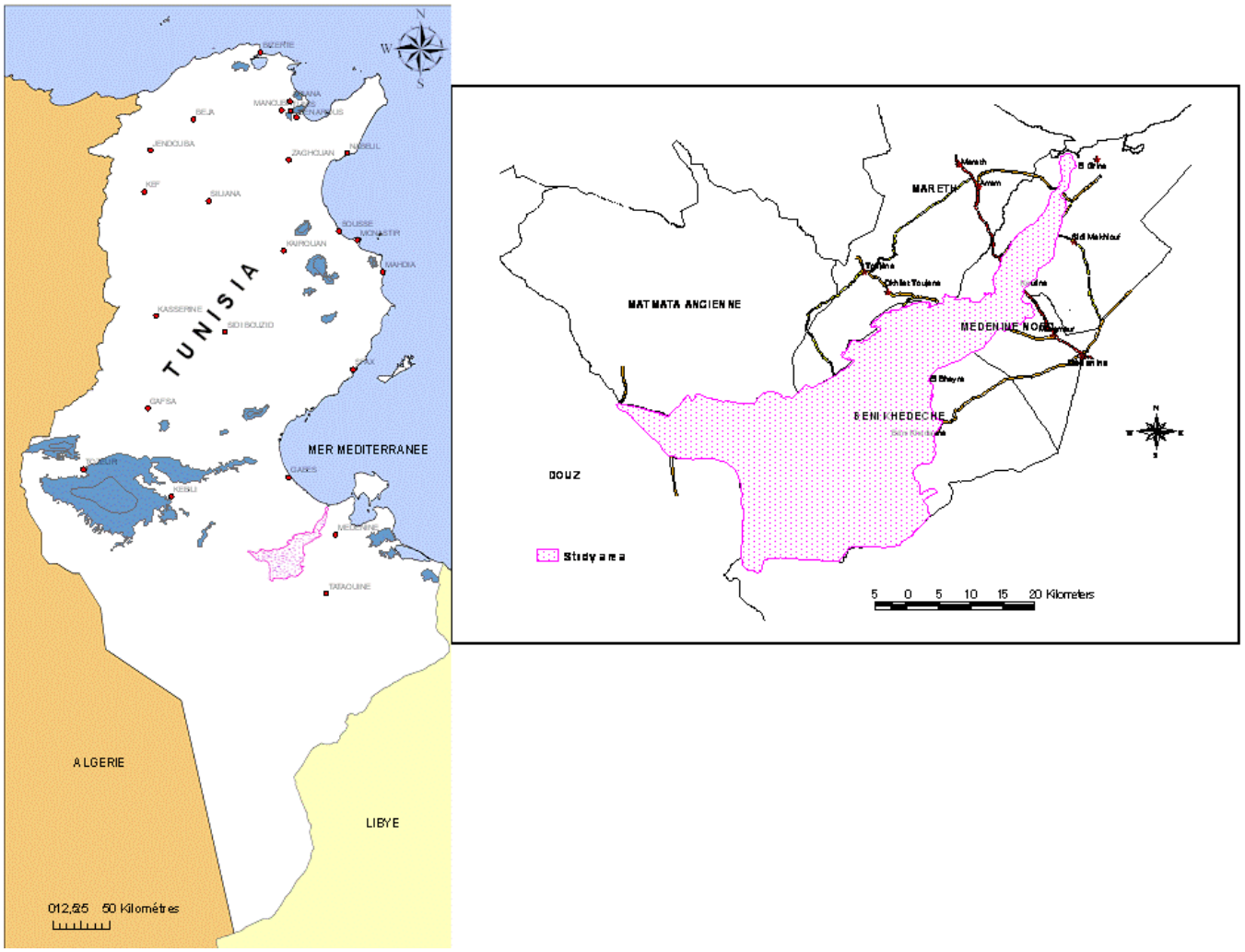
Zeuss Koutine study site, Tunisia

Highlights of work carried out in the DESIRE Project
Based on work carried out at IRA, Tunisia

The study site

The problems of land degradation here are the result of historical changes in land use. The former tribal lands that were used for grazing were privatised and exploited mainly for irrigated crops and rainfed agriculture , especially fruit trees. Competition for natural resources, particularly water, increased. There are new schemes for soil and water conservation, and rehabilitation of rangelands. Strategies will be tested and evaluated, particularly to determine which strategies will be acceptable to local stakeholders.



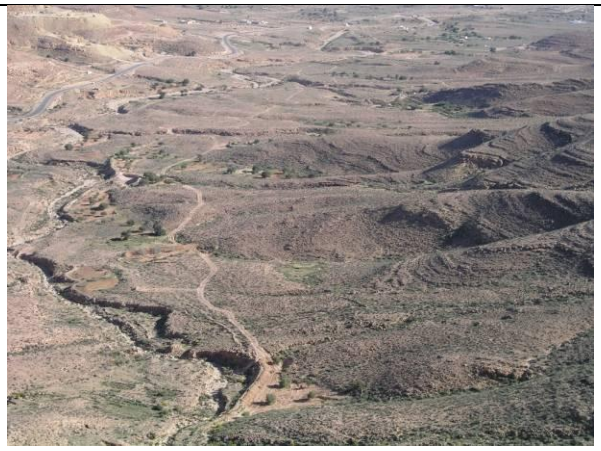
Study site location

The site was selected based on the following reasons:

- From the ecological and socio-economic point view, it is considered as representative of the region of south east Tunisia where the problem of desertification is a major concern,

- Since 1995, many integrated research for development cooperation projects (funded by the EU, CSFD, USDA, Flanders, etc.) have been undertaken in the same region such as: WAHIA (water harvesting impact assessment), MEDRATE (Evaluation of rainfed agriculture in the Mediterranean), GISTUN (GIS for watershed management), Jeffara, SUMAMAD (Sustainable management of marginal drylands), etc.,
- Major development projects have been carried out: soil and water conservation strategy, water resources mobilization strategy, natural resources management and livelihood improvement (World Bank); rural development progrms; basic infrastructures (water, electricity, roads, etc), etc.
- IRA contributed actively in 2006 in the elaboration of the local action plan for combating desertification as part of the NAP-UNCCD in the county of Béni Khédache.

The rapid and remarkable evolutions of the production systems and natural resource exploitation increased with the exploitation of groundwater aquifers by drillings and fast extension of fruit trees orchards at the expense of natural grazing lands after the privatization of collective tribal lands. It resulted in accelerated rated of land degradation and higher risks of desertification.

	
Soil erosion by water	Rangeland degradation by overgrazing

The overall strategy was based on water harvesting and land improvement conditions. Three sites were selected:

* Lathmen : Based on combination of techniques : Jessour, Tabia, supplemental irrigation and resting
* Zammour : Based on combination of techniques : Jessour, Tabia and supplemental irrigation
* Bahayra : Based on combination of techniques : Spreading groundwater recharge and Tabia

The selection of techniques was based mainly on the specifics biophysical and socio-economic characteristics. In addition the local know-how played a major role too.

Bio-physical description

By its position, the climate in the study site is of the Mediterranean to Saharan type. The coldest months are those of December, January and February with occasional freezing (up to -3 °C). June-August is the warmest period of the year during which the temperature could reach as high as 48°C. The temperature in the SS is affected by the proximity to the sea and the altitude. Having an arid climate, the rainfall in the SS is characterized by low averages, high irregularity (both in time and space) and torrentiallity. It receives, on annual average, between 150 and 240 mm in the mountain and eastern parts but this amount decreases rapidly to less than 100 mm in the zones close to the desert. The prevailing winds affecting the

plain and the plateau are: in winter the cool and humid eastern/northeastern winds, and in summer the hot and dry southeastern winds, called *Chhili* or *Guebli*. With high temperature and low rainfall, the potential evapotranspiration (ETP) is very high (around 1321 mm/year) and the climatic water balance is almost negative around the year (Ouessar et al., 2006).

The study site is drained by two main wadis (dry streams): Oum Zessar (367 km^2) looking east while the Hallouf Dahri (530 km^2) is looking west. The average runoff is estimated to 8.74 Mm^3/year (Fersi, 1985).

