Rambla de Torrealvilla, Guadalentín basin, Spain

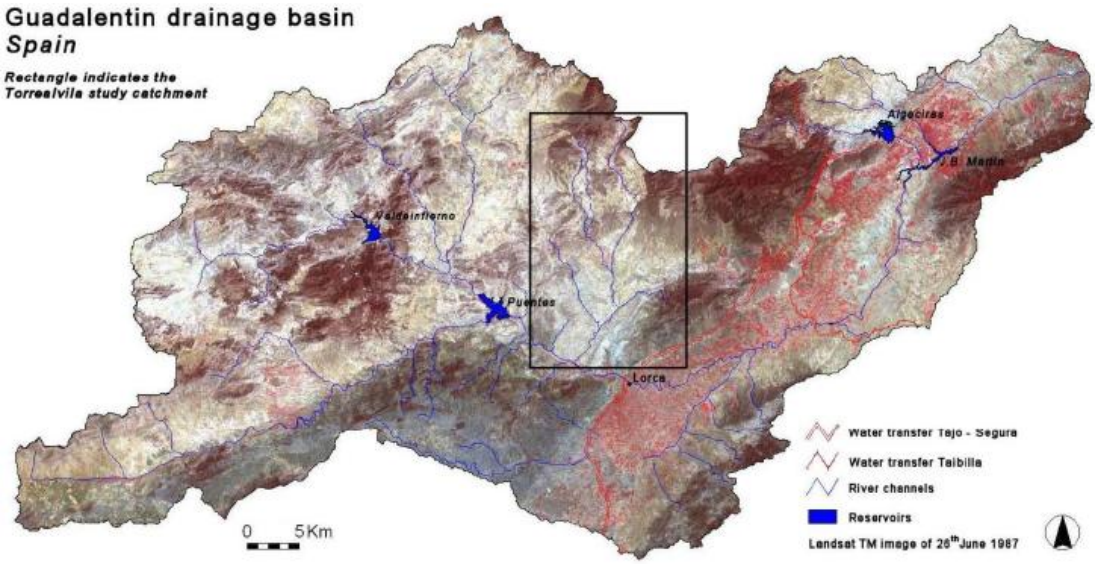
Highlights of work carried out in the DESIRE Project
Based on work at EEZA-CSIC, Spain

The study site

- **Coordinates:**
  Latitude: 37°47'8"N
  Longitude: 1°41'55"W
- **Size:** 266 km^2
- **Altitude:** 378 – 1499 mm
- **Precipitation:** 300 – 500 mm
- **Temperature:** 12°C - 17°C
- **Land use:** rainfed agriculture (cereals, almonds, olive), irrigated agriculture (horticulture, fruit trees, grapes), livestock.
- **Inhabitants:** na
- **Main degradation processes:** water erosion, soil salinization
- **Major drivers of degradation:** agriculture, water availability, human population, tourism, transport, climate, and land use subsidies.

Location map

Location of the Torrealvilla catchment



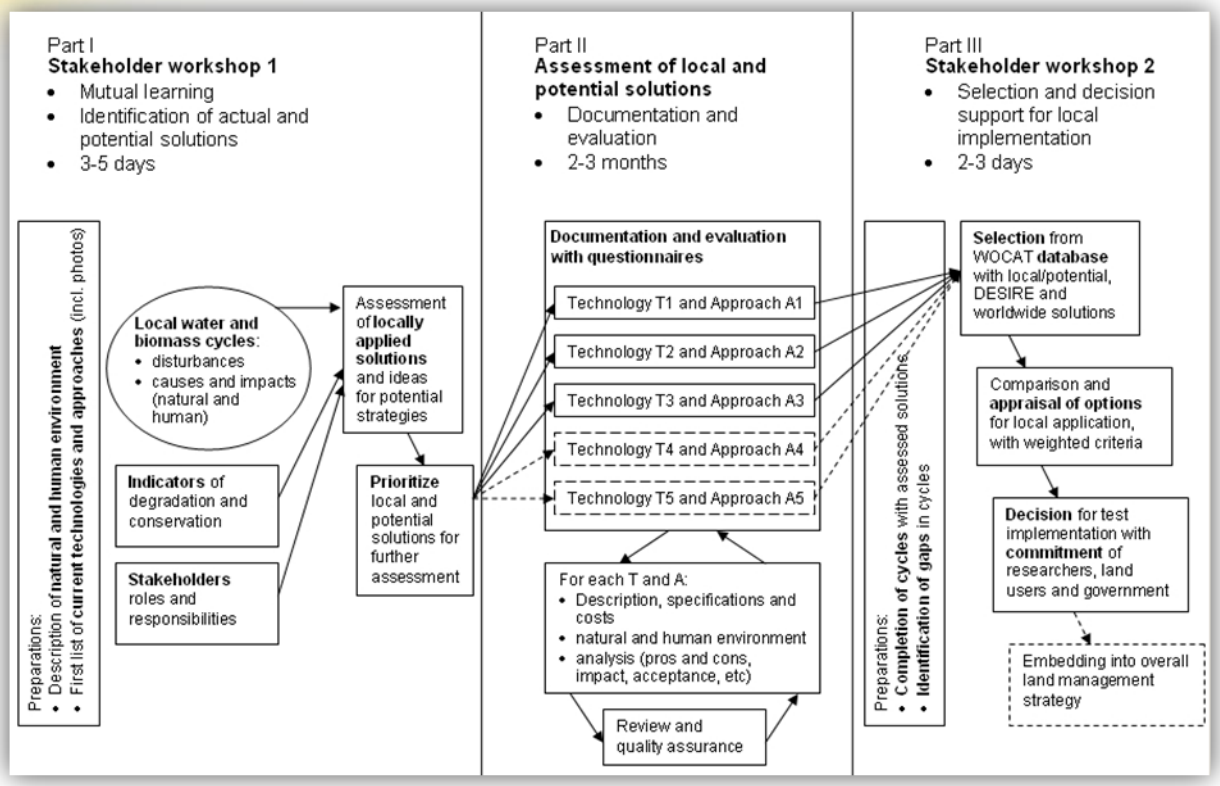
The 'Rambla de Torrealvilla' is a catchment within the Guadalentin basin in south-eastern Spain near the city of Lorca. The study site suffers from severe land degradation problems caused by diverse processes such as soil erosion by water and tillage, salinization, overexploitation and contamination of aquifers, and forest fires. These processes are favoured by a combination of the Mediterranean climate, characterised by dry summers followed by intense autumn rainfall, an often steep topography with fragile soils on highly erodible lithologies. In addition, initiated by political and socioeconomic changes, important land use changes have taken place over the last couple of centuries, which have formed an important driver for further land degradation.

Land degradation processes in the Guadalentín have a range of local and regional impacts on crop productivity, reduced soil organic carbon content, loss of soil structure, water shortage and sedimentation of reservoirs. The main objective of Sustainable Land Management (SLM) measures in the Guadalentín as identified by DESIRE researchers and stakeholders is therefore to reduce soil and water loss and increase soil fertility.

