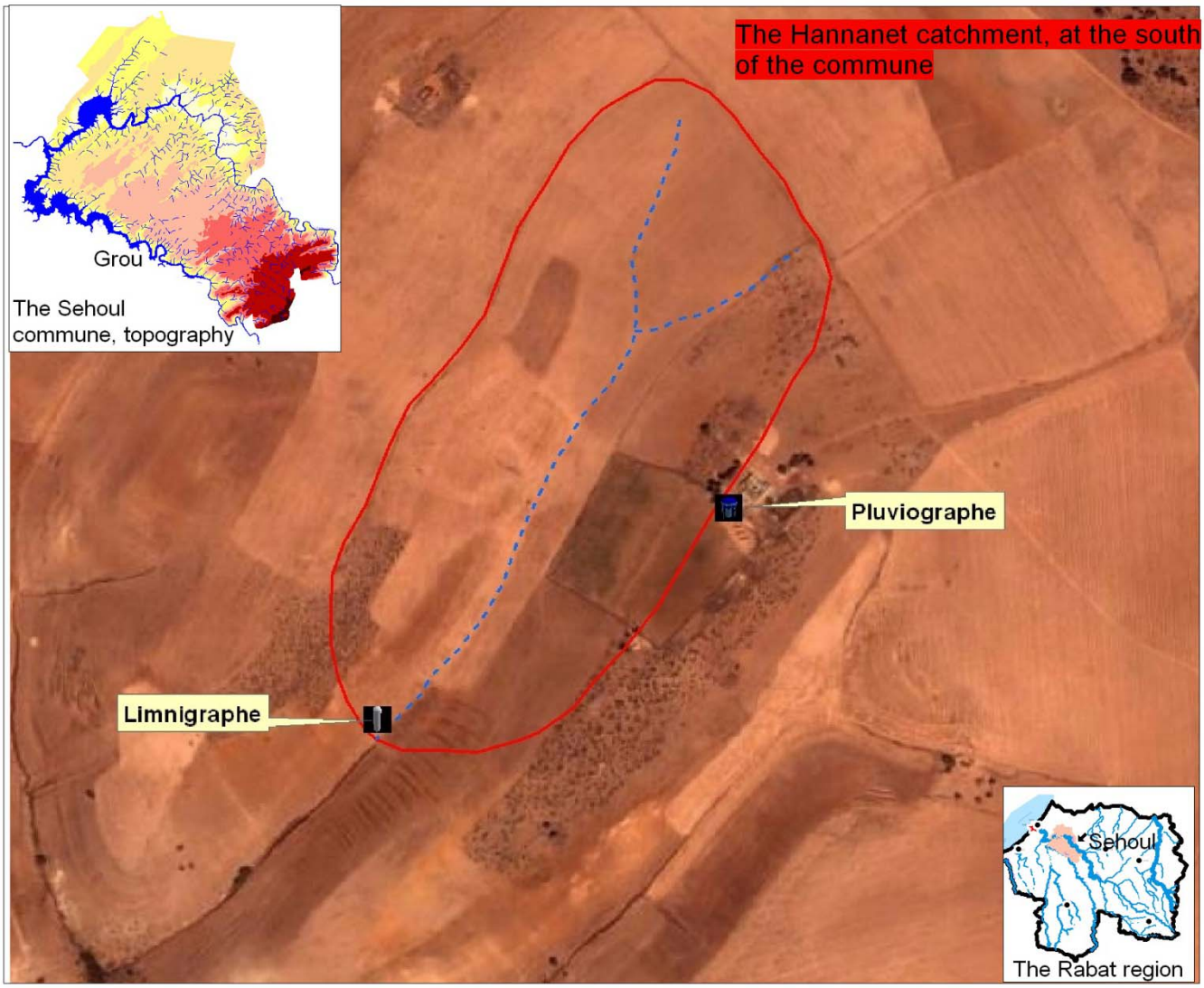
WB 4 - MONITORING AND IMPLEMENTATION



The experimental field, the Hannanet catchment, close to the Grou valley

Sehoul commune, Morocco
Site Implementation Plan, for SLM monitoring (Conservation technologies and approaches)

Site Implementation Plan

A

Site Information

Site: The Sehoul commune Nr 11

Site Coordinator - Partner: Mohammed V University, UNESCO-GN Chair

Joining Partners:

-INRA, National Institute for Agronomic Research

-DPA, Provincial Direction of Agriculture

-CRF, Centre for Forest Research

-ENFI, National School of Forest Engineers

-ABHBR, Hydraulic Watershed Agency of the Bouregreg

-Local representation of IRD (France) in Rabat

B

Summary

(Brief summary of the problems at this particular location and the SWC chosen, summary from WB3)

The existing agro-system in the Sehoul region which has many positive effects, in social and environmental terms, can be rather inefficient; the economic income from this association grains/breeding is irregular. The annual production is less than 15q/ha and the income under the severe dry climatic conditions of some years is not sufficient to maintain a sustainable equilibrium. As the possibilities for diversification of the production are limited to some great farmers and as the development of breeding is exposed to risks, the adoption of other activities and emigration seem to represent now the unique options for small farmers to respond to the scarcity of their income.

