Zeuss-Koutine, Tunisia

Study site details

The study site is a transect from the Great Oriental Erg and the Dahar plateau in the west, crossing the Matmata mountains, Jeffara plain and sebkhat before ending into the Gulf of Gabès.

- **Coordinates of central point:**
  Latitude: 33°16’ N
  Longitude: 10°08’ E
- **Size:** 897 km²
- **Altitude:** -3 – 666m
- **Precipitation:** below 100 mm in the Oriental Erg to 240 mm in the Matmata mountains.
- **Temperature extremes:** -3ºC – 48ºC
- **Land use:** rangeland, tree crops, annual crops (cropping linked to water harvesting)
- **Inhabitants:** 151,000 (1994)
- **Main degradation processes:** water & wind erosion, rangeland degradation and drought.
- **Major drivers of degradation:** population growth, deficient information, insecure land tenure, lack of institutional mechanisms

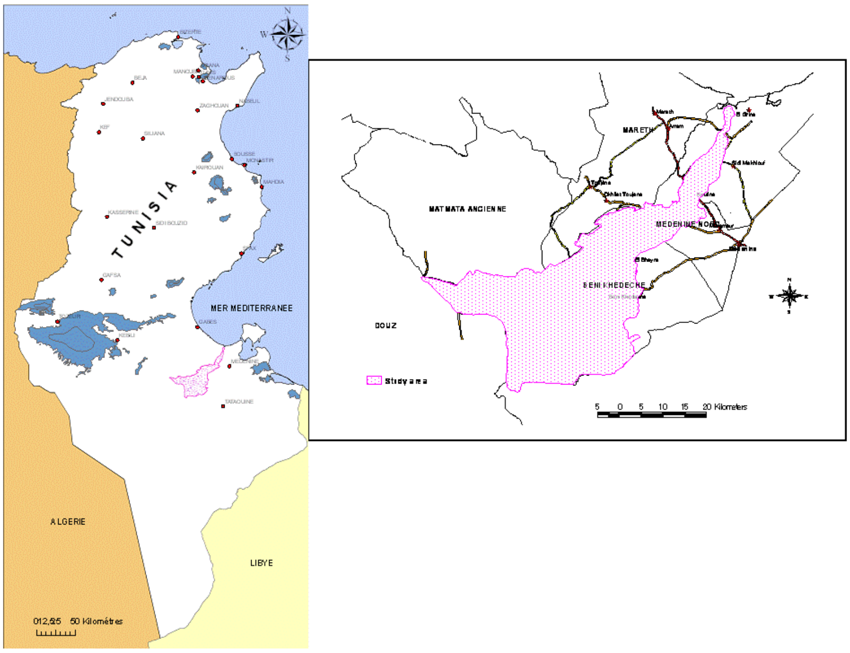

Figure 1 Study site location

Overview of scenarios

1. Baseline Scenario: PESERA baseline run
2. Technology Scenario: Jessour (TUN09)
3. Technology Scenario: Rangeland resting (TUN11)
4. Technology Scenario: Tabia (TUN12)
5. Policy Scenario: Subsidising alternative feed purchases (TUN11)
6. Policy Scenario: Subsidising the construction of jessour and tabias (TUN09 & 12)
7. Global Scenario: Food production
8. Global Scenario: Minimizing land degradation

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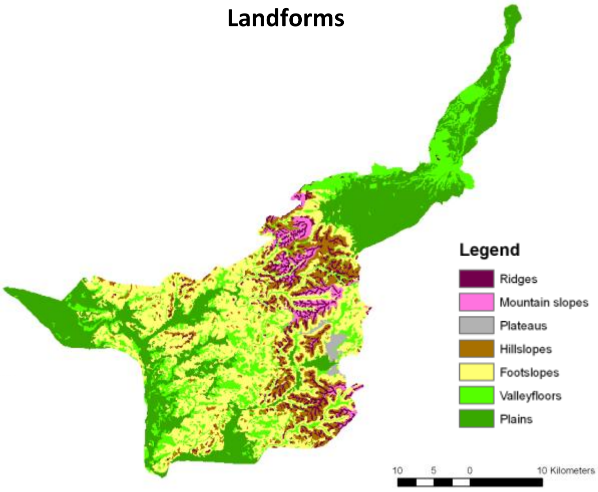
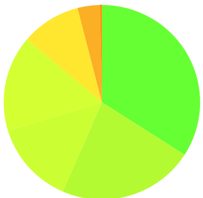
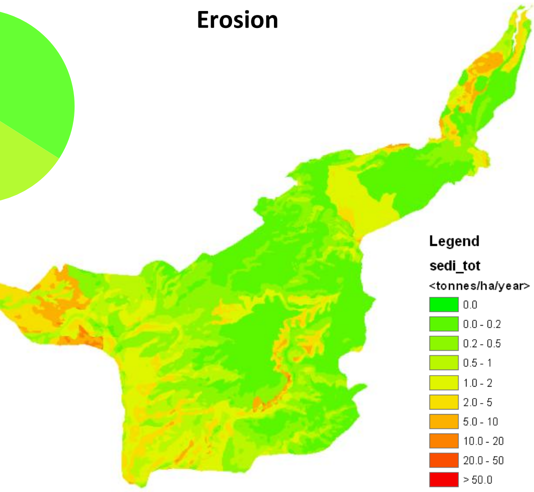
Baseline Scenario
PESERA baseline run

The erosion baseline map is affected by land use, soil cover and availability of erodible sediment. Hence, the Matmata mountain range does not feature prominently, whereas some footslope, valleyfloor and plain areas represent higher maximum erosion values. For the estimation of biomass production it was assumed that grazing is an intrinsic part of the system and an average of 30% of annual production is grazed annually.