Almond field with green manure in the central part of the Guadalentín basin, SE Spain (May 2007) © J. de Vente

Example of degraded land in the Guadalentín (photo: J. de Vente)

WOCAT workshops for choosing sustainable land management technologies



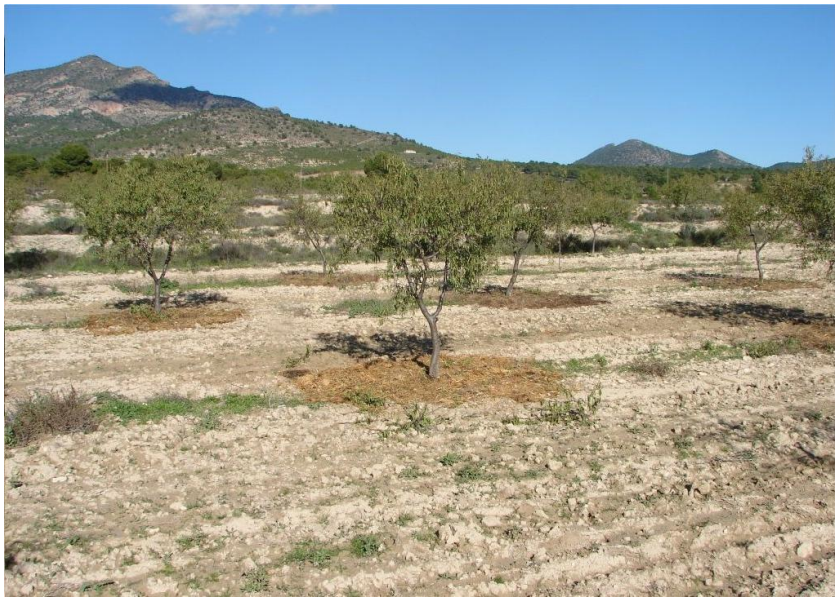
Researchers talked with local people and policy makers, and together they decided on the best options for sustainable land use. In the DESIRE Project the three Parts to WOCAT methodology were developed as outlined above. This provides decision support for choosing technologies suited to the local environment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

The first two DESIRE workshops with local stakeholders were held in 2008, and five SLM measures were selected to be implemented and tested in the field of the Alhagüeces farm. Strategies were selected by participants because they were thought to be easy to implement, economically feasible and effective towards protection of soil and water resources. These strategies were:

- ***Green manure in an ecological almond orchard***: In this technology, green manure, a mixture of barley and vetch (*Vicia sativa*) was seeded under almond trees in autumn and ploughed into the soil in spring. The green manure provides a continuous vegetation cover throughout the winter protecting the soil from soil erosion. The vetch is a nitrogen fixating species and has a fertilizer effect on the soil.
- ***Reduced tillage of an almond orchard***: In this technology, an almond orchard is ploughed only twice a year (spring and autumn) instead of the 3-5 times that are common in the region.
- ***Traditional water harvesting (boquera)***: This SLM measure aims to increase the available water for crops by diverting water during rainfall events from a nearby ephemeral stream (rambla) towards nearly flat terraces.
- ***Straw mulch under almonds***: In this measure a straw mulch cover under almond canopy is applied to reduce evaporation losses from the soil.
- ***Reduced tillage of a cereal field***: Here, a cereal field was ploughed maximum of 3 times in 2 years with a chisel plough. This is much less than under traditional tillage where fields are ploughed five times in two years of which once with a mouldboard plough.

Trials of technologies (I) Straw mulch under almonds



Field trials were carried out to provide information on the possibilities of a more efficient use of water by applying straw mulch under the canopy of almond trees to reduce evaporation losses from the soil. The experimental field is located in the upper part of the Rambla de Torrealvilla in the 'Los Alagüeces' farm, Murcia, Spain.

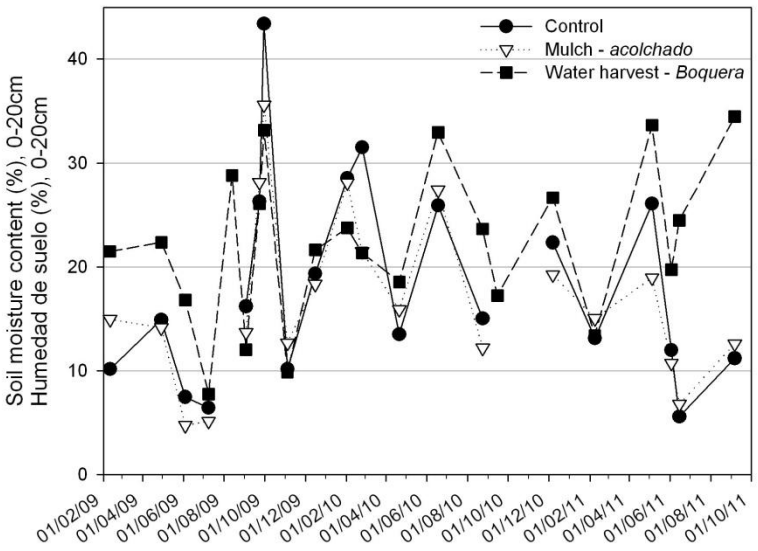
The performance of the straw mulch was compared with a nearby almond field where no mulch was applied and which was ploughed 3-5 times per year. The field with straw mulch was ploughed only twice a year. In both fields soil water content was registered hourly at 35 cm depth, and about monthly for the first 20 cm with FDR equipment. Besides, almond harvest was determined separately for both fields. The experiment started in 2009 and continued until 2011.

Results

•In the mulch treatment soil moisture content was similar or sometimes slightly lower than under

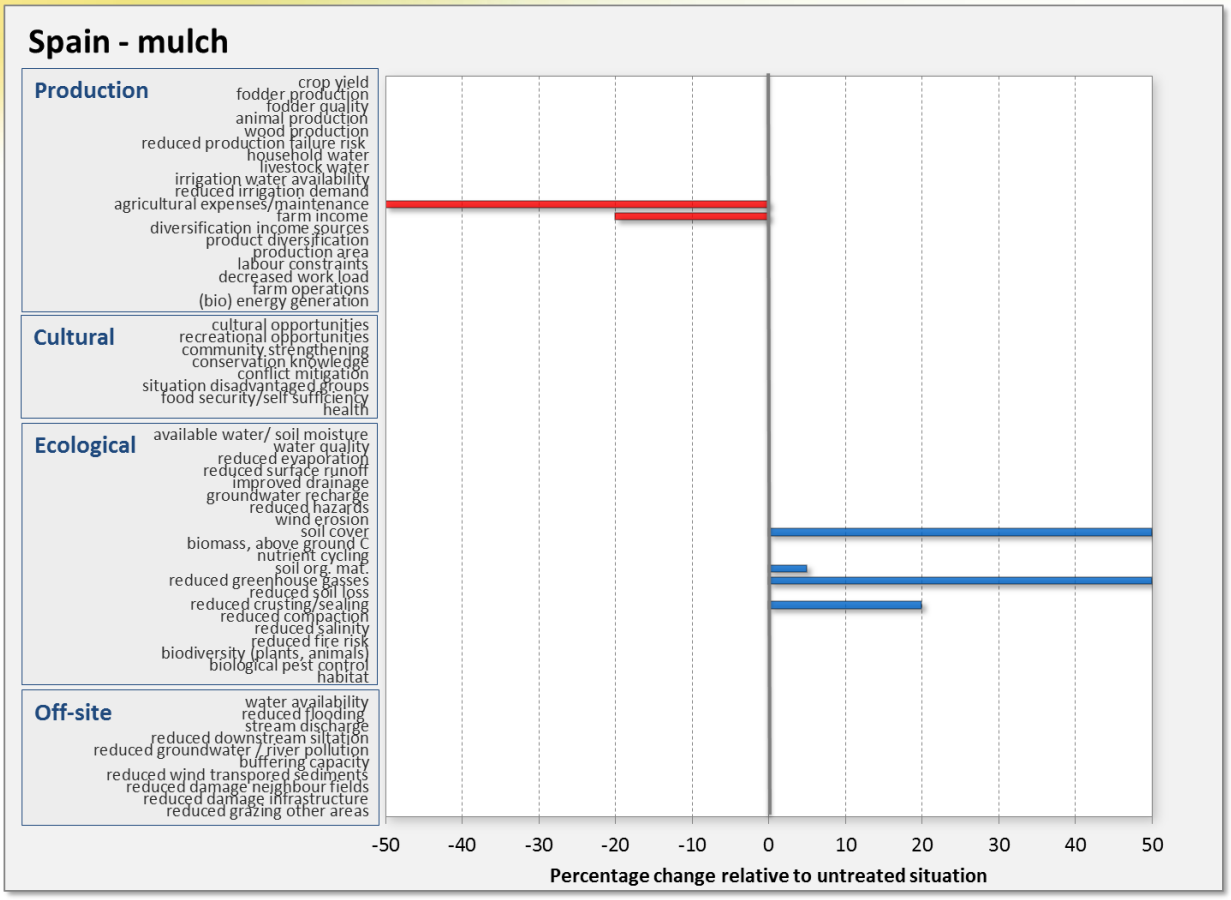
control conditions in the upper 20 cm. At greater depth soil moisture content under mulch was almost always lower than under control conditions.

