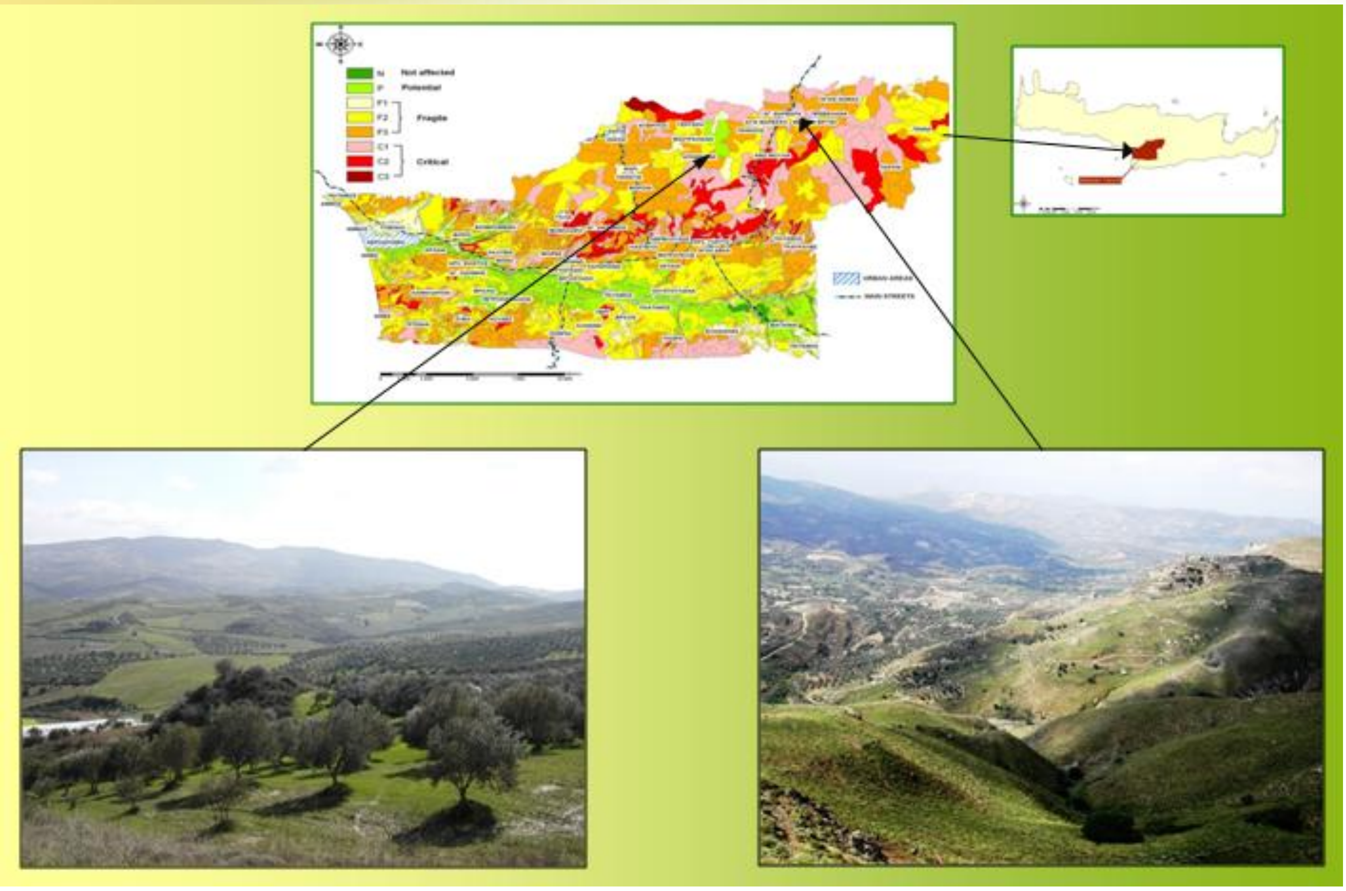
Crete, Greece

Highlights of work carried out in the DESIRE Project
Based on research at the Agricultural University of Athens, Greece

The study site

Crete has been subjected to overexploitation of its natural resources for a long period. Large-scale deforestation of the sloping lands accompanied by intensive cultivation and overgrazing resulted in accelerated erosion and the formation of badlands with very shallow soils through the progressive inability for regeneration of the vegetation and soils. Based on the land desertification risk map of Greece, more than 50% of the island is characterized by high desertification risk. The high erosion rates occurring in Crete are attributed to climatic conditions, topographic characteristics and the generally poor vegetation cover. In the last decades, the availability of ground or surface water in areas with favourable soil and climatic conditions has encouraged intensive farming of the lowlands. The aquifer system has been overexploited by farming and a variety of other uses (mainly tourism) causing gradual intrusion of sea water. Soil salinization is a potential desertification threat for lands located mainly along the coast characterised by high xerothermic climatic indices.

