RESEARCH PROGRAM ON Dryland Systems

CGIAR

Impact and adoption of SWC techniques: research progress and preliminary results

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Food security and better livelihoods for rural dryland communities

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Foreword

This report was produced in the frame of the activities carried out by the CGIAR Research Program on Drylands Systems, North Africa and West Asia Flagship, Agro-Pastoral System. More specifically the report is part of the outputs generated by the Activity "6- "Management of water scarcity" (2015-12 month Deliverable).

The activity is being conducted as a collaborative effort of ICARDA, INRGREF (Institut National de Recherches en Génie Rural, Eaux et Forêts; reference person, Dr Taoufik Hermassi) and IRA (Institut des Régions Arides; reference persons, Dr Mohammed Ouessar and Dr Mongi Sghaier). As a result of the integration between Activity 6 and Activity 4, and through the researchers involved in the former activity, collaboration was established also with INRA (Institut National de Recherche Agronomique de Tunis; reference persons, Dr Sonia Bedhiaf).

Several other senior and junior researchers and technical support staff also contributed to the research. Among them Stefan Strohmeier, Walid ben Khélifa, Mohamed Abdeladhim, Mongi Ben Zaied, Hamed Daly, Zied Dhraief, Mariem Ouslati, Mira Haddad, Shinan Kassam & Aden Aw-Hassan.

I. Scientific objectives and background

The main objective of this research is to model the impact of soil and water conservation (SWC) structures on runoff and erosion processes at the watershed scale, by means of watershed-based modelling (SWAT software). Modelling is performed in selected watersheds for which good calibration and validation data are available. Selected watersheds are located in different regions of northern, central and southern Tunisia.

The activity largely builds on existing databases and on a limited amount of high quality data purposely collected in the field. The main example of this is the monitoring equipment installed to measure the water level changes of a hill lake located in the Zoghmar site (Sidi Bouzid), and the bathymetric surveys previously performed in the same lake.

Data collection and modelling are on-going in both study sites in collaboration with the NARS partners. This report outlines the modelling work that is going on at watershed scale (section II), although some experimental activity is going on also at microscale. A comprehensive publication plan has been drafted (section IV) that lists the scientific articles that the research team is planning to submit to international journals.

This report was preceded by a literature inventory ("2015 - 6 month Deliverable") aimed at summarizing the historical and recent work conducted in Tunisia on the impact of SWC techniques. Particular emphasis was given there to the most relevant SWC structures studied by the project team in the Tunisian study sites, notably the terraces or contour benches, the hill lakes, the jessour, and the recharge/check dams.

The inventory highlighted that important knowledge gaps still exist regarding the understanding of the social and economic impacts of SWC, and of the factors influencing the adoption by the farmers.

To contribute to fill this gap synergies between this Activity and Activity 4 were developed. Activity 4 is carried out in the same study sites with the aim of evaluating the economic and social (including gender-related) aspects connected with the adoption of SWC techniques, and with their impact.

In the frame of this collaboration, data referring to household level surveys carried out in 2014 by INRA researchers were acquired and analysed, particularly to investigate the factors influencing the adoption of SWC methods by the farmers. Preliminary results are illustrated in section III.

II. Watershed modelling sites

The research on the impacts of SWC techniques at the watershed level is ongoing in two sites located in the Béni Khedache-Sidi Bouzid transect (Kaf-Hamam – Zoghmar watershed, central Tunisia; Koutine watershed, Southern Tunisia), and in a third site (Sbaihia – Rmel watershed) located in semi-arid northern Tunisia (Figure 1 and 2).

