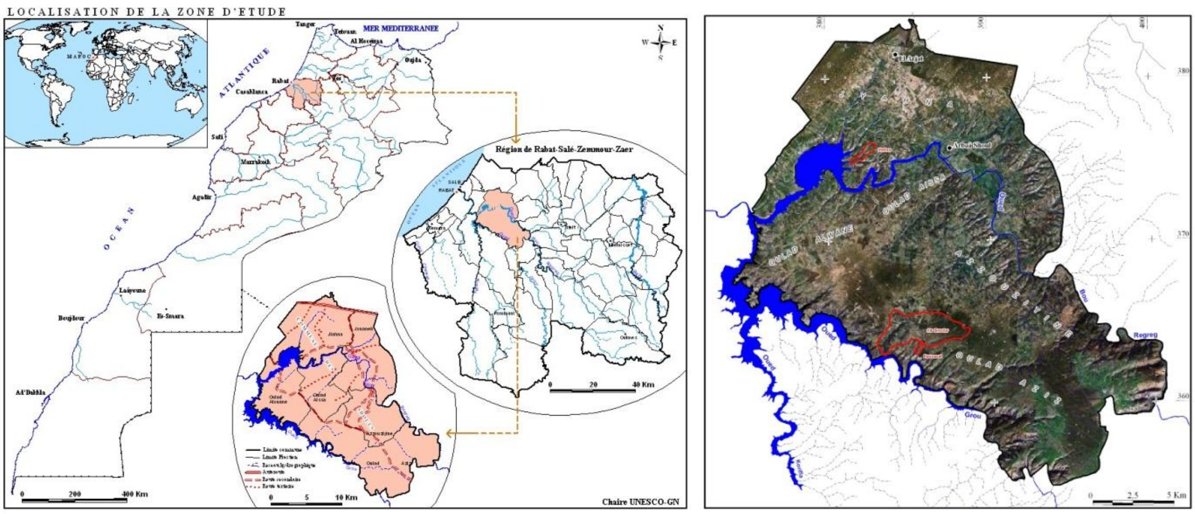


*Figure 1: Study site location*

## Overview of scenarios

1. Baseline Scenario: PESERA baseline run
2. Technology Scenario: Protection of pastures affected by gullies and rills, by fencing and the plantation of fodder shrubs (atriplex) (MOR15)
3. Technology Scenario: Mulching (fencing) and cultivation techniques (conventional tillage - MOR 16A or direct seeding - MOR16B)
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5. Policy Scenario: Prohibiting livestock stubble grazing (MOR16A/B)
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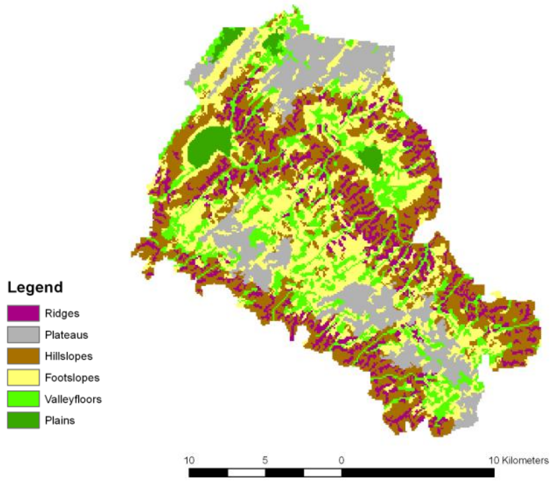
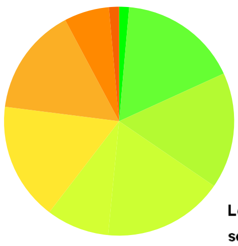
## Baseline Scenario
PESERA baseline run

The baseline scenario shows that soil erosion risk is highest on the steep hillslopes along the rivers that dissect or limit the area in a predominantly northwest-southeast direction. The plateaus, for the larger part forested, stand out as low erosion areas. Biomass production correlates with land use, with highest values for forest areas and lowest values for arable land. For forests, the biomass is relatively low due to high amount of grazing. For arable land, the areas with steep slopes and shallow soils are much less productive than alluvial areas.

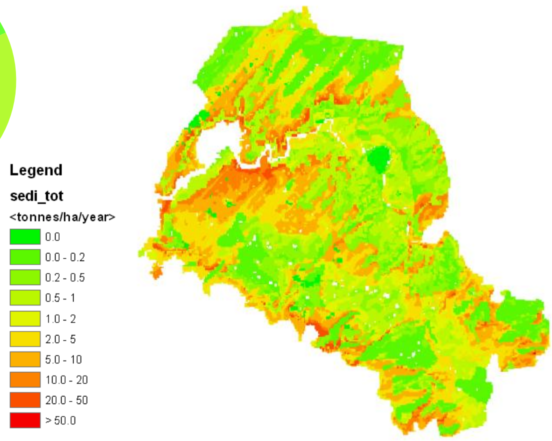
**Landforms**



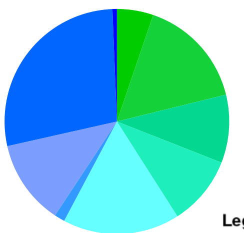

## Soil erosion



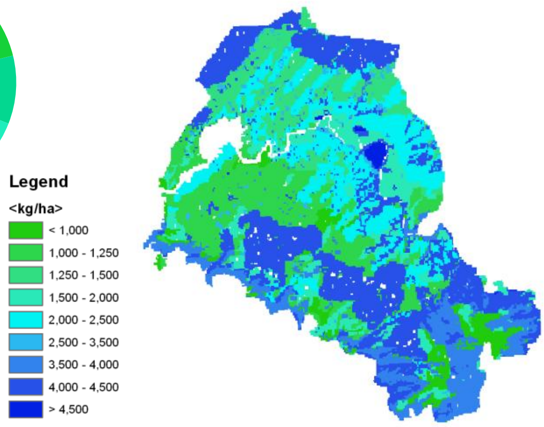
**Soil erosion**




## Biomass production



**Biomass production**



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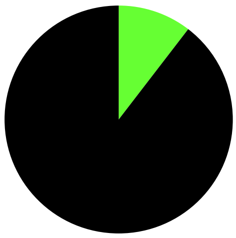
## Technology Scenario:

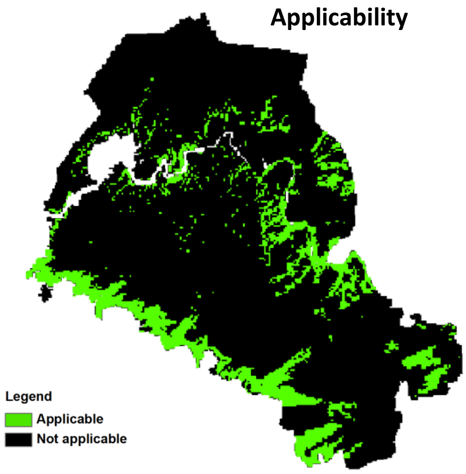
Protection of pastures affected by gullies and rills, by fencing and the plantation of fodder shrubs (atriplex) (MOR15)

- The investment costs for atriplex plantation amount to 28,020 MAD/ha (€2480)
- Full biomass increase is assumed to be achieved after 20 years; a linear growth trend is assumed.
- Grazing is assumed in without case. Apart from differences in fodder production, fodder quality is assessed by a conversion factor of 35% (without case) and 56% (technology) of fodder units to biomass.
- Price of fodder is 2.16 MAD/fodder unit (€0.19)
- Cost of fodder collection and feeding is assumed to be equal to herding animals
- A discount rate of 10% is applied

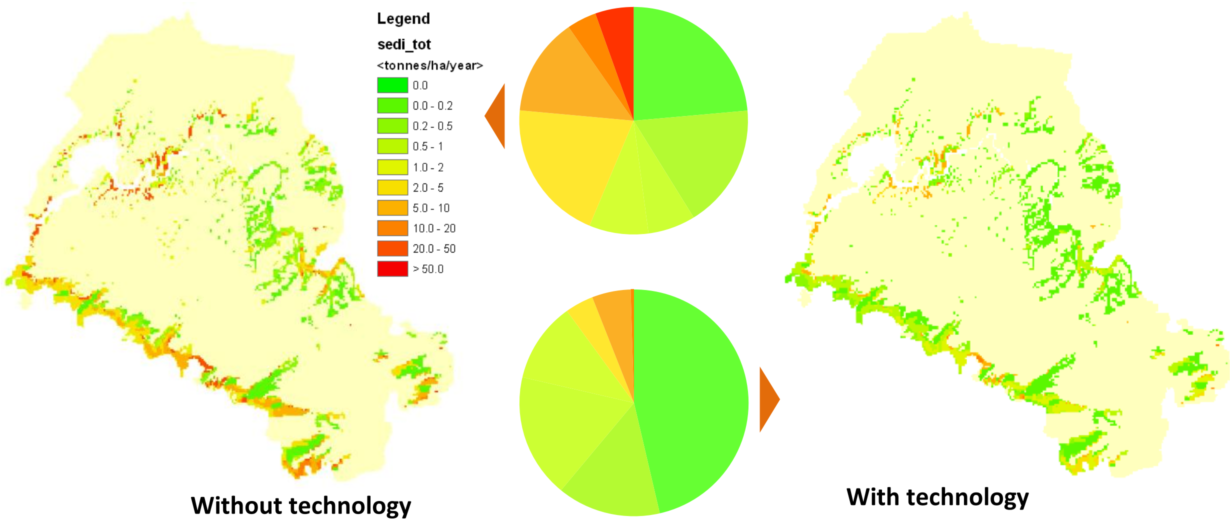
## Applicability

- The technology is applicable on extensive grazing land and bare land. It can also be applied on steep cropland prone to gullying. All cropland above 20% slope is assumed to fall in this category.



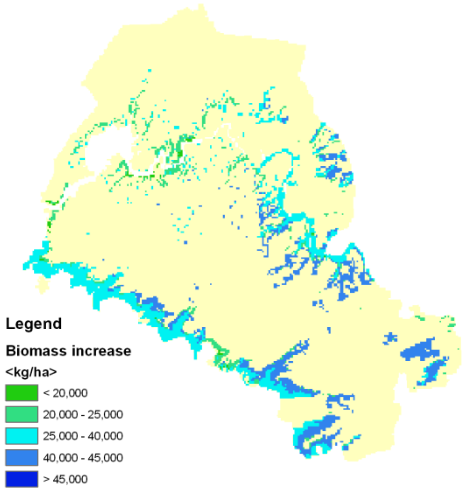


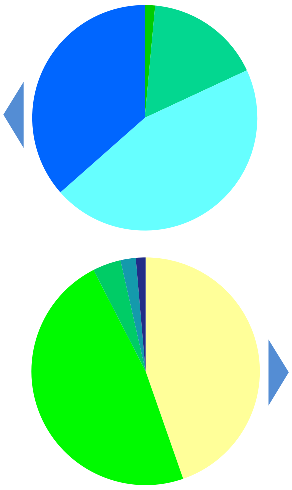

## Biophysical impact: soil erosion



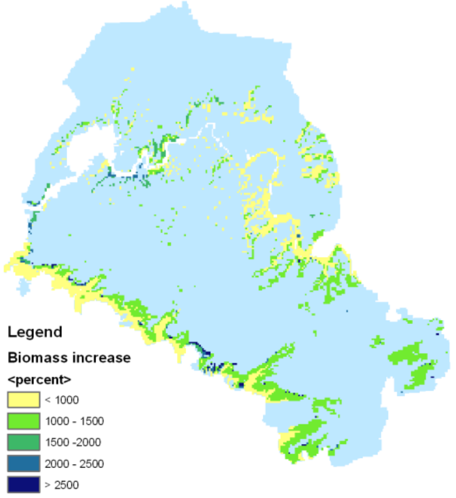
## Biophysical impact: increase in biomass