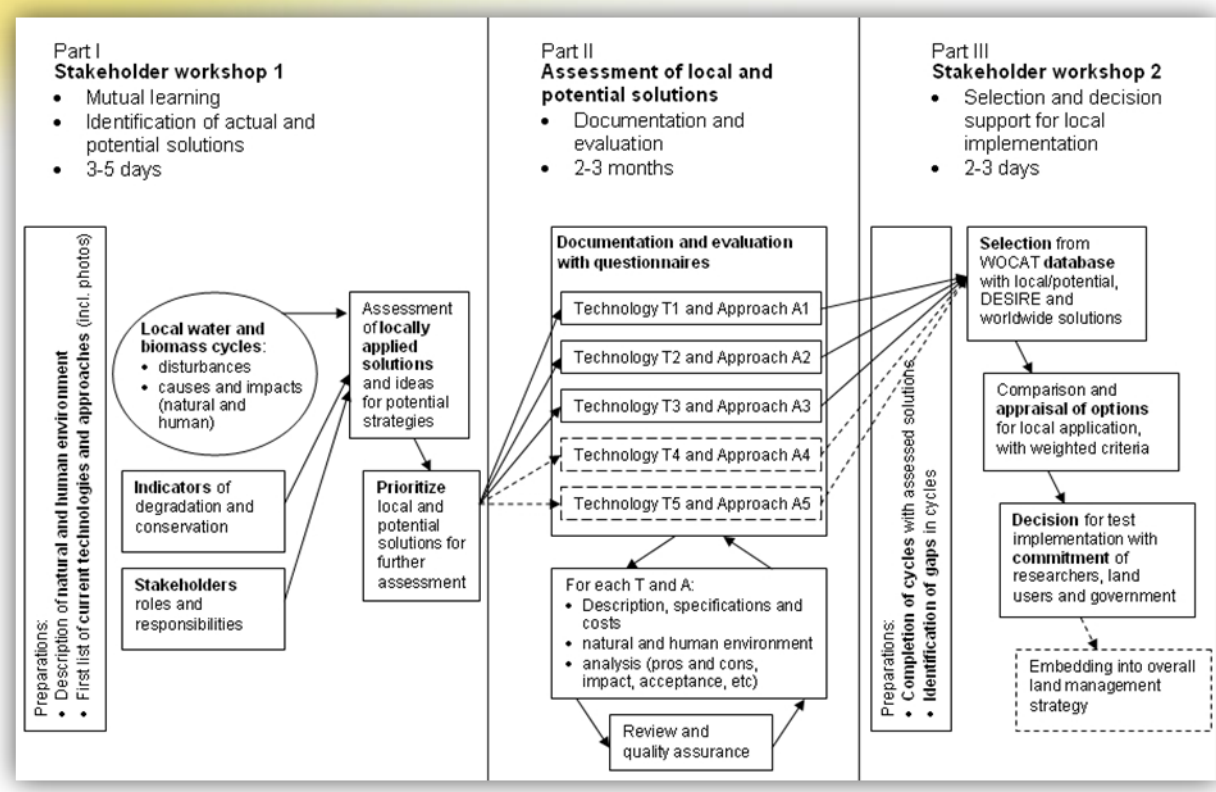
Olive plantation, Chania, Crete.Photo by C. Kosmas, 2008



Two monitoring sites in western Crete

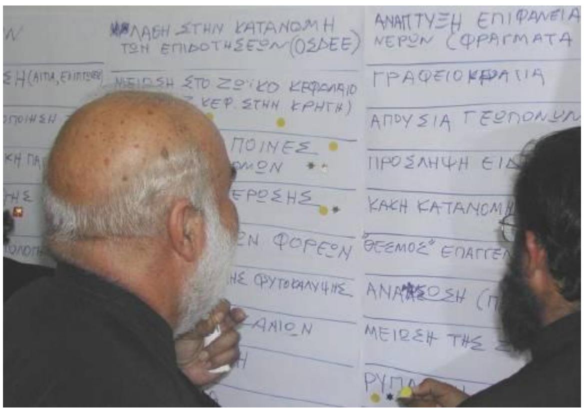
Workshops for researchers and stakeholders to select sustainable land management technologies
Researchers talked with local people and policy makers, and together they decided on the best options for sustainable land use. In the DESIRE Project the three Parts to WOCAT methodology were developed as outlined 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.