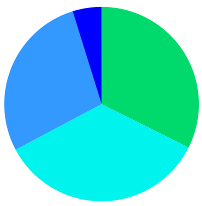


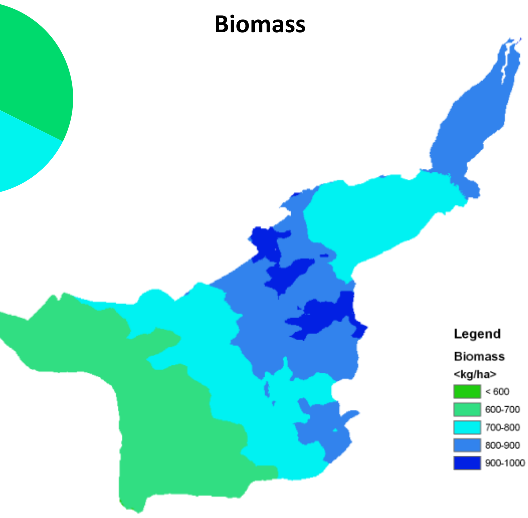
Soil erosion





Biomass production





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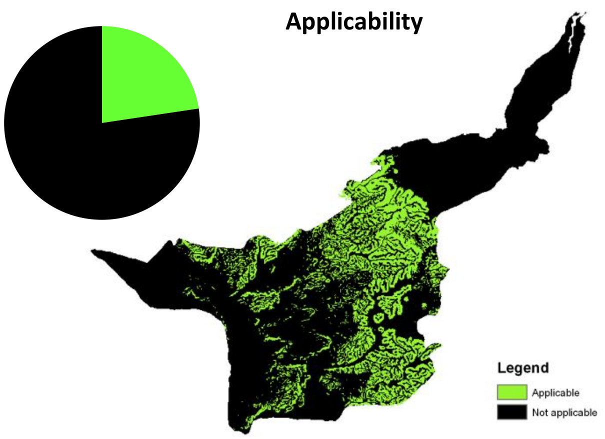
Technology Scenario:
Jessour (TUN09)

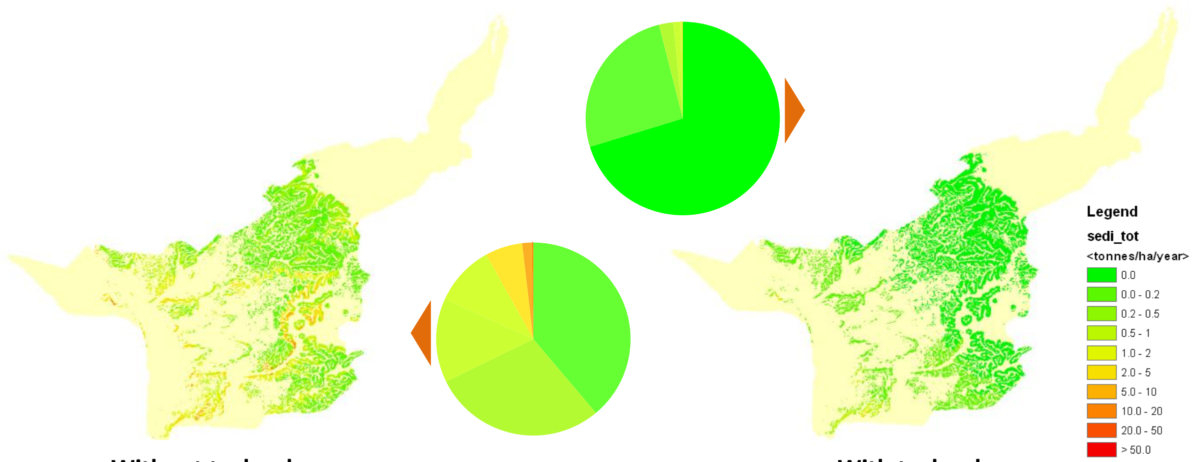
- Investment cost is fixed at TND 3,900 (€1945).
- An economic life of 20 years has been set.
- Maintenance costs amount to TND 1170 (€584), including agricultural management.
- A discount rate of 10% has been applied.
- A CCR of 1:6 has been assumed. Extensive grazing (without case) is not affected.
- Terrace is cropped to olive. Trees become productive after 6 y (25%); mature after 12 y.
- Olive harvest index (HI) is set at 0.1 and olive price at TND 0.55 (€0.27) per kg.
- Wheat intercropped until year 12. Max. yield is 930 kg/ha; price is TND 0.43 (€0.21) per kg.