- The result also shows that the mulch treatment does not have an effect on the almond harvest.



Soil moisture content for the upper 20cm of soil under mulch and control conditions.

The results are evaluated from a production, socio-cultural and economic point of view. This evaluation is based on the WOCAT system by making use of the questionnaire designed to evaluate conservation technologies (www.wpcat.net). The bars express the estimated or measured percentage of change with respect to the reference situation (untreated plots). 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.



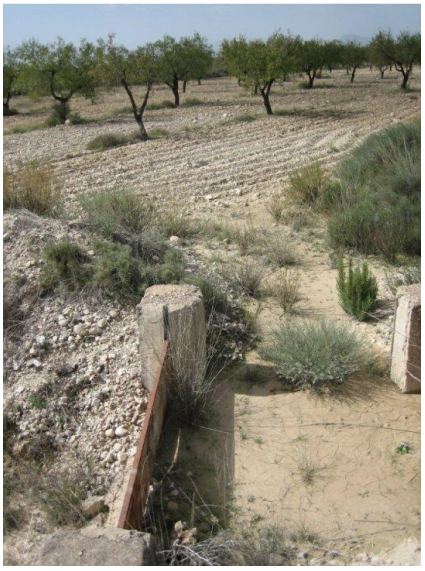
Farmer opinions

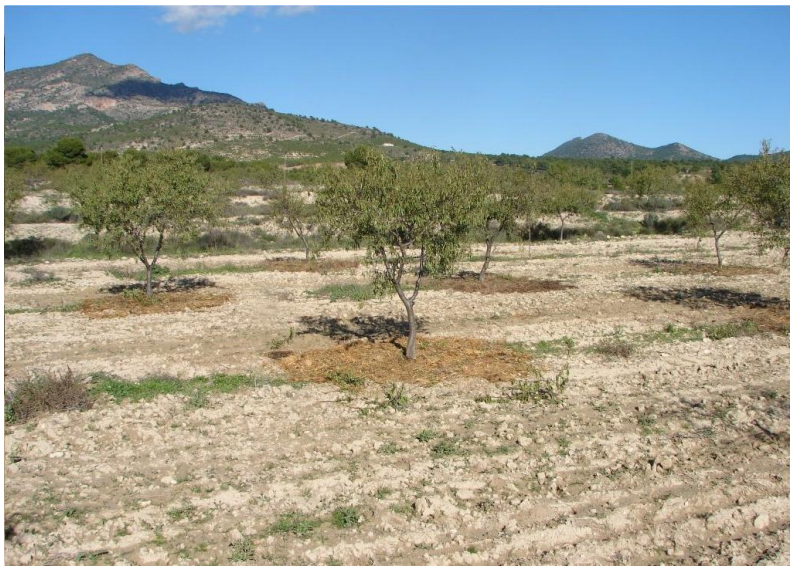
Farmers were involved from the beginning in selecting the SML technologies. Stakeholder workshops and field demonstration days were organized.

Mulching as applied in these experiments is not profitable compared to conventional cultivation practices since it does not increase the yield and implies significant additional costs.

Trials of technologies (II) Water harvesting

Field trials were carried out to provide information on the possibilities of a more efficient use of water by collecting surface runoff through traditional water harvesting technique (i.e. *boquera*) in terraced almond field. The experimental field is located in the upper part of the Rambla de Torrealvilla in the 'Los Alagüeces' farm, Murcia, Spain. A *boquera* is a system of diverting (partly or fully) water from the ephemeral stream (rambla) to the nearby terraced fields through a series of man-made gateways and corresponding channels (i.e. *acequia*s).





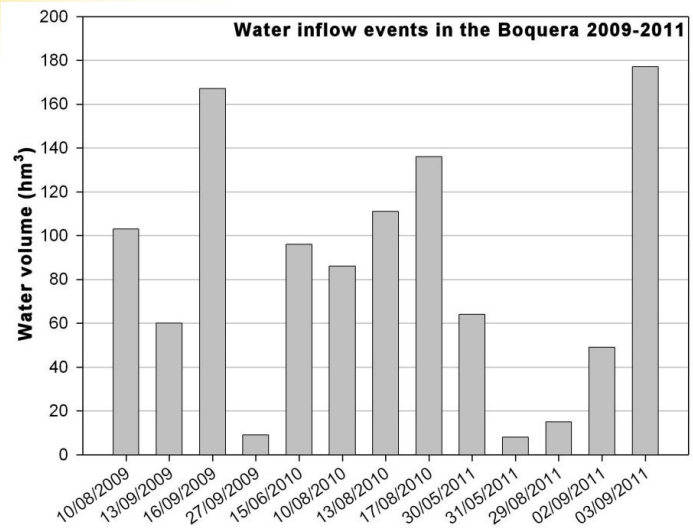
In order to reduce evaporation, mulching was also applied. To estimate volume of water during flow events, a probe was installed that registers water height in the *acequia*s channel every 20 seconds. In another terrace, without *boquera*, a straw mulch (~15cm thick) was applied under the canopy of the almond trees. To compare the effects of the water harvesting technology and of mulching, a control terrace field without a *boquera* was used.

