Secano Interior, Chile

Study site details

The 'Secano interior' (interior dryland) is a sub humid Mediterranean climate region of Chile **extending from the V to the VIII Administrative Regions.**

- **Coordinates:**
  Latitude: 35°57' S
  Longitude: 72°23' W
- **Size:** 9097km² (1699km^2 simulation zone)
- **Altitude:** 92 – 728 m (simulation zone)
- **Precipitation:** 250 – 1200 mm
- **Temperature:** 5° – 29°C
- **Land use:** cereals, forest plantations, grass and shrubland
- **Inhabitants:** ca. 300,000 farmers
- **Main degradation processes:** water erosion
- **Major drivers of degradation:** inappropriate land management, soil mining, destruction of natural woodland vegetation

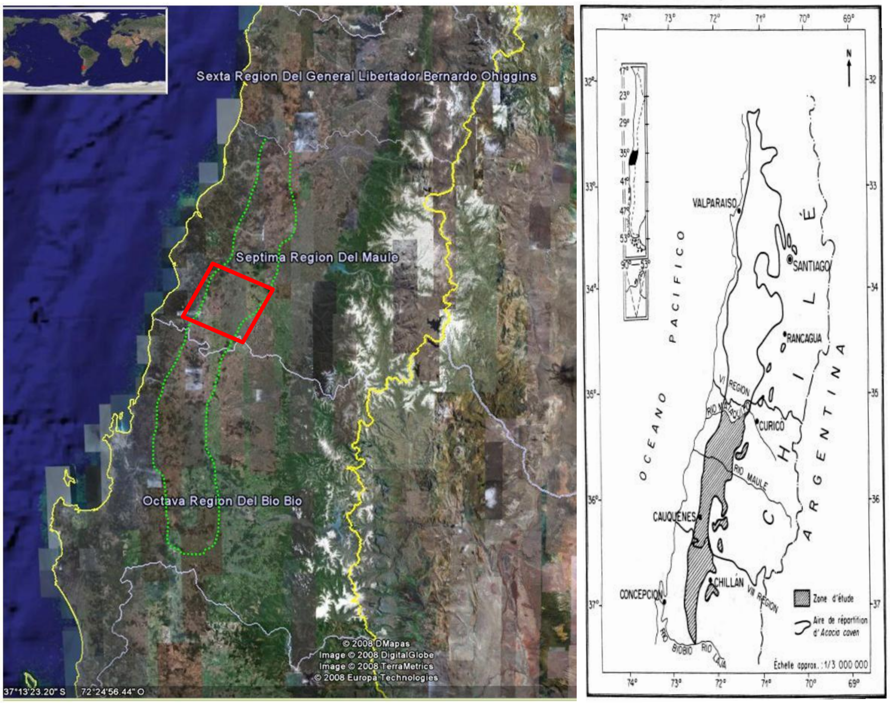

Figure 1: Study site location (green: interior dryland area, red: simulation zone).

Overview of scenarios

1. Baseline Scenario: PESERA baseline run
2. Technology Scenario: No tillage with sub-soiling (CHL01)
3. Policy Scenario: Subsidising no tillage with sub-soiling (CHL01)
4. Global Scenario: Food production
5. Global Scenario: Minimizing land degradation

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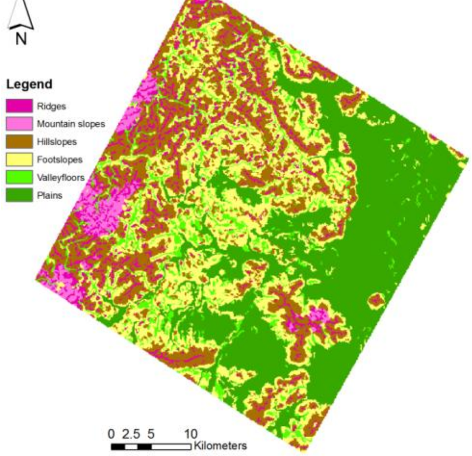
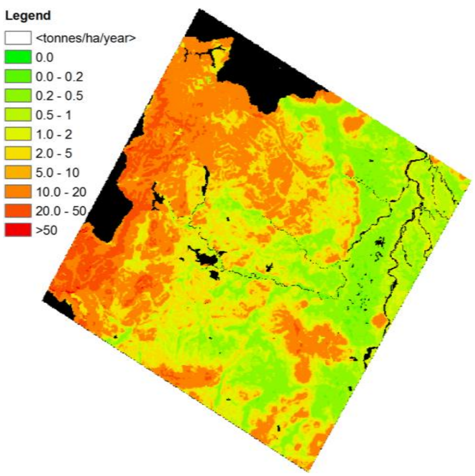
Baseline Scenario
PESERA baseline run