The study site covers three major geomorphologic landscapes; the Dahar plateau, Jebel (mountain) Matmata and the Jeffara plain. Djebel Matmata crosses the region from the northwest to the southeast the range becomes less massive and is cut into a number of hills of an average height of 400 meters, whereas in the north altitudes reach more than 600 m (Jbel Mzenzen culminates at 690 m). The Djeffara is the coastal plain coming from Gabès, clears into the south at the level of Mareth, into the Djeffara, which also stretches NW-SE, forming the coastal area. At highest it reaches an altitude of 100 meter above sea level, and it ends in the sea (or lagunes/sebkhas). The geological formations are of alternating continental and marine origin. The oldest submerging layers are represented by a marine, superior Permian, and the most recent ones are of the recent Quaternary. In between appear strata of different age, which is generally declining in northward direction.

The most important aquifer is that of Zeuss-Koutine. It is situated between the mountains in the southwest, the submerging jurassics of the Tadjeras in the south-east, and the fault of Médenine in the north east, and consists in layers of jurassic age. It is sustained by infiltrating water from the wadis Zigzaou, Zeus, and Oum Zessar and the C.I. (*Continental Intercalaire*). Renewable resources are estimated to 350 l/s with a salinity ranging from 1.5 to 5 g/l. The depth varies between 170 and 680 m. The second one is that of *Grès du Trias***,** extending from Harboub in the south, the zone of Médenine and Metameur in the east, Wadi Hallouf in the north, and the Dahar fault in the west. Fed by the wadis of the plain of El Ababsa, it dwells in formations of the upper Trias. Salinity ranges from 0.9 g/l at El Megarine and 1.5 at Harboub. Actual exploitation is 128.2 l/s, with the renewable resources estimated at 150 l/s. The average depths is about 150 m. The characteristics of the various deep aquifers in the study were summarized by Labiadh (2003). Except, the Jurassic aquifer of Beni Khédache, the pumping rate of the various aquifers is very important. In addition, the salinity is also high. Shallow aquifers are found in the form of limited resources surface aquifers within less than 50 m depth but with high salinity in most of the cases. They are mostly generated by the subsurface underflow of the big wadis (Labiadh, 2003; Ouessar and Yahyaoui, 2006).

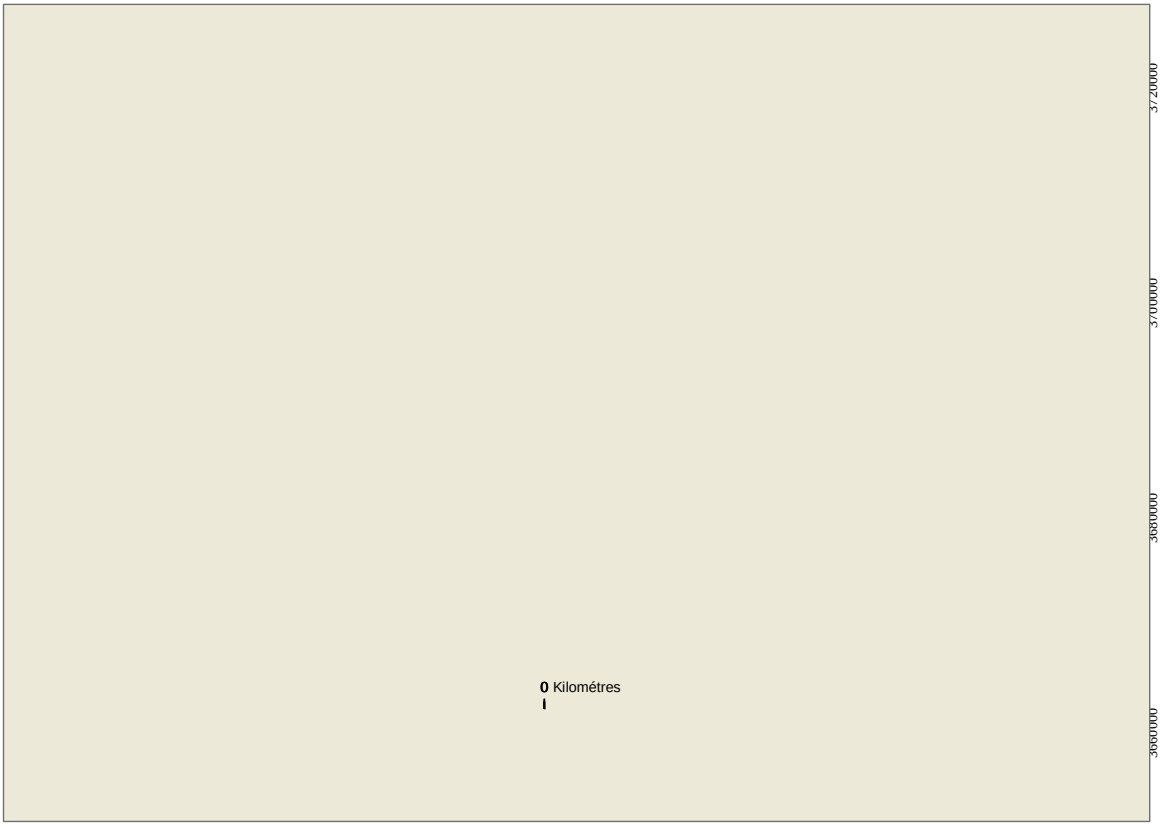
Five main soil classes have been identified by Taamallah (2003):

- *Les sols minéraux bruts (d'érosion)(*lithosols*)* made mainly of dolomites, limestone outcroppings and stony regs. They are located in the upstream area (mountains and hills). They cover 20% of the study area.
- *Les sols peu évolués* (Fluvisols) occupy a relatively reduced area and are found in the plain and the downstream parts. They represent 13%.
- *Les sols calcimagnésiques* (Calcimagnesic) represented by rendzinas on calcareous or gypsum crusting or on the miopliocene. They cover an important area on the upstream and piedmont parts (35%).
- *Les sols isohumiques bruns calcaires tronqués* (Isohumic)*:* They are not very deep soils overlaying on the dismantled calcareous crust of villafranchian and covered sometimes by a shallow (few centimetres tick) of wind deposits. They cover 20% of the region.
- *Les sols halomorphes et hydromorphes* (solonchak and solonetz) are encountered at the level of the depressions (*sebkhas* and *garaas)* on the coastal areas. They are characterized by a very high salinity (12%).

Soil map of the study area (source: Taamallah (2003)

The study area is characterized by a high diversity of the vegetation types. They are linked to several ecological groups whose major part is soil groups (Ouled Belgacem et al., 2003) (Associations of *Anarrhinum brevifolium* and *Zygophyllum album*, of *Artemisia herba-alba* and *Hammada scoparia*…) but also human pressure (Association of *Pituranthos tortuosus* and *Haplophyllum vermiculare*, facies of *Pituranthos tortuosus* and *Artemisia campestris*). This could be explained by the important part of the role of soil and man in the determination of the plant cover in these arid regions of Tunisia. This analysis allowed us not only to locate the main vegetation types which have been determined earlier but also identify new degraded facies of *Helianthemum lippii var. intricatum* of the *Anarrhinum brevifolium* and *Zygophyllum album* association. The determination of these different vegetation types and the spacialization of the field data meaning the GIS permitted the establishment of the vegetation map of 2001 (Ouled Belgacem, 2003). A high diversity of vegetation types was found due to biotic factors (soil water availability, physico-chemical characteristics of soils..) as well as to abiotic factors (topography, human activities). According to the topsequence "amont aval", we can distinguish relics of the *Juniperus phoenicea* and *Rosmarinus officinalis* evergreen garrigue at higher calcareous mountains followed by the *Stipa tenacissima* steppe which dominates the calcareous crust mountains. When degraded, this steppe has been replaced by the *Artemisia herba-alba* and *Hammada scoparia* steppe with its *Gymnocarpos decander* facies. In the piedmont with gypseous crusts, the *Anarrhinum brevifolium* and *Zygophyllum album* is mostly degraded and very often replaced the *Astragalus armatus*, *Atractylis serratuloides* or *Lygeum spartum* steppe. The low-lands are very often covered by steppes of *Ziziphus lotus*, but in "stream beds" the *Artemisia campestris* and *Thymus capitatus* steppe often dominated. The sandy valleys to the south-west of the study area are mainly dominated by a very degraded *Rhanterium suaveolens* steppe which has been generally replaced by different deterioration stadiums of *Astragalus armatus* or *Lygeum*