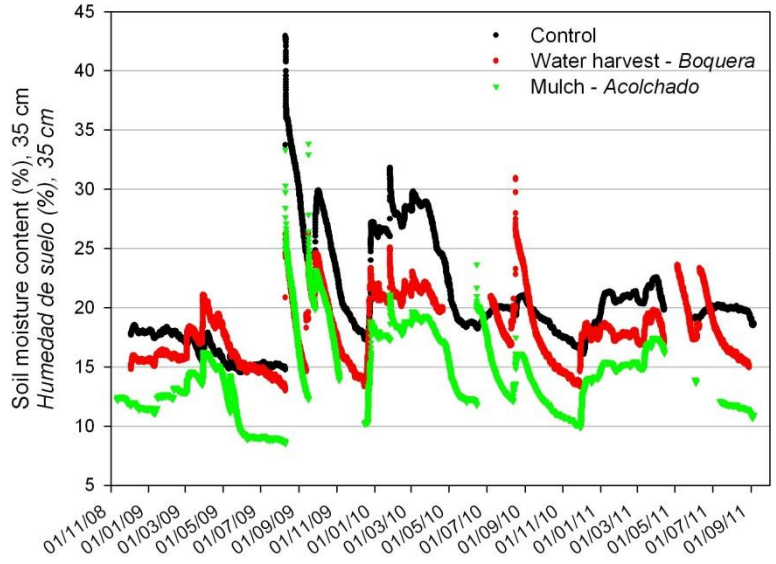
In all three plots soil water content was registered hourly at 35 cm depth, and about monthly for the first 20 cm with FDR equipment. The *boquera* and control fields were ploughed 3-5 times per year, whereas the field with straw mulch was ploughed only twice a year. The experiment started in 2008 but data on soil moisture content, inflow amount of water and almond crop harvest were recorded as from 2009 which continued until 2011.

Results

- The results indicated that during the monitoring period of 2 years, a total of 13 events of water entering through the *boquera-acequia* system were recorded. By these events, the *boquera* provided over 550mm of additional water to a field of 10 ha. This means that with a mean annual rainfall of about 300mm, the total available water for this field was almost triplicated.
- Under *boquera* soil moisture content is lower which is probably due to the development of surface crusts which impede infiltration of water.
- In the mulch treatment and without *boquera*, soil moisture content was similar or sometimes even slightly lower than under control conditions in the upper 20 cm, whereas at greater depth soil moisture content under mulch was almost always lowest of the three treatments (Figure 3).

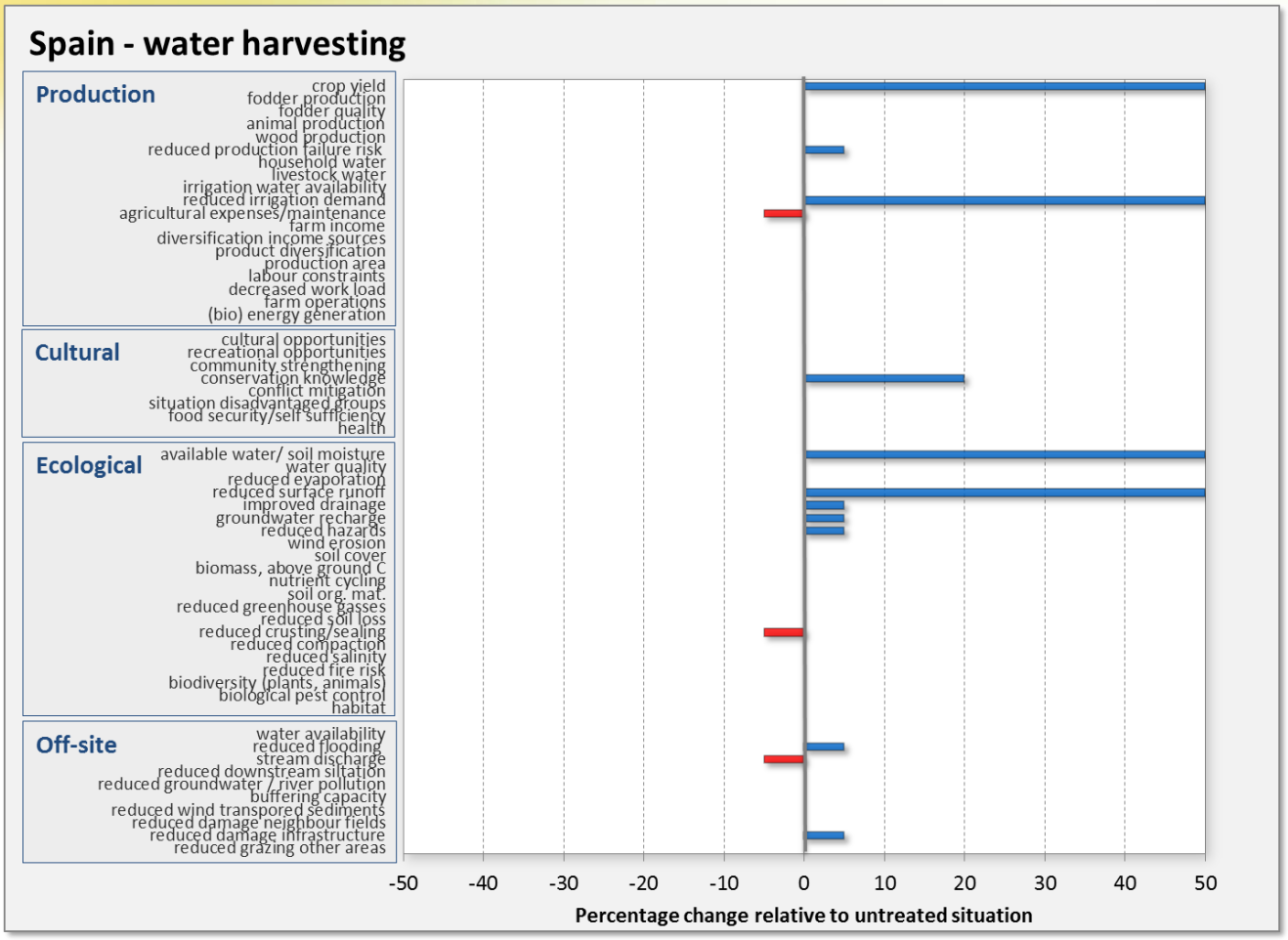
- The result also shows that the almond harvest in the *boquera* system is almost double of the harvest under conventional treatment or under mulching.





Soil moisture contents at 35 cm depth

The results are evaluated from a production, socio-cultural and economic point of view. This evaluation is based on the WOCAT system by making use of the questionnaire designed to evaluate conservation technologies (www.wpcat.net). The bars express the estimated or measured percentage of change with respect to the reference situation (untreated plots). 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.



Stakeholder evaluation

- Farmers were involved from the beginning in selecting the SML technologies. A stakeholder workshop was also organised. A lot of farmers show interest in SLM technologies to protect the land.
- Despite the implementation and maintenance costs, the *boquera* increases the benefits enormously (52%) so the farmers will continue using this.
- Mulching is not profitable compared to conventional cultivation practices since it does not increase the yield. Moreover the farmers consider the land not tidy when mulching is applied.

Trials of technologies (III) tillage and mulching

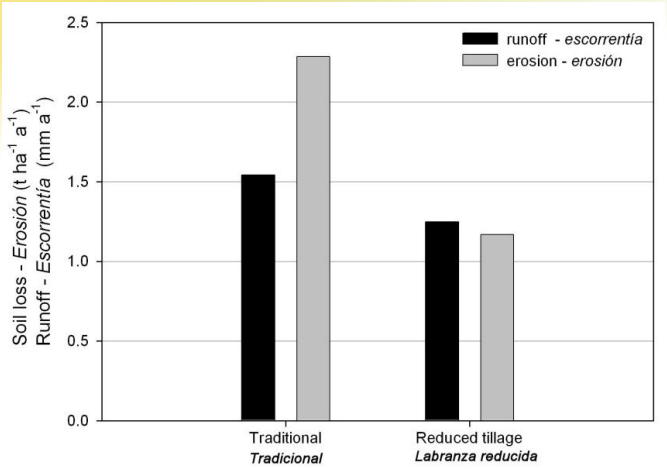
The experiment was carried out in a cereal field where minimum tillage was compared with a conventional tillage. Under conventional farming practice winter wheat is seeded in October-November after the autumn rains. Crop matures in May and harvesting is done in June. Crop residues are left on the field as mulch or for a post-harvest grazing by cattle until September, the fields are then ploughed with a mouldboard plough for seeding in November or left fallow for one year. Under conventional tillage, the land was ploughed 5 times in two years, one of which with a mouldboard plough. Under minimum tillage, the land was ploughed only three times in two years with a disc or chisel plough and never with a mouldboard plough.

