Internship Report

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What are the main drivers behind Ethiopian farmers soil and water conservations practices?

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BLUE	Best Linear Unbiased Estimator
CEEPA	Centre for Environmental Economics and Policy in Africa (University of Pretoria, South Africa)
CGIAR	Consultative Group on International Agriculture Research
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement, France.
CPWF	Challenge Program on Water and Food
CSRIO	Commonwealth Scientific and Industrial Research Organization
DA	Government Development Agent
ENBCCA	Ethiopia Nile Basin Climate Change Adaptation
EDRI	Ethiopian Development Research Institute
ETB	Ethiopian Birr, National Currency.
FAO	Food and Agriculture Organization
FFW	Food for Work
GDP	Gross Domestic Product
ILRI	International Livestock Research Institute
IWMI	International Water Management Institute
HDI	Human Development Index
LDV	Limited Dependent Variable
MLE	Maximum Likelihood Estimation
MDG	Millennium Development Goals
NBDC	Nile Basin Development Challenge
NGO	Non-Governmental Organization
OLS	Ordinary Least Squares
SLP	System Livestock Program
UNDP	United Nation Development Program
SSA	**S**ub-Saharan Africa
WLS	Weighted Least Squares

0. INTRODUCTION

The present report describes my internship done at the ILRI Research Center of Addis Ababa (Ethiopia) from May 2011 to August 2011. This internship was required for the fulfillment of a Master in Economics at the Université Catholique de Louvain (Belgium). This report is structured in three sections. First, a description of the host organization is depicted along with the internship topics and objectives and the methods solicited. The analysis related to the economical question about the drivers of soil and water conservations adoption and a personal evaluation of the experience are then presented.

My internship project was initially specified within the International Livestock Research Institute (ILRI) Center located in Addis Ababa. However, after one month of internship, the proposed tasks were completed and it was found not adequate to continue on this topic due to the findings of this preliminary investigation. As the ILRI Center in Ethiopia hosts various interdisciplinary teams belonging to various organizations of the Consultative Group on International Agricultural Research (CGIAR), I had the opportunity to work for another ILRI-IWMI research project. Therefore, the internship project was formally reviewed and redesigned based on a work embodied in the Nile Basin Development Challenge (NBCD).

I am very thankful to Dr. Bruno Gerard, Dr. Catherine Pfeifer and Dr. Diego Valbuena for the opportunity they provided me and for support that made my experience tremendously instructive in this exciting multidisciplinary and international environment. Beyond their supervision, the sharing of their personal visions and rich experiences opened my mind more than ever. I am also grateful to the IRLI and IWMI staff members who welcomed me warmly as well to all the great people I had the chance to meet during my time at the IRLI Campus.

1. INTERNSHIP PROJECT DESCRIPTION

A. BRIEF DESCRIPTION OF HOST ORGANIZATION: ILRI Center, Addis Ababa

The ILRI Center of Addis Ababa is one of the many research centers that made up the CGIAR. The CGIAR can be defined as an international partnership of private and public donors supporting the research in agriculture of 16 autonomous centers conducted in collaboration with government, civil society's organizations as well as private businesses. The World Bank has leaded the establishment of the CGIAR in 1971 and membership in the consortium has grown since then from 18 organizations and governments to 62 these days, consisting of governments of industrialized, developing and transition countries in parallel with international and regional organizations[1]. The total consortium revenue was $553 million.

The following section depicts first the overall missions of the CGIAR and more specifically the mandates of ILRI and IWMI. Then, the internship topic is presented.

i. Mission, Values, Vision of the CGIAR

The CGIAR's core mission is reducing hunger and poverty[2]. Moreover, the work' objective is stated as follow "to contribute to food security and poverty eradication in developing countries through research, partnership, capacity building and policy support, promoting sustainable agricultural development based on the environmentally sound management of natural resources" (CGIAR, ICW98). They have three distinct objectives: Food for People (enhancing productivity and production of healthy food), Environment for People (natural resources and biodiversity focus) and Policies for People (target policy and institutional change toward agricultural growth and equity). The consortium agreed to achieve the Millennium Development Goals (MDG)[3] by 2015 as several goals were what the CGIAR research was yet committing to in its vision[4].

More recently, food and energy price volatility has prompted numerous crises affecting individuals all around the planet but most severely on approximately 2.1 billion people living with less than 2 USD a day. This vulnerable share of population lives for the majority in rural areas and their livelihood depend on farming. For the purpose of alleviating poverty, those goals imply forefront science in the agricultural sphere.

Research Centers' major reasons to associate in the CGIAR are the economies of scale and scope and the provision of public good. In other words, they came together to on the one hand, improve their individual research and on the other hand, to enlarge the range of possible research. Indeed, private entities have not enough incentive to invest reliably in this type of public research.

ii. Host Institute

My internship project was carried out at the ILRI Center first within an ILRI group and then within an ILRI-IWMI project. ILRI mission is defined as "to work at the crossroads of livestock and poverty, bringing high quality science and capacity building to bear on poverty reduction and sustainable development or poor livestock keepers and their communities". In other words, it targets poverty mitigation in aiming research at keeping

[1] More accurately, members entailed are 24 governments' representation of developing countries and 22 of industrialized countries, 12 international and regional organizations, and 4 private foundations.
[2] The CGIAR's vision is to reduce poverty and hunger, improve human health and nutrition, and enhance ecosystem resilience through high-quality international agricultural research, partnership and leadership.
[3]The MDG are a set of development targets agreed by the international community, promoting human dignity and development as a key to sustaining social and economic progress in all countries, by the year 2015.
[4] Rural poverty (Goal 1, Target 1), hunger (Goal 1, Target 2), health (Goal 4, 5 ,6) and the environment (Goal 7).

livestock alive and productive, promoting sustainability between farming and livestock and also in the finding of profitable markets. As livestock main issue is the lack of feed, crop residue management in smallholder agricultural system is an important focus. My internship topic was initially designed in an ILRI's research project on crops residue, which is part of the System Wide Livestock Program (SLP). The latest is taking an integrated approach assembling crop, agroforestry, natural resource, policy and livestock dimensions.