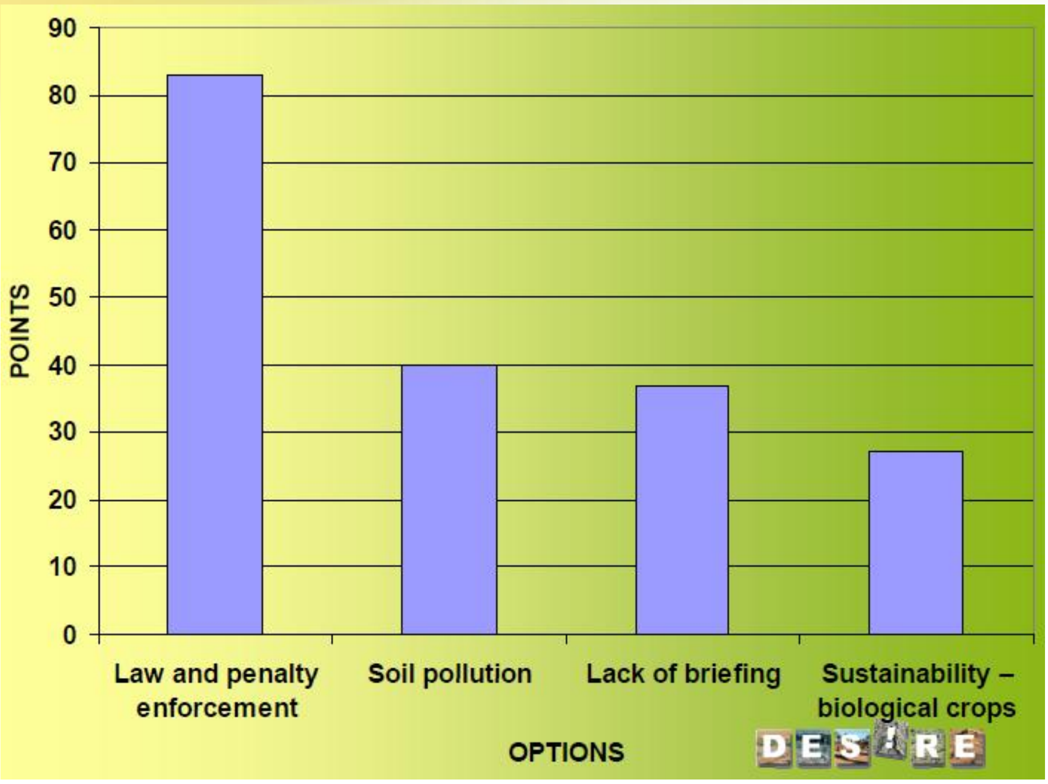


An outline of DESIRE-WOCAT methodology

Stakeholder workshop



Voting by placing sticky spots on the lists of options…..



The stakeholder meeting did not choose technologies, but discussed improvements to law and penalty enforcement

Technologies to improve sustainable land management (I) Minimum tillage

Soil erosion due to surface runoff and tillage operations, collapse of terraces, overgrazing, salinization of lowlands, and overexploitation of ground water are the major processes of land degradation in western Crete. A lot of forested areas were converted into cultivated land In the last century. Overgrazing and fires further destroyed the natural vegetation cover and prevented its regeneration.

Olive groves are an important form of land use in the area, but have various degrees of due to the different land management practices. Farmers perceive a herb cover as a competition for water for the Olive trees and keep the field clean and bare below the trees. A minimum tillage experiment with and without herbicides was carried out to see if it is possible to maintain a soil cover, restore the natural soil structure, promote infiltration and reduce runoff and helps in minimizing soil losses.

The experimental field was located on a moderately steep slope (slope gradient 17%) which is prone to erosion. The soil is moderately deep (55-65 cm). The experimental setup included three management practices prevailing in the area with two replicates: (a) no tillage – no herbicide application, (b) no tillage – herbicide application, and (c) tillage operation – no herbicides with soil cultivated perpendicular to the contour lines at depth 20 cm using a disk harrow. The plots are of the size 3x5m^2. Tipping buckets were installed at the bottom of the plots to collect surface runoff. Also there are facilities for collecting soil sediments. One time measurements were carried out such as: texture and stoniness, organic matter, aggregate stability, etc. Repeated measurements were conducted such as soil moisture with permanent installed TDRs, soil temperature, while sediment loss was measured every rainfall event, and surface water runoff every 5 minutes.

Soil Water Conservation Techniques, in an Olive grove


no tillage – no herbicides


no tillage – herbicides application

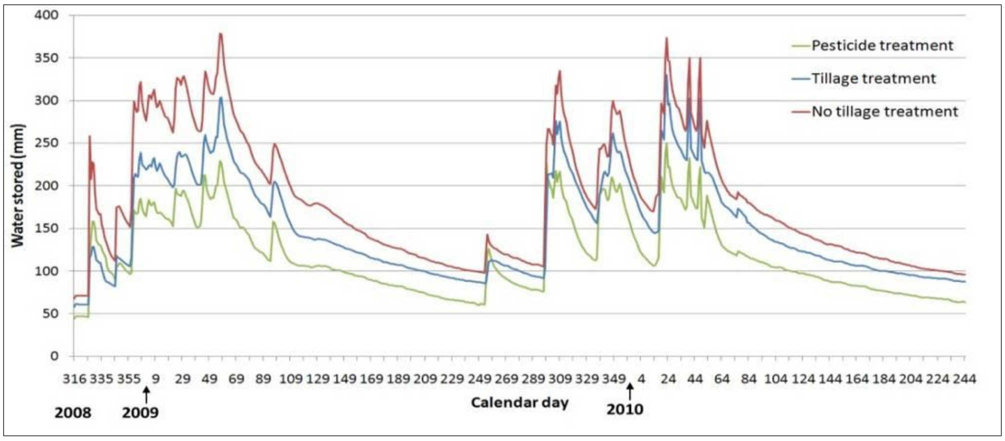
Tillage perpendicular to the contour, lines at depth 20 cm using a disk