**Biomass increase**



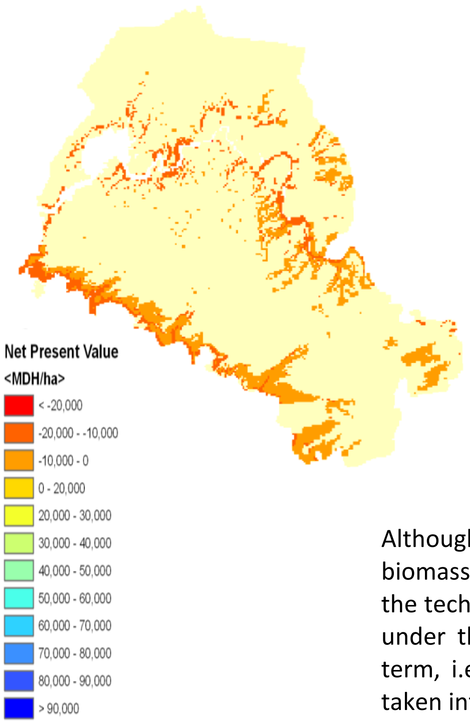



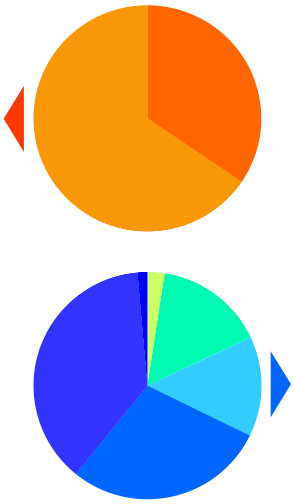
**Percentage biomass increase**



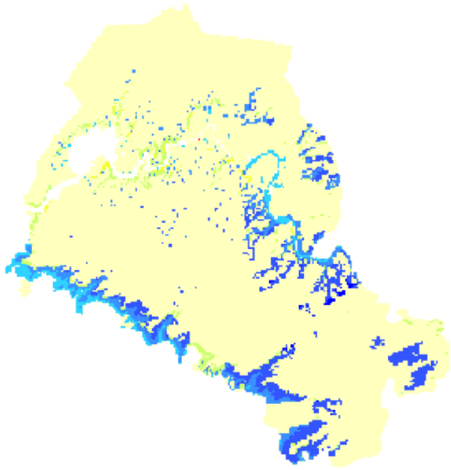

## Economic viability

**Net present value after 10 years**



**Net present value after 20 years**



Although the technology is projected to lead to a very strong increase in biomass, this is likely a slow process, particularly on degraded lands for which the technology is intended. An investment for a time horizon of 10 years leads - under the assumptions made - to negative net present value. In the longer term, i.e. 20 years, the technology is highly profitable. Some effects are not taken into account, e.g.:

- Adoption of the technology reduces need for stubble and forest grazing, and productivity of cropland and forest may go up as a consequence.
- Off-site effects, such as avoiding the development of gullies in adjacent farmland and reduced sedimentation in the river network.
- Costs of implementing the technology may have an element of spatial variability (distance to markets for inputs, water source for irrigation and opportunity cost of labour for livestock grazing)
- The scale of application (e.g. fencing costs per unit area can be much reduced by closing contiguous larger areas – for instance by 50% for 4 ha and by 75% for 16 ha).

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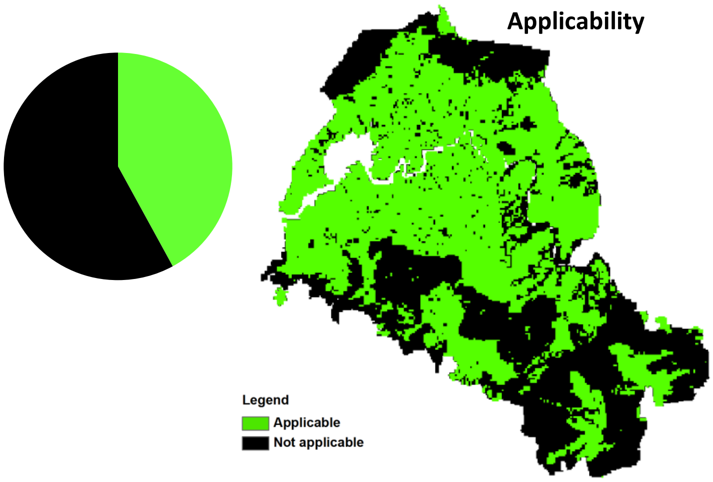
## Technology Scenario:
Mulching (fencing) and cultivation techniques (conventional tillage - MOR 16A or direct seeding - MOR16B)