spartum or its abandoned fallow lands with *Artemisia campestris* and *Pituranthos tortuosus*. Toward the downstream and in the salty closed depressions (sebkhas), the plant cover is generally dominated by halophytes such as *Nitraria retusa*, *Suaeda mollis* and *Limoniastrum guyonianum*. By comparing the dynamic of the vegetation between 1972 and 2001, Ouled Belgacem *et al.*, (2003) found that: 1) An important extension of the cropping area especially in the sites where the topography is favourable for sediment and runoff collection. In fact, the data provided by the GIS showed an important decrease of the pure steppe area between 1972 and 2001 of about 13700 ha (36%) in favor of the cropping area which increased of about 200%, and 2) a high dynamics of the different vegetation types in a relatively short period (30 years). This dynamics is linked to anthropic factors (agricultural development, grazing) favored by the endogenous conditions (physico-chemical characteristics of soils, stock of seeds in the soils…). It was shown also the important extension of crops at the expense of high range value vegetation types covering the good soils (ex: steppes of low-lands). These vegetation types are often replaced by deterioration steps dominated by spiny species of low range values (e.g.: steppe of *Astragalus armatus* replacing steppes of *Rhanterium suaveolens*…) (Ouled Belgacem *et al.*, 2006).



Simplified land use map of the study area (adapted from Ouessar, 2007).

Two major types of combating desertification works have been carried out: water harvesting techniques (WHT) and sand dune fixation (Ouessar et al., 2006b).

A wide variety of water harvesting techniques is found in the study area. In fact, the hydraulic history of this watershed is very ancient (Carton, 1888) witnessed by the remnants of a small retention dam, supposed to be built in the Roman era, near the village of Koutine and the abandoned terraces on the mountains of wadi Nagab in addition to numerous flood spreading structures (henchir Zitoun, henchir

rmadi, etc….) (Ouessar *et al*., 2002; Ben Khehia *et al*., 2003; Ben Mechlia & Ouessar, 2004). The main encountered systems are: Jessour on the mountain ranges, tabias on the foothills and piedmont areas, cisterns, and groundwater recharge gabion structures in the wadis courses. Within the framework of the national strategy for soil and water conservation, huge works have been realized between 1990 and 2000. In fact, there have been the: treatment of approximately 6500 ha in jessour, tabias, etc., installation of more than 175 units for groundwater recharge and flood spreading, installation of more than 10 recharge wells, and safeguard and consolidation of more than 8500 ha.

Jessour system in the mountains of Béni Khédache.

Spreading structure on the wadi Nkim.

The sand dune fixation techniques include:
- *Mechanic fixation:* It is the first step in sand fixation. It consists of creating obstacles against prevailing winds in order to decrease its speed and to enhance sand accumulation in the form of artificial dunes. Two materials have been used: fibrocement plaques which were gradually replaced by dry date palms (Khatteli, 1996).
Squaring: This technique consists of the installation of a network of palisades laid out in chess-board (Khatteli, 1996).
Afforestation and pastoral improvement: This operation consists in fixing the moving sand dunes by plantations ounce the mechanical stabilization is completed. Various forest species, used for combating sand encroachmenet in the study area are divided into two groups (Mekrazi, 2003):
* Introduced species: *Eucalyptus*, *Acacia cyanophylla*, *Acacia ligulata*, *Prosopis will juliflora*, *Parkinsonia, Pine of alep, Acacia horrida, Acacia tortillis, Acacia cyclopis, Casuarina*.
* Local species: *Calligomaum azel, Lycium arabicuim, Atripex halimus, Tamarix*
The Office of livestock breeding and pastures (OEP) practices rangelands enclosures and pastoral improvement by the plantation of fodder shrubs at the level of the private lands (Ouled Belgacem & Genin, 2003). An enclosure of 3 to 5 years allows the vegetation to regenerate naturally without any intervention. The pastoral improvements are carried out with plantation of fodder shrubs: *Atriplex halimus, Atriplex nummularia, Rhanterium suaveolens, Periploca laevigata, etc.* In the Jeffara region, the Afforestation programs, which started in the colonial period along the Tripolitan road in particular, have been continued during the sixties by the Forest services aiming at protecting the agglomerations and infrastructures from sand encroachment. These plantations have been installed on state owned lands or collective rangelands subject to forestry regime. The OEP duplicated the same practices private rangelands by installing enclosures or fodder shrubs plantations in exchange of providing the owners with subsidies for three year period depending on the success of the operation (Mekrazi, 2004). In the study area, almost 25 sites have been identified where the Forest services or the OEP have intervened.

The major degradation processes which need to be addressed are: water erosion, wind erosion, rangeland degradation and drought.

Socio-economic description

The total population is around 151000 inhabitants (in 1994). The population of the study zone doubled between 1975 and 2004. This evolution was marked by the migratory movements especially during the period 1975 -1984. Compared to the rural Tunisia, the average age of household head is rather high (53 years). It is higher in the upstream than in the downstream areas (56.2 years in Béni Khedache and 50.8 in Mareth) which confirms the maintenance of a more long-lived patriarchal authority within the framework of large families in mountain and piedmont zones of than in the plains (IRA, IRD, 2003). The average age of the population of the study zone is higher of 3 years than that observed for the province of Médenine and for rural Tunisia (28.8 years with the survey, 25.8 with the census of 1994). This difference is due to the low relative number of young children, mainly in the age group of 0-4 years, and the emigration (Picouet et al., 2003).

The education level is very diverse in relation to the sexe. The proportion of illiterate men is relatively low and estimated to 8 % for the age between 15 and 49 years. It is estimated to 60 % for the old men who have an age over than 50 years. For women this proportion is higher than 35 % and 95 % respectively for women aged between 15 and 49 years and old women. Less than 50% of the people have a primary education (47 % for men and 43 % for women) and only 4 % got university education for men aged between 15 and 49 years (Picouet, 2003)

The place occupied by the agricultural sector in the province of Médenine can be determined by the importance of the annual income generated by this sector which reached, in 1994, 116 million dinars as well as the percentage of the labor affected to this sector which reached at the same date 19% of the active population. This rate is, however, in continuous regression passing from 26.6% in 1989 to 21.6% in 1994 (MEAT, 1998). This sector is confronted to certain problems, like desertification, scarcity of water, the marginalization of pasture lands. The productivity of certain cropping species remains low and variable and not very competitive. The agricultural production is, in all cases, highly depending of the climatic conditions. Nevertheless, agriculture represents always an important sector with twofold dimensions economic and socio-cultural. It represents a source of subsistence and production of richness and management of risks, on one hand, and a cultural and patrimonial reference, on the other hand.

The traditional production systems combined the concentration of the production inputs on limited areas and the extensive exploitation of pastoral resources. During the last forty, a rapid evolution of the production systems has taken place and it was marked by the exploitation of the natural resources, particularly the increased use of ground water resources by drillings for the extension of irrigated fields and the agro-food industries, as well as the extension of arboriculture on the coastal areas because of land property transfers. In this context, the spatial agrarian complementary systems disappeared and replaced by inter-connected production systems whose dynamic is expressed by a competition for the access to natural resources and especially towards water (IRA, IRD, 2003). The farming systems are marked by their diversity from the upstream to downstream areas. These systems are essentially distinguished by: 1) a non regular agricultural production that varies from a year to another depending on the rainfall regime, 2) the development of fruit trees orchards and the extension of newly cultivated fields at the expense of rangelands, 3) the gradual transformation of the livestock husbandry systems from the extensive mode, highly dependent on the natural grazing lands, to the intensive mode, 4) the development of the irrigated agriculture exploiting the shallow and deep groundwater aquifers of the region, and 5) the predominance of the olive trees (almost 90 %) and the development of episodic cereals. The main encountered farming systems are: System of "Jessour", system of irrigated perimeters, system of olive trees, and system of multicrops – breeding. Arboriculture represents the main agricultural activity in the area. The olive-tree is the main species cultivated in row cropping with other trees (fig, almond) on the terraces of the water harvesting structures. The olive-growing production dominates almost the totality of the agricultural production in the various geophysical zones of the watershed area. The pasture lands, which represent the main support of the breeding sector, cover 187,507 ha in the Zeuss-Koutine regions, that is 3 % of the national rangelands. According to the livestock census 2000 the livestock is made of 98,800 heads of sheep, 60400 heads of goats 1,150 heads of camels. The herd is made on average of 8.5 sheep, 4.59 goats 1.95 camels. This number varies largely from one site to another (Sghaier et al., 2003).