For all these reasons, the Sehoul environment is characterized by soil erosion and land degradation. But, because of poverty and the absence of traditions of the resources protection, this has not lead to investment in adaptive management strategies. There are, however, several measures, like crop rotation, mobile breeding, ploughing along the contours which signify the will to restore soil fertility and reduce soil degradation. But the indicators of degradation are much more important than those of conservation.

Following the workshop organized in June 2007, the team of research worked in the field, with the participation of Master students, for the evaluation of the state of degradation and the techniques of WSC. The Wocat tools - questionnaire technology and questionnaire approach - were used, to evaluate the practices comprising a dimension of conservation.

The results were presented to the stakeholders within the framework of two workshops. The first one was organized with technicians who delivered their opinion on the procedure of evaluation and discussed the validity of the results. The participative approach of the evaluation and the choice of technologies to be adopted were performed during a second workshop, in December 2008, with the farmers, the local technicians, the elected officials and associations.

8 of the presented options were classified on the basis of 12 criteria, economic (cost of production and of implementation of SWC technology, agricultural yield, animal production, general income), ecological (recharge of the groundwater, density of the plants and soil cover, fertilization, reduction of the soil loss), and socio-cultural (social cohesion, organisation of the population, job creation, valuation of the land, reduction in the working hours and time availability for other activities).

For every indicator the participants were invited to score each of the 8 options, considering each of the 12 criteria. The phase of the scoring allowed engaging discussions about the validity of every option with regard to these various criteria. The attribution of every score was held only if justified and accepted by all the participants (except particular rare cases, where certain actors were not able to be convinced).

The farmers had a predominant role in term of scoring. Their choice was for the conservation of the current system based on cereals and grazing, to add a minimum of innovations, and to minimize the effort necessary to implement these innovations.

That is why they gave privilege to the solution of grass strips, because cereals will remain dominant between these strips and because the latter will serve as a fodder complement.

Our group had to make the choice for the techniques recommended by the workshop, but also to implement those which seem to be feasible:

a- Implementation of permanent grass strips between annual cultivations; but we discovered many constraints to implement this technique and had to cancel this project;

b- Improve of the land cover in autumn, before the first rains, in cereal fields, by the conservation of mulch and the choice for minimum tillage,

c- Protection of slopes affected by gullies and rills by the plantation of fodder trees like atriplex.

The choice for mulch and better tillage was made to follow the desire of farmers to continue on cereal system and our will to prove that it is possible to conserve the soil on quite steep slopes devoted to annual cultivations by the introduction of some small innovations.

The choice for the vegetative protection of gullies can be explained by the will to demonstrate that the grazing areas can be more productive and at the same time less eroded if the soil cover is improved.

The implementation of WSC techniques

The techniques implemented are:

- The gullies treatment

Although limited in space, gully erosion removes and transports large volumes of material, and the risks it creates to the stability of the slopes located upstream are very high. The selection of species adapted to this environment is very important and the decision was to plant Atriplex halimus. The technology implementation in the gullied area in Hannanet was made by strips (with a distance of 6m) to stabilize the gully, and stop the movement of the soil.

The Hannanet gullies in November 2008

Gullies planted wit atriplex in July 2009

Irrigation of the atriplex during summer

The atriplex strips in autumn 2009

- The improve of land defence by conservation of mulch and by adapted tillage

The technique consists of mulch covering the soil with a protective layer as uniform as possible to protect against the wind and prevent the direct effect of first rain on the floor. Keeping as much as possible the crop residue on the soil, improve several soil properties (regeneration of organic matter, infiltration and water conservation, aggregation of particles), also content of nutrients (nitrogen, phosphorus, potassium...) and limit the impact force of the first drops of rain. This method has been applied in two plots, the first at MATLEG and the other in HANANNAT.

The field with residues conserved after harvest

Seeding the field without ploughing in December

The use of a herbicide before seeding

A major constraint during seeding, the accumulation of residues

A second constraint is the number of pebbles in the soil

The hydrologic station

The team installed a rain gauge and equipped in September 2008 a small catchment with a V-nodge, in order to obtain a general overview of the functioning at this scale.