Applicability

- The technology is not applicable in very steep and flat areas



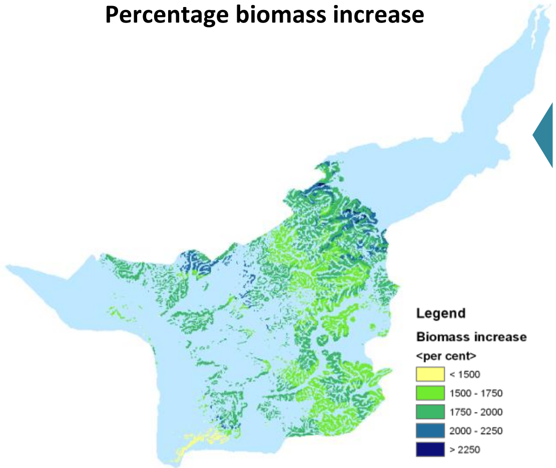
Biophysical impact: soil erosion



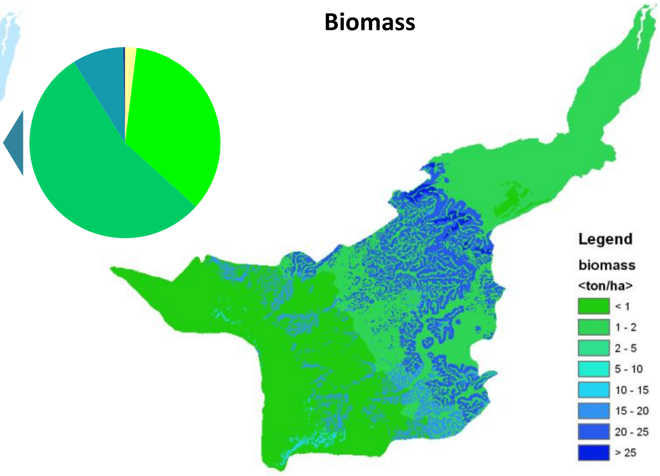
Without technology **With technology**

Biophysical impact: increase in biomass

Percentage biomass increase

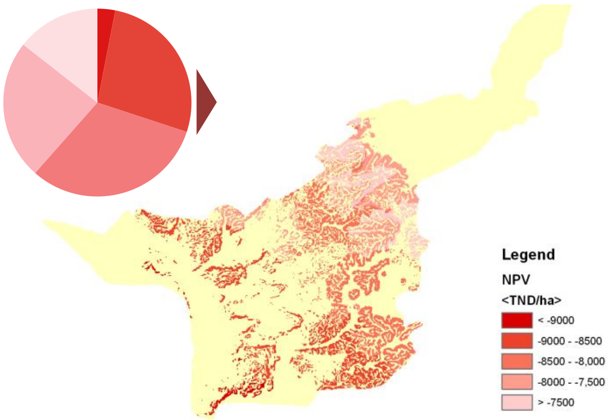


Biomass

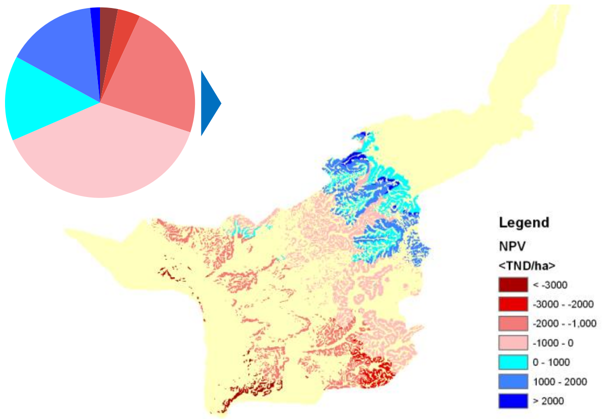


Economic viability

Net Present Value (20 years): olive trees newly planted



Maintenance of jessour with existing olive trees



In the case of construction of new jessour, planting of new olive trees means that it takes 6 years before the first olives can be harvested, and 12 years before the trees reach full productivity. Even if in this build up period wheat is grown, the investment and maintenance costs are too high, resulting in negative Net Present Value. However, the maintenance of existing jessour where olive trees have reached maturity is profitable in part of the applicability area: there is a positive NPV in 31% of the applicability area. These analyses are based on average conditions, and years with insufficient runoff-producing rainfall events may see much lower olive harvests. Equilibrium biomass per hectare of terrace area may seem high; the olive harvest index has been set quite low to arrive at a yield of 100 kg per full-grown tree. Note that NPV is given per hectare of terraced land, so for total land productivity including the impluvium values should be divided by 6 (the CCR ratio).

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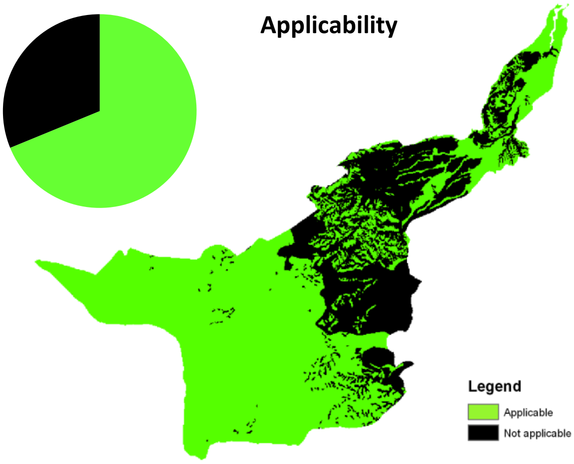
Technology Scenario:
Rangeland resting (TUN11)