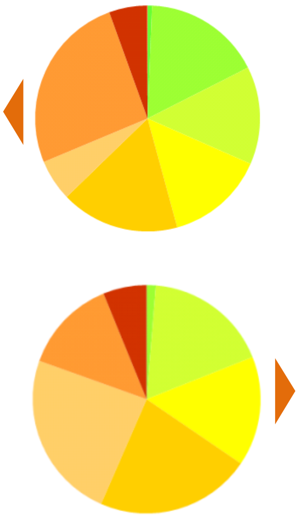
Two baseline scenarios were run: one is the basic PESERA run while the other takes into account the soil compaction reported by the study site. From the erosion maps it is clear that under compacted conditions (of which the spatial extent is unknown), soil erosion increases relative to the baseline. Highest erosion rates are reported for the steeper western and southern areas of the study area. The biomass production in the baseline run follows the land use distribution, with lowest values for cropland and highest for forest. Forest on mountain slopes has clearly lower biomass production. Under soil compaction, slope becomes a dominant factor.

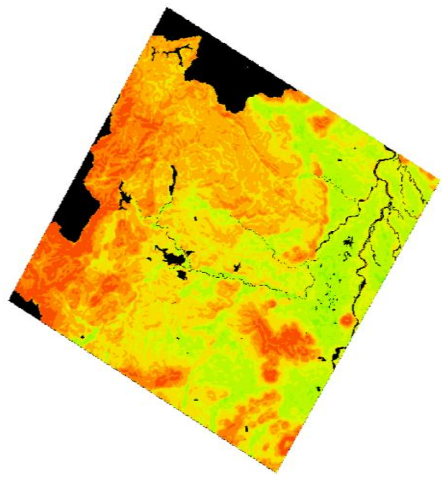
Landforms



Soil erosion



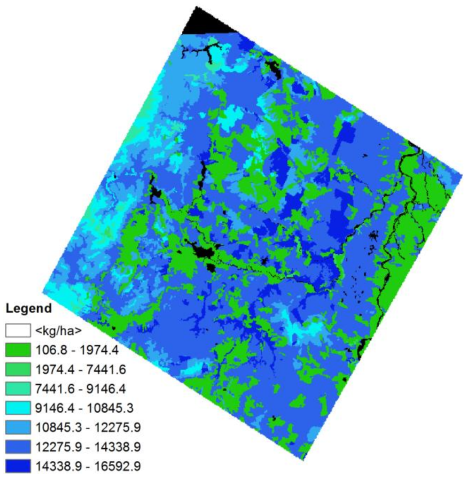


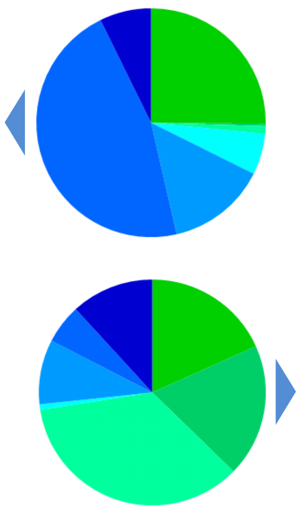


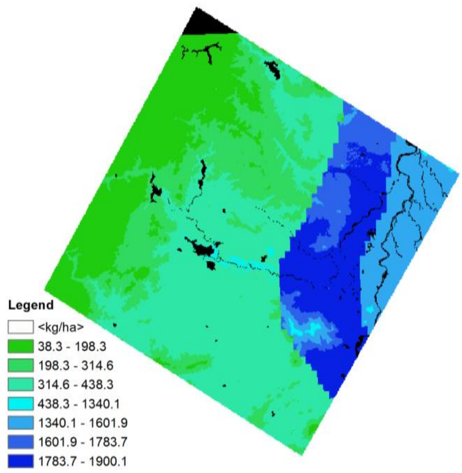
A. PESERA basic run

B. Under soil compaction

Biomass production







A. PESERA basic run

B. Under soil compaction

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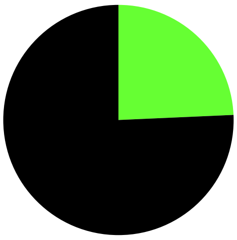
Technology Scenario:
No tillage with sub-soiling (CHL01)