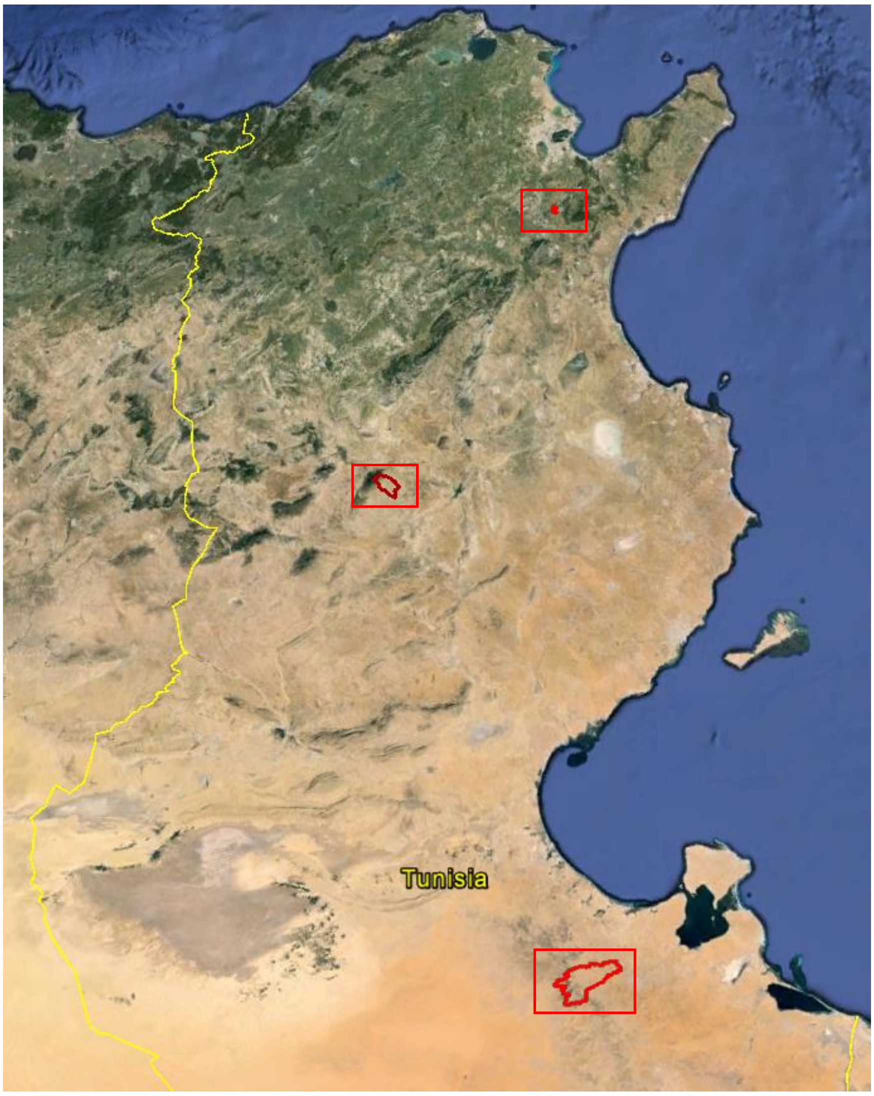

Figure 1. Location of the three experimental watersheds. Source image for background: Google Earth.

The selected catchments represent three different bioclimatic contexts. Koutine watershed, in the south, is arid and natural vegetation is dominated by lowland steppe formations. Elevation ranges between 120 and around 500 m a.s.l. Kaf-Hamam is located in the semi-arid, more continental and colder highland region of central Tunisia, with elevation ranging between 500 and 1,300 m a.s.l. Sbaihia is located in the semi-arid but relatively more humid north-eastern part of Tunisia, few km from the coast. Elevation ranges here between 130 and around 450 m a.s.l.