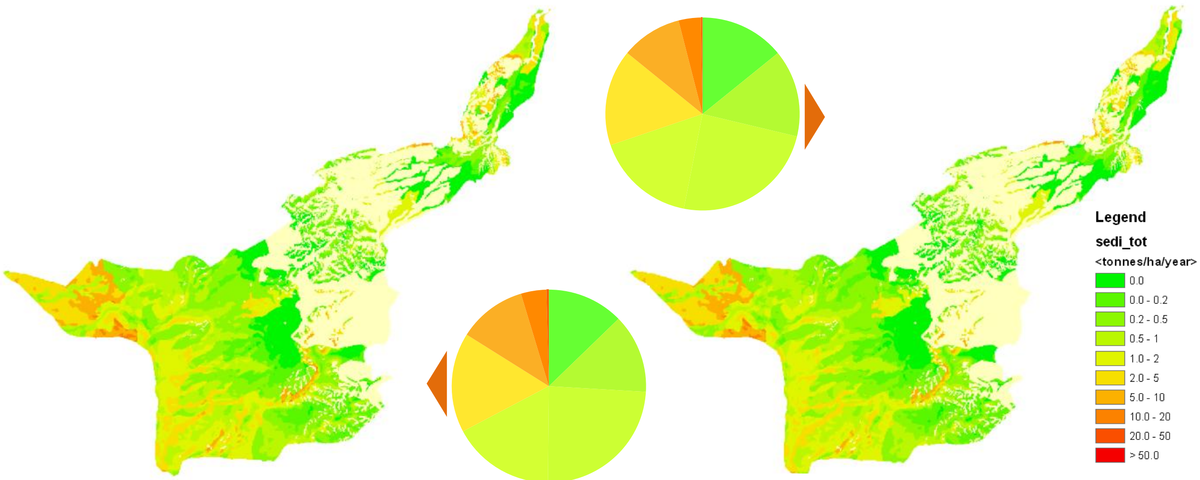
- Standard fencing cost is TND 72 (€36) ha^{-1}.
- In the without case 30% of biomass is grazed.
- Conversion rate of biomass to fodder units is 35% both with and without technology; the price per fodder unit is TND 0.20 (€0.10).
- The economic life of the technology is 4 years; benefits in the form of increased productivity occur in the 4th year only.
- If not rested rangeland provides fodder, the equivalent of which needs to be purchased if resting is applied.
- A discount rate of 10% is applied.

Applicability

- The technology is not applicable in very steep areas and is confined to rangeland areas.



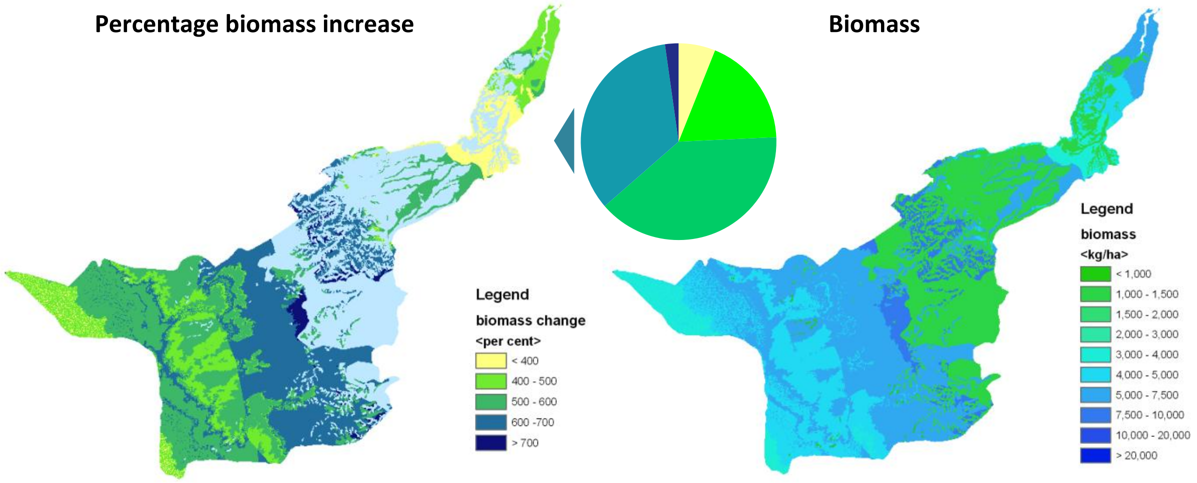
Biophysical impact: soil erosion



Without technology

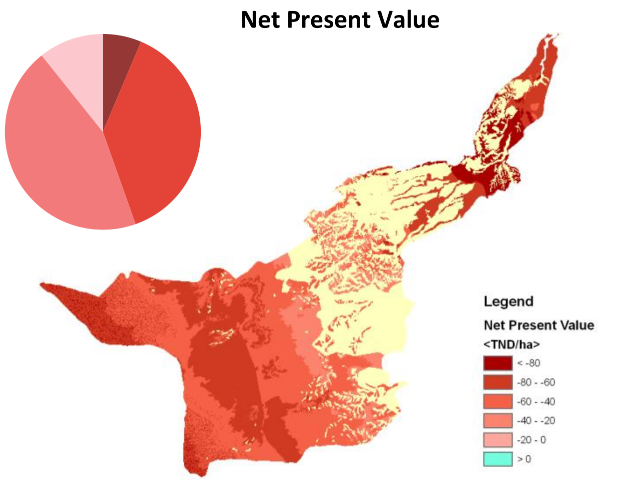
With technology

Biophysical impact: increase in biomass



Economic viability

Rangeland resting is not economically viable. The present analysis was performed with opportunity costs for fodder equal to the productivity of rangeland if used continuously (i.e. if animals were to be grazed on comparable areas); the analysis would turn even more negative if fodder would need to be purchased from the market. The Tunisian government has introduced a subsidy to purchase alternative livestock feed to stimulate the uptake of rangeland resting.