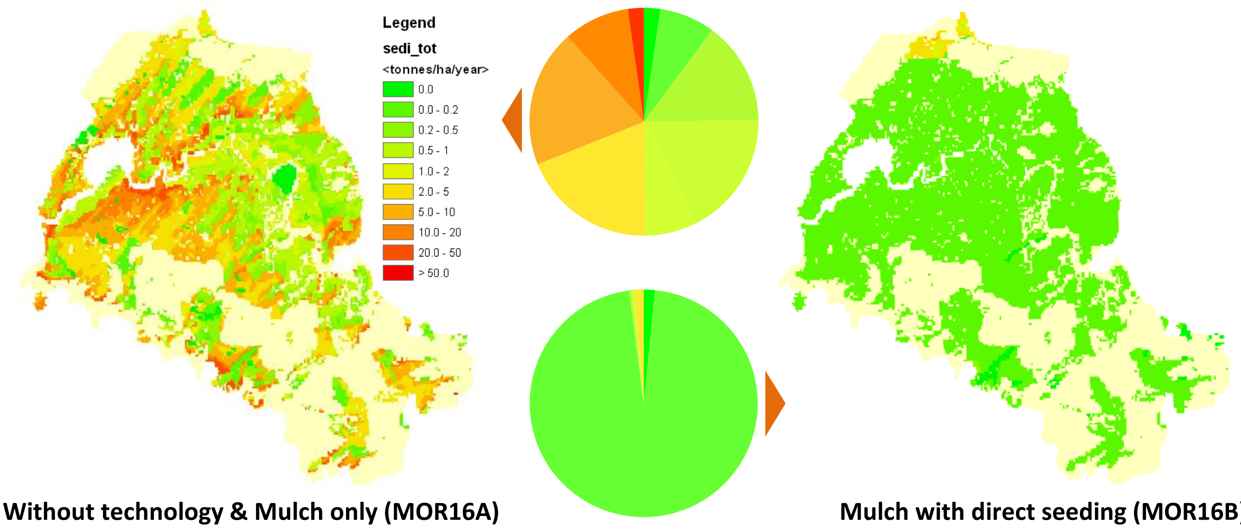
- Two variants considered MOR16A and B.
- The investment costs for fencing amount to 6,520 MAD/ha (€577) in both cases.
- Due to initial fencing cost, an investment analysis with an economic life of 10 years is made.
- In the without case, conventional tillage is assumed followed by fallow grazing.
- Technical assumptions: harvest index of 31%; 0.4 fodder units (FU) per kg fallow stubble.
- Unit prices (kg or FU): barley 4 MAD (€0.35); straw 0.5 MAD (€0.02); fodder 2.2 MAD (€0.19)
- Added cost direct seeding is 1500 MAD (€133)
- A discount rate of 10% is applied

### Applicability

- The technology is applicable on arable land.