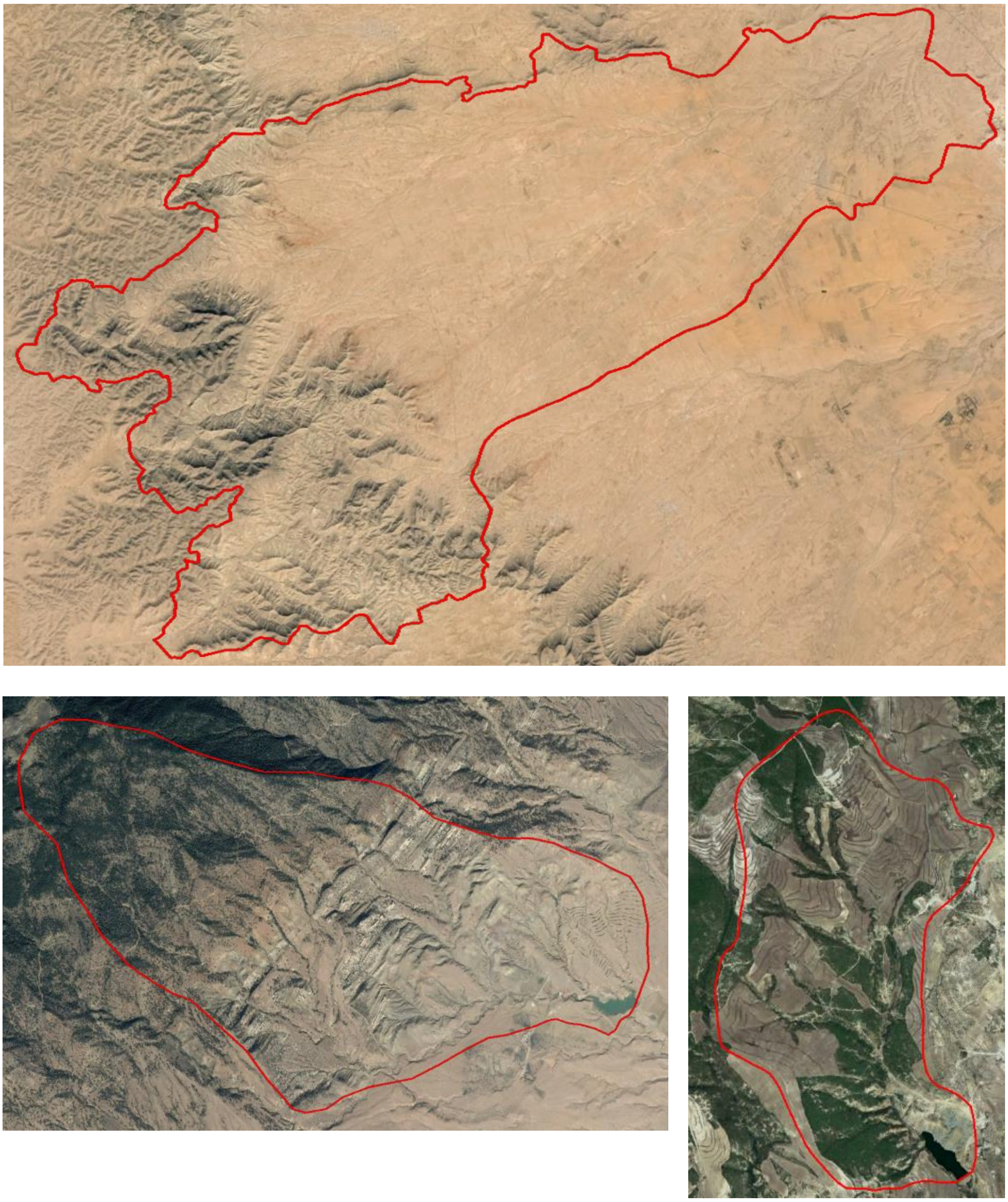

Figure 2. The three experimental watersheds as they appear in satellite images. Images are not in the same scale and not the same date. Source image for background: Google Earth.

Among the SWC structures considered in the study sites, the terraces or contour benches, the hill lakes, and the jessour are the main ones. These are among the most widespread and relevant SWC techniques in the Tunisian CRP-DS study sites (Béni Khedache-Sidi Bouzid transect). Their main characteristics and functions are summarized below.

Terraces or contour benches. The contour benches are earth embankments built along contour lines, perpendicular to the slope, to intercept and store runoff water. They improve infiltration locally. The benches also reduce both the length of slope susceptible to runoff and the runoff velocity, which remains below the critical threshold of gully erosion. They are increasingly built with earthmoving machines and are referred to as machine-made benches. There are two types of erosion control benches: total retention benches and diversion benches, the former being the most common. In the Mediterranean regions, these structures have been considered to be effective in regions where rainfall is rare, brief and very intense, falling on dry soil with low permeability.