Results

The experiments in the olive grove showed significant differences in surface runoff and sediment loss as a result of applying different land management practices. The highest amounts of surface runoff were measured in the experimental plot subjected to tillage operation with 44.7 mm and 7.9 mm of runoff recorded in the first and second year of study, respectively. Under no tillage and no tillage-herbicides application the surface runoff reduced by approximately 1/4 times. The lowest runoff was recorded under the no tillage land management practices since soil was fully covered with vegetation.

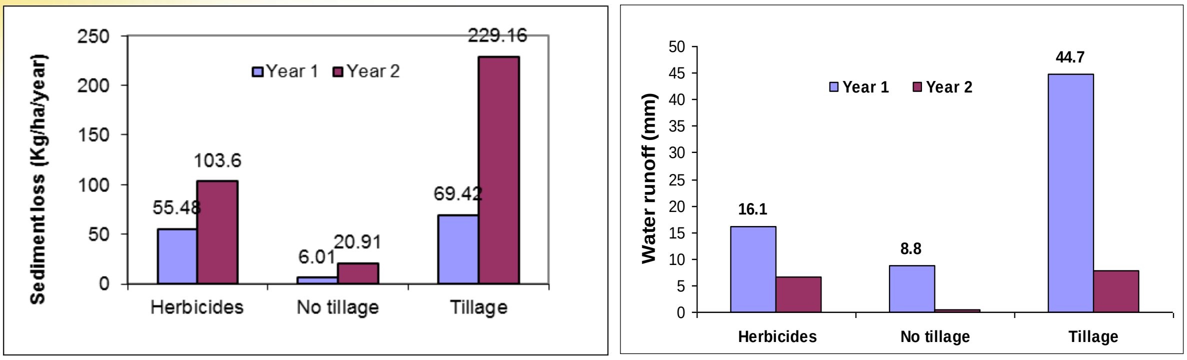
Soil losses showed similar trends. The soil loss was highest in the tillage land management practices, especially in the first year of measurements. This was due to high rainfall amount in that year. Sediment loss in this management practice ranged from 44.2 to 255.9 kg ha^{-1} yr^{-1} during the two year period of measurements. The no-tillage land management practices also reduce production costs by minimizing cost involved in man power.

The three treatments: minimum tillage, no herbicide (top),
minimum tillage with herbicide (middle), conventional (bottom)