IWMI mandate covers land and rainwater management in order to improve agricultural productivity and rural livelihoods. Food insecurity can be partly explained by climate variability, affecting directly rural household and their food production. The project in which the main part of intern's work is in line with is the Nile Basin Development Challenge. It is a joint project associating ILRI and IWMI in a wider program funded by the CGIAR Challenge Program on Water and Food (CPWF). CPWF addresses the rigidity of rural livelihoods in the Ethiopian highlands. Its idiosyncratic frame is to take a landscape approach rainwater management (ILRI and IWMI, 2011).

The NBCD project is defined as the systematic integration of the system paradigm through Integrated Watershed Management. This unusual approach aim is to go beyond hydrological boundaries by incorporating social, economic and institutional networks. Concretely, it includes assessing and anticipating the consequences of innovation in rainwater management techniques, in addition to exploring the 'matching' of specific technologies with particular environment[5].

B. INTERNSHIP TOPIC

As explained above, I was assigned two distinct topics which are described as the initial objectives along with the tasks assigned and then as the reviewed objectives and tasks. For all that, the time spent on the first topic corresponds to the CGIAR acquaintance period[6]. Indeed, the first objective gave me the opportunity to go to the field. It enabled me to get a better grasp and understanding of the extent of the conducted research's applications. The reviewed objective was related to the exploration of a large dataset in the light of a specific question within the vast NBDC project.

i. Initial Objectives

The initial objectives were twofold: on the one hand an investigation of static models for household level management and on the other hand, a review of different methods of results' discussion of village's farming system analysis between the investigator and the farmers.

The first sequence of the task has to be put in line within the SLP framework. A collaboration between CIRAD, CSIRO and IRLI had freshly been launched to develop an integrated modeling platform for mixed animal-crop systems. The wider horizon is to produce a standard system-level dataset that would enable to test the effects of different management strategies on the system and at the household's scale. Any user would be able to clearly see, through the simulation, the impacts of an existing management practices on their farming system (Herrero and Gonzalez, 2005).

[5] It includes five linked projects Environment Institute, Ethiopian Economic Policy Research examining: 1) Learning from the past; 2) developing integrated rainwater management strategies, 3) targeting and scaling out of rainwater management innovations 4) assessing and the anticipating the consequences of innovation in rainwater management systems; and 5) catalyzing platforms for learning, communication and coordination across the projects.

[6] Acquaintance to both the institutional structure and the studied topics.

The assessment of existing static household models consist of a critical and comparative review of a model known as IAT developed in the Australian's Commonwealth Scientific and Industrial Research Organization (CSIRO) with the Cikeda model created by the French research in agriculture 's organization for development (CIRAD). Beyond those two models, a parallel with IMPACT, ILRI's static household simulation model has also completed the analysis. This work corresponds to an extensive assessment and a critical review of the differences between the models. More precisely, it consists of distinctions in the aim, the data required as inputs and the available one collected for previous projects, the modeled simulation, the outputs, the relevance and the programming involved.

As the project was very recently initiated, my task was really exploratory in order to provide a critical overview of the existing platforms of household simulation and afterward, to enable an identification of the most suitable and compatible model with the available data set. As none of the models was neither open source nor fully documented, no modification or improvement of the programming was possible making the continuation of that internship topic quite difficult.

Beyond the proper testing and learning of these modeling environments, the literature reading and lively discussions and meetings with field worker, agriculture specialists and scientists which were required for the assessment of the models contributed very much to my understanding of the Ethiopian agricultural systems.

Poles apart from the former section, the second part of the initial internship topic was planned out in a more concrete perspective. Indeed, the task assigned was to take part in an ongoing quantitative and reflective qualitative analysis of resource interactions at both villages and household levels. I joined the team at the finishing stage of the qualitative research that was supplementing the quantitative one priory led by SLP. More specifically, an analysis of the village level discussion and of the evaluation's methods was completed. The best level for solutions was discussed in-depth, assessing the relevance of farm level rather than more macro-level solutions given the findings of the two previous examinations of Nek'emte's[7] resources uses and interactions. Thanks to a comprehensive documentation of the methods such as the Focus Group Meeting and the Feasibility Discussion Approach, several farmers from Nek'emte were brought together to discuss the potential solutions to their problems in their opinions and to presents the quantitative research core findings in order to collect their feedbacks.

ii. Reviewed Objectives

The most of the internship time, which accounts for two months, has been spent executing the reviewed objectives. This is the reason why my economical question presented in the next section has been thought out, for relevance criteria, of the reviewed internship's aim.

Those new objectives were set within the NBDC seeking to investigate rainwater management strategies in order to improve agricultural productivity and rural livelihoods in the Nile Basin. My internship supervisor was in charge a specific component, the "targeting and scaling out" phase. In brief, it consists of a wide analysis of, on the one hand, the physical fitness of some locations with the implementation of specific techniques of land and water management, and on the other hand, of the correlation between adoption of a land or water management practices and household characteristics. The complementarity of these two distinct analysis produce by their merging, a feasibility map taking both households and landscape features into account in a wider analysis aiming at assessing potential combination of techniques and their impacts based on those features at the landscape level.

[7] Nekem'te is a village located in western Ethiopia.

The main purpose of this phase is to develop “rainwater management strategies” conditional on the landscape type of the household’s location.