Hill Lakes. The hill lakes, are small earthen dams built by man. They are situated at the depressions between hills, which allows the runoff collect. Their establishment and promotion are an interesting strategic choice for the mobilization of natural water resources to meet the water needs, ever increasing, mainly for agriculture. The hydraulic works of water harvesting and soil conservation, in particular hill lakes, are intended to collect additional quantities of rainwater to be used in diverse purposes such as the domestic use and in the farm.

Jessour. *Jessour* is an ancient runoff water harvesting technique widely practiced in the arid highlands. Arranged in the form of *gradoni* (a series of contour ditches used mainly for growing trees), the *jessour* generally occupy runoff watercourses (*thalwegs*). In fact, *jessour* is the plural of *jessr,* which is a hydraulic unit made of three components: the *impluvium*, the terrace and the dyke.

The research is aimed at modelling hydrological processes (runoff, erosion) in watersheds under varying land use and SWC scenarios and is performed through the SWAT software. Model calibration will be performed based on high quality datasets (e.g., runoff and sediment yield measurement at the watershed outlets) partly available as historical data series and partly purposely collected by the NARS researchers involved in the project.

The research is ongoing in all watersheds. Results will be available in 2016, in agreement with the output schedule of the project and as shown by the publication plan in section IV.

III. Adoption of SWC by farmers. Preliminary results.

Introduction and background

The adoption of soil and water conservation technology has attracted much attention from researchers and police decision makers mainly because agricultural productivity and food security are being seriously threatened by the steady decline in soil nutrient depletion and soil moisture stress. Although the failure of soil and water conservation intervention can have many causes, the root causes for non-adoption of soil and water conservations were not well identified in many cases. The need therefore to economically examine the adoption of soil and water conservation technologies (SWCT) options to improve agricultural production becomes imperative in order to evaluate the impact of their uptake by the resource-poor Tunisian farmers.

Objectives of the study

In view of the importance of the subject and the lack of knowledge with regard to the causes of non-adoption, it appears useful to us to undertake a study to understand and explain why the farmers in the study area seem to be weakly interested to SWCT. The specific objective of this research was to determine the major factors influencing farmers' adoption decisions and estimate the elasticity of adoption of factors that are significant in explaining farmers' decision in the study area and draw conclusions that might help in developing policy and institutional interventions to encourage adoption.

Conceptual framework

A number of related literatures were reviewed to reveal factors affecting adoption of soil and water conservation practices. Literature review on factors affecting adoption of soil and water conservation indicates adoption of soil and water conservation by small holders farmers are influenced by overall economic factors, social factors, institutional factors and natural physical factors in rural areas. Based on literature reviews and the researcher's observation in the study area, potential determinants which were assumed important in influencing adoption of soil and water conservation were identified as: socioeconomic factors and institutional factors and natural physical. Therefore, we tried to identify and analyze relationships among factors influencing adoption of soil and water conservation by small holder farmers in the study region.

Methodological framework

Data types and Data Sources. Data for this study were collected from households using a semi structured interview schedule. The study focused on both primary and secondary sources of data. Moreover, both qualitative and quantitative types of data were collected.

Sampling Technique and Procedures. In this study multistage sampling technique was employed. In the first stage two regions (Zoghmar and Selta) were selected randomly. On the second stage eleven districts were selected randomly. Data were collected from (n=250) 97 adopters and 153 non-adopters sample respondents using probability proportional to sample size method.

Data collection and methods. Data were collected by employing interview schedule, which was administered by enumerators to collect data on various factors affecting adoption of soil and water conservation by small holder farmers.

Data Analysis Methods. The available data was compiled using SPSS (V.20). Data were analyzed using descriptive statistics such as mean; standard deviation and econometric analysis were made to compare adopter with non-adopter of soil and water conservation in study area.

Model Specification

In the study, econometric model (binary logistic regression model) was used to evaluate the determinants of farmers' decisions to adopt SWCT and its elasticity of adoption in this rainfed farming system. Qualitative data were analyzed through interpretation, narration, and finally complement the econometric analysis.