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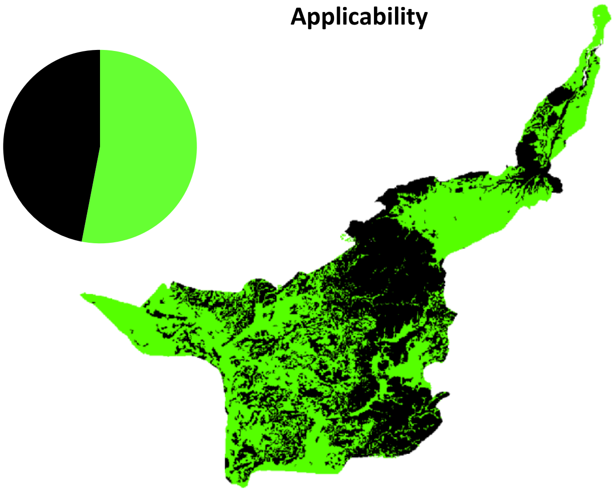
Technology Scenario:
Tabia (TUN12)

- Investment cost is fixed at TND 871 (€435).
- An economic life of 20 years has been set.
- Maintenance costs amount to TND 260 (€130), including agricultural management.
- A discount rate of 10% has been applied.
- A CCR of 1:6 has been assumed. Extensive grazing (without case) is not affected.
- Terrace is cropped to olive. Trees become productive after 6 y (25%); mature after 12 y.
- Olive harvest index (HI) is set at 0.1 and olive price at TND 0.55 (€0.27) per kg.
- Wheat intercropped until year 12. Max. yield is 930 kg/ha; price is TND 0.43 (€0.21) per kg.