Livestock is an important activity but overgrazing may lead to desertification.

Studies conducted in the region (Sghaier et al., 2003; Sghaier and Ouessar, 2006) showed that the activities of the households providing the main sources of incomes are respectively, paid works (38%), tertiary sector (22%) and agriculture (17%). This diversification of incomes is confirmed by the importance of the households which make recourse to several sources of income (65.4 %) whereas 34.6 % only have only one source of income. Average income of the households is estimated at 2992 DT/year with a standard deviation of 2784 DT/year. a minimum of 300 DT/year and a maximum of 22.000 DT/year. Apparent disparities between the various counties are noticed. In fact, the average annual family incomes are 3337 DT in Mareth. 2906 DT in Beni Khedache. 2764 DT in Northern Médenine and 2684 DT in Sidi Makhlouf.

Concerning the land tenure, following the promulgation of many laws, the process of privatization has been accelerated which encouraged the people to transform the rangelands into cropping fields and now most of the land became private. It resulted in the extension of olive growing orchards at the expense of grazing lands. The evolution of the land tenure is linked to the attribution of the collective lands as private ownerships. The collective situation of the land has undergone a constant evolution during the three main periods (1901-1964, 1964-1974 and 1974-1998). The area of the collective lands decreased from 99,150 ha in 1901 to 19,680 ha in 1998, i.e. a reduction of 80 %. 86 % have been attributed to private owners whereas the remaining (14%) are proclaimed as ranges within forest lands. During the period 1964-1974, the private lands doubled whereas it increased only of 19% between 1974 and 1998 due to the attribution procedures as well as the encountered difficulties at the level some communities. The current land tenure situation of the study zone is characterized by two features: The prevalence of the small sized properties. 50 % of the farms have a maximum area of 5 ha, the property division is rather reduced (Sghaier et al., 2003).

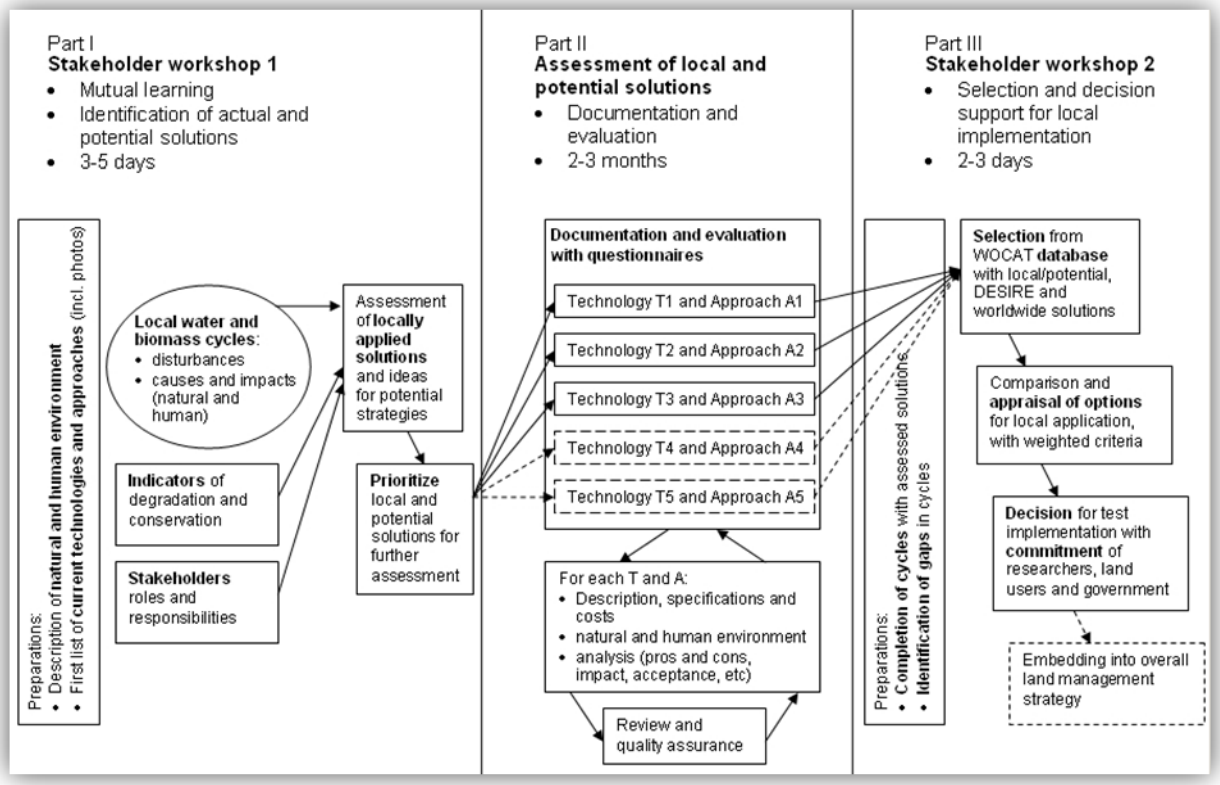
The major degradation drivers are the increased pressure on natural resources due to extension of cropping areas on very fragile soils (sandy soils) and the increased livestock on already degraded rangelands.

Institutional and political setting

The institutional network in the study region is relatively dense made of :

- basic organizations formed by a grouping of agricultural development (GDA), a co-operative of agricultural services (CSA) and 23 groupings of collective interests (GIC);
- 4 NGOs: AJZ (Association des Jeunes de Zammour), ADD (Association de Développement Durable), APBB (Association de la Protection de la Biodiversité à Béni Khédache), ACPPBK (Association de Conservation du Patrimoine), etc.
- Representatives of the central administration/ministries: UTAP (farmer union), UNFT (women union), the ODS (development agency of the south), CTV (agriculture), OEP (grazing and livestock agency)

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.

Meetings of researchers with stakeholders were used to help break the cycle of desertification. Together they discussed and tried out suggestions to find the best ways of reducing the incidence and impact of land degradation while addressing goals for sustainability.

Rangelands in Zeuss Koutine, Tunisia (January 2009) © M. Ouessar

The selected monitoring sites represent the main encountered problems in the region namely: water scarcity and rangeland degradation. Water harvesting techniques (jessour and tabias) are used for the improvement of water content of soil and thus evapotranspiration of plants and trees. Replenishment of groundwater aquifers are ensured through the recharge structures (gabion check dams and recharge wells). Rangeland degradation is cured using the rangeland resting techniques.

Monitoring activities

Meteorology

- Meteo measurements
- Rainfall recording
- Outflow at subwatershed level
- Piezometric levels

Repeated measurements

- Soil moisture gravimetric method,
- Leaf resistance using a porometer
- Plant cover, species diversity/density,biomass, range production.

Agronomical activities by stakeholder

- Dates and type of tillage
- harvest and other inputs
- Animal practices

Yield assessment

- Total yield in kg/ha
- General yield quality or herd/grazing quality assessment
- General impression by stakeholders.

Preliminary results

- The implementation of the SLM technologies have been conducted by a close collaboration with all stockholders who worked effectively together from the phase of planning, through the field execution and the finial evaluation of the completed works.

- As farmers are already well acquainted with the technologies, the implementation was relatively a smooth exercise.

- If the simplification of the monitored parameters to the farmers is absolutely necessary to gain their implication, the involvement of the developments agents is rather an easier task.

- The last year was exceptionally dry (≈ 100 mm). Therefore no major agricultural activities have been carried out.