Discharge measurement with a V-nodge and a limnigraph (pression), with the constraint of sediment accumulation behind the channel, during flood events

C

Location description

Coordinates: Lat. 33.859921, Long. -6.638768

Situation : a small catchment, with large area covered mainly by annual crops representing the control fields with what can be considered the normal local land use in this area. Some small plots receive SLMs:

- agronomic measures (conservative ploughing, mulch)
- Plantation of atriplex in the gullied area

Physiographic setting :

The plots are located on a slope of about 15 %

Soil : Red soil with stones in its top horizon on the slope. The original texture: sandy loam and stones; but the erosion on slopes often washed the fine material and let a concentration of stones on the surface.

The remnant soil is fragile and its structure is very weak, it is often covered by a crust.

Geology : Paleozoïc sandstones and shales.covered by old Pleistocene terrasses , made of pebbles and sand

Annual rainfall and seasonality information: 480-500 mm rainfall annually, single rainy season from October to May.

General landscape around the study site : view from North to south

At the plot scale, the normal land use type in this area corresponds to wheat or barley cultivation; only some limited slopes have other cover; one small plot on the western side conserved the matorral and the original thick soil; another plot is planted by grapes; a third one is planted with eucalyptus; some plots are abandoned to long term fallow because their state of degradation (loss of their soil in certain cases, or development of gullies in others).
In the annual cultivations (cereals, beans, lupine…), the soil is ploughed by animal traction or mechanically. Grazing during summer consumes the whole residues. In September, the soil is completely bare. Sheet erosion and gully erosion export important amounts of material.

D

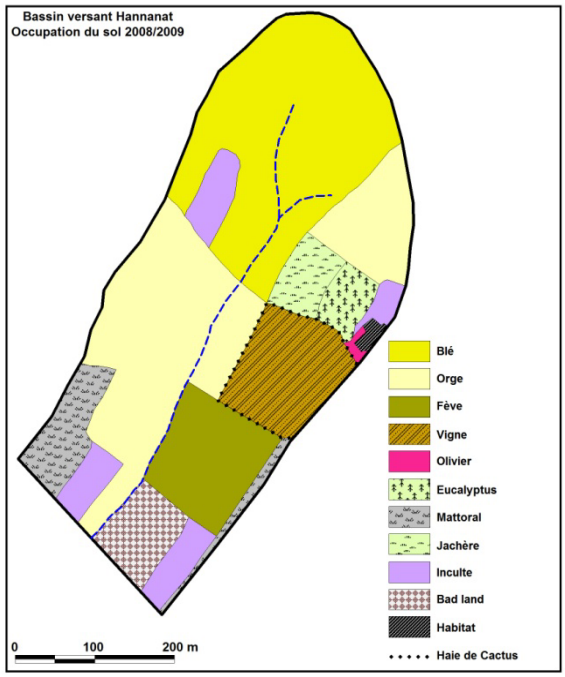
Stakeholder information

Landowner name: Mr Mohammed, his father and brothers

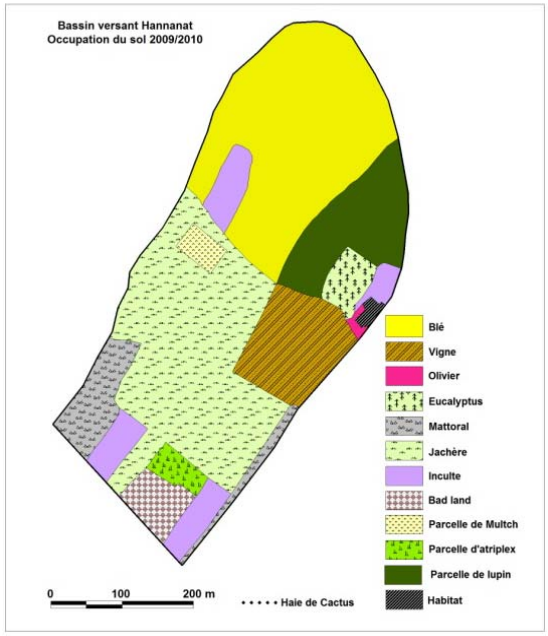
Level of input (e.g. mechanization): Good level of mechanization; normally all the cereals cultivations are prepared by tractor. The Farmer has other activities, as breeding, but the agriculture represents his main source of income.
Main activity on this location: arable farming
Other stakeholders (if active at this location): none, but we tried to involve the local technicians of Agriculture and forests.