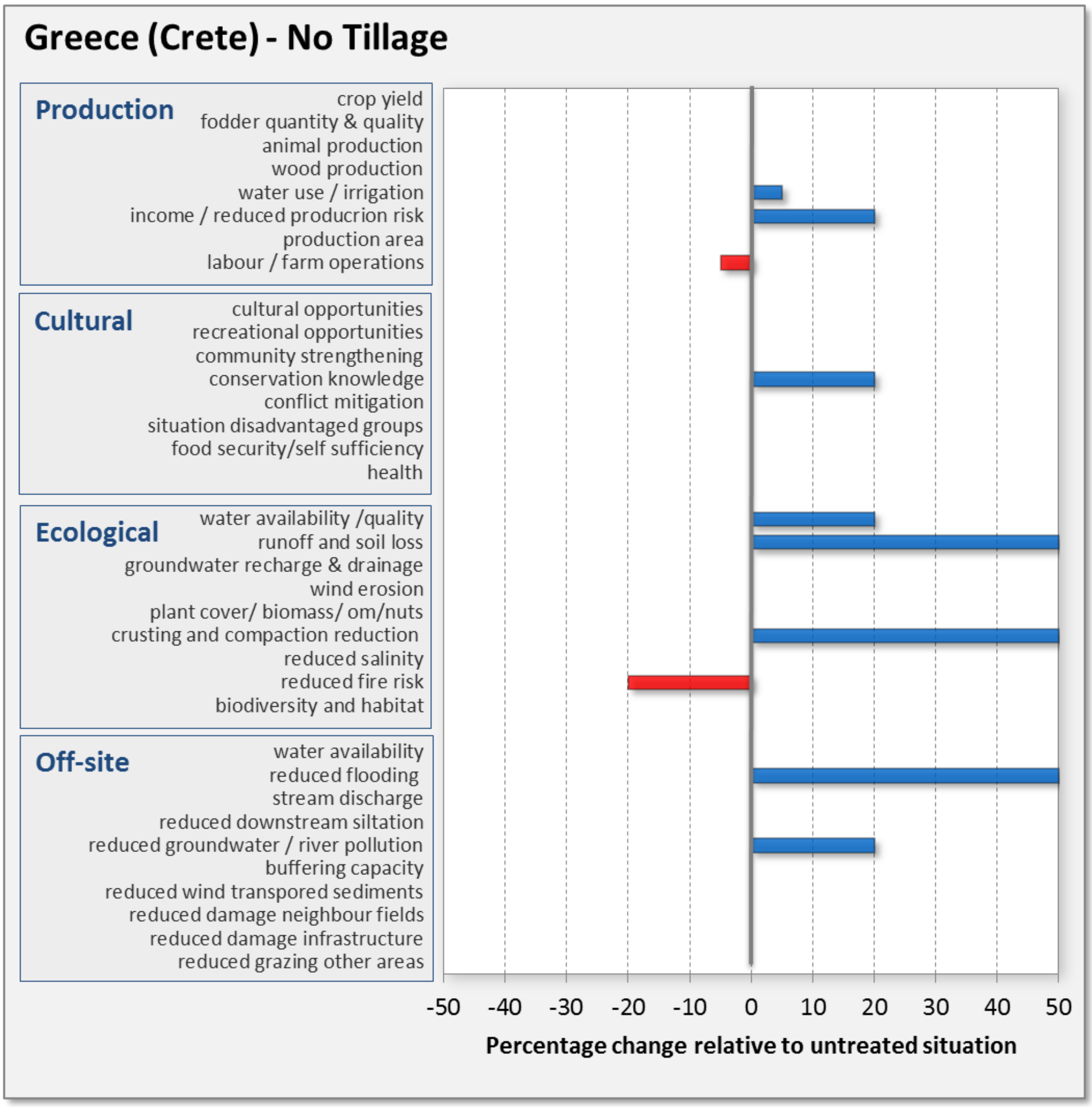


Left: recorded runoff is consistently hiogher in the tillage plot

Totals in runoff and sediment losses for the two years. Year 2(2010) was a wetter year



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.



Stakeholder opinions

Many local farmers visited the monitoring site and observed the work carried out. They discussed the issues of desertification and the measures for protecting the land from further degradation in local meetings. They considered the applied land management practices included in the agricultural program of "Integrated Land Management of Olive Groves" for receiving higher subsidies.

The benefits of sustainable land management are related to: (a) lower cost production of olive oil, (b) higher income due to the application of integrated land management of olive groves for protection of the environment. The application of no-tillage or minimum tillage land management practices did not require additional cost for implementation. On the other hand there is still a discussion on whether the herb layer competes with the olive trees for water, which has not yet been resolved. Moreover in a very dry year the dried out herb layer could give an extra wildfire risk.

Conclusions

The application of the appropriate land management practice greatly affected land protection and reduction in runoff and erosion, consistently over the two years of experiments. The experiment shows that the no tillage – no herbicides land management resulted in minimizing sediment loss due to low surface runoff. Added ecological effects were higher soil water storage, lowering soil temperature, higher biodiversity. This was confirmed by a longer experience in the area and results from previous studies.

Several stakeholders have accepted this type of land management practice due to low olive oil prices. It may be that if the olive price rises, a reversion to traditional tillage will be seen because farmers will want to minimize production risk. There are clear economic benefits as the reduced tillage reduces labour and fuel costs.

An important bottleneck is the lack of knowledge transfer by the Greek Ministry of Agriculture on new sustainable land management practices and decreasing cost production.

Technologies to improve sustainable land management (II) Rangeland fencing

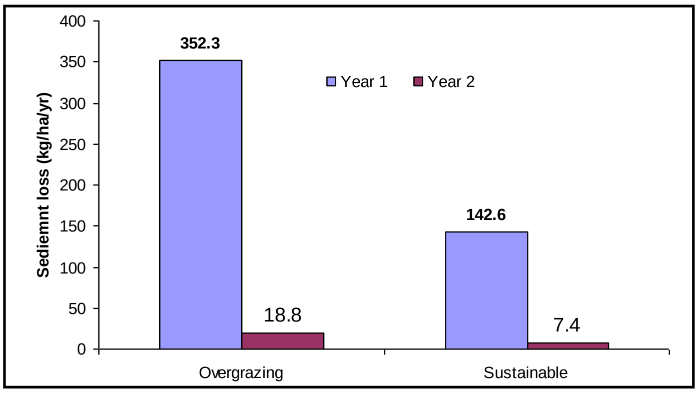
Overgrazing on the shallow stony soil decreases cover and destroys soil structure, and therefore promotes runoff and erosion. This further destroys what little soil there is left and jeopardizes the entire ecosystem that depends on it. Erosion is therefore seen as the main problem and a driver behind environmental degradation.

Rangeland fencing to reduce overgrazing effects was carried out near Agia Barbara village on a steeply sloping overgrazed land (23% slope) with shallow soil (35-45 cm deep). Four runoff plots of size 10 m^2 were established (two treatments with two replicas with (a) sustainable grazing (SG), and (b) overgrazing (NSG). At the bottom of each plot a drainage ditch and a tube connecting to a dipping bucket and a sediment trap are installed to collect surface runoff and suspended sediment from the corresponding LMPs with their replicates. Plant cover was recorded periodically throughout the period during which field observations were carried out.