Since conventional regression analysis (Ordinary Least Squares or OLS) cannot accommodate zero observations on the dependent variable, Logistic Regression is used instead to predict a categorical (usually dichotomous) variable from a set of predictor variables. In this case study, the research is predicting an event that has two possible outcomes, adopt vs. not adopt, which means that the dependent variable is not continuous but has only two possible outcomes, 1 or 0. This case violates the assumption that the variable is normally distributed (single peak), since a 1/0 variable by definition has a binomial distribution (double peak). The Binary Logistic model (Logistic Regression model) solves this problem by putting the predicted dependent variable as a function of the probability that a particular subject will be in one of the categories, i.e., by determining the odds of 1 or 0. If the odds of 1 are higher than the odds of 0, then a 1 would be expected and not a 0.

This is accomplished by estimating the Log Odds Ratio, which is the log of the odds of 1 divided by the odds of 0. Since odds are a probability, there will be a ratio of 2 positive numbers. The log of a positive number can have a value between –infinity and + infinity, which removes the upper and lower bound on the dependent variable, which can now be estimated by a regular regression model.

Binary Logistic Regression was applied in this research to regress the dependent variable, y, of whether the household's head has adopted SWC technology, against the factors affecting household head's adoption decision.

$$Y = 1 : \text{adopted}; \quad 0 : \text{otherwise} \qquad (1)$$

Let Xi represent the set of factors influencing the adoption decisions of the ith farmer. For the farmer, Yi is an indirect utility derived from the adoption decision, which is a linear function of k explanatory variables (X), and is expressed by the following prediction equation:

Yi = ln {odds(event)}

= ln {(prob(event)/prob(nonevent)}

= ln {(prob(event)/1-prob(event)}

$$=Ln(\frac{P_i}{1-P_i}) = Ln\ odds = \beta_0 + \sum_{i=1}^{n} \beta_i X_{ki} = Z_i$$

$$= \beta_0 + \beta_1 X_1 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots.. + \beta_k X_k \qquad (2)$$

where $\hat{Y}$ is the predicted probability of the event coded with 1 (adopt), $1-\hat{Y}$ is the predicted probability of the other decision, α is the intercept, and X_k represents the following predictor variables: AGE, EDUC, FSIZ, FEXP, LABE, TENUR, OFFA, CRED, CBOS, VLIVST, CONT, CapBui, LFRA, and FSR, whereas β_1, β_2, β_3, ..., β_i are the coefficients associated with each explanatory variable X_1 to X_{ki}. The model can therefore be expressed as follows:

$$Y = \alpha + \beta_1 AGE + \beta_2 EDUC + \beta_3 FSIZ + \beta_4 FEXP + \beta_5 LABE + \beta_6 TENUR + \beta_7 OFFA + \beta_8 CRED + \beta_9 CBOS + \beta_{10} VLIVST + \beta_{11} CONT + \beta_{12} CapBui + \beta_{13} LFRA + \beta_{14} FSR + \xi \qquad (3)$$

In this study, the above econometric model was used to analyze the data. The model was estimated using the interactive maximum likelihood estimation procedures. This estimation procedure yields unbiased, efficient and constant parameter estimation. The description of each explanatory variable included in the empirical logistic model is presented in table (1).

Table 1: Description of the variables specified in the empirical binary logistic model (N=250)

Acronym	Description	Type of measure	Expected Sign
Dependent variables			
ADOP	Whether a farmer has adopted or not SWC technology	Dummy (1 if yes, 0 if no)	
Explanatory variables			
#1 - AGE	Household head's age	Years	-
#2 - EDUC	Educational background of the household head	Dummy (1 if the farmer accumulate more than 6 years in education, 0 if less than 6 years)	+
#3 - FSIZ	Household in number of people	Numbers (#)	+
#4 - FEXP	Household head's farming experience	Years (Yrs)	+
#5 - LABE	Family labor force size	Active labor force numbers (#)	+
#6 - TENUR	Status of land ownership	Dummy 1 (1 if fully owned; 0 otherwise)	+
#7 - OFFA	Farmer has any off-farm activity	Dummy (1 if yes, 0 if no)	?
#8 - CRED	Obtained credit / funding	Dummy (1 if yes, 0 if no)	+
#9 - CBOS	Member to CBO's/cooperative	Dummy (1 if yes, 0 if no)	+
#10 - VLIVST	Importance of livestock in the farming system	% of livestock income in total farm income	?
# 11 - CONT	Contact with extension	Numbers of visit of extension agents to the farm (#)	+
# 12 - CapBui	Farmer attendance at training meetings	Dummy (1 if yes, 0 if no)	+
# 13 - LFRA	Land fragmentation	Number of plots divided by total land area	-
# 14 - FSR	Stocking rate and risk of overgrazing	Flock size divided by total land area	-

Source: Own elaboration from survey (2015).