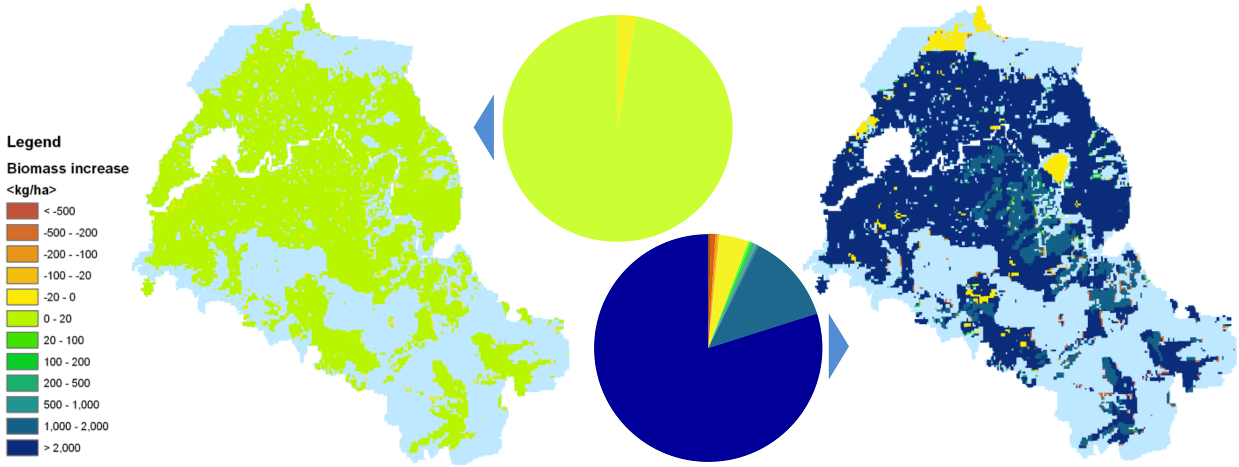

### Biophysical impact: soil erosion



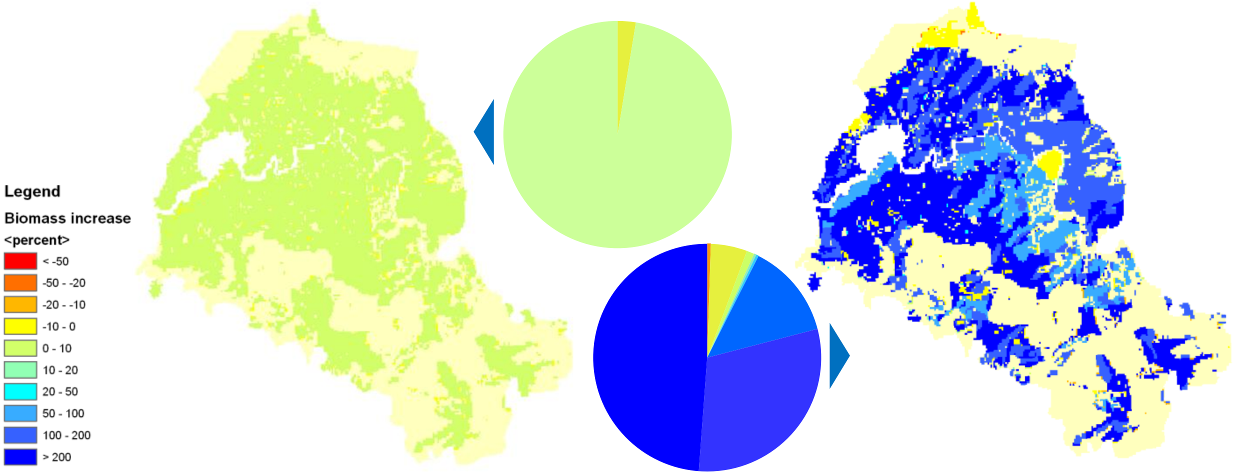

**Without technology & Mulch only (MOR16A)** **Mulch with direct seeding (MOR16B)**

## Biophysical impact: increase in biomass

**Biomass increase: Mulch only (MOR16A)** **Mulch with direct seeding (MOR16B)**

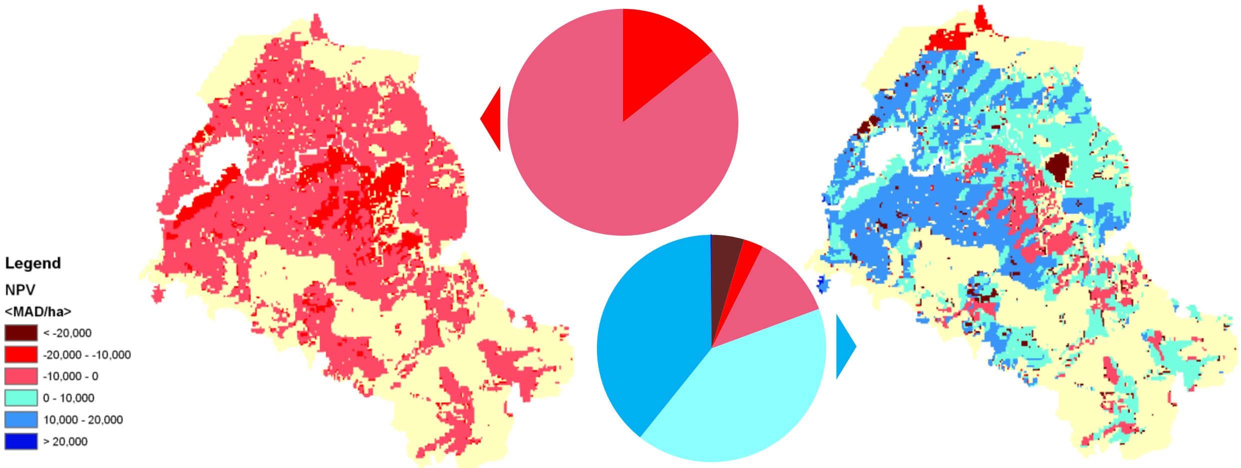



**Percentage biomass increase: Mulch only (MOR16A)** **Mulch with direct seeding (MOR16B)**




## Economic viability

**Net present value ( 10 years): Mulch only (MOR16A)** **Mulch with direct seeding (MOR16B)**



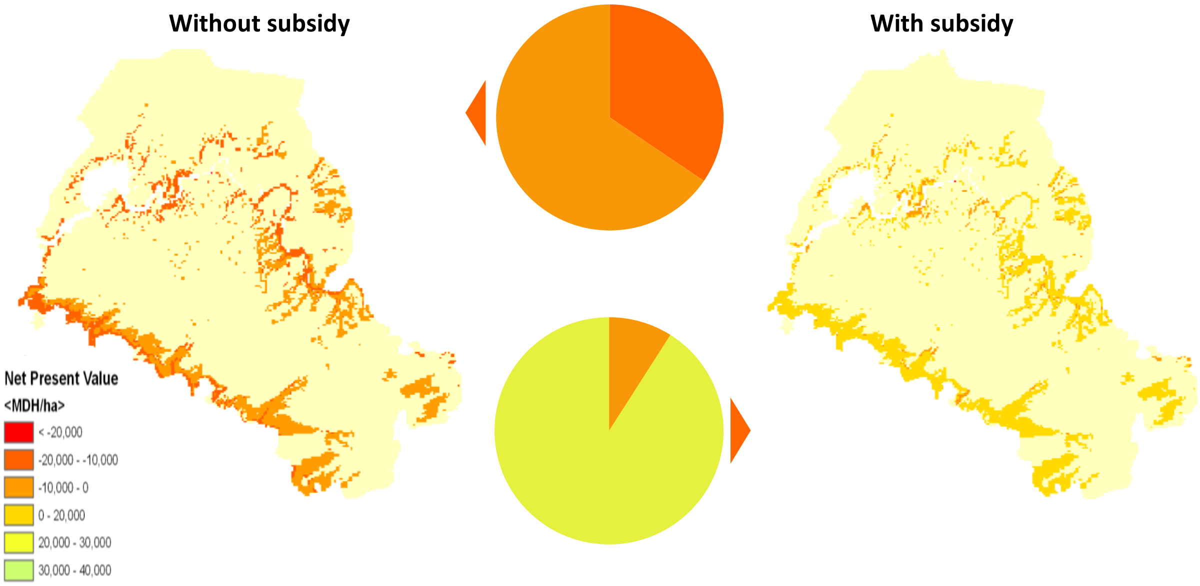

The important upfront fencing costs are not justified in the case of mulch only as the technology leads to only very modest (<10%) biomass increase. Moreover, no erosion reduction results (fallow period dry). In the case of direct seeding, erosion rates and biomass respond impressively. Economic viability is more mixed due to high operational costs of direct seeding but profitable in 81% of the applicable area.

# Sehoul, Morocco

## Policy Scenario:
## Subsidising the protection of pastures affected by gullies (MOR15)

At a time horizon of 10 years, fencing and planting atriplex is not profitable. 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 and/or coordinating the scale of implementation which will reduce per area unit cost. A subsidy could be part of a payment for ecosystem services scheme as stabilization of areas affected by gullies and rills has important off-site effects, e.g. reduction of sedimentation of the reservoirs in the study area, and relieving pressure on state forests. In this scenario a cost reduction equal to 50% of the investment costs is explored.


### Profitability:




### Cost-effectiveness indicators:

- A reduction in investment costs of 50% makes the technology profitable in 91% of the applicable area, based on the net present value after 10 years.
- This will result in an average reduction of erosion of 3.27 ton/ha/year.
- In total, an annual reduction of 16,582 tonnes of eroded soil can be expected.
- If the cost reduction would be in the form of a subsidy, the total cost would be 71.4 million MAD (€6.28 million).
- Hence a cost-effectiveness of 4,306 MAD/ton (€379) of soil conserved.