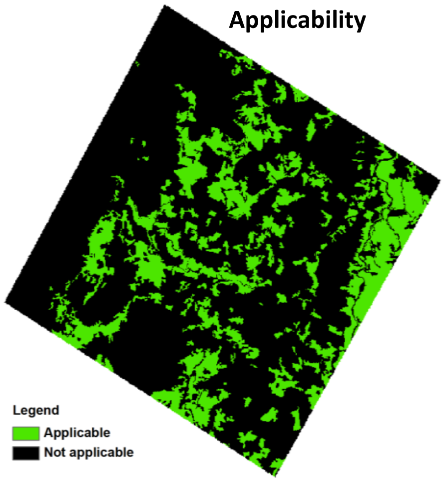
- Total operation costs under different practices:
  - traditional tillage 483,478 CLP/ha (€455)
  - traditional mechanized 222,548 CLP/ha (€210)
  - no tillage with sub-soiling 306,979 CLP/ha (€289)
- The above operation costs include renting of equipment to implement each practice
- A harvest index for grains of 45% of total biomass was assumed
- The price of grains is 110 CLP/kg (€0.10)

Applicability

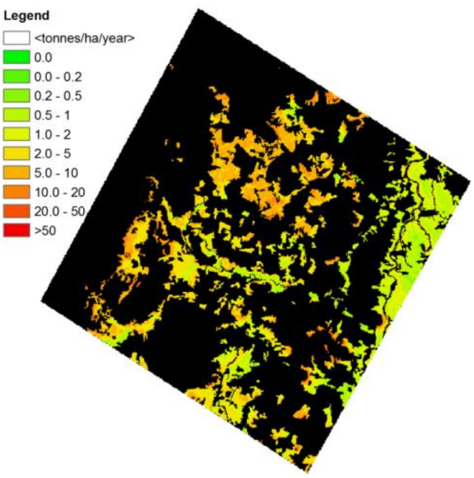
- The technology is applicable on arable land with slopes below 20%, cultivated to cereal crops