The dataset’s analysis was to identify the drivers behind the adoption of three type of strategy and run first trials of soil and water management practices’ adoption model. Using a geo-referenced farm household survey (IFPRI, 2005) including a broad range of farm household characteristics, as well as production characteristics, information about access to water, water storage, water lifting technologies as well as soil moisture land conservation, my work was to merge the numerous relevant subsections and to reorganize the variables. Following an extensive and time-consuming data handling preparation step[8], descriptive statistics and three adoption model‘s trials, an analysis of the type of practices often combined (water lifting and soil conservation) has been written.

C. BRIEF TOOLS AND METHODS DESCRIPTION

The execution of the internship topic assigned went along with the learning of new skills. Concerning the initial objectives, in a first time a literature review was written about the three main bio-economic models at farm level. To support review, I learned to master softwares running the various modeling platforms, i.e. Visual Basics for the Cikeda model, the Impact software and the IAT software. Sensitivity analyses have been completed for each modeling environment with regards the variables of interest.

In addition, I had to collect and compile comprehensive documentation on various methods for discussion at both villages and household levels. The main ones described included the Focus Group Method, Emergent Learning Map, Participatory Rural Appraisal, multi-attribute value theory and multi-attribute utility theory (Keeney and Raiffa, 1976), Farmer participatory research approach, Visual Aids in Participatory Processes, Resource map, Resource Picture Cards, Strengths, Weaknesses, Opportunities and Threats (SWOT).

Regarding the second phase of the internship, a familiarization to the issue of rainwater and land management practices in the Ethiopian Highlands allowed a better apprehending of the adoption drivers. Furthermore, a literature review was conducted on adoption model analysis. A survey of a thousand households targeting climate change adaptation in the Ethiopian Nile Basins including hundreds of variables was made available but required in-depth data reorganization and the computation of new variables more suitable to the studied topic. This step was very time consuming before the actual data analysis and results interpretation. An initiation to the software STATA was really a prerequisite in order to structure in an appropriate way this large data set and proceed with the data analysis.

D. CRITICAL REFLECTION ABOUT INTERNSHIP’S EXPERIENCE

This internship experience was very rewarding to me. The discovery of a totally new environment was an amazing opportunity for which I am very grateful of. This environment was totally new to me at two degrees. On the one hand, I discovered that CGIAR’s work on developing issues is very focused on agricultural-related issues; and on the other hand, I had the opportunity to immerse myself in a research atmosphere.

The acquaintance to the agricultural domain was not the easiest part. As it will be explained in details in the personal evaluation section, this inter-domain confrontation challenged my economic knowledge. This complex step enabled me to have a perspective opinion of my academic background. The exposure to the research

[8] Data cleaning and files merging.

community was thus very stimulating. Indeed, the profile of people working in research is a very specific one, nearly solely highly qualified people are hired. I found it a bit overwhelming. In addition, the multidisciplinary of each team working on a same topic makes collaboration very interesting although more complex. However, as the offices are part of a bigger entity, conducting a collaborative work on worldwide project required flexibility. Indeed, being spread around the world, Skype meeting were sometimes the main communication device with project's partners. My first supervisor was regularly abroad for his duties leaving me autonomous for this exploratory task. The second one had high stake in the results of my job and thereby were more dedicated for my supervision.

International community, i.e. the ILRI Campus, can be qualified as a rather diversified research center. While many CGIAR Institutes have an office in Addis Ababa, those are, for the majority, made of small to middle size team. Officially, each office works pretty independently from one another, with several common projects. However, in reality, as all scientists work along one another in the same buildings, a lot of interactions take place. Thanks to this collaboration, I was lucky to be given a second project for my internship. Indeed, working in research makes it difficult to predict how an exploration phase will turn out. Digging in different potential research embryos is a necessary step in deciding which one to continue. It prevents any rushing in a project. Fortunate circumstances enabled me to pick up on another subject. These two very different insights taught me a lot. Throughout the first topic, I was able to work both in team and individually. Being responsible of definite tasks, I was asked to report my work to the SLP team in order to make decision. In addition, thanks to the picking up of the second topic, this internship pushed me forward intellectually and enabled me to link up economics theory and agricultural-related issues. The diversity of the tasks enabled me interactions with scientists with various experience.

2. ECONOMIC QUESTION ANALYSIS

A. INTRODUCTION

i. Background

According to the annual U.N.D.P. Human Poverty Index (UNDP, 2010), Ethiopia is ranked as the second poorest countries in the world. As the majority of low-income countries, its economy relies mainly on agriculture, contributing to about 52 percent of the GDP and providing livelihood for about 80 percent of the Ethiopians. The agricultural sector is a subsistence one, composed of small-scale, mixed crop and livestock farmers (CSA, 2004)[9]. Such significant low-income economy dependence makes this population extremely vulnerable to climate change[10] and food insecurity (Seo and Mendelsohn, 2008). Finding sustainable equilibrium of land uses is a struggle. That is to say land pressures combine necessity of expanding agricultural production, of reducing poverty and to use resources in a sustainable way. In addition, the Sub Saharan Africa (SSA) has the highest rate of soil erosion in the world (Cleaver and Donovan, 1995) These burdens are constrained by one of the world's fastest rural population growth, i.e. a 3.19 percent per year rate (CIA, 2011). Complexity of addressing these inter-linked burdens (World Bank, 1996) results in a downhill spiral of un-sustainability leading to the poverty trap[11] (Greenland and Adams, 1994).Therefore, future growth in agriculture will increasingly have to come from yield increases rather than from area expansion (Eicher, 1994).