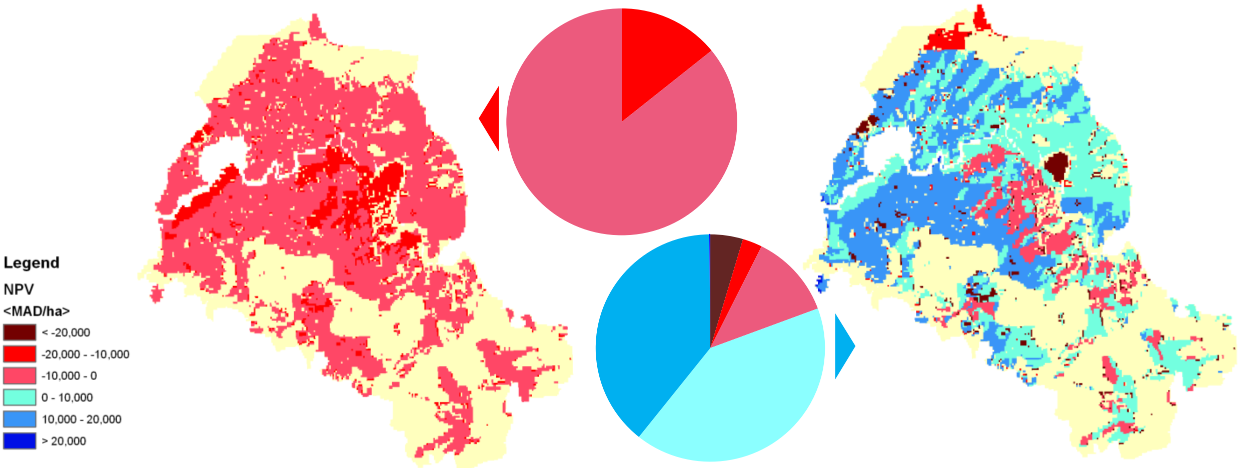
# Sehoul, Morocco

## Policy Scenario:
## Prohibiting livestock stubble grazing (MOR16A/B)

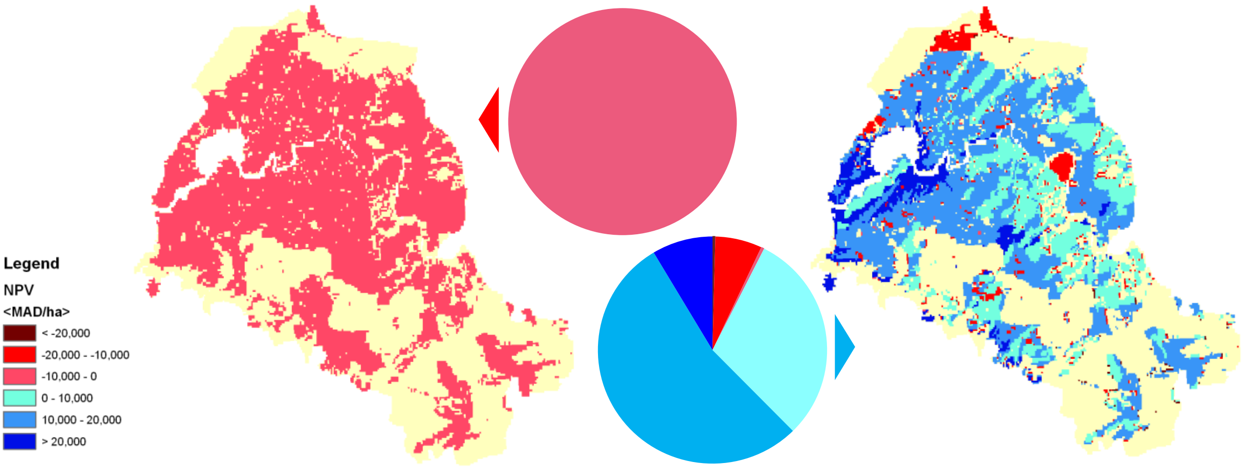
The need for fencing makes the application of mulching (with conventional tillage or direct seeding) difficult. Fencing implies a need for upfront investment – the resources for which may not be readily available. Moreover, land users might consider it a risky investment as they are unsure if costs can be recouped and when this will happen. This scenario explores the changes in economic viability of the mulching technologies if fencing would not be required. This could be the case if animals can be kept of the land, e.g. through policy enforcement.

### Profitability:

**Without policy: Mulch only (MOR16A)** **Mulch with direct seeding (MOR16B)**




**With policy: Mulch only (MOR16A)** **Mulch with direct seeding (MOR16B)**



**Cost-effectiveness indicators:**

- Without a need for fencing, the technology (MOR16B only) becomes profitable in 93% of the applicable area, based on the net present value after 10 years. This is an additional 12%.
- This will result in an average reduction of erosion of 0.59 ton/ha/year, much lower than the average reduction obtained in the area where the technology is already profitable without policy (4.91 ton/ha/year).
- In total, an annual reduction of 1,553 tonnes of eroded soil can be expected.
- The cost of such a policy would from a governance perspective entail controlling implementation. From a land user perspective differences in livestock keeping systems would need to be assessed. For arable land productivity, it is clear that productivity will increase significantly.

# Sehoul, Morocco

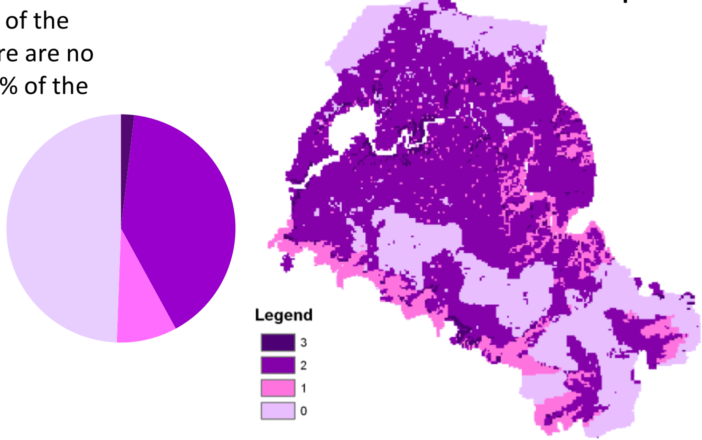
## Adoption Scenario:
## Fencing and atriplex (MOR15), Mulching (MOR 16A) and Mulching with direct seeding (MOR16B)

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 Sehoul, fencing and atriplex plantation (MOR15), applicable on degraded land, and the two mulching variants (conventional tillage and direct seeding – MOR16A/B) for arable land are considered. All three options are compared for a 10 year time horizon.