Main encountered difficulties

- The highly variable rainfall regime and the slow development of local species, typical of drylands, require more patience from the researchers and the other stakeholders.
- Generally, poor farmers are more interested in immediate returns rather than long term benefits.
- Very few stakeholders do care about global impacts (off site land degradation, climate change, etc) as their concern about household living priorities.
- Parallel large development programs with consistent budgets, undermine the effects of small scale research projects with relatively very limited financial resources.

Soil water sampling (left) and leaf resistance measurement (right).

The piezometric level of aquifers and rainfall were monitored by the Water resources division of the Ministry of Agriculture in Medenine since the 90s.

The resting technique activity was s carried out in three sites (Alamet Mechlouch, Beni Ghezaiel and Sidi Makhlouf) within four management modes: RK3: rested rangeland, RK2: moderately degraded rangeland, RK1: overgrazed rangeland, rk: abandoned cultivated rangeland. Several transects of 20 m long each, were established in the different representative plant communities of the target rangeland, and used to determine plant cover parameters according to the points-quadrats method .The monitoring concerned the evolution of some descriptors (global plant cover, specific frequencies, flora richness, the plant density and the range biomass production as well as the grazing capacity). The experiment was conducted during four years: spring 2007 (initial state), spring 2008, spring 2009 and spring 2010.

Rested and overgrazed sites in the Stipa tenacissima rangelands (up) (3) and field monitoring measurements (bottom).

Priority Remediation Technologies

The scoring of the technologies at the second stakeholder workshop (2008) and the final workshop (2011) at the three sites (Bhayra, Lathmane, Zammour) are given in the following table.

Bhayra	Score 2008	Score 2011
Stone ridges	5.0	
Flood spreading & Recharge units	5.1	5.3
Tabia and jessour	6.6	5.4
Cisterns	4.9	
Range resting	5.0	
Medicinal herbal and aromatic plants	2.9	
Supplement irrigation	5.6	

Lathmane	Score 2008	Score 2011
Stone ridges	7.0	
Flood spreading & Recharge units	6.6	
Tabia and jessour	8.0	7.4
Cisterns	4.9	
Range resting	4.9	5.1

Medicinal herbal and aromatic plants	3.7	
Supplement irrigation	6.3	5.2

Zammour	Score 2008	Score 2011
Stone ridges	4.3	
Flood spreading & Recharge units	6.9	
Tabia and jessour	7.4	3
Cisterns	6.4	
Range resting	4.7	
Medicinal herbal and aromatic plants	7.1	
Supplement irrigation	6.1	5

The analysis of table shows that, except flood spreading & Recharge units and range resting, there are practically lower scores for most of the assessed technologies. However, it was noticed that for the jessour, the score falls from 7.4 to 3 in Zammour zone, reflecting either a dissatisfaction with respect to this technique or an initial overestimation of the impacts. This result should be well explained through additional and further investigations.

This table was discussed with the stakeholders (especially farmers) who mentioned that:

- The same evaluation criteria have been maintained,
- Due to the short monitoring period and the occurrence of droughts, the farmers focused on priority technologies,
- Focus was made on the technologies having direct impacts on the income of the farmers.

3How can we enable priority remediation options to be adopted?

In order to enable priority remediation options to be adopted:

- Consolidate further the synergies between research programs and development projects so as to ensure a rapid and smooth promotion of remediation strategies.
- Ensure maintenance of traditional techniques and local know how in the management of natural resources while introducing improvements where it is relevant. However, site specific conditions should be taken into account.
- Integration of those remediation strategies in the regional/local action plans for combating desertification and climate change impacts mitigation.
- One of the major obstacles that needs specific attention is the migration of rural population into the cities for the search of alternative income generation sources and better living conditions. Therefore, diversifying the economic activities in those areas is a corner stone for any sound sustainable development plans.

Feedback from participants

- The participants said that it was a very good opportunity to debate frankly key issues relevant to the management of the natural resources in the region. Others participants requested to organize more frequently such events.
- They highly encouraged the synergies between all the partners: research, development, policy, regional and international cooperation.
- Though the direct contribution of the project was relatively not so very important, the farmers were very enthusiastic about the undertaken actions.

- The major challenge: how we can have significant impacts with limited funding and harsh natural environment.

WATER HARVESTING

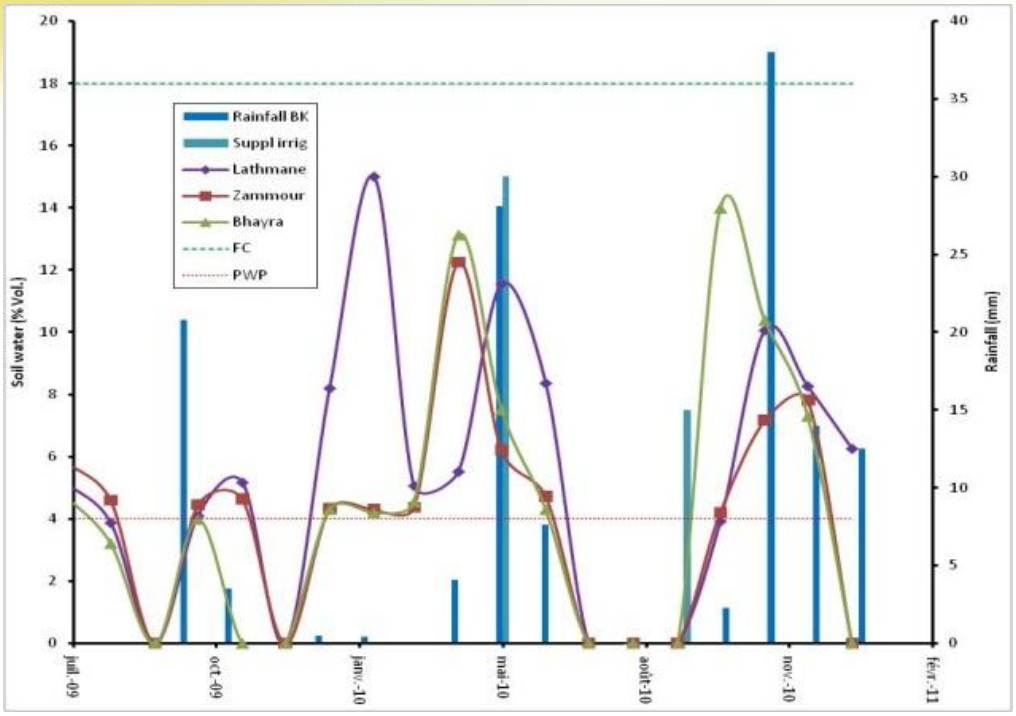
The Zeuss Koutine area in Tunisia suffers from over exploitation of the aquifers, and extension of orchard cultivation at the expense of natural grazing lands. Severe long drought periods reduce soil water content to levels where olive plantation can suffer enormously. Traditional water harvesting techniques (Jessour and Tabias) are used for the improvement of water content of soil. Replenishment of groundwater aquifers are ensured through the recharge structures (gabion check dams and recharge wells). However, current cropping levels versus water availability may not be sustainable. The experiments are geared towards monitoring water levels, as the water harvesting techniques are well established.

Jessours and Tabias are variations of a system of water harvesting whereby checkdams along flat valley floor capture the runoff water and sediments from the surrounding slopes (called impluvium). In the central flat area behind small dams dam (Tabia) fruit or olive trees are grown. Ratios of surrounding Impluvium versus cropped area vary from 6 to 20. The differences between the tabia and the jessour systems are that the former contains two additional lateral bunds (up to 30 m long) and sometimes a small flood diversion dyke (Mgoud). Besides their water harvesting qualities, these systems also have a positive effect on soil erosion and groundwater recharge. At three sites, gravimetric methods were used to monitor soil water at different depths: 0-20 cm, 20-40 cm, 40-60 cm, 60-80 cm, and 80-100 cm. The piezometric level of aquifers and rainfall were monitored by the Water Resources Division of the Ministry of Agriculture in Medenine since the 1990. Apart from rainfall also irrigation supply was monitored.