In the Ethiopian highlands case, the decline of soil fertility and severe soil erosion is due to water outflow on steep and fragile land that have been under intensive farming (Amsalu and de Graaff, 2006). Researches assessed an actual rate of erosion exceeding the regenerating one[12]. In 1986, estimations of the erosion damage were as followed: regarding the highlands, 50% were significantly eroded, of which 25% are seriously one and 4% of those are impossible to regenerate (FAO, 1986). By targeting 40% of the Ethiopian population (Deressa and Hassan, 2008), the NBDC seeks to investigate rainwater management strategies in order to improve agricultural productivity and rural livelihoods. Promotion of SWC measures has been suggested by the scientific literature as a key adaptation strategy for developing countries and more particularly in SSA (Kurukulasuriya and Rosenthal 2003). In the SSA region, the SWC practices produce a net present value (Knowler and Bradshaw, 2006) and mitigate the production risk in Ethiopian regions (Deressa and Hassan 2008). Studies show that agro-ecology differences have to be taken into account as technologies 'performance varies with the location, in that line, NBDC uses a watershed approach. It is in that context that the core object of this economical question is to identify drivers influencing smallholders' decision making to implement certain type of water management practices, in the Ethiopians highlands of the Blue Nile Basin.

B. CONCEPTUAL FRAMEWORK

i. Data

For this study, the cross-sectional Ethiopia Nile Basin Climate Change Adaptation (ENBCCA) dataset is used. The ENBCCA takes place in the project Food and Water Security under Global Change: Developing

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[9] Typical farmers are smallholders; they own a few small plots from which they live out from.
[10] Intensifying overgrazing, deforestation, desertification, etc.
[11] The vicious circle is described as the link of low productivity, i.e. land degradation reducing the production potential of the land and this, in return, makes it difficult for farmers to produce enough and invest in protecting the land and increases poverty.
[12] Estimations show an annual soil loss of about 42 t ha-1 from Ethiopian croplands. (Hurni, 1988)

Adaptive Capacity with a Focus on Rural Africa, which is financially supported by the CGIAR's CPWF and the German Federal Ministry for Economic Cooperation and Development; the collection was taken in charge by the Ethiopian Development Research Institute (EDRI) and IFPRI between December 2004 and November 2005 production year. It is a geo-referenced community and household level survey[13]. To reflect as closely as possible the proportion of the entire Ethiopian Nile basin, twenty woredas[14] were selected across bio-physical criteria.

This cross-sectional dataset size is 1,000 households with 6,000 plots. It covers 5 regions, 20 districts, 13 zones and 20 woredas, within each woreda 50 households were selected. This makes a total of 6,168 interrogated individuals. The collected data set is organized in ten core section; it goes across a broad range of characteristics from household to production, access to water along with its storage and climate change perception (IFPRI 2008). For more details on the sample design and procedure see Deressa and Hassan. (2008).

ii. State of Art

A literature review of adoption of conservation technologies has to be depicted in answering the economical question of this analysis. Considering the fact that the economic theory does not provide a strong foundation in determining factors affecting soil conservation behavior (Norris and Batie, 1987), the identification of potential drivers of conservation measures adoption has to be done in the light of previous studies. Amsalu and de Graff (2006) and Bekele and Drake (2003) largely inspired this section. While Duncan and Bradshaw (2006) conducted a review analysis on over 30 studies dealing with this topic, those were conducted predominantly in regions out of the Horn of Africa. Thereby, given that such SWC technique performances are location specific, this attempt to produce aggregate knowledge on variables explaining technology adoption has to be relativized. Commonly assessed influential factors are classified in four distinct categories: personal, physical, socio-economic and institutional factors (Lapar and Pandey, 1999; Mbaga-Semgalawe and Folmer, 2000).

Personal Factors

Household and farm exploitation idiosyncratic characteristics are classified in this category. Let's start with variables related to the household head and his family. The farmer's age is expected to affect conservation decision either negatively or positively. The influence is considered positive when assuming age is an indication of the farming experience period, whereas it is negative as a younger peasant has a longer planning horizon. Therefore, the net effect is not beforehand obvious (Baidu-Forson, 1999). The household's family size is likely to be a positive decision variable in the adoption model. On the one hand, having more kids relaxes the high need of labor in implementing SWC practices, and on the other hand, the necessity to produce more encourages somehow investments improving crop yields.

Regarding the farm and more specifically its size, the impact on adoption is not evident. A large farm is the evidence of greater wealth, thus capital availability. The probability to invest in SWC measures is high (Norris and Batie, 1987). However, owning less or smaller crops may encourage in investments such as SWC ones as the stake in preserving the land is more critical (Gebremedhin and Swinton, 2003).

Whether the farm holds livestock or not will also affect the adoption behavior. Livestock may be associated with financial assets as well as working asset in the SWC's implementation process (Norris and Batie, 1987). Yet,

[13] Some models are also at plot level.
[14] A woreda is the lowest administrative division of Ethiopia (managed by a local government).

farm specialization in livestock comes narrowing the economic necessity of facing soil erosion. Indeed, when focusing in breeding livestock, cropping activity accounts for a smaller income share (Shiferaw and Holden, 1998). Accordingly, livestock holding impact is hardly predictable a priori.

In a similar line, forecasting crop diversification effect is easier. Crop diversification such as cash crops has a positive influence on the adopting equation (Lapar and Pandey, 1999).

Distance between the farm and the crop can be expected to shape negatively such decision. Indeed, while it increases transactions costs (Gebremedhin and Swinton, 2003), it also makes supervision more difficult (Bekele and Drake, 2003).