### Mitigation options

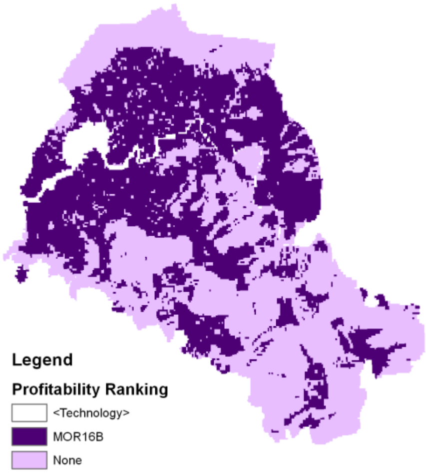
- The three mitigation options are all applicable in 2% of the area; two options are available in 40% of the area; only 1 option is suitable on 9% and there are no applicable technologies for the remaining 49% of the area.

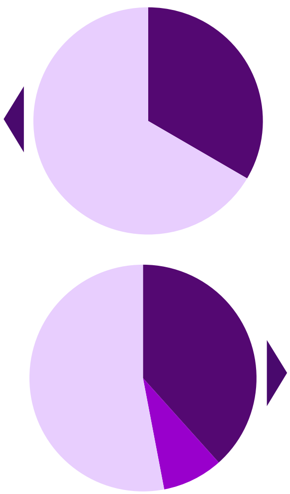
**Number of options**



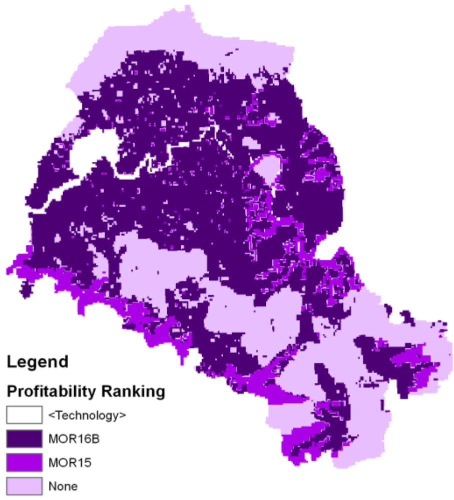

### Adoption of most profitable technology

**Without policies**



**With policies**



# Sehoul, Morocco

## Global Scenario:
## Food production

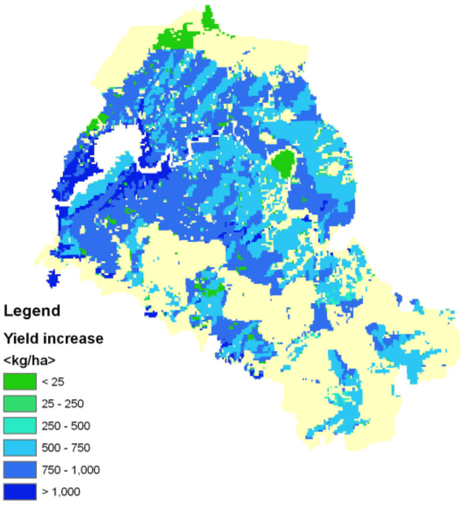
The food production scenario selects the technology with the highest agricultural productivity (biomass) for each cell where a higher productivity than in the baseline scenario is achieved. The implementation costs for the total study area are calculated and cost-productivity relations assessed. To facilitate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

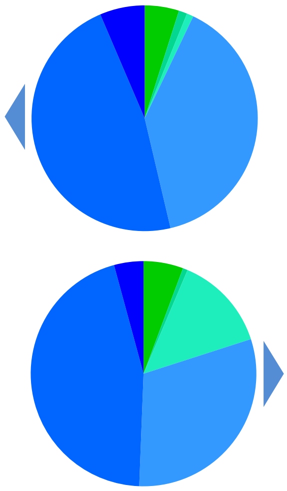
**+758 kg/ha**

**+841 kg/inhabitant**

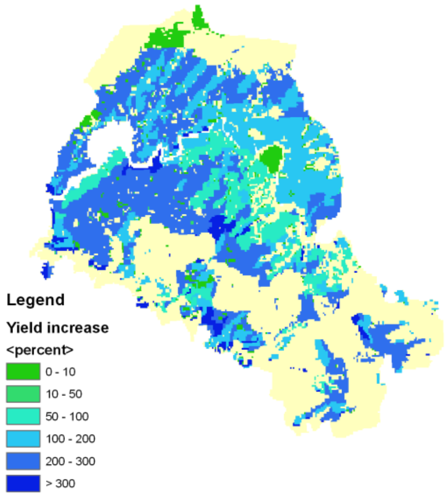
### Scope for increased production

**Yield increase**



**Percentage yield increase**




### Biophysical impact: yield increase

- Yield increase in 99 % of applicable area
- Average absolute yield increase: 758 kg/ha
- Average yield increase: 181 %

### Economic indicators

Average costs:
- Investment cost: €577/ha
- Unitary cost year 1: €928/ton
- Unitary cost lifetime: €243/ton

Aggregate indicators:
- Study site: €15.4 million
- Augmented annual production: 16,568 ton
- Augmented total production: 165,683 ton