Results and discussion

Soil and water conservation practices in the study area.

In the study area, as other parts of the country, improved soil and water conservation measures were introduced from different sources, through different national and international programs. The survey result indicates that the use of improved structures in the study area have been in use since the 1980's. The most widely and intensively used improved structures in the study area were physical and agronomic/biological conservation (Table 2). More specifically 16.4% and 26.8% of farm households were practicing physical and biological conservation respectively.

Table 2: Soil and water conservation practices in study area (N=250)

Soil and Water conservation Practices	Adopters - of at least 1 practice (N=97)*		Non Adopters (N=153)	
	N	%	N	%
Agronomic practices				
Manuring	16	6	234	94
Crop rotation	47	19	203	81
Minimum tillage	3	1	247	99
No tillage	1	0	249	100
Physical structures				
Terraces	35	14	215	86
Soil bunds	3	1	247	99
Stone bunds	3	1	247	99

*Source: Own elaboration from survey (2015). * 10 farmers adopt two different practices in at least one of their plots, and one adopts three practices.*

Factors affecting adoption of soil and water conservation technologies in study area

In the preceding section of this report the qualitative analysis of important constraints that were expected to affect adoption of soil and water conservation, were presented. In this section, the selected explanatory variables were used to estimate the binary logistic regression model to analyze the factors affecting adoption of soil and water conservation technologies among farmers. A binary logistic regression model was fitted to estimate the effect of hypothesized explanatory variables on the probability of being adopter or non-adopter of soil and water conservation by among farmers.

As discussed earlier, the logit model was used to analyze factors affecting adoption of soil and water conservation technology by farmers. The sample households were adopter or non-adopter of soil and water conservation. Consequently, the variable which shows adoption of soil and water conservation by farmers was a binary dependent variable, taking a value 1 for adopters of soil and water conservation, and 0 otherwise.

Fourteen explanatory variables (seven continuous and seven dummy) were included in the model. The summary of the variables hypothesized to affects adoption of soil and water conservation technologies in study area are presented here below (Table 3).

Table 3: Summary of explanatory variables included in the logistic regression model (N=250)

Variables	N	Minimum	Maximum	Mean	Std. Deviation
ADOP	250	0.00	1.00	0.3880	0.48827
AGE	250	24.00	90.00	54.9880	15.19260
EDUC	250	0.00	1.00	0.4440	0.49785
FSIZ	250	1.00	30.00	6.4040	2.98066
FEXP	250	2.00	75.00	31.1240	15.61808
LABE	250	0.00	9.00	2.7240	1.65977
TENUR	250	0.00	1.00	0.3400	0.47466
OFFA	250	0.00	1.00	0.3400	0.47466
CRED	250	0.00	1.00	0.0800	0.27184
CBOS	250	0.00	1.00	0.0720	0.25901
VLVST	250	0.00	1.00	0.6580	0.29048
CONT	250	0.00	24.00	0.2320	1.66048
CapBui	250	0.00	1.00	0.1600	0.36734
LFRA	250	0.25	100.00	4.7607	8.51697
FSR	250	0.00	6.10	0.5340	0.68551

Source: Own elaboration from survey (2015).

In order to test the existence of multi-collinearity, both the continuous and discrete explanatory variables were checked using Variance Inflation Factor (VIF). This statistical analysis indicates that there is no strong association among the variables (Table 4). For this reason, all of the explanatory variables were included in the final analysis.