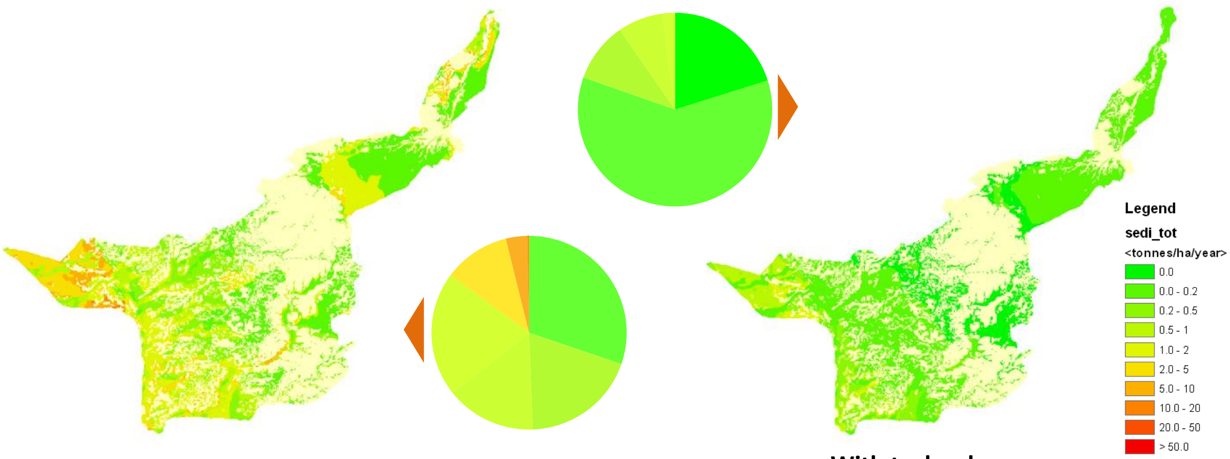
Applicability

- The technology is applicable in gentle sloping areas with deep soils

Applicability



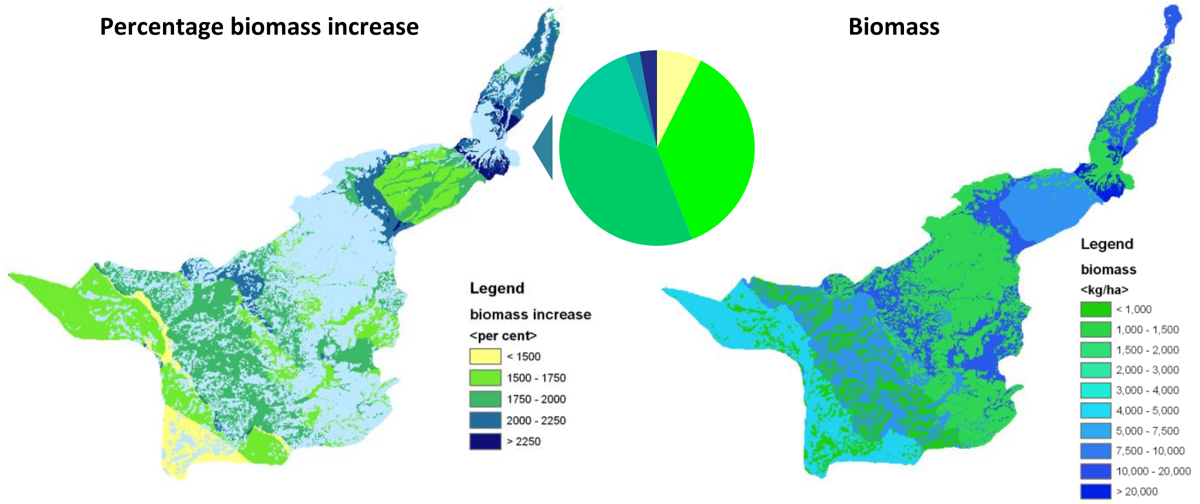
Biophysical impact: soil erosion



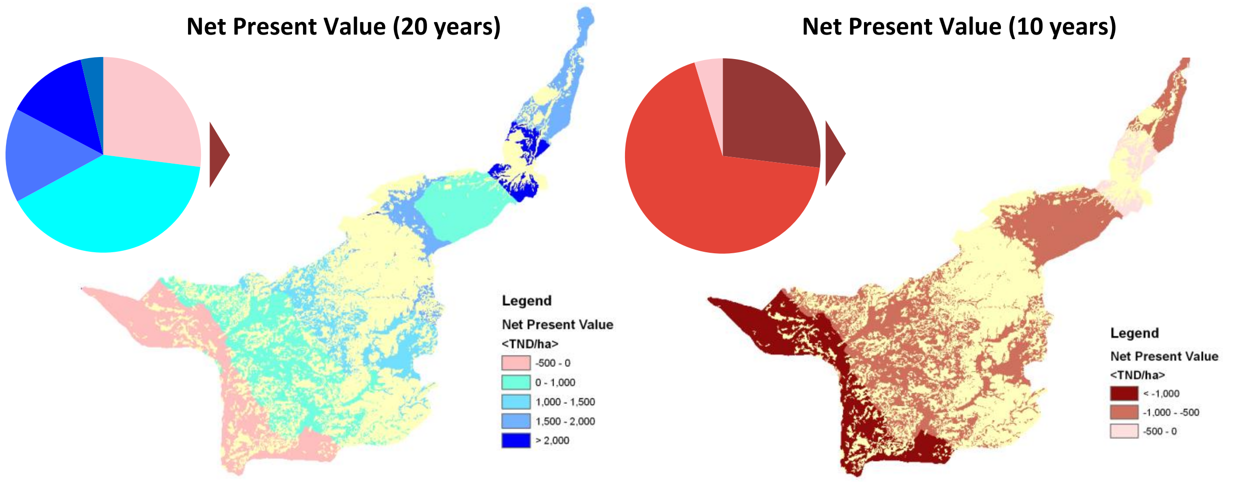
Without technology

With technology

Biophysical impact: increase in biomass



Economic viability



Although tabias are profitable in most of the applicability area, planting of new olive trees means that it takes 6 years before the first olives can be harvested, and 12 years before the trees reach full productivity. Therefore, land users have to wait a long time before the investment pays off, as demonstrated by the 10-year investment analysis, where all analyses point to a negative return. These analyses are based on average conditions, and years with insufficient runoff-producing rainfall events may see much lower olive harvests. Equilibrium biomass per hectare of terrace area may seem high; the olive harvest index has been set quite low to arrive at a yield of 100 kg per full-grown tree. Note that NPV is given per hectare of terraced land, so for total land productivity including the impluvium values should be divided by 6 (the CCR ratio).

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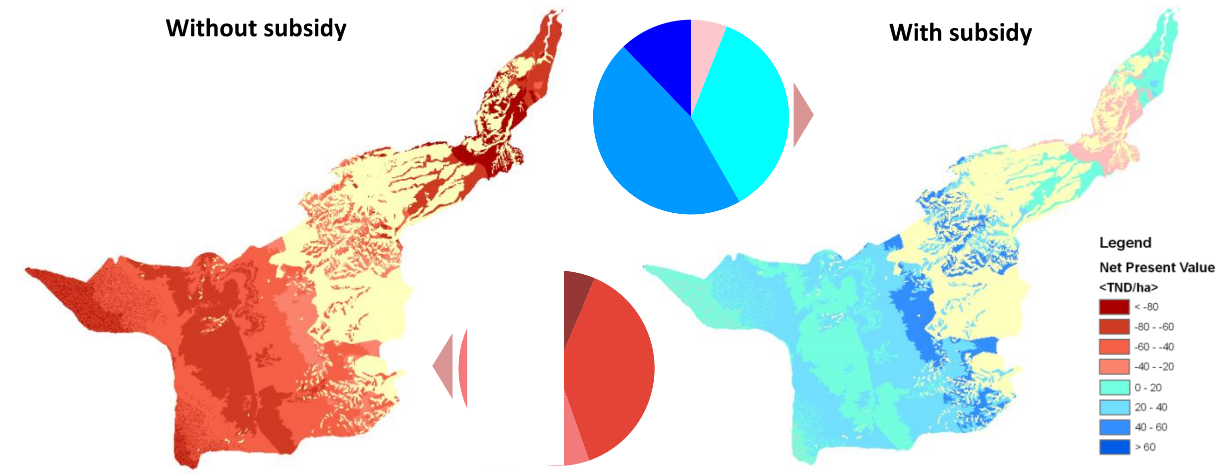
Policy Scenario:
Subsidising alternative feed purchases (TUN11)

Rangeland resting is difficult for farmers as it requires access to alternative feed, which is expensive if sourced from the market. The government has devised a subsidy to compensate land users for alternative feed requirements. The subsidy amounts to TND 30 (€15) per ha in the first year, and TND 70 (€35) spread over the next three years. The policy applies to designated areas and requires land users to rest rangeland for a minimum of four years.

Profitability:



Cost-Effectiveness indicators:

- Bridging of the period in which the rested rangeland is closed for grazing with subsidies for alternative feed purchases makes the technology profitable in 94% of the applicable area.
- This will result in an average reduction of erosion of 0.1 ton/ha/year.
- In total, an annual reduction of 8,225 tonnes of eroded soil can be expected.
- The subsidy for the area where the technology would become profitable amounts to TND 7.9 million (€3.96 million).
- Hence a cost-effectiveness of TND 964 per ton (€482) of soil conserved.