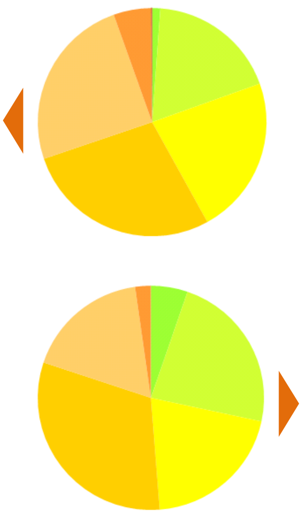
Applicability

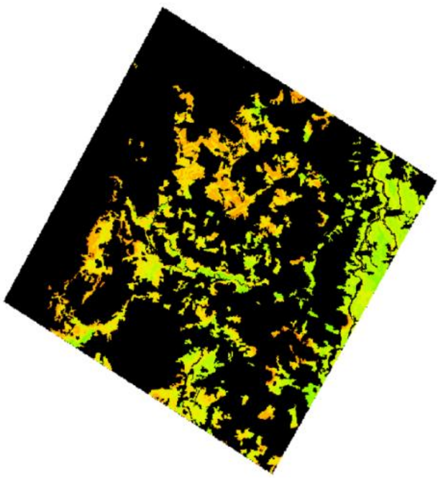


Biophysical impact: soil erosion



Without technology



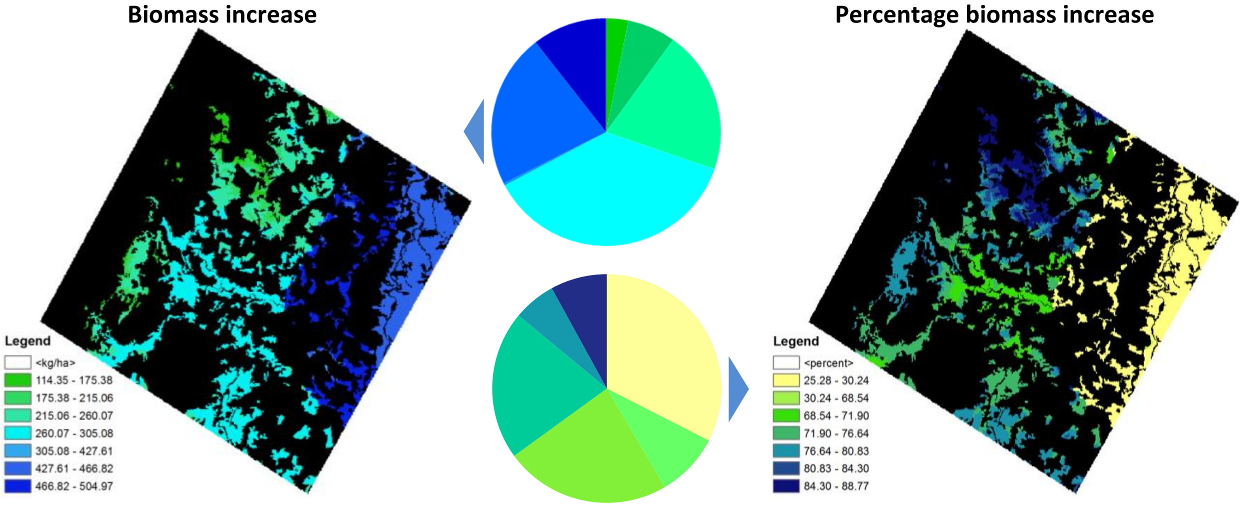


With technology

Biophysical impact: increase in biomass

Biomass increase

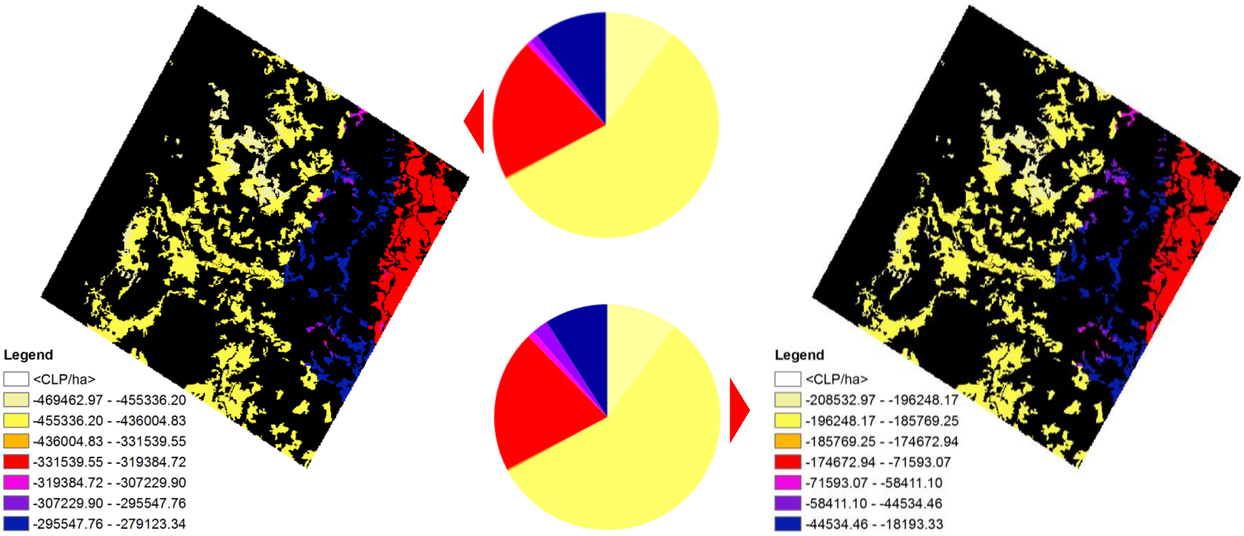
Percentage biomass increase



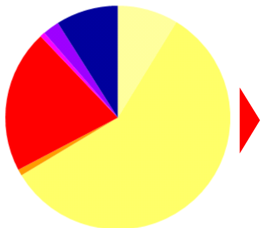
Economic viability

Net profit under traditional tillage system

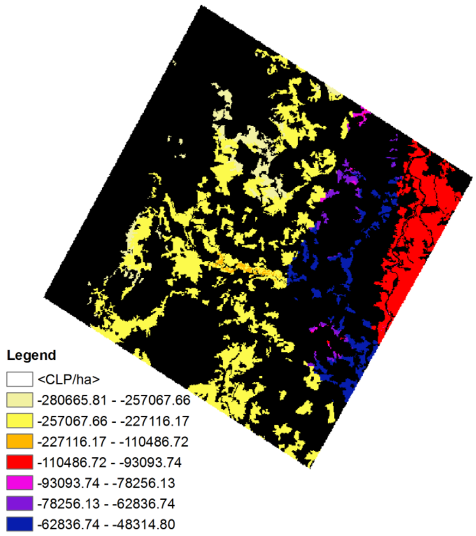
Net profit under mechanized tillage system



Although the technology leads to increased biomass production, the operational costs are too high in relation to the benefits. Experimental results come to the same conclusion regarding traditional and conventional mechanized tillage systems. However, in experiments no-till did show a positive return. The highest yield according to the PESERA