Once the decision was made regarding the variables to be included in the empirical model, the Maximum Likelihood method of Estimation (MLE) was used to draw the parameter estimates of the binominal logistic regression model. Out of the fourteen explanatory variables hypothesized to affect adoption of soil and water conservation in the study area, four were found to be significant at less than or equal to ten percent probability level, shows the signs, magnitude and statistical significance of the estimated parameters and how much the observed values were correctly predicted by the logistic regression model (Table 5). This estimation procedure yields unbiased, efficient and constant parameter estimation.

The likelihood ratio test statistic exceeds the Chi-square critical value with 15 degree of freedom. The result is significant at ($P<0.01$) probability level indicating that the hypothesis that all the coefficients except the intercept are equal to zero is rejected. The goodness of fit of the model was found to be 67.2 percent. Another measure of goodness of fit used in logistic regression analysis is the count R2 that indicates the number of sample observations correctly predicted by the model. The count R2 is based on the principle that if the estimated probability of the event is less than 0.5, the event will not occur and if it is greater than 0.5 the event will occur. In other words, the ith observation is grouped as user if the computed probability is greater than or equal to 0.5, and as a non-user otherwise.

Table 4: Variance Inflation Factor (VIF) for continuous explanatory variables (N=250)

Variables	Collinearity Statistics	
	Tolerance	Variance Inflation Factor (VIF)
AGE	0.378	2.646
EDUC	0.868	1.152
FSIZ	0.878	1.139
FEXP	0.379	2.642
LABE	0.940	1.064
TENUR	0.794	1.260
OFFA	0.743	1.346
CRED	0.873	1.145
CBOS	0.775	1.290
VLVST	0.794	1.260
CONT	0.777	1.287
CapBui	0.846	1.182
LFRA	0.927	1.079
FSR	0.868	1.153
a. Dependent Variable: ADOP		

Source: Own elaboration from survey (2015).

In this study, fourteen explanatory variables were used. Based on the model results, farming experience, farmer adherent to community based organization/cooperative, plot area, flock size had a positive sign of association with adoption of soil and water conservation technologies. Out of the 14 proposed variables, four of them were statistically significant in the model while the rest were not significant at ($P<0.10$) probability level (Table 5).

The significant variables included farming experience, farmer adherent to community based organization/cooperative, farmer attendance at training meetings, and livestock holding. The interpretations of the significant explanatory variables are given below.

Farming Experience (FEXP): The model result reveals that farming experience affect adoption of soil and water conservation positively and significantly at ($p<0.1$). The odd ratio of 1.021 indicates under constant condition, the odd ratio in favor of the adoption of soil and water conservation increases by a factor of 1.021 as the farming experience of household head increases by one year of experience.

Farmer adherent to CBOS/cooperative (CBOS): The model result indicates that being member of a CBOS or cooperative affects the decision of farmers positively and significantly at ($P<0.01$) to adopt soil and water conservation technologies. This means that as the member of the household is a CBOS/cooperative member will acquire sufficient knowledge and skill about soil and water conservation techniques. The odds ratio of 5.311 indicates that under constant assumption, the odd ratio in favor of adoption of soil and water conservation techniques increases by a factor of 5.311.

Table 5: Parameter estimates of the logistic regression model (N=250)

Variables	B	S.E.	Wald	df	Sig.	Exp(B)
AGE	-0.019NS	0.015	1.553	1	0.213	0.982
EDUC	-0.038NS	0.292	0.017	1	0.896	0.963
FSIZ	-0.040NS	0.049	0.646	1	0.421	0.961
FEXP	0.021*	0.014	2.093	1	0.148	1.021
LABE	-0.031NS	0.083	0.138	1	0.710	0.969
TENUR	-0.037NS	0.315	0.013	1	0.908	0.964
OFFA	-0.185NS	0.321	0.331	1	0.565	0.831
CRED	-0.389NS	0.530	0.538	1	0.463	0.678
CBOS	1.670***	0.635	6.914	1	0.009	5.311
CONT	-0.004NS	0.091	0.002	1	0.965	0.996
CapBui	-0.790**	0.439	3.245	1	0.072	0.454
LFRA	0.002NS	0.016	0.012	1	0.914	1.002
FSR	0.222NS	0.206	1.159	1	0.282	1.248
VLVST	-1.016**	0.515	3.896	1	0.048	0.362
Constant	0.897NS	0.812	1.221	1	0.269	2.453

a. Variable(s) entered on step 1: AGE, EDUC, FSIZ, FEXP, LABE, TENUR, OFFA, CRED, CBOS, CONT, CapBui, LFRA, FSR, VLVST.