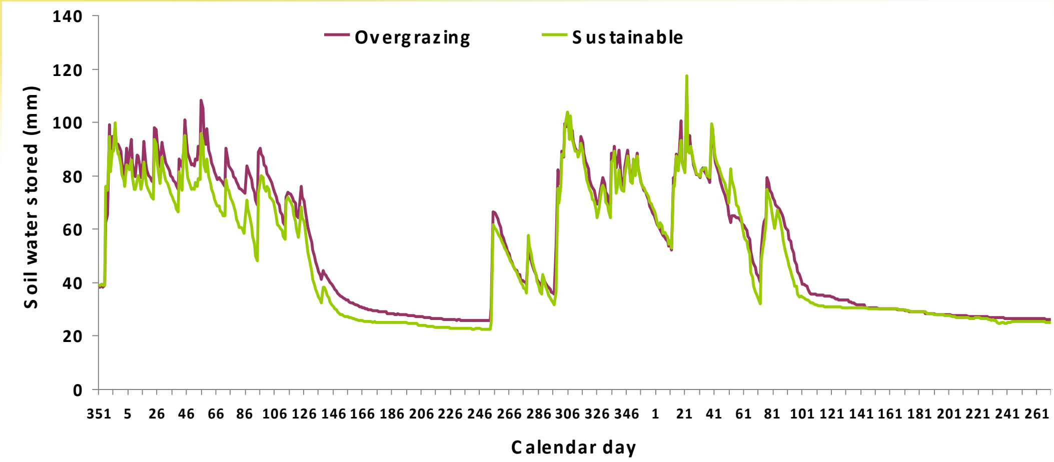
Top: overgrazed area, bottom, fenced area

In year 1 and 2 of the experiment annual rain was 520 mm and 625 mm respectively. During that period 10 big rainfall events occurred for which surface runoff volumes were measured. In the sustainable grazing plots the annual as well as the perennial vegetation and the plant residues covered about 85% of the soil surface, protecting the soil from splash detachment, formation of surface crusting, and minimizing surface runoff. The sustainable grazing management practice reduced surface runoff by more than half in both the study years. In year 1, surface runoff from overgrazed plot was 43.7 mm and that of sustainable plot was 28 mm. In year 2, the difference was even more (19 mm verses 7 mm).

Sediment loss was similarly affected by grazing intensity. The results showed that soil losses could be reduced by about 2.5 times by employing sustainable grazing.