model is 3956 kg/ha, and not 4500 as was obtained in experiments. The negative return for the two conventional systems can also have to do with labour opportunity costs being valued higher than farmers who practice these systems do apparently accept. As capital input in the no-till system is higher, it seems unlikely that the technology will spontaneously be widely adopted.



Net profit under no tillage with sub-soiling



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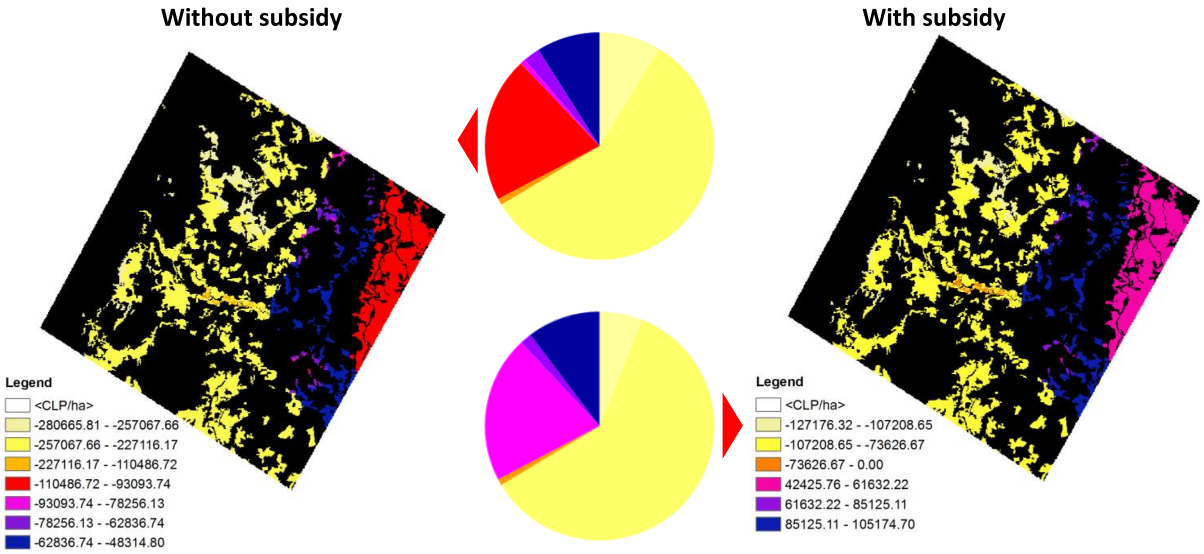
Policy Scenario:
Subsidising no tillage with sub-soiling (CHL01)

Due to low productivity in many parts of the study area and the relatively high cost of implementing no tillage with sub-soiling, 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 operational costs on profitability of the technology and the potential for mitigating land degradation are explored.