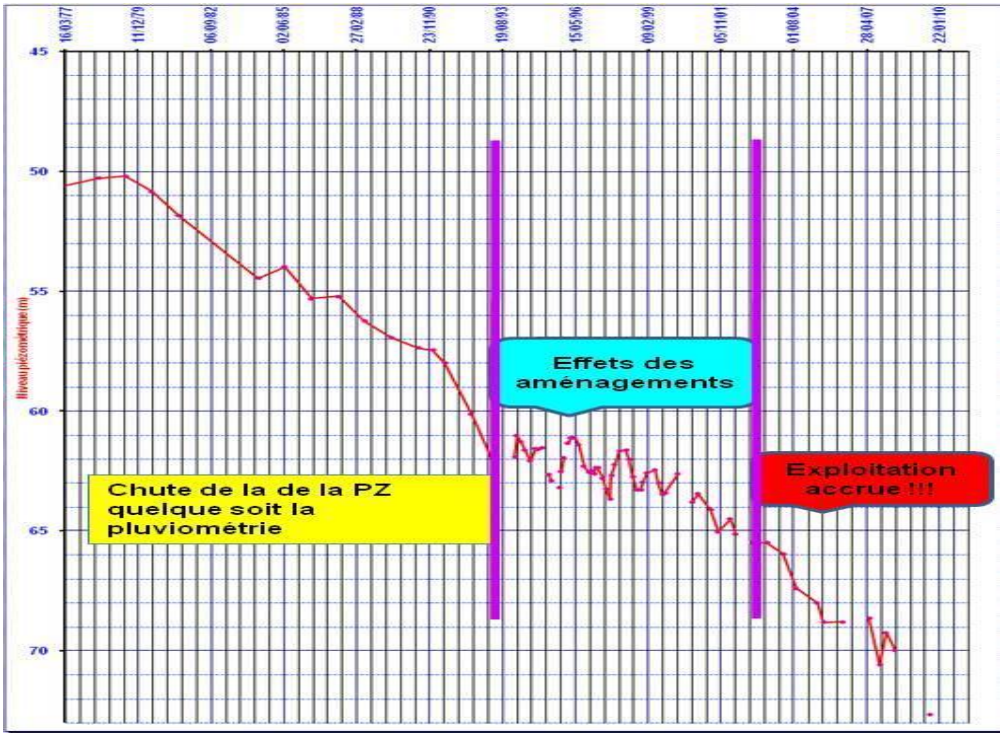
RESULTS

The observation period lasted for one and half year which was an exceptionally dry period. No runoff was recorded from the impluvium and the only supply of water was the rainfall itself. Consequently, the soil water content was very low in the three sites especially during the summer time which did not reach the field capacity throughout the period (see graph below).

The monitoring year happened to be exceptionally dry. The total recorded rainfall was 132 mm in Béni Khédache while the average annual rainfall is around 220 mm. Due to high spatial variability of rainfall and due to logistic reasons the monitoring of soil water was discontinued.