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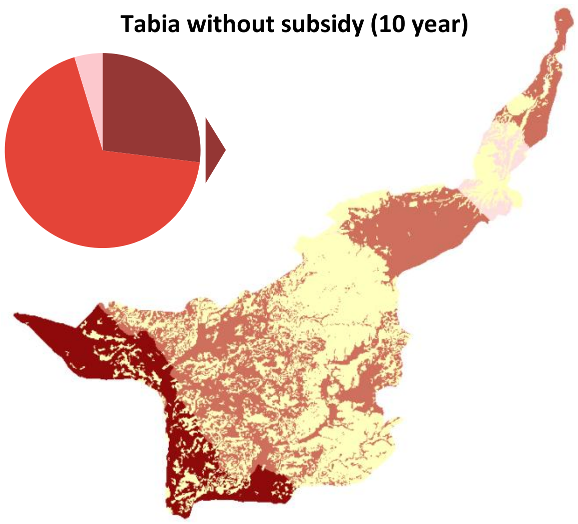
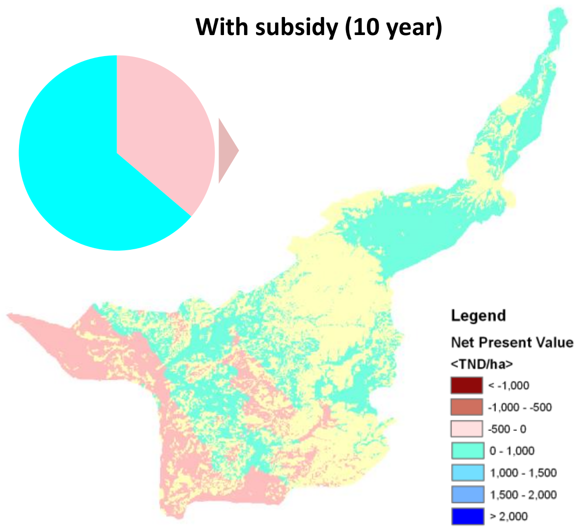
Policy Scenario:
Subsidising the construction of jessour and tabias (TUN09 & 12)

At a time horizon of 10 years, jessour and tabias are 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.

50%

Profitability:





Cost-effectiveness indicators:

- A reduction in investment costs of 50% makes tabias (TUN12) profitable in 64% of the applicable area, based on the net present value after 10 years; jessour (TUN09) however are too costly in construction and maintenance, and an investment subsidy does not make any difference.
- On the area where NPV becomes profitable, an average reduction of erosion of 0.69 ton/ha/year is obtained.
- In total, an annual reduction of 4742 tonnes of eroded soil can be expected*.
- The subsidy for the area where tabias would become profitable amounts to TND 3.0 million (€1.5 million)*.
- Hence a cost-effectiveness of TND 632 per ton (€316) of soil conserved.

*Note: these figures reflect the fact that the technology can in fact only be implemented on 1/6th of the applicable area due to the need to take into account a catchment to cropped area ratio.

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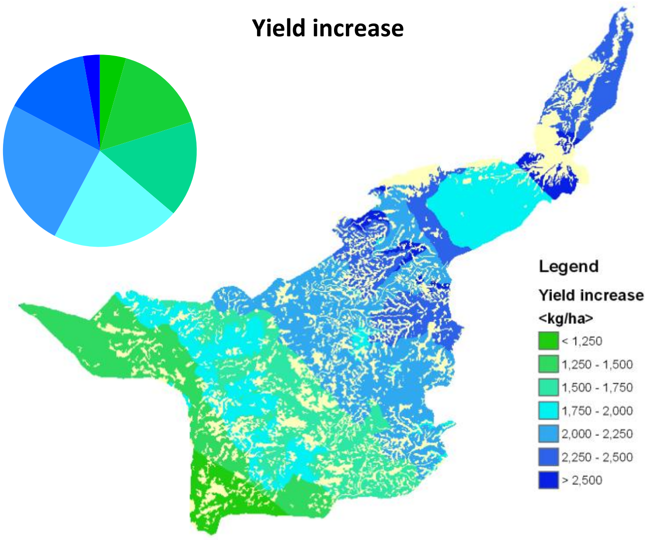
Global Scenario:
Food production

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.

+1863 kg/ha*

+187 kg/inhabitant**

Scope for increased production



Biophysical impact: biomass increase

- Yield increase in 100 % of applicable area
- Average absolute yield increase: 1,863 kg/ha
- Average yield increase: na

Economic indicators

Average costs:
- Investment cost: €888/ha
- Unitary cost year 12: €477/ton***
- Unitary cost lifetime: €40/ton

Aggregate indicators**:
- Study site: €13.5 million
- Augmented annual production: 28,260 ton
- Augmented total production: 339,111 ton

*Note: this yield increase is for fresh weight olives
**Note: the per hectare increase is only feasible on 1/6th of the applicable area due to the catchment to cropped area ratio (CCR) of jessour and tabias. These values reflect this reduction.
***Note: year 12 is the first year when full production is reached

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Global Scenario:
Minimizing land degradation