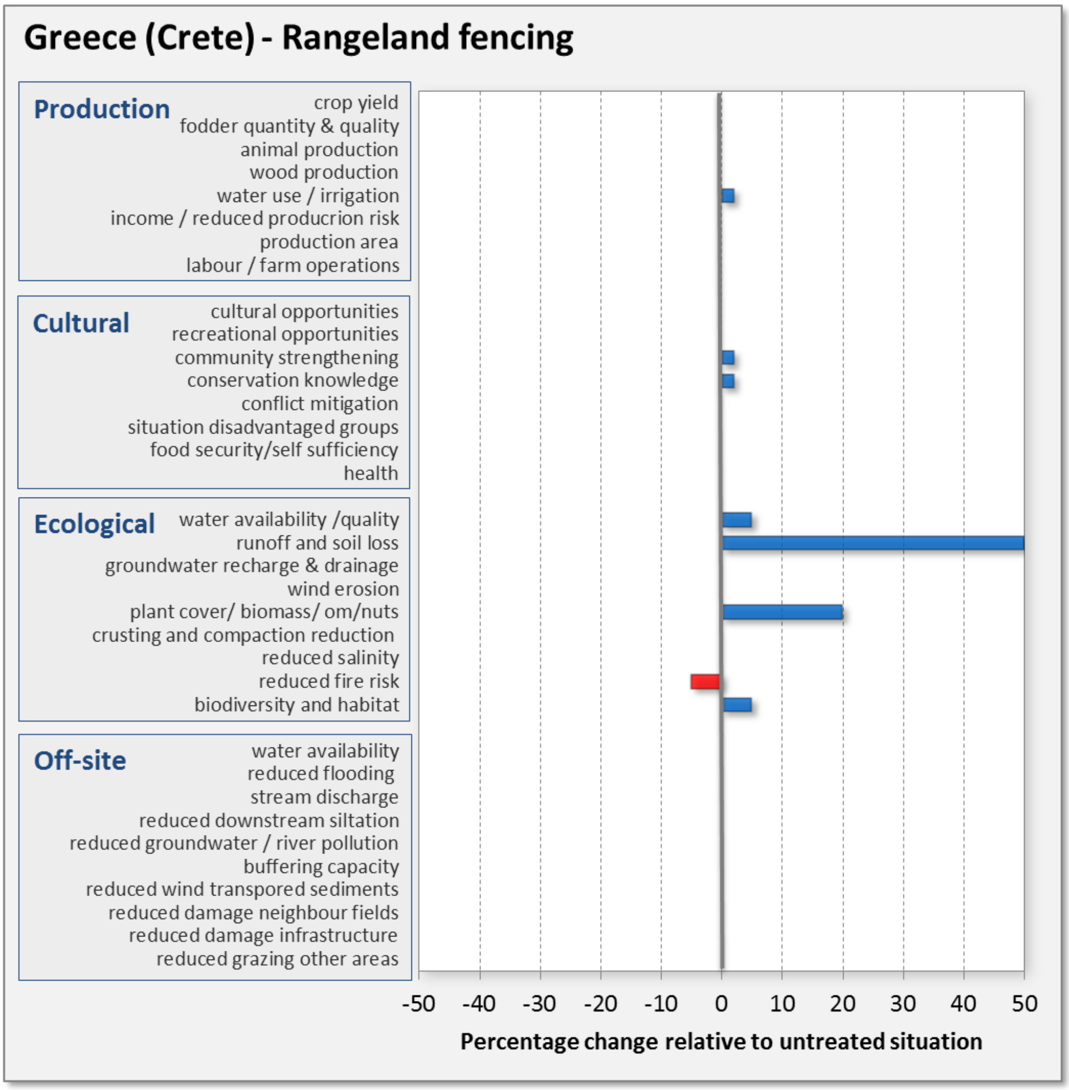


Effect of grazing management practices on soil losses



Soil moisture monitoring in the two plots. A slight increase in soil moisture was measured in the first year while in the second year the moisture contents were almost equal

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.



Soil Water Conservation Techniques, Grazing land

Sustainable grazing

Overgrazing

Opinions of stakeholders

While it is ecologically a good measure, fencing would be very costly for very little return for land owners. Rangeland resting where agreements are made to leave an area as set aside without fencing might be possible. However, the landowners receive EU subsidy based on the number of animals so this effectively negates any means to protect the fragile soil. Since fencing or set aside would mean a decrease in animal density, this is a further loss of income.

Conclusions

The experiment showed that the sustainable grazing resulted in reducing surface runoff and sediment loss by more than half of that in the overgrazed areas. Sustainable grazing resulted in increasing plant cover and biodiversity, higher soil organic matter content and higher soil water storage. This showed that soil loss in this case was not only about sediment dynamics (the losses are actually small in absolute values), but that these thin and fragile soils are an important part of natural ecosystem.

The main bottleneck is the reduction of farm income due to reduced number of grazing animals. Currently the farmers receive EU subsidy based on the number of animals they have. The policy of farm subsidy has to be changed if the SLM technology has to be successfully implemented. Also funds should be made available to compensate for the reduction of animals. In this case conservation would mean providing an alternative means of income or some form of compensation, i.e. changing the subsidy from heads of livestock to nature conservation.

Using desertification indicators

Desertification risk
(DRI=desertification risk index, DR=desertification risk class)