To monitor the effect of the treatments on ecological criteria, three replica open runoff-erosion plots (Gerlach type) were installed for each treatment, giving a total of 6 runoff plots. To determine the exact contributing areas to the open runoff plots, a terrestrial laser scanner (TLS) was used to construct a high resolution digital elevation model. After every event, runoff and soil loss were measured by collecting the water and sediments from the runoff plots and storage tanks. To evaluate the economic impact of these SLM measures, all farm operation costs of each treatment (ploughing, implementation, seeding, etc.) were registered in a logbook, and the harvest was determined individually per treatment. Since each harvest is followed by a fallow year, only 1 cereal harvest was obtained during the monitoring period.

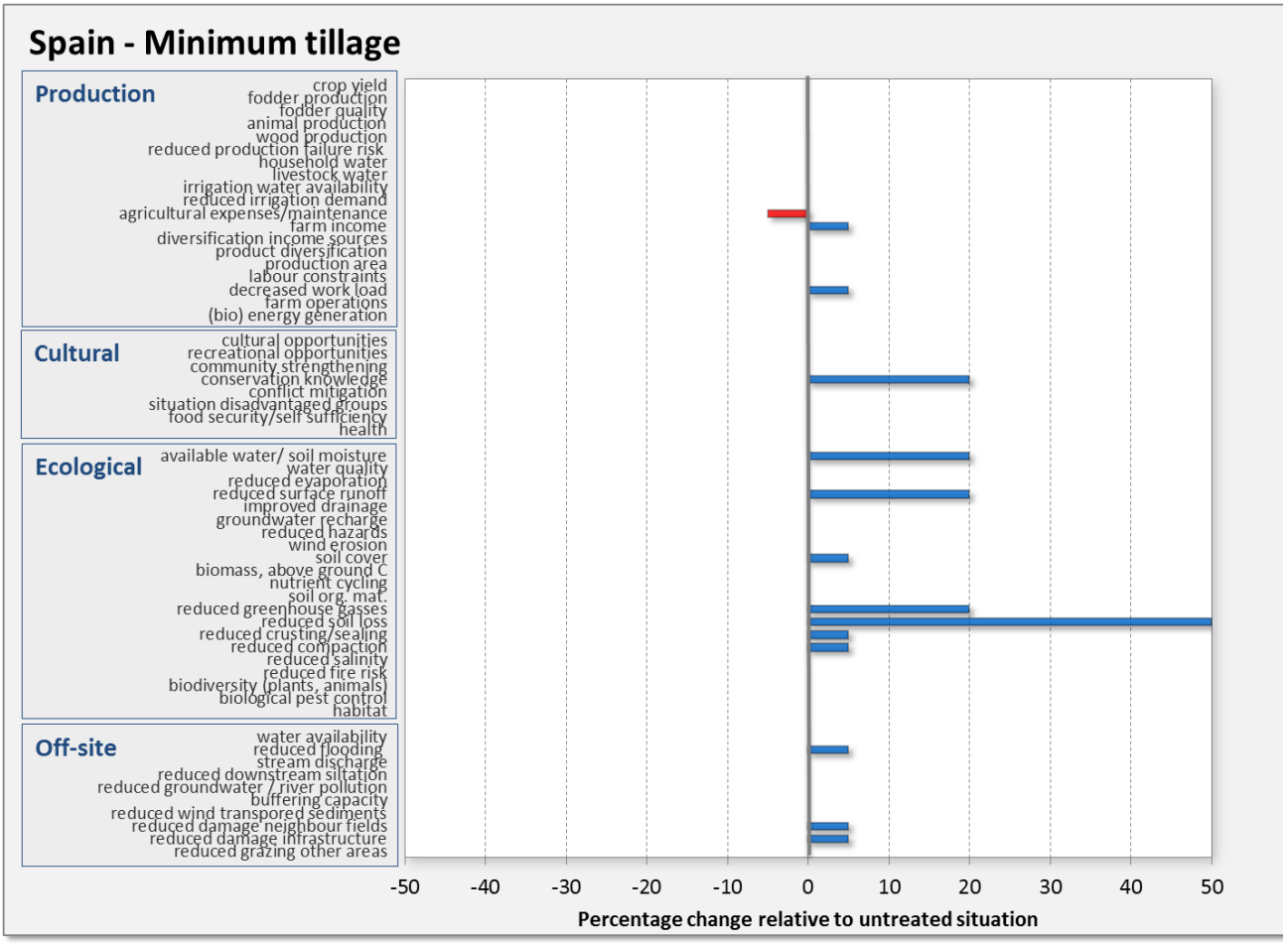
Results

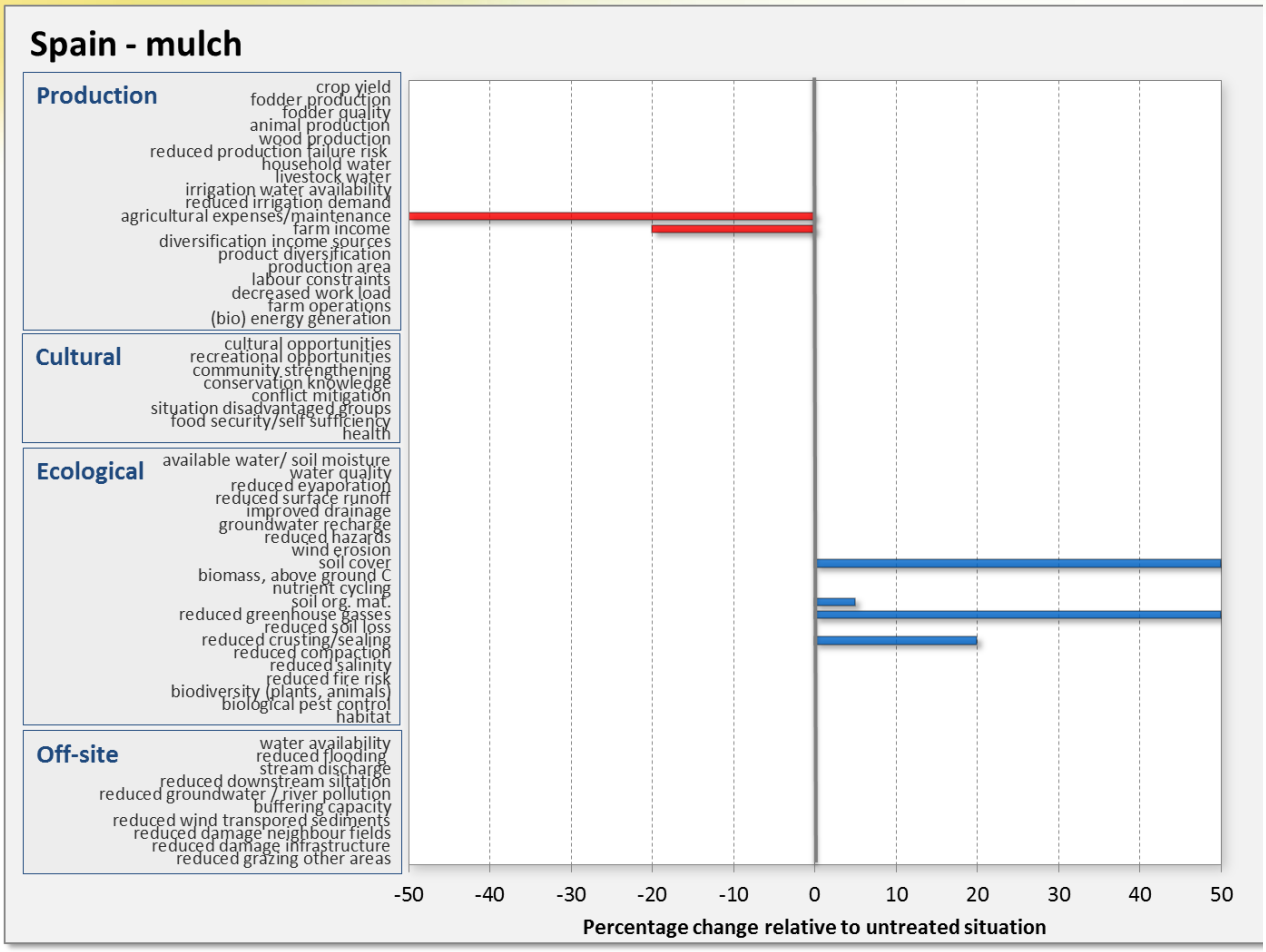
The results indicated that under minimum tillage there is decrease of soil (56%) and water loss (30%) as compared to conventional tillage (see figure below). These data are based on 2 years of monitoring in which 18 events were registered. It is expected that the reduction in soil and water loss may be higher on the longer term when soil organic matter content in the soil under reduced tillage increases.

The result also shows that the reduced tillage with mulching results in a 12% higher profit due to a reduction in operation costs for ploughing. It is expected that on the longer term, harvest under reduced tillage will increase due to an increasing organic matter content of the soil.

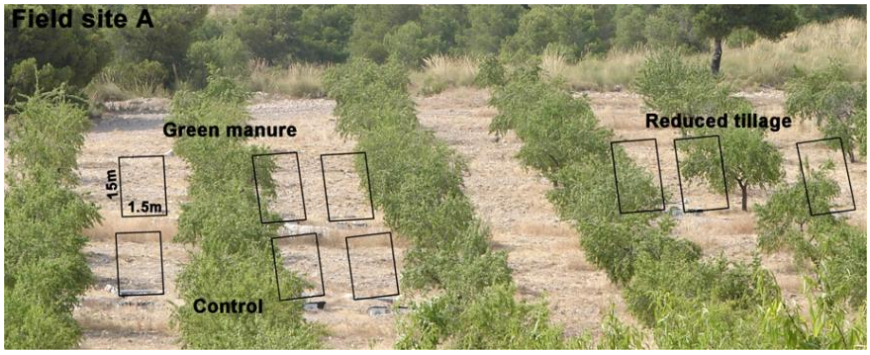