Physical Factors

Factors characterizing the soil and the plot are exposed in this section. Plot size, slope and soil fertility are hypothesized to be positive. A larger plot will increase the return yield by SWC measures. The field slope can be understood as an indicator for erosion potential (Lapar and Pandey, 1999). Indeed, erosion is likely to be more severe when the slope is steeper (Ervin and Ervin, 1982; Pender and Kerr, 1998).Furthermore, there is a high probability that soil fertility' affects the adoption decision positively (Bekele and Drake, 2003).The marginal productivity loss of erosion is larger on more fertile crop.

Socio-economic Factors

The ethnical identity and the involvement of women in field activities are considered as sociological characteristics. In Ethiopia, two main ethnic groups, belonging to different religion, coexist[15] and their respective religious adherence has to be highlighted. Moreover, the states are organized along these ethnic boundaries. That is to say, adoption decision will be influenced by the perception of soil erosion by the ethnical group and whether the household's ethnical identity converges with the dominant one. If women work in field, the household available labor force becomes larger. This variable is positively linked with the adoption decision.

Institutional Factors

Among the institutional framework, information-relative characteristics are filed. The access to information mainly depends on government programs and on international community development projects, i.e. respectively via extension agents and NGO's one. Specific knowledge on addressing soil erosion problem is those agents along with project input required[16]. Indeed, farmer awareness of erosion problem is positively influenced by this knowledge transfer. Recognizing the existence of soil problem is the ex-ante step for adoption process (Ervin and Ervin, 1982 and Norris and Batie, 1987).

In addition, land tenure stability affects return on investment in land. Peasant's profitability's perception relies on the security of his property rights. In Ethiopia, the majority of land is under public ownership; therefore, there is a non-negligible risk that land redistribution will occur. In the literature results are also diverging on the impact (Shiferaw and Holden, 1998).

[15] Oromo 34.5%, Amara 26.9% (CIA, 2012).
[16] Covers the initial investment cost.

iii. Theoretical model

Estimating the influence of factors explaining decision of adopting conservation measures is by definition a multivariate decision. In order to identify variables correlated with adoption in a statistical significance manner, Feder et al. (1985) suggests choosing a number of potential independent variables based on prior theorizing and test.

Behavior regression analysis is associated to a limited dependent variable (LDV) model (Wooldridge, 2006). The dependent variables in technology adoption decision are binary; it equals one if one adopts it and zero if one does not. When the dependent variables are qualitative and dichotomous, using the response model framework is appropriate. LDV may be either modeled linearly or non-linearly. Linear model drawback[17] is addressed by using non-linear LDV model. In the literature, technology adoption has extensively been done by probit and logit analysis (Burton et al., 1999). The selection of one of the option comes as a computational choice (Green, 1997).

Farmers 'adoption decision may be based, although not observed directly, on a linear random utility maximization problem (Rahm and Huffman). The adoption of a specific technology is defined in the econometric framework when the predicted utility from using it is larger than the one of non-adoption.

$$Uij = \beta_j X_i + \varepsilon_j \quad \text{j = 1, 0 and i= 1, n}$$

Where Uj is the utility of the ith farmer of technology j, Xi a vector of various attributes, βj a vector of unknown parameter which can be interpreted as a net influence of vector of independent variables on adoption, and εj the random disturbance term. The former is assumed to be independently and identically distributed.

Where a score of 0 and 1 express the adoption and non-adoption.

Assumption is made that farmers act in their interest, thus implement the one providing them the largest utility. The i^{th} farmer adopts conservation measures (j = 1) if $U_{i1} > U_{i0}$

Let Y be the variable that denotes the adoption decision:

$$Y = 1 \; if \;\; U_{i1} > U_{i0}$$
$$Y = 0 \; if \;\; U_{i1} \leq U_{i0}$$

The probability that Y is equal to one can be stated as a function of various features, which are represented by the explanatory variables.

$$Pr \;\; y = 1 \;\; x \;\; = G(\beta_0 + \beta_1 x_i + \cdots + \;\beta_k x_k) = G(\mathrm{B}^* \mathrm{X} \;\;)$$

Where *Pr (.)* is a probability function and *G(.)* is a function taking on values strictly between 0 and 1.

$$0 < G(z) < 1 \; \textit{For all real numbers z}$$

[17] The fitted probability can be outside the 0 and 1 interval.

Regarding the estimation of a nonlinear binary response model, ordinary least squares (OLS) and weighted least squares (WLS) are not applicable. Indeed, the inherent nature of $E(y|x)$ has to be taken into account by using maximum likelihood estimation (MLE) to estimate such model.

C. **ECONOMETRIC MODELS AND ESTIMATION PROCEDURE**

i. Empirical Model

Given that factors influencing adoption decision cannot be restrained to economic incentives (Drake et al., 1999). Expected utility maximization behavior can be used to estimate the peasant's probability of adoption. Nevertheless, the specification of the function's arguments is yet challenging. Thereby, the selection of the model variables was based on the field knowledge of experts and on the literature review insight.

The study approach uses both descriptive and econometrics analysis. Regarding the descriptive analysis, correlation test and join t-tests for hypothesis testing are done. Concerning the econometric analysis, a LDV model is used; more specifically a probit one (Aldrich and Nelson, 1984). As mentioned above, the selection of this method comes as computational choice (Green, 1997). When the binary response model is a probit one, *G(.)*, is a standard normal cumulative distribution function of ε evaluated at $B*X_t$.

$$G(z) = \phi(z) = \int_{-\infty}^{z} \phi(v)\, dv$$

Where $\phi(v)$ is the standard normal density.

$$\phi(z) = (2\pi)^{-1/2} \exp(-\frac{z^2}{2})$$

MLE estimation method will be used instead of OLS, because of the nonlinear feature of the relation. Coefficient estimators of a probit estimation do not satisfy BLUE estimators' criteria. The square coefficient of determination (r^2) is not a good measure of equation performance; hence Pseudo-square-r (pseudo-r^2) will be used as the goodness-of-fit measure. The estimated coefficient can't be taken as granted. The magnitude of the partial effect depends of the function specification, i.e. to define it with a probit function or a logistic one.