# Sehoul, Morocco

## 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.

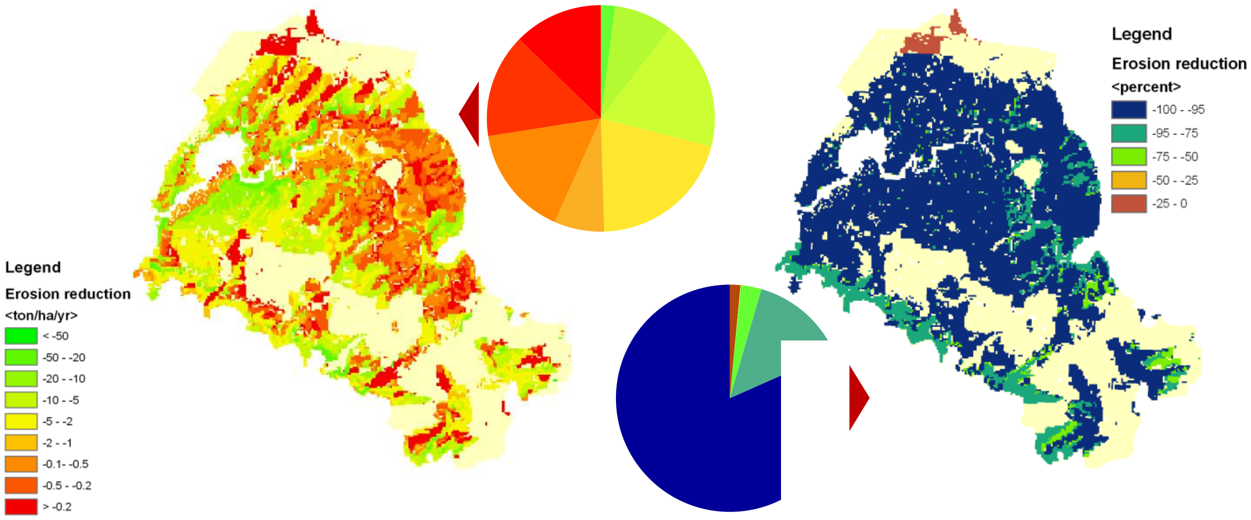
**-3.93 ton soil/ha**

**€50/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 94 % of applicable area
- Average absolute erosion reduction: 3.93 tonnes/ha/yr
- Average percent erosion reduction: 95 %

### Economic indicators

Average costs:

- Investment cost: €1008/ha
- Unitary cost year 1: €257/ton soil
- Unitary cost lifetime: €50/ton soil

Aggregate indicators:

- Study site: €25.2 million
- Aggregate annual erosion reduction: 99,486 ton
- Total erosion reduction: 0.995 million ton

# Sehoul, Morocco

## Concluding remarks

- Baseline simulations show a mixed picture of soil erosion in the Sehoul area: about half of the area has soil erosion rates below 1 ton/ha/yr, but over 20% has rates of more than 10 ton/ha/yr.
- Improved crop rotations for cereals and improved rangelands with control of gullies were prioritised by scientists and local stakeholders to control soil erosion, soil fertility depletion and vegetation decline. Two concrete technologies were tested: protection of pastures affected by gullies and rills (MOR15) and mulching (fencing) of arable land (MOR16A/B). The technology scenarios show that both technologies can drastically reduce erosion rates. However, for mulching this only applies in combination with direct seeding (MOR16B) – mulching with conventional tillage (MOR16A) is ineffective in PESERA simulations. Atriplex planting on degraded land is according to model output capable of leading to 10-fold increase in biomass production. The time scale over which this occurs would need to be assessed, but experimental results were encouraging. A doubling of biomass production is obtainable in cereals under mulching and direct seeding, but only marginal improvements (<10%) are simulated for mulching and conventional tillage. Experimental results showed issues with direct seeding, and the divergence between both variants was not clear cut. Due to high initial cost of fencing, the tested technologies are only in the long term (> 10 years) profitable. Mulching with direct seeding performs best and is simulated to be profitable in 81% of the applicable area over a 10-year planning horizon.
- In the workshop to evaluate monitoring and modelling results, stakeholders downgraded the mulching technology based on inconclusive experimental results. This might also be due to the perception that cereal farming is not profitable, and needs to be diversified with leguminous crops and tree species. On the other hand, management measures that can be adopted without the need for profound changes in cultural practices were suggested to have better adoption prospects. Incentives and 'bold political decisions' were deemed necessary to exclude grazing and reverse degradation trends.
- A policy scenario reducing fencing costs by 50% made atriplex planting profitable in 91% of the applicable area. Such a subsidy would reduce soil erosion by on average 3.4 ton/ha/yr, at a cost of 4,306 MAD/ton (€273). Given that the zones where the technology would be implemented are riparian areas surrounding waterways and reservoirs, there could be important off-side benefits. For mulching, a policy scenario considered the effect of regulations to keep animals off the land – which would remove the need for fencing. An additional 12% of the applicable area would see mulching and direct seeding become profitable, but with limited further decrease of soil erosion problems. Throughout the applicable area, productivity (and profitability) would increase. The combination of mulch and conventional tillage is too ineffective to become profitable. Importantly, the implications of such changes for livestock keeping must be clearly understood. As expressed in the workshop, the land users' priorities lie with their livestock and there is reluctance to change grazing systems.
- The adoption scenario summarises the above: the technologies tested are together applicable in about halve of the study area (woodlands being excluded). Without policies, only mulch with direct seeding offers scope for adoption, in about a third of the area. Considering the policy scenarios separately for each technology, roughly 15% of the area could be additionally made attractive to 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 relatively low, at €243/ton grain and €50/ton soil conserved. Per area unit, investment costs are nevertheless substantial. The modelling results need further experimentation to support claims of the effectiveness of direct seeding in particular.
- Planting atriplex and mulching and direct seeding are in principle robust land degradation mitigation strategies. However, fencing of determined areas might lead to overgrazing elsewhere; a holistic natural resource management approach is necessary to balance human and ecosystem needs. Planted on degraded land, atriplex can reclaim areas that have become unproductive. The mulching systems need further testing to identify risks and establish best practice.