The results are evaluated from a production, socio-cultural and economic point of view. This evaluation is based on the WOCAT system by making use of the questionnaire designed to evaluate conservation technologies (www.wpcat.net). The bars express the estimated or measured percentage of change with respect to the reference situation (untreated plots). 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.





Trials of technologies (IV) Minimum tillage and green manuring



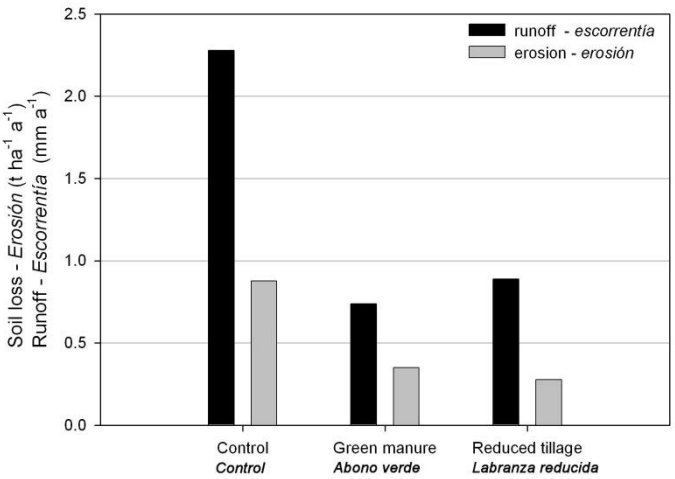
An experiment was carried ou in an almond field withou terraces where reduced tillag and green manur technologies were applied. Th location of the experiment wa in the Torrealvilla catchment Murcia, Spain.

For green manuring a mixtur of barley and vetch (*Vicia sativa)* was seeded in autumn and ploughed into the soil in spring. Ploughin was done only twice in a year in both the green manure field and the reduced tillage field, whereas th field under conventional tillage was ploughed between 3-5 times per year, a practice commonly followe in the study area. To monitor the effect of the treatments on ecological criteria, three replica open runof erosion plots (Gerlach type) were installed in each treatment, giving a total of 9 runoff plots (Figur above). To determine the exact contributing areas to the open runoff plots, a terrestrial laser scanne (TLS) was used to construct a high resolution digital elevation model. Furthermore, soil moisture of th upper 20 cm was measured about every month at 30 random points in each field with FDR equipment

After every event, runoff and soil loss were measured by collecting the water and sediments from the Gerlach runoff plots and storage tanks. Experiment started in autumn 2008. Data on soil moisture, runoff and erosion was collected. In addition amount of applied green manure seed and almond crop harvest data was also collected.