ii. Descriptive Statistics

A summary of the data is depicted in order to understand and master the dataset (IFPRI-2005) on which the analysis is conducted. Over the 1,000 households interrogated, corresponding to 6,168 individuals, a proportion of 51.4% (Std. Dev. 1.57) of male and 48.6% (Std. Dev. 1.467) of women are observed. The dominant ethnic's identities found corresponds to the actual distribution of the Ethiopian population (CSA, 2007). In the sample, 40% (Std. Dev. .4627) of the population is from the Oromo Ethnic group and 31% (Std. Dev. .4887) from the Amhara one. Households head are for 90.10% (Std. Dev. .299) male. On average, they are 45 (Std. Dev. 13.68) years old while their spouse being 35 (Std. Dev. 11.829) years of age. Slightly less than 6 (Std. Dev. 2.238) persons make the average household. The mean of farmer's experience in agriculture equals 23 (Std. Dev. 31.307) years. The average time spends at school is 5 (Std. Dev. 2.477) years, 50% (Std. Dev. .499) of the household heads declare themselves illiterate, 20% (Std. Dev. .3649) able to read and write informally against 30% (Std. Dev. .4655) formally literate.

Household Economics

The net income from farm activity in a normal average year equals to 709.6 ETB (Std. Dev. 4513). Last week's total expenditure mean, according to 96.3% of the household equals to 64.6 ETB[18] (Std. Dev. 73.9).

[18] To give an idea of the amount, in 2004/2005 the mean exchange rate rises to 1 ETB = .1185 USD. 64,6 ETB equals 7.6551 USD.

Regarding household's asset holding, 66.6% (Std. Dev. .4406538) of the households own at least one iron cooking pan, 41.1% (Std. Dev. .498) have a radio, 31.4% (Std. Dev.) have a toilet, 30.8% (Std. Dev. .4742) own gold or jewelry, 17% (Std. Dev. .3909) of household have at least one modern bed and .33% (Std. Dev. .057) have a cellphone. In addition, the type of housing may be a good indicator of the household wealth. The share of household having a metal roof in their primary residence corresponds to 45.7% (Std. Dev. .5) of the total sample whereas only 13% (Std. Dev. .351) households are living in a concrete house made of stone or bricks. The average wage paid per day equals to, respectively for male, female and child, 61.43 ETB, 6.44 ETB and 6.74 ETB. Over 90% of the labor is provided on average by the own household and less than 10% (Std. Dev. .4627) are hired outside the household. Regarding the off-farm jobs, it is scarcely observed and the trend is seasonal. Indeed, .04945 % of individuals have a job outside the farm during Meher (rainy season[19]).

Farm Management

Regarding land, the mean household's holding is 1.9 (Std. Dev. .4743) hectares. In this dataset, 6036 plots have been observed. Most households have three crops, 67.50% of households have a fourth one and only 40.70% have a fifth one. The average yield does not vary significantly across the three primary crops. Plot's mean size is of .79 (Std. Dev. 4.42663) hectares . The main types of soil are red soil and dark Soil, followed by clay and sandy soil. Concerning the fertility of the land, a majority is reported to be moderately to highly fertile with no big variation across types of soil. A large percentage of lands are reported as having no erosion: 50.00% (Std. Dev. .2958713) have no erosion and 38.33% (Std. Dev. .4895836) have mild erosion exposure. Erosion level does not appear to be linked significantly to soil type. However, the level of exposure to erosion of a land seems to be related with the degree of land's slope; the steeper it is the more severe the erosion will be. Regarding land ownership, there are different alternatives. Land shared by farmer accounts for 75.10% (Std. Dev. .3602), and on average, 50.00% (Std. Dev. .29767) of plots is shared. Households have in majority 94% (Std. Dev. .41717) of land uncertified. On average, the distance from these plots to homestead rises to 1.4 (Std. Dev. 3.248) kilometers.

Households owning respectively an oxen, donkey and horse are in the following proportions: 72.2% (Std. Dev. .442), 32.4% (Std. Dev. .47) and 12% (Std. Dev. .327). Most commonly, oxen are used as drought power followed by donkey and horse. Join ownership of equipment with other household or farm entity is reported to be true in 1.7% (Std. Dev. .1454) of the cases. The main source of water for agriculture is the rain for 95,26 % (Std. Dev. .217) and river for 2% (Std. Dev. .159) of households.

Fertilizer wise, 9.70% (Std. Dev. .423 of household apply at least one type of fertilizer on at least one crop, 5.134% (Std. Dev. .278) of plots are fertilized. Fertilizers are used in very similar proportion. However the quantity that is applied differs; an increase in compost use and quantity and a decrease in manure quantity and use are observed. Oxen, milk cattle and sheep, goat and chicken are the main types of livestock owned. The total number of livestock reported in the whole dataset raises up to 3,576 animals. 92.3% (Std. Dev. .785) of households own at least one type of livestock. Communal grazing is the main source of feed for livestock followed by grain and leftovers and crop residue. A combination of crop residue and communal grazing comes up next with 12% (Std. Dev. .237) of households along with private grazing which accounts for 10% (Std. Dev. .42) of households.

[19] The 2 main crop seasons in Ethiopia are Belg (October to June) and Meher (June to October).