Sustainable grazing, DRI = 5.9, DR = high

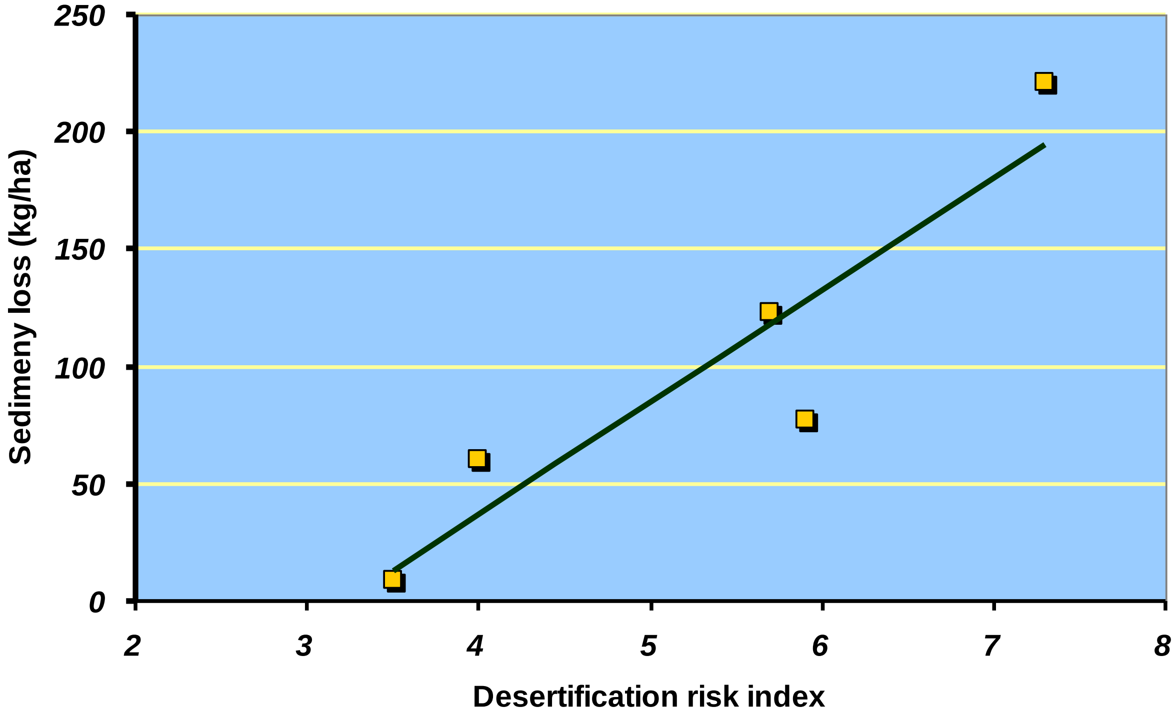
Overgrazing, DRI = 7.3, DR = high

No tillage, DRI = 3.5, DR = moderate

Herbicides, DRI = 4.0, DR = moderate

Tillage, DRI = 5.7, DR = high

Relation of sediment loss and desertification risk index



Overall conclusions

The effect of land management practices on soil erosion and land degradation in an olive grove has been assessed by conducting experimental measurements for a period of two years (2008-2010). The obtained data have shown that the no tillage – no herbicides application land management practice compared to the other techniques derived nil sediment loss (1-25 kg ha^{-1} $year^{-1}$), lowest water runoff (0.4-8.8 mm $year^{-1}$), highest amount of water stored into the soil, lowest soil temperature, highest biodiversity, lower desertification risk, lowest olive oil cost production. The herbicides application showed the lowest amount of water conserved into the soil and intermediate values of water runoff (6.7-16.1 mm $year^{-1}$) and sediment loss (40-110 kg ha^{-1} $year^{-1}$). The tillage land management practice showed the highest sediment loss (44-250 kg ha^{-1} $year^{-1}$) and surface water runoff (7.9-44.7 mm $year^{-1}$), the highest desertification risk, intermediate amount of rain water conserved into the soil. While water erosion appears not so important for land degradation in the study field site and for the two years period, tillage erosion caused by the used implements for cultivating the land is the most important process of land degradation and desertification. The average soil loss due to tillage erosion has been estimated at 3.7 mm per year.

Other indicators important on land protection such as soil organic matter content and aggregate stability were related to the applied land management practice. Aggregate stability and organic matter content were higher by about 30% in the soil under no tillage – no herbicides application. The estimated Pieri (1989) soil crusting susceptibility index was 2.3 for the soil under tillage, while this index was 3.2 for the no tillage – no herbicides application.

The proposed sustainable land management practice of no tillage – no herbicide application has already been applied in many cases in the Crete study site. This type of management has been favoured in the last decade by local farmers due to the low olive oil price and reduced farm income. Considering that the olive fruit production has decreased by about 35% in the area in the last 3 decades, farmers have realized the importance of no tillage or minimum tillage in protecting olive groves from land degradation and desertification, and conserving water resources, as well as reducing the risk of low land flooding.

Overgrazing is considered the main cause of soil erosion, land degradation and desertification in hilly areas of Crete study site used as pastures. The obtained results showed that under sustainable grazing surface water runoff was 7.4-28.0 mm per year, compared to 18.7-43.7 mm per year in the overgrazing plots, while sediment loss was 0.007-0.14 t $ha^{-1}year^{-1}$, and 0.018-0.35 t $ha^{-1}year^{-1}$, respectively. Under overgrazing conditions, organic matter content was 35% lower and the average soil temperature 2.3^{o}C higher compared to sustainable grazing. Soil moisture content was higher in the overgrazed soil due to lower plant cover but the total rain water stored into the soil was lower compared to the soil under sustainable grazing. Mean values of soil penetration and shear strength were higher under overgrazing conditions. Finally, desertification risk was assessed as high in both cases but the desertification indices for sustainable grazing were lower indicating lower vulnerability to desertification if sustainable grazing is applied.

Desertification of grazing lands and landscapes caused by grazing animals is a complex process affecting both vegetation and soil characteristics. Overgrazing results in removal of palatable plant species followed by less- or no-palatable ones dominating in the grazed land. Under such conditions, farmers set fires deliberately fires to remove unpalatable plant species, but causing severe problems of soil erosion and land degradation. Besides overgrazing, undergrazing can also cause desertification due to the growth of high amounts of flammable biomass increasing ignition risk of wildfires and leading to high erosion rates and degradation of the land. In addition, undergazed and non-burned areas can be invaded by woody species resulting in loss of biodiversity due to high plant competition. Therefore, a sustainable grazing of the pasture land is considered the best land management practice for protecting such areas from desertification. Even though grazing land in the island of Crete is highly degraded in many places, it is necessary for farmers to remain on the land keeping sustainable number of animals for (a) protecting the land, (b) providing the market with high quality of products, and (c) supporting local culture and their income.

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