Results

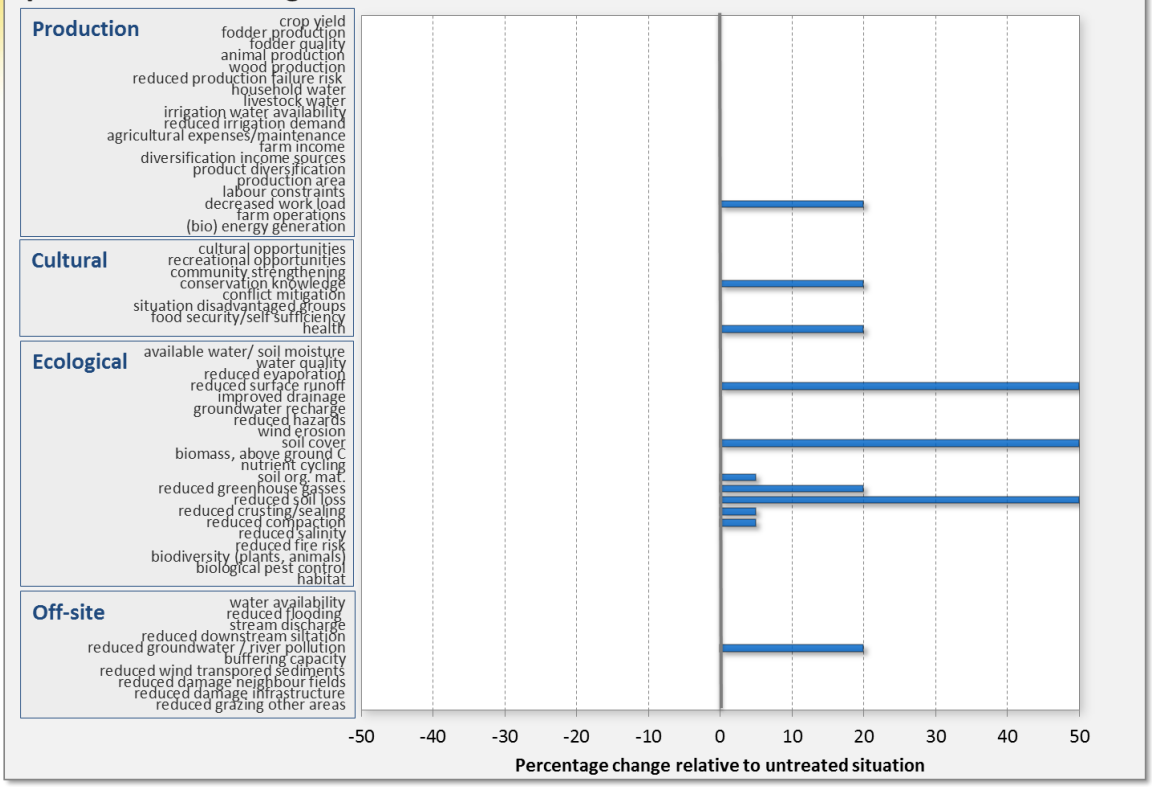
The results show that green manuring reduces surface runoff whereas soil loss amount is the lowest in reduced tillage (see figure). These results also show that erosion under reduced tillage and green manure treatment was reduced by about 60% as compared to a conventional tillage regime.



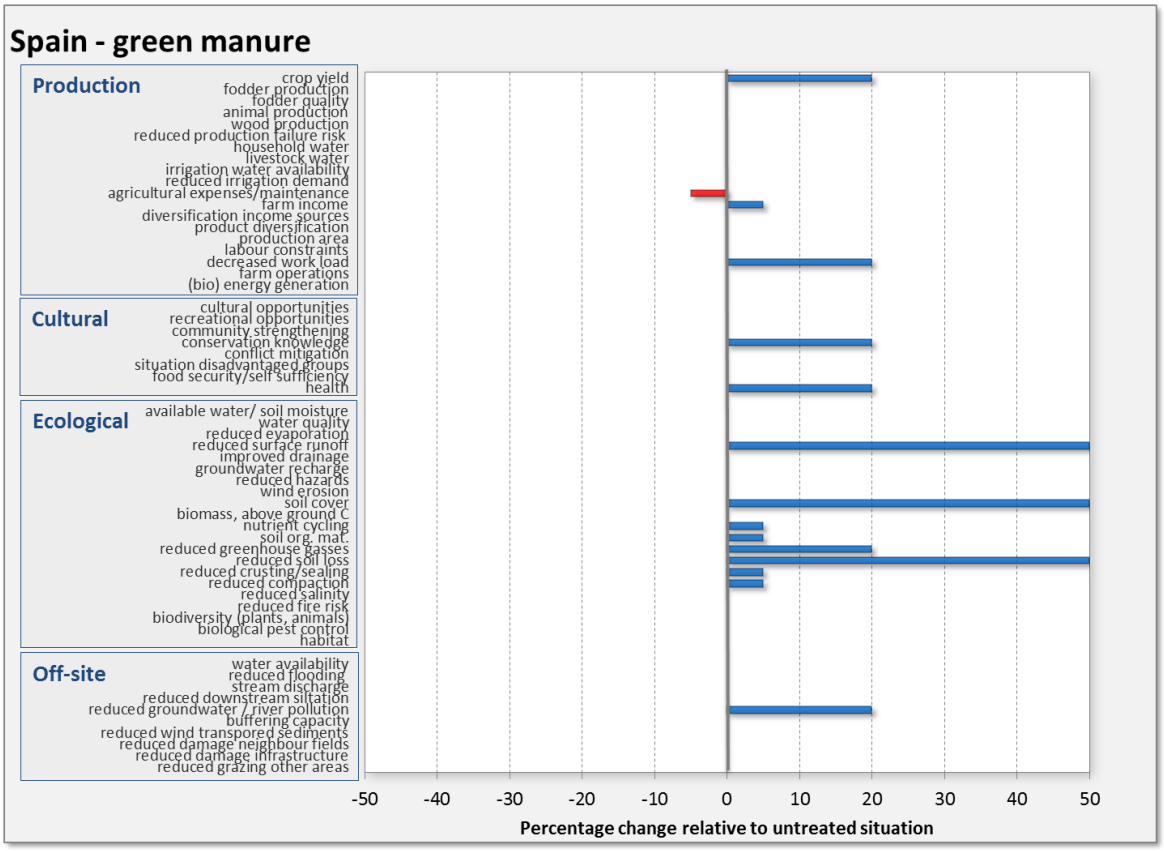
Monitoring of soil moisture did not show consistent differences between the different treatments. Differences were very small, and if there were differences, in general soil moisture tended to be even higher under reduced tillage and green manure treatment than under control conditions, possibly due to the effect of dew formation on plants below the almond trees. Reduced tillage reduces production costs as compared to conventional cultivation practices but it does not increase the yield.

The results are evaluated from a production, socio-cultural and economic point of view. This evaluation is based on the WOCAT system by making use of the questionnaire designed to evaluate conservation technologies (www.wpcat.net). The bars express the estimated or measured percentage of change with respect to the reference situation (untreated plots). 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.

Spain - reduced tillage in almonds



Spain - green manure



Stakeholder evaluation

- Farmers were involved from the beginning in selecting the SML technologies. A lot of farmers show interest in SLM technologies to protect the land.
- Low operation cost due to reduced tillage and with high quality ecological product is interesting for the farmers but there should be better marketing of eco-almonds and olives.
- Green manure is effective and feasible.

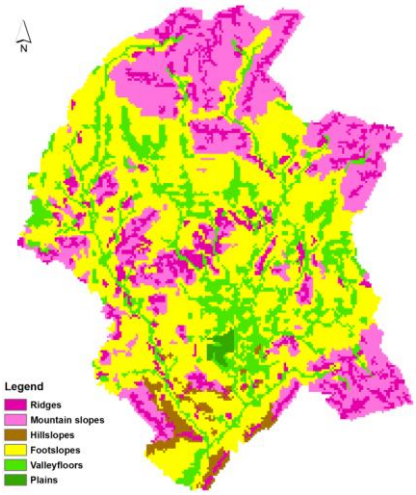
Scenario modelling

Baseline Scenario

PESERA baseline run

The baseline scenario shows mostly low and moderate soil erosion risk. Mountain slopes in the North-East have the highest risk. Valleyfloors display low risk. Biomass production follows the rainfall gradient towards the East, and is also influenced by land use. For example, the dry central area of the catchment with its dry land farming area shows very low biomass production (0 – 2000 kg/ha). Nevertheless, in more than half of the catchment area biomass production surpasses 10,000 kg/ha.