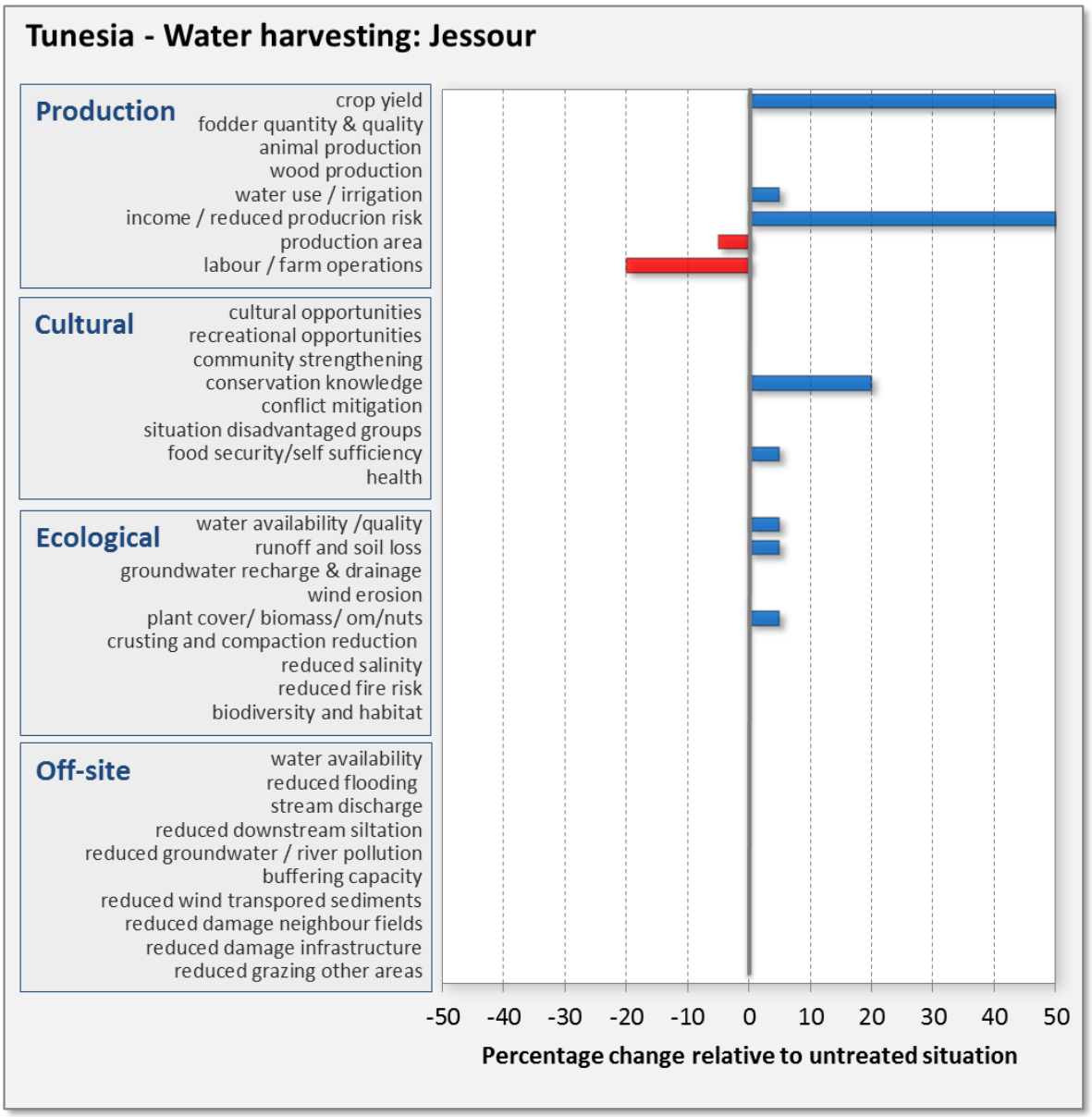


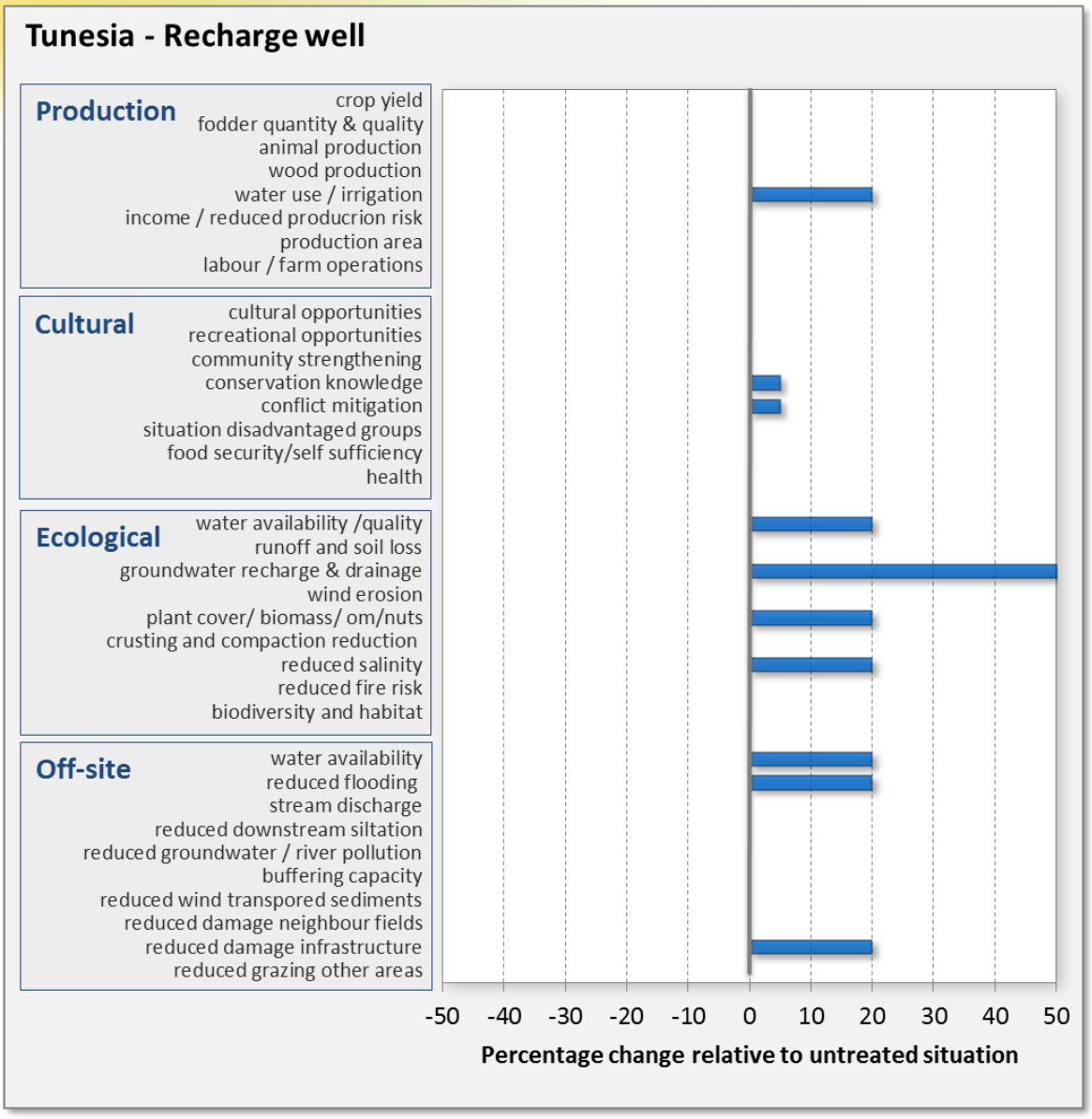
Irrigation from groundwater was supplied 2 times to prevent Olive crop failure. The use of irrigation water can be seen directly in the lowering of the local aquifer system (see below). There is no reaction of the groundwater to the rainfall as this is evaporated entirely. These systems are local and react fast to pumping and are therefore vulnerable. They are replenished by wide check dams across the valleys but in the dry years of the experiment this did not occur.



Evaluation

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'S OPINIONS

The stakeholders meetings show the technology as well adapted technique for the environment (90% of the land user families have applied the technology).

The evaluation shows that the Jessour/Tabia is evaluated positively and without there would be a severe risk of crop failure. This is offset by maintenance to the dyke system and some loss of production land (flat valley floor is used for checkdams). The recharge well is positively evaluated for its bio-physical effects and effect on available irrigation water, but has no direct production value.

RANGELAND RESTING

The Zeuss Koutine area in Tunisia area suffers from the exploitation of pastoral land. Ever since the ground water has been exploited by means of drilling a lot of pastoral land was converted into irrigated cropland or orchard. This has increased the pressure on the remaining land causing over grazing and associated soil erosion problem. An experiment was carried out to improve plant cover and biodiversity in the grazing areas aiming at minimizing land degradation.

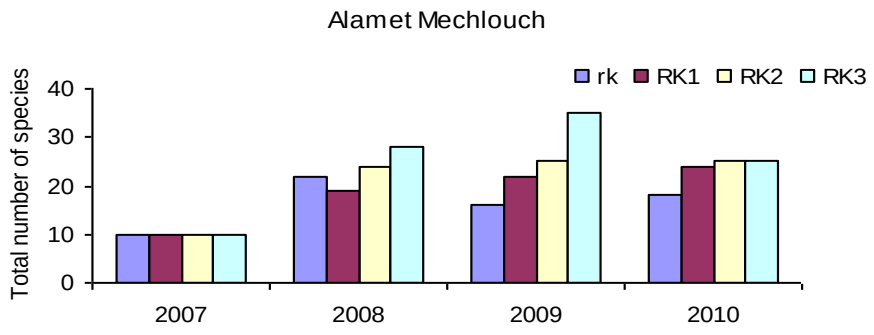
THE EXPERIMENT: SET ASIDE A PART OF COMMUNAL GRAZING LANDS

The resting technique was carried out on three sites (Alamet Mechlouch, Beni Ghezaiel and Sidi Makhlouf) within four management modes: RK3: rested rangeland, RK2: moderately degraded rangeland, RK1: overgrazed rangeland, rk: abandoned cultivated rangeland.

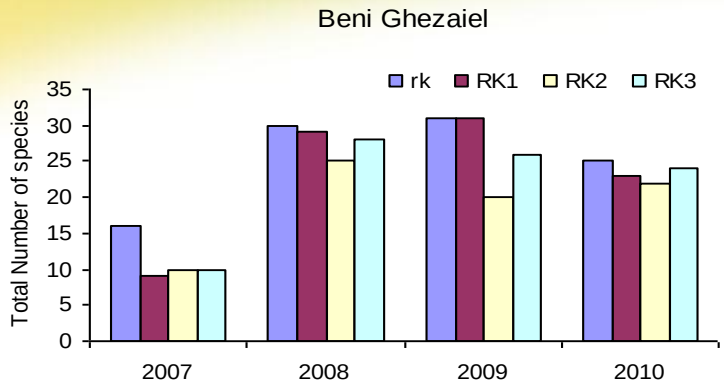
Several transects of 20 m long each, were established in the different representative plant communities of the target rangeland, and used to determine plant cover parameters according to the points-quadrats method. The monitoring concerned the evolution of some descriptors (global plant cover, specific frequencies, flora richness, the plant density and the range biomass production as well as the grazing capacity). The experiment was conducted during four years: spring 2007 (initial state), spring 2008, spring 2009 and spring 2010.

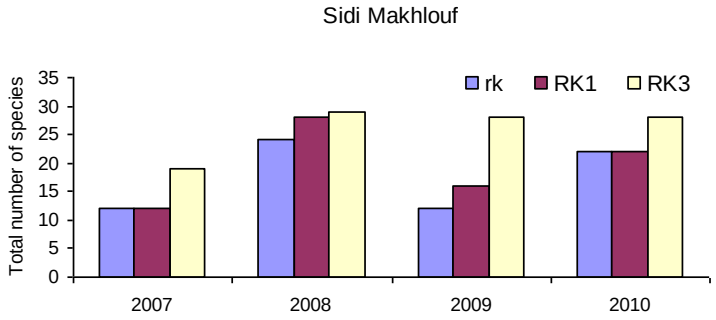
RESULTS

The experiment shows that there is an increase of plant species when the plots are rested for several years. The the number of species already doubles from 10 to >20 in the first year of resting and fluctuates after related to lacel circumstances. The degraded plots (RK2) have the lowest species number (see figures below). In all the sites, the beneficial effect of resting on plant diversity is clear.