50%

Profitability:



Cost-effectiveness indicators:

- By introducing 50% subsidy towards the total operation cost of implementing no tillage with sub-soiling, the technology becomes economically attractive in 33% of the applicable area.
- This will result in an average reduction of erosion of 0.44 ton/ha/year.
- In total, an annual reduction of 5902 tonnes of eroded soil can be expected.
- The total amount of subsidy would be 3.3 billion CLP (€3.1 million) (excluding transaction costs).
- Hence a cost-effectiveness of 558,000 CLP/ton (€525) of soil conserved.

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Global Scenario:
Food production

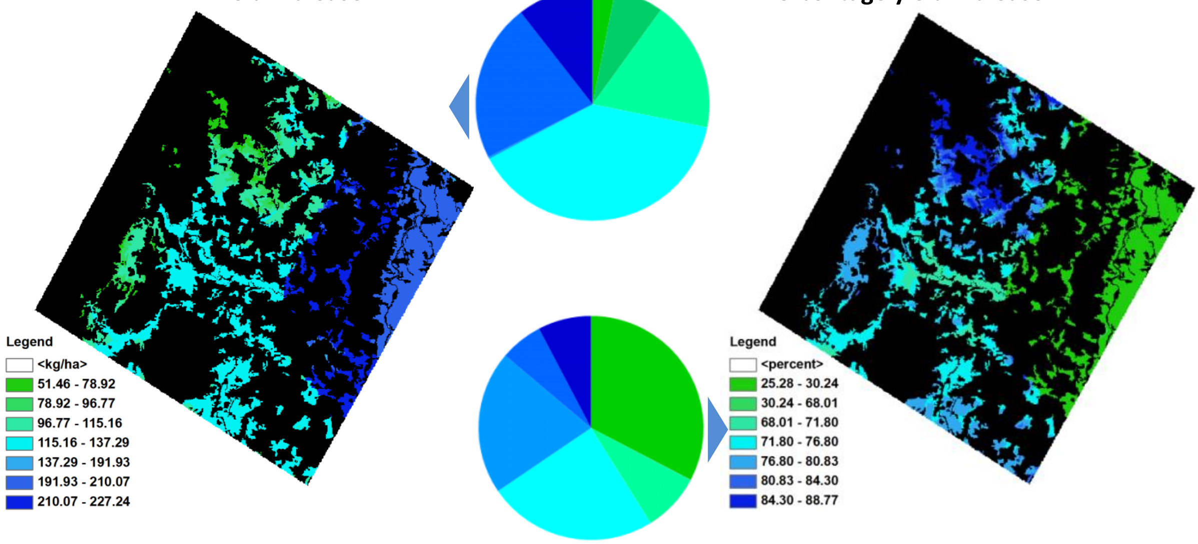
The food production scenario selects the technology with the highest agricultural productivity (biomass) for each cell where a higher productivity than in the baseline scenario is achieved. The implementation costs for the total study area are calculated and cost-productivity relations assessed. To facilitate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

+145 kg/ha

+20 kg/inhabitant*

Scope for increased production

Yield increase **Percentage yield increase**



Biophysical impact: yield increase

- Yield increase in 100 % of applicable area
- Average absolute yield increase: 145 kg/ha
- Average yield increase: 61 %

Economic indicators

Average costs:
- Extra operational cost: €125/ha/yr
- Unitary cost: €862/ton

Aggregate indicators*:
- Study site: €5.2 million
- Augmented annual production: 5990 ton

* Note: aggregate indicators are calculated for the entire hotspot area assuming similar average yield increases as for the simulation zone. The total number of inhabitants is not reported; the per capita statistic is based on ca. 300,000 farmers.