b. LR chi2(15) 85.844

c. Probability > chi2 0.0000

d. Pseudo R^2 67.2

e. Log likelihood 308.078

f. Number of observations 250

g. *** Significant 1%, ** 5% and * 10% probability level, NS= not significant

Farmer attendance at training meetings (CapBui): The variable is significant at ($p<0.05$) and negatively related with the adoption of soils and water conservation techniques by farmers. The result is not consistent with the hypotheses in that those farmers who have participated in training have the probability to adopt such technologies. However, in this case, it was included all types of trainings which cannot provide a clear picture of the real impact on soil and water conservation technologies.

Livestock holding (VLVST): The variable is significant at ($p<0.05$) and related negatively with adoption of soil and water conservation technologies. This trend has significant implication for adoption of technology as overgrazing by livestock population is also another factor that led to land degradation and consequently to non-adoption of soil and water conservation technologies. The odd ratio of 0.362 shows that under constant assumption the odd ratio in favor of the adoption of soil and water conservation decreases by a factor of 0.362 as the income from livestock (folk size) increase by one year.

The findings indicated also that there is scope for improving farmers' income through increased use of the SWCT. This also suggests that there is the need on the part of the stakeholders to explore more avenues for providing adequate incentives, particularly technical assistance to the farmers to use a lot more of the SWCT options on their farms.

The finding also reveals that physical and biological soil and water conservation were highly practiced in study area.

Conclusions and recommendations

The study concluded that there are a number of socio economic, institutional and natural physical factors that affect adoption of soil and water conservation technologies in Sidi Bouzid (Central Tunisia). Therefore, the study recommends that concerned stakeholders and partners found at different levels should attempt to address those factors affecting adoption of soil and water conservation. Given this, the study recommends that linear processes of knowledge generation and dissemination, through training and extension, need to be augmented with more dynamic engagement of inclusive innovation systems which necessarily include rural institutions.

IV. Publication plan

The following articles are planned for submission to international research journals.

- Ben Zaied et al., 201x. Hydrologic process modelling with climatic change simulation at the watershed scale (case study: Koutine watershed, Southern Tunisia).
- Ben Zaied et al., 201x. Erosion simulation using soil resources management tool.
- Sghaier et al., 201x. Assessment the impact of the conjunctive use of SI-WH on olive trees.
- Hermassi et al., 201x. Simulation modelling of runoff and erosion under different scenarios for Sbaihia Watershed, Northern Tunisia.
- Hermassi et al., 201x. Simulation modelling of runoff and erosion under different scenarios for Kaf-Hamam – Zoghmar watershed, Central Tunisia.
- Hermassi et al., 201x. Assessment the impact of WSC structures using empirical methods.
- Zucca et al., 201x. Review paper on integrated evaluation of the impact of SWC and WH structures in Tunisia.
- Dhehibi et al., 201x. Biophysical and Econometric analysis of adoption of soil and water conservation techniques in the semiarid region of Sidi Bouzid (Central Tunisia).

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The CGIAR Research Program on Dryland Systems aims to improve the lives of 1.6 billion people and mitigate land and resource degradation in 3 billion hectares covering the world's dry areas.

Dryland Systems engages in integrated agricultural systems research to address key socioeconomic and biophysical constraints that affect food security, equitable and sustainable land and natural resource management, and the livelihoods of poor and marginalized dryland communities. The program unifies eight CGIAR Centers and uses unique partnership platforms to bind together scientific research results with the skills and capacities of national agricultural research systems (NARS), advanced research institutes (ARIs), non-governmental and civil society organizations, the private sector, and other actors to test and develop practical innovative solutions for rural dryland communities.

The program is led by the International Center for Agricultural Research in the Dry Areas (ICARDA), a member of the CGIAR Consortium. CGIAR is a global agriculture research partnership for a food secure future.

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