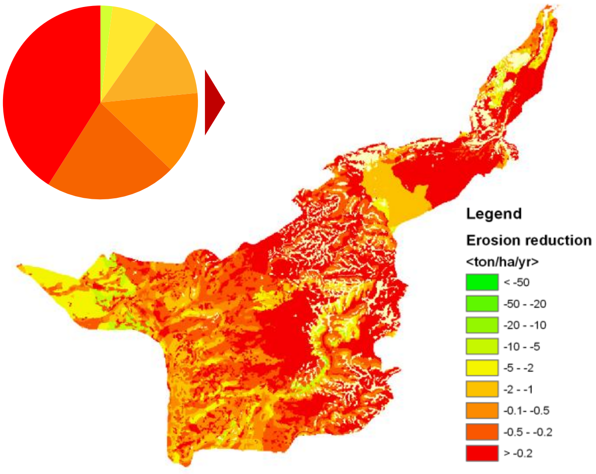
The minimizing land degradation scenario selects the technology with the highest mitigating effect on land degradation or none if the baseline situation demonstrates the lowest rate of land degradation. The implementation costs for the total study area are calculated and cost-productivity relations assessed.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

-0.77 ton soil/ha

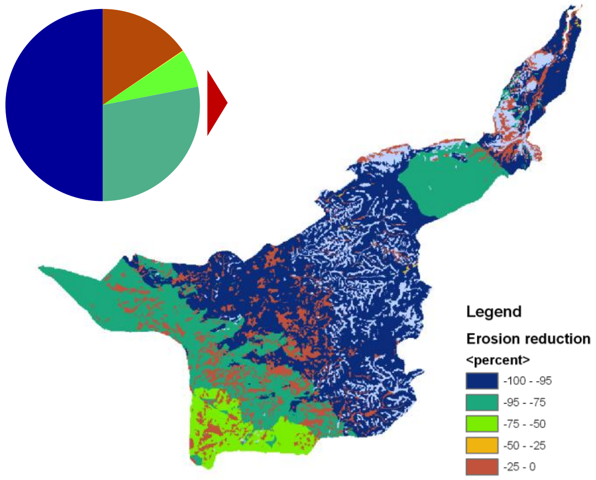
€1087/ton soil

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: 0.77 tonnes/ha/yr
- Average percent erosion reduction: 80 %

Economic indicators

Average costs:
- Investment cost: €837/ha
- Unitary cost year 1: €1087/ton soil
- Unitary cost lifetime: €57/ton soil

Aggregate indicators*:
- Study site: €8.63 million
- Aggregate annual erosion reduction: 18,200 ton
- Total erosion reduction: 365,000 ton

*Note: for jessour and tabias only 1/6th of the applicable area is counted to account for the catchment to cropped area ratio (CCR) involved in these technologies.

Zeus-Koutine, Tunisia

Concluding remarks

- Baseline simulations show that the Zeus-Koutine area has mostly low soil erosion rates, with rates over 2 ton/ha/yr confined to about 20% of the territory.
- Jessour, tabia, supplemental irrigation, rangeland resting and groundwater recharge structures were prioritised by scientists and local stakeholders to mitigite soil erosion, water scarcity and vegetation degradation. Available data allowed to simulate the effects of jessour (TUN09), rangeland resting (TUN11) and tabias (TUN12). The technology scenarios show that jessour, and to lesser extent tabias are effective in reducing erosion rates. The effect of rangeland resting is not very pronounced, possibly because the aridity of the area means vegetative soil cover remains limited even if not grazed. Jessour and tabia can by concentrating runoff at a ratio of catchment to cropped area of 6 : 1 greatly enhance biomass production. The time scale over which this occurs is not specifically addressed in research, but as olive trees are planted it takes several years for trees to accumulate the important increase in biomass. Experimental results were hampered by droughts and short monitoring period. Due to high initial cost the tested technologies are only in the long term (> 10 years, or even >20) profitable. Tabias perform best and are simulated to be profitable in over 75% of the applicable area over a 20-year planning horizon. Jessour are too expensive to newly develop cost-effectively, but maintaining existing ones is economically feasible in about a third of the area.
- In the workshop to evaluate monitoring and modelling results, stakeholders downgraded all tested technologies, either because they were initially assessed too positively or because of inconclusive experimental results. A greater coping ability with the harsh environment and adverse climatic conditions was considered essential by participants, who now choose for groundwater recharge structures, supplemental irrigation and medicinal herbs and aromatic plants as preferred technologies. Recommendations for upscaling included the streamlining of various research and development activities, integration of local and scientific knowledge and the need to look at land management integrally with diversification of livelihood opportunities.
- A policy scenario of the existing government policy to subsidize supplementary feed for animals showed high effectiveness in augmenting the profitability of rangeland resting in 94% of the applicable area. Such a subsidy would however reduce soil erosion only by on average 0.1 ton/ha/yr, at a cost of TND 964 per ton (€482) of soil conserved. For jessour and tabias, a policy scenario reducing the investment cost by 50% was run. While for jessour, the investment and maintenance cost were so high that the policy is not effective, such a policy enables tabias to become profitable after 10 years in 64% of the applicable area.
- The global scenarios show that the technologies can achieve very significant yield increases and erosion reductions in the entire applicability area. The investment costs to achieve this are low at €40/ton olives and €57/ton soil conserved. Per area unit, investment costs are nevertheless substantial at over €800/ha.
- Jessour and tabias are in first instance water harvesting technologies to allow making productive use of land in an area otherwise too arid for any form of agriculture except extensive grazing. Rangeland resting may restore vegetation but requires a bridging period of four years during which feed must be purchased from markets. All these measures remain critically linked to rainfall, as the performance during field experimentation clearly indicated.