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Global Scenario:
Minimizing land degradation

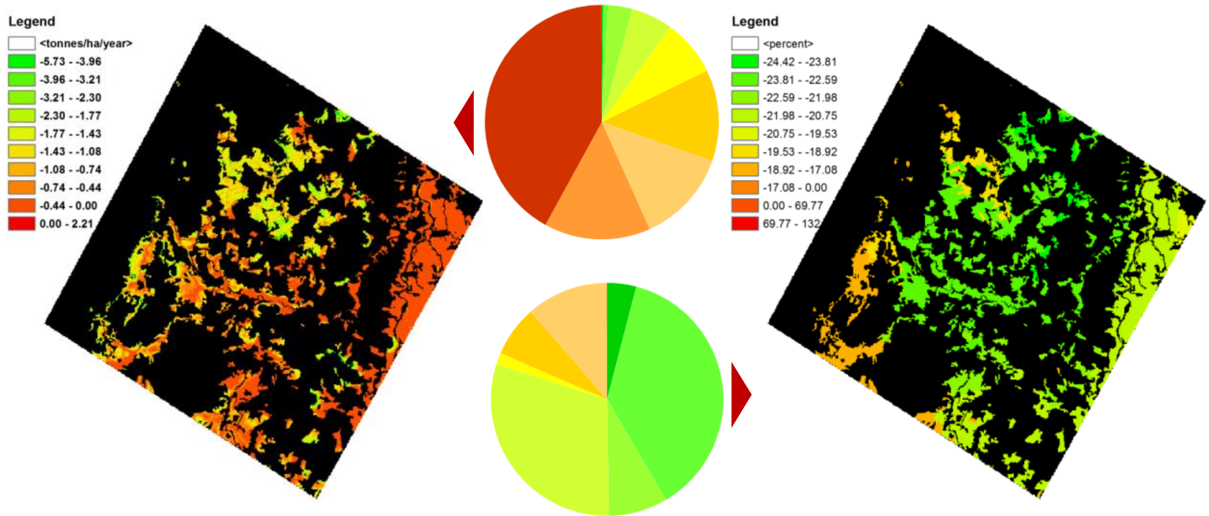
The minimizing land degradation scenario selects the technology with the highest mitigating effect on land degradation or none if the baseline situation demonstrates the lowest rate of land degradation. The implementation costs for the total study area are calculated and cost-productivity relations assessed.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

-0.84 ton soil/ha

€148/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 99.97 % of applicable area
- Average absolute erosion reduction: 0.84 tonnes/ha/yr
- Average percent erosion reduction: 22 %

Economic indicators

Average costs:
- Extra operational cost: €125/ha/yr
- Unitary cost: €148/ton soil

Aggregate indicators*:
- Study site: €5.2 million
- Aggregate annual erosion reduction: 33,600 ton

* Note: aggregate indicators are calculated for the entire hotspot area assuming similar erosion reduction as for the simulation zone.

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Concluding remarks

- **Baseline simulations show a rather severe soil erosion problem in the Secano Interior, with PESERA model output suggesting that one third of the area has erosion rates over 10 ton/ha/yr.**
- **No tillage with subsoiling (CHL01) was selected by scientists and local stakeholders as the first-ranked of three technologies to counter soil loss by water erosion. The technology scenario shows that erosion rates can be reduced by the technology. No-till leads to considerable increase in biomass production, between 25 and 90%. Despite of this, application of the technology is not profitable. Although the conventional systems assessed also showed net losses, the no-till technology is the most capital intensive. Acceptance of lower return to labour may explain why these systems are nevertheless applied.**
- **Evaluating the results in a workshop, stakeholders did consider the technology to be highly profitable, perhaps as field experiments demonstrated higher yield than modelled by PESERA. They saw access to the machinery and loss of local employment as negative effects, and identified adequate and timely subsidies and pooling of machinery as main issues to enable widespread adoption. The technology maintained its preferred rank among mitigation strategies.**
- **A policy scenario reducing costs by 50% made the technology profitable in 33% of the applicable area. Such a subsidy would reduce soil erosion by on average 0.44 ton/ha/yr, at a cost of** 558,000 CLP/ton (€525)**. The competitiveness of no-till relative to conventional systems would greatly improve, so that any underestimated profitabilities could play out to additional potential uptake.**
- The global scenarios show that the technology can achieve yield increases and erosion reductions across virtually its entire applicability area. The extra operational cost of €125/ha/yr, i.e. the difference between the use of the no-till technology and conventional (mechanised) tillage, lead to an average yield increase of 145 kg/ha/yr and erosion reduction of 0.84 ton/ha/yr, at a cost of €862 and €148/ton food product and soil respectively.
- No-till leads to higher yields because of better soil water availability. As such, there are little risks involved in applying the technology, and it might be a sensible strategy with regards to adapting to climate change.