Water Access and Structure related

Among households interrogated 87.7% (Std. Dev. .32747) have at least one access to water for domestic use. On average, the distance to household's first water source is 31.7 (Std. Dev. 163.5574) kilometers. The primary water sources that have been dominantly observed are river or lake (37.10%, Std. Dev. .4829145), spring water is the secondary source of water for 31% (Std. Dev. .453) of the sample population. 11.94% (Std. Dev. .3244)of the sample population has access to a second source of water for domestic purpose.

Among thousands farmers that contributed to the survey, only 7.60% have a type of water storage structure and .90% have two water storage structures. It is equivalent to say that there are 8.50% of farmers have water storage in the whole sample.The main type is a pond or a lake (37.65%), followed by a hand-dug borehole (25.88%) and 14.12% of household have access to a drilled borehole . We will consider two categories of water storage structure: the ex-situ water harvesting consisting of: pond or lake, mirco reservoir, barrel, cistern, dam; and representing 60% of the storages, the boreholes (both hand-dug and drilled). All that can be said is that hand-dug boreholes and ponds/lakes are the type of storage used by a majority of privately owned households. Farmers associations are the secondary type of ownership, followed by joint household. Water storage structures are mainly used to water livestock, irrigate gardens and crops and then for drinking purposes.

Pumps are used by only 2.60% (Std. Dev. .1592) of the total sample. The large majority of pumps require Diesel and in 23.00% (Std. Dev. .42966) functions manually. The average price of a pump in 1996 was 5,662 ETB. Most of the pumps are owned jointly (69.20%). The main purpose of pump is to irrigate the crops then the garden. Because there are very few observations (below the significance bench), we must be careful when using these variables in further analysis.

Access to Information, Market and Credit

Regarding access to information, there are four important variables. Firstly, trainings are distinguished from visit by Development Agents (DA). Two types of training have been reported; one third (Std. Dev. .479) of household have attended training either focusing on crop or livestock. Trainings, regardless of their focus, are mainly provided by Government Agency in 54% (Std. Dev. .346) of the case or by the Agriculture Research Station for 48% (Std. Dev. .390). However, 12% (Std. Dev. .298) of trainings are organized by DA. Government's extensions agents are in charge of development of rural area, among many, one task is visiting farmers. 47.10% (Std. Dev. .4985) of households have received at least one visit of a DA advising them on crop production issues and 53.30% (.4994) about livestock activity. On average, households have received between four and five visit depending whether it is about crop production or livestock activities (Std. Dev. .499).

The distance from household to the nearer market has been measured in two different units. Households were asked both the distance in kilometers along with the time it takes them to get there. Two types of market were distinguished, the one for input and the one for output. On average, they differ slightly, with respectively 5.66 (Std. Dev. 4.47) km and 5.70 km (Std. Dev. 4.13) or 3.37 (Std. Dev. 8.91) hours and 3.75 (Std. Dev. 11.3)hours. The most spread transportation is on foot for 93.83% (Std. Dev. .258) of the household, followed by animal for 3.34% (Std. Dev. .17). Motorized vehicle concerns only 2.43% (Std. Dev. .153) of the household interrogated.

The credit section of the dataset is classified according to the creditor's identity. When we aggregate each individual variable, it turns out that 50.00% (Std. Dev. .50) of the households have never accessed credit in the past and that the other 50.00% (Std. Dev. .467) have at least borrowed money once. Credit are contracted mainly in order to buy food or household good, to pay for health expenses or to buy livestock. Most commonly, 28.70%

(Std. Dev. .19) of the households tend to borrow money in a non-contractual way by asking their relatives. The majority of contractual credit reported appears to be provided by Governmental Organizations. They provide credit to 11.30% (Std. Dev. .26) households in order to buy farm inputs or livestock. The share of household having contracted a credit with private money lender is very low and concerns 1.10% (Std. .234) of the households.

Shocks and farmer's reaction to it

Most shocks took place between 1993 and 1997. The main shocks are as follows, in decreasing frequencies: Drought, Hailstorm, Flood, and Animal Disease. According to the study interest, we will mainly focus on drought and flood shocks to observe their results as well as the actions implemented in consequence of these shocks and the party responsible of this action. Drought represents 31% of the shocks reported by this survey whereas Flood represents 11.58%. The results of Drought are, in decreasing impact, decline in crop yield (43%) followed by a loss of assets (17%) and food shortage (16%). The outcome of this shock was mainly the selling of livestock followed by nothing as shown in the graph. Flood is in majority reported to have occurred in between 1995-1997. The results of this shock are mainly a decline in crop yield followed by food insecurity and shortage, decline in consumption and loss of assets. Aid has been provided to 12.8% of the households. The most common type of aid received is Food For Work (FFW). Aid is implemented mainly by Regional Government, Federal Government and NGOs. The main reason to launch any kind of aid is drought. The main activity that was started through aid and more specifically the Food for Work program, launched for drought is soil conservation and water harvesting.

Climate Change Perceptions

In order to quantify people's opinion on climate change they were asked, on the one hand about noticed changes in the temperature and on the other hand about the variations in rainfalls. Two measures were used: the mean and the number of days. It has to be noticed that the number of observations concerning these issues equals to more or less the third of the whole sample. More variation in the mean of rainfall (75.45%) has been perceived than in the mean of temperature in the last 20 years (53.62%). In addition, household were asked their point of view on the rainfall variation 'causes, according to 78.98% of the household, poor vegetation cover is responsible for the declined in rainfall. Finally, household's opinion about the vegetation cover over the last 20 years turned out to be for half unchanged and for 35% decreasing. Furthermore, they were asked about the nature of their response to these changes. While over half of household do no change behavior, 19.96% of household react to the long-term shifts in temperature by changing crop variety. The second adjustment is to put tree for shading, afforest the area or use irrigation. Implementing soil conservation schemes is the answer to rainfall decline in 31.12% of the households, 11.12% of household are changing the variety of crop they are growing, following these two reactions implemented by a large majority of household, we find early planting, planting trees or using irrigation.