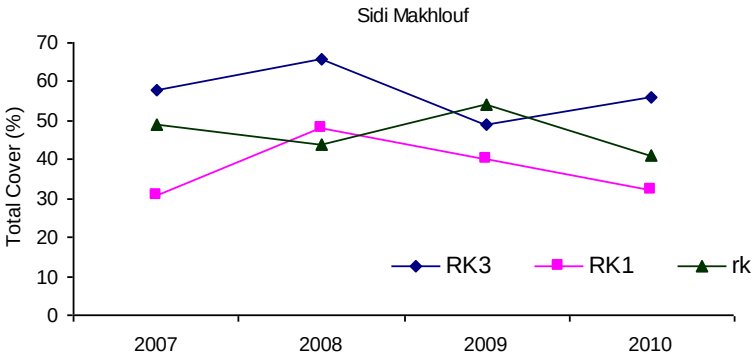


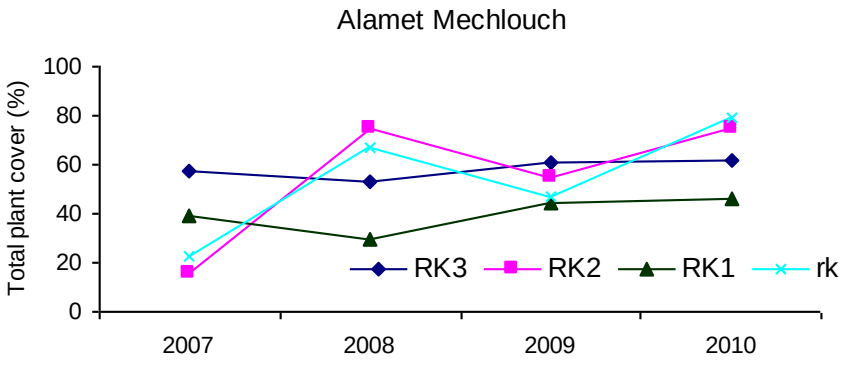
This effect may be hidden by the climatic conditions of the year. In rainy seasons, annual species are very abundant also in degraded sites.

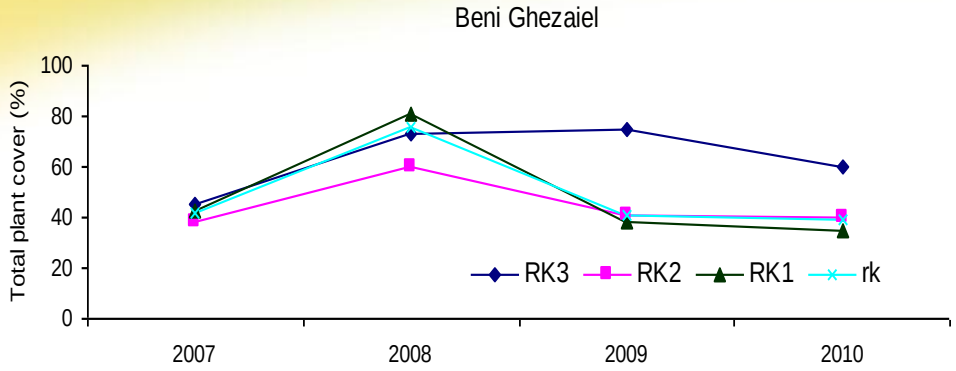




The resting technique also helps in improving the total plant cover (see figures below). This is more obvious in dry periods when only perennial cover can be observed.







EVALUATION

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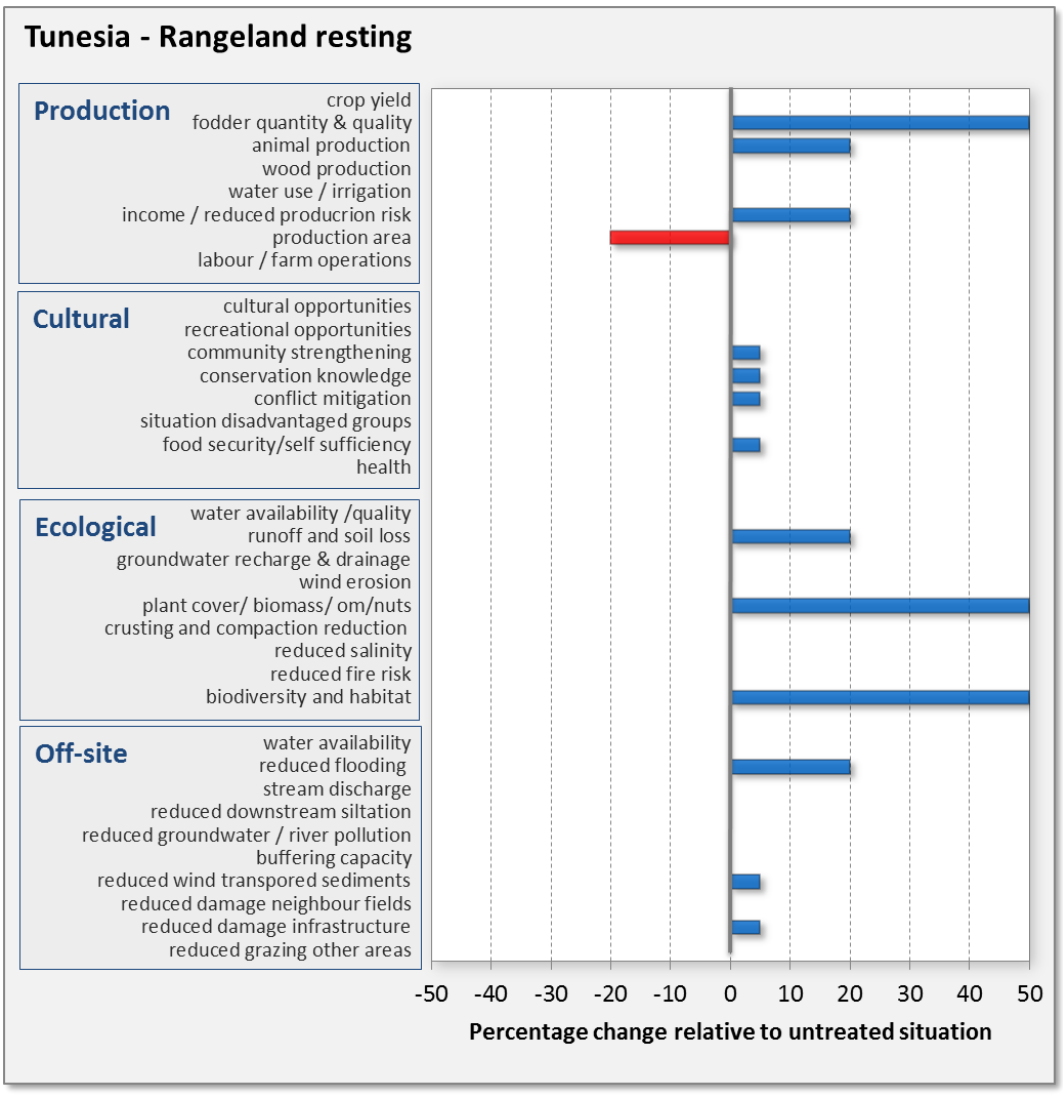

STAKEHOLDER OPINIONS

The stakeholders meetings show the technology as well adapted technique for the environment. About 10% of the land user families have applied the technology with external support and 1% of the land user families have applied it without external support. This support is needed because resting means land is taken out of production temporarily and with current animal stocking levels this means either subsidy in the form of fodder or an increased risk of overgrazing the remaining area.

Conclusions

The rangeland resting technology helps increase plant cover and plant biodiversity, especially in dryer years, as compared to conventional grazing land. In wetter years the degradation is less visible, so resting is especially beneficial for resilience: recovery in dry years.

To make the technology successful and sustainable it has to be accepted by the people. It could mean change of grazing culture (planning of resting areas which is agreed upon by the community and adapting to less grazing areas. This needs management of the communal lands and in the beg7inning possibly extra subsidy for fodder .

- The implementation of the SLM technologies have been conducted by a close collaboration with all stockholders who worked effectively together from the phase of planning, through the field execution and the finial evaluation of the completed works.
- As farmers are already well acquainted with the technologies, the implementation was relatively a smooth exercise.
- If the simplification of the monitored parameters to the farmers is absolutely necessary to gain their implication, the involvement of the developments agents is rather an easier task.
- The observation period was exceptionally dry (≈ 100 mm). Therefore no major agricultural activities have been carried out. However, it was an opportunity to assess the role of the implemented techniques in coping with drought and consequently also with CC which will become a major concern in the coming decades.

The water harvesting technique increases farmer's income and it is very popular. The system is fragile and crop failure cannot be prevented without outside assistance in very dry years. A wider hydrological research is necessary to see how resilient the groundwater system is.
The technology is well known by the local population but training is necessary for the younger generations to make them aware of the wider setting.

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During the period January 2007- January 2012, this work was carried out by:
Dr. Mohamed Ouessar

See: http://www.desire-his.eu/en/zeuss-koutine-tunisia for full details of DESIRE research