E

Land use



Land use in 2008-2009



Land Use in 2009-2010

Crops (and rotation) : single Barley or Wheat crop in Biannual rotation crop/fallow; fallow remaining one or two years, in relation with the amount of rain in autumn. The fallow fields are used for grazing. Nowadays, Fallows are practiced less and tend to disappear completely, causing a decline in soil fertility.

Crop calendar & tillage practices: tillage with mechanic traction in October or November, sowing after first rain. Weeding by hand. No pesticide application, Harvest manually, normally at end of June.
Chemicals (fertilizer, pesticides) applied: manure when cattle grazes on fallow fields and after harvest; + Chemical fertilizers

Irrigation: none
Natural vegetation, main types and species composition: *chamaerops humilis* on some remnants of the matorral
Some trees of cactus opuntia on the hill summit
Plantation of eucalyptus in a plot close to the house
A vineyard for grapes, fenced by cactus opuntia
Stocking density of animals: farmer owns cattle, ships and goats

F

Conservation measures and experimental setup

Experimental setup:
1-The behavior of the various types of land use, by comparison between:
-the parcel of land still covered by original matorral,
-the plot planted with eucalyptus,
-the vineyard, planted along contours,
-the plots continuously cropped with cereals (monoculture)
-the plots with rotation cereals / beans or cereals / lupine
-the plots abandoned to long term fallow, after deep soil degradation
-the gullied plots .

2-Experimentation of mulching and minimum tillage
Expected effects:
Mulch will reduce evaporation and conserve soil moisture. It will also provide resistance to rain splash and to runoff.
The cover of mulch protects the soil against water erosion, preventing leaching and runoff. Along with this, mulch helps improve soil fertility. It regulates and reduces temperature, inhibits the mineralization, resulted in better retention of water, especially during critical droughts. Over the years, the system of direct seeding promotes the process of soil biological activity.
The use of Herbicides is necessary to control the development of herbs between the crops.

In addition, crop residues are a new source of organic matter to the soil surface.

3- Gullies are specific areas where were planted Atriplex trees by bands with a distance of 6m in between to stabilize gullies, and stop the movement of the soil
The Atriplex is able to grow and reproduce under conditions of rainfall between 100 and 400 mm of rain per year. But in our case, as planting was delayed it was necessary to irrigate in summer.

There are two objectives for this plantation: The main objective is to improve the pastoral productivity. Which is the main original way of life in this region, until the middle of the 20th century; The second objective is the reduction of sediment yield and to stabilize the flow.

The solution of planting Atriplex which gave the best results so far, has a similar orientation to the needs of farmers in the region, it is based on the possibility to replace the dominant cereal crop in the region, such as barley, by fodder shrubs which, thanks to their great ability to resist to drought, and to the soil improvement by the addition of organic matter, can have had beneficial effects on the environment and restore the fertility of the ecosystem.

The use of Atriplex fodder in fragile and degraded environments, such as the badlands, characterized by degraded soils can give excellent results. Thanks to its strength and its hardiness, the plant grows vigorously even after being cut and grazed.

G

Monitoring activities

The monitoring of soil, vegetation and dynamics of water, in various plots in the catchment, cumulated with the hydrologic follow-up at the outlet will allow to run a model in order to obtain a spatial functioning of the catchment and to determine the hot spots inside it (the plots responsible of delivering runoff and erosion).

A- In the whole catchment: the general functioning

Meteorology

Meteo measurements by a rainfall gauge, installed on top of the hill. Rainfall amount and intensity are recorded

One time measurements:

Soil parameters at measurement points, which correspond to the various plots determined by the superposition of the land use map on the topography and the soil distribution : texture and stoniness, organic matter, saturated hydraulic conductivity, porosity, depth. Ksat, porosity and bulk density are measured with 100CC sample rings

Repeated monitoring and observation (2 weekly):

a. Regular soil surface assessment (crusting/surface structure, roughness,

The random roughness is measured using a pinmètre consists of several pines of equal length. Sampling is done randomly within measurement plots.

The measurement of cohesion is made using a TORVAN, 10 measurements per plot in different places

The penetration resistance is a means to determine the carrying capacity load of soil and the ease with which the roots will penetrate to reach deep. The measurement principle is to enter a graduated rod into the ground, whose resistance is measured using a spring that provides directly the value on a scale calibrated in kg/cm2. The methodology for each sample is taken with a penetrometer 10 measurements per plot in different locations to determine the average penetration.

b. Crop characteristics: height (cm), cover fraction

-coverage and vegetation height

Determining the rate of plant is covered by the point quadrat method which involves taking readings at 100 points along a meter tape of 1 meter in length. Reading is the reduction of a plot to the size of a point for every inch.