Landforms



Conclusions on scenario modelling

- Baseline simulations show comparatively low erosion rates in the Torrealvilla catchment. More than 80% of the area displays soil erosion rates below 1 ton/ha/yr. High risk areas are limited in extent. Expert mapping showed a more generic concern of soil erosion by water.
- Reduced tillage in cereals (and almonds) was the second-ranked technology selected for field testing by scientists and local stakeholders. The technology scenario shows that minimum tillage involves a reduction of operational costs. Such a saving, even in absence of a positive effect on crop yield, could make the technology profitable. The technology scenario shows that crop yields are not affected by introduction of reduced tillage. The technology is profitable in only one third of the applicable area, which seems to indicate that cereal farming is a marginal economic activity. In field experiments, the savings on operations were confirmed as was the fact that no significant change in yield was observed between minimal tillage and control.
- In the workshop to evaluate monitoring and modelling results, stakeholders reiterated their

views that minimum tillage in cereals is economical and that it does not lead to yield reduction risks. The technology was ranked second again. The simulations by PESERA confirm the view that yields are comparable but contradict that it is economical. Margins on cereal farming are low, so that can be one factor that easily influences outcomes of model simulation. It is also possible that labour costs are not valued according to market price. Incentives for adoption of sustainable land management strategies were among the recommendations to improve adoption, which might indicate general concerns over profitability of cereal farming.

- A policy scenario reducing costs by 50% did not lead to any additional uptake of the technology. With no evidence of environmental benefits, it would be inappropriate to stimulate adoption through a subsidy. Likely, the subsidies would be applied for in areas where the technology is economically feasible without support.
- The global scenarios show that minimum tillage is beneficial through cost-saving relative to conventional tillage. It actually pays to reduce tillage operations, with environmental benefits (soil and water conservation) as side effect. Although the technology is not beneficial in the entire applicability area, the aggregate study site result is still positive. The technology will however not lead to important productivity increases: this will roughly stay the same.
- The cost-saving nature of the technology has led to it being appreciated as an easy to implement measure by local land users. Margins are small though, and dryland cereal farmers in the area may generally struggle to generate a profit. However, *relative* to conventional tillage there is little risk involved in adopting minimum tillage.

Evaluation at the final DESIRE stakeholder workshop

The final DESIRE stakeholder workshop on SLM measures in the Guadalentín drainage basin, was held in September 2011 in the village of Totana. After presentation and discussion of monitoring results, the participants were asked to rank each of the five SLM measures according to the twelve evaluation criteria that were selected and used in previous workshops

Stakeholder discussions at the DESIRE workshop in Totana

Ranking of SLM before and after the field trials

Rank	Before field trials (workshop 2)	After field trials (workshop 3)
1	Traditional water harvesting (Boquera)	Green manure in Almonds orchards
2	Reduced tillage in Cereal and Almond fields	Reduced tillage in Cereal and Almond fields
3	Organic mulch to reduce water losses	Traditional water harvesting (Boquera)
4	Green manure in Almonds orchards	Organic mulch to reduce water losses

Not all measures can be used in all settings and therefore, a combination of these five options is suggested as the best strategy towards SLM. The highest ranked options are effective in that they reduce soil and water loss and increase or maintain farm income, and are relatively simple and economically feasible to implement.

Participants were also very positive about traditional water harvesting, but ranked it somewhat lower because it requires some initial costs, it cannot be applied in all fields, and it may have undesired effects downstream like reducing water availability to other fields. Most participants were not enthusiastic about straw mulch to reduce evaporation losses because the field trials demonstrated that this measure is relatively expensive and did not increase the soil moisture content. However, straw may not have been the best mulch to use here, and other types of mulch could be more effective. Therefore this issue needs further research before the measure can be recommended for wider implementation.

The main groups of ideas about how selected SLM strategies can be best disseminated for uptake by land managers and policy-makers are given in the ranked list below:

1. **Training**: a) of technical representatives at farmers organizations , and b) at high-schools and universities to create awareness and put environmental sustainability higher on the agenda.
2. **Demonstration activities** in the field and development of a network of demonstration and experimental farms throughout the region
3. **Better cooperation and collaboration** between different institutes (i.e. researchers, administration and farmers organisations)
4. **Economic support** for implementation of SLM measures
5. **Lobby** and convince responsible policy makers
6. **Put higher economic and social value** on products that are produced in a sustainable manner
7. **Link payment of agricultural subsidies to implementation** of effective SLM measures
8. **More dissemination and publicity** for SLM measures through newsletters and websites

Part of these actions may very well be linked to the Rural Development Programmes. Currently, the first steps are made to develop the next RDP in which subsidies for soil and water conservation measures and good practice for agriculture will be described. A priority action is therefore to feed the DESIRE workshop results into this process. Furthermore, existing training activities from the regional ministries towards farmers and technicians of farmers' organisations may also benefit from these results.

Participants agree on the fact that the main obstacles for adopting the priority solutions are related to awareness, knowledge and a fear amongst farmers about high economic costs related to any change in land management activities. Moreover, many farmers feel that anything they do to protect natural resources is not really valued by the wider society. To overcome these challenges, there is therefore a great need for training and awareness building at various levels, as reflected in the first action line.

Most participants indicated that optimal dissemination is achieved through field demonstrations to farmers and technicians of farmers' organisations. Websites and information folders are far less effective ways of communication. Further changes at a larger scale and with possible economic support can only be achieved through lobbying responsible policy makers.

Generally, participants valued the workshop and their experience in DESIRE very positively. Participants indicated they learned a lot from each other, from discussions and from the results of field trials. The interactive approach of workshops was considered effective to achieve interaction between participants, and was highly valued. However, all participants agreed that a higher participation of farmers is required and that to achieve this, a different approach may be needed, with meetings outside in the field and only for maximum half a day.

CONCLUSIONS

Main conclusions and implications for DESIRE as a whole

The traditional water harvesting technique does not necessarily improve soil moisture but the crops with shallow root system benefit the high water availability which will increase crop yield.
Additional funds should be available to construct and maintain the traditional *boquera* system of water harvesting.
Mulching does not increase soil moisture in very dry environment. It is not profitable and not liked by the farmers.
Minimum tillage in combination with mulching require adaptations and further research before they can be recommended for wider application. Moreover, an important conclusion is that sustainable land management requires implementation of a package of SLM measures rather than only 1 or 2 specific ones.
Minimum tillage reduces soil loss (56%) and water loss (30%) as compared to conventional tillage. After the relatively short period (2 years) of monitoring with only 1 harvest, no effect was observed on cereal yield. This may be different after more years of monitoring. Nevertheless, even if yield is not affected by this treatment, a higher benefit was achieved because of less operation costs under reduced tillage. Longer term monitoring is still required since most soil and water loss occurred during the low frequency high intensity events.
Reduced tillage reduced soil and water loss, but yield was not increased, at least not after 2 years of monitoring. Nevertheless, operation costs are lower, so if the yield is maintained at least at the same level there is an economic benefit compared to conventional treatment.
Green manuring proved to be effective and feasible in reducing soil and water loss while increasing almond production. Since operation costs do not significantly increase, the profit is also higher than under conventional

production.

The results show that there are various opportunities to increase economic benefits and at the same time provide increased ecological services by protecting and maintaining soil and water resources under rainfed agriculture in semi-arid conditions. For these reasons, these measures have a relatively high level of acceptance amongst stakeholders.

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Dr. Joris de Vente

See: http://www.desire-his.eu/en/guadalentin-spain for full details of DESIRE research