- The leaf area index (LAI)

The sampling procedure is to collect 20 leaves representing the whole plot with the distinction between different species and taking into account their frequency and size of leaves.

c. mulch cover fraction, digital analysis using 1m^2 frames at sample locations
d. Erosion features (rill and gully density and dimensions)

All incisions that were identified and measured the width and length of trenches are measured every five meters along the incision.

Repeated measurements (monthly for most, 2 weekly for humidity):

Soil moisture with portable TDR probe (0-6 cm depth), average of 5 measurements per sample location. Frequency 2 weekly and after rainfall. The humidity measurements are made with TDR to take each sample at different locations, 5 measurements per plot to determine an average moisture content for each plot,

Surface roughness (max difference microrelief in cm)

Infiltration rate, using double ring infiltrometer (mm/h): Infiltration is measured using a double cylinder infiltrometer implanted in the soil. The outer cylinder is filled with water to saturate the soil around the central cylinder and also to limit the lateral flow of water infiltrated into the soil from the latter to promote vertical flow of water.

Continuous measurements

Discharge measurement with a V-nodge installed in September 2008

The flow measurement requires the installation of the weir at the outlet of the watershed with a pressure gauge. The gauge measures the pressure variations caused by changes in water level, with a permanent record of 2min repetition.

Radio-isotopes measurements

7Be is a natural radioisotope with short half life of 53 days. Its production is relatively constant. 7Be is also highly adsorbed by fine soil particles but only in upper soil surface, about 4cm, because of its short half life. Its analysis is based on comparison between site inventories and local reference inventory. 7Be technique informs on soil redistribution related to rainfall event. Rates of soil loss and gain are given by using converting models.

7Be technique can also be used to study the efficiency of sustainable strategies of soil conservation. Indeed, after use of the selected soil conservation technique, because of its short life, 7Be can inform if this technique contributes to preserve soil from degradation.

The samples will be taken in the field two times, one year and 2 years after implementation of the conservation measures.

As we already had results on soil erosion rates, by applying 7Be technique, in three agricultural fields since last year (2009), this year and next year we will study, by using the same technique (7Be technique), the impact of permanent grass trips between annual cultivations and conservation of mulch, implemented in those fields.

Also starting from this year, by using 7Be, we will monitor the effects of atriplex trees plantation to remediate gullies and rills.

Surface runoff in the catchment will be modelled using the event-based LISEM which simulates surface runoff and erosion for individual rain events. LISEM works with maps of soil physical, soil surface and crop parameters. These maps will be constructed by attributing parameter values to the various fields based on their land use and soil type.

Agronomical activities by stakeholder:

e. Dates and type of tillage: ploughing, sowing, weeding, harvest
f. Application of chemicals/fertilizer etc
g. Animal practices (stocking density)
h. Other input (fuel, labour, time)

Yield assessment:

i. Total yield in kg/ha
j. General yield quality or herd/grazing quality assessment
k. General impression by stakeholder (advantages/disadvantages)
l. Comparative assessment with regular practice

Participatory monitoring

	B- In the plots where were implemented WSC techniques Two types of land use are considered: -Annual cultivations -Grazing pastures Two types of processes are responsible of land degradation: -overland flow -Gullies Two kinds of intervention: -In a cereal plot, Mulching, followed by minimum tillage, for the reconstitution of the biological mechanisms in the soil, -in a gullied area, plantation of Atriplex to restore the land and prevent extension of the gullies. Two modes of monitoring: -In the cultivated plot, soil and vegetation measurements -In the gullied area, micro-topography follow up and vegetation measurements **Monitoring the plot with mulch and minimum tillage** -Permanent installation of sets of TDR at 5, 15 and 30 cm depth to monitor the soil -Repeated measurements of the crops during the vegetative cycle -Measuring the yield in and outside the mulch field -Observations on the soil behavior after rains **Monitoring the effects of the atriplex plantation** -Follow-up of the surface and of the vegetation cover (the atriplex, the herbs, the soil surface) by comparison between the planted field and the other gullies -Micro-topographic monitoring of two gullies, one in the planted field and the other outside.
	Analysis <u>Bio physical</u> ▪ Results comprise soil moisture series upslope and downslope, and between the treatments and the reference field. ▪ LISEM is used to simulate soil erosion and calibrated on sediment totals in storage tanks. <u>Socio-economical</u> ▪ Cost-benefit analysis ▪ inventorize the need for subsidies or external funds and assistance to continue practice.