Moreover, the survey inquired about reasons of not adopting each behavior. The main recurrent reasons for not changing behavior are lack of information, of money followed by shortage of land and then by a shortage of labor. The two justifications for not changing crop variety, not building a harvesting scheme, not buying an insurance and not finding an off-farm job are firstly a lack of information and secondly a lack of money.

Soil and Water Conservations Measures

Given the study aim, a focus is made on the most commonly observed soil conservation implementations. Annex A depicts more specific consequences of each practice on soil erosion mitigation. The most common SWC techniques observed are the following (Table A) : the construction of water ways on at least one crop is implemented by 40.5% of households, soil bunds concerns 36.8% households, stone bunds 22%, grass stripes 4.8% and ploughing around contours 4.1%.

Out of 1000 households, 26 have access to a pump. Most pump are collectively owned, it is the case for 18 households whereas 8 own it privately. The majority of pumps are diesel ones against manual ones, the majority accounts for 20 households. Pump purpose is defined as follow: 2 pumps are used for domestic use and livestock watering while 24 to irrigate crops.

Regarding Tree planting as a way to mitigate soil erosion, 88.4% of households do not practice it. Among the minority implementing it, 47.56% do it on solely one plot. Given that the average plot holding is three, it concern, among the 47.56% of household practicing it, 26.68 % households.

Table A. *Descriptive Statistics of Soil and Water Conservation Techniques.*

Variable	**Description**	**Type**	**Mean**	**Std. Dev.**	**Min**	**Max**
SCTSoilbundT	*Number Plots with Soil Bunds*	1000	1.385	2.384	0	16
SCTStonebundT	*Number Plots with Stone Bunds*	1000	.663	1.792	0	18
SCTGrassstripesT	*Number Plots with Grass stripes*	1000	.15	.8149	0	10
SCTWaterwayT	*Number Plots with Waterway*	1000	1.688	2.528	0	13
SCTPlantintreeT	*Number Plots where Tree are planted*	1000	.316	1.075	0	10
SCTPloughingT	*Number Plots Ploughed*	1000	.126	.7103	0	7
Pump	*Whether HH has a pump or not*	1000	.026	.1592	0	1
PumpDom	*For domestic use*	26	.0769	.2717	0	1
PumpWater	*Pump used to water livestock*	26	.0769	.2717	0	1
PumpIrri	*Number Plots irrigated by a Pump*	26	1	.4	0	1

Finally, it has to be recall that this dataset is a geo-referenced. Indeed, because this dataset has been made out of a survey; variables such as distance to market or to water source are subjective as those are biased by the farmer's perceptions. The mapping will relativize them by relating household to spatial data already existing. Therefore, mapping providing objective spatial benchmark will make up for the subjectivity of the farmers interrogated. Nevertheless, considering the unavailability of such a map, the variables out of the survey will be used as first proxy to provide an insight on the adoption model.

iii. Model Variables Description and Hypothesis

Accordingly to the background literature depicted in the previous subsection, relevant variables were selected given the available ones described two subsection above. However, a range of explanatory variables lacking consistency in the conservation literature were also taken into account given the variability of the previous literature review.

Dependent Variables

Given the large range of variable found in the dataset and the few observations using those techniques, aggregate categories were form in order to satisfy the minimum sample size criteria. In this analysis, the implementation of three techniques are being considered, those are named water pump, planting tree and a selection of SWC techniques. One is considered an “adopter” of the specific technique tested if he implemented the measure on one or more of his plots. Hence, non-adopters are those who never implemented this technique on any of his plots. The way the three dependent variables were created is exposed below (Table B). The choice of these variables was made accordingly to the broader NBCD project objective. The three variables used as explained variables are the following ones: whether the household uses a pump, whether the household plant tree to conserve soil and water, and a combination of SWC techniques. The share of household using a pump equals to 2.6% households. Regarding tree planting, 11.6% of the dataset households do so, commonly on one or two plots. The former is formed by soil bunds, stone bunds, grass stripes and ploughing contours practices. Non-practitioner of such techniques accounts for 57.7% households. Among those who do, the mean number crop where those techniques are implemented accounts respectively for, 3 plots or less and 2 plots or less for the three lasts kind of techniques.

Table B. *Description and Summary statistics of Dependents Variable used in probit estimation*

Variable	Type	Description	Freq	Mean	Std. Dev.	Min	Max
PUMPDOM	*Continuous*	*For domestic use*	26	.0769	.2717	0	1
PUMPWATER	*Continuous*	*Pump used to water livestock*	26	.0769	.2717	0	1
PUMPIRRI	*Continuous*	*Number Plots irrigated by a Pump*	26	1	.4	0	2
PUMPTOT	*Binary*	*Whether HH has a pump or not*	1000	.026	.1592	0	1
SCTSOILBUND	*Continuous*	*Number Plots with Soil Bunds*	1000	1.385	2.384	0	16
SCTSTONEBU	*Continuous*	*Number Plots with Stone Bunds*	1000	.663	1.7923	0	18
SCTGRASSSTRI	*Continuous*	*Number Plots with Grass stripes*	1000	.15	.81496	0	10
SCTWATERW	*Continuous*	*Number Plots with Waterway*	1000	1.688	2.5288	0	13
SCTPLANTIN	*Continuous*	*Number Plots where Tree are planted*	1000	.316	1.0757	0	10
SCTPLOUGHI	*Continuous*	*Number Plots Ploughed*	1000	.126	.71037	0	7
SCTNONE	*Continuous*	*Number Plots without SWC practice*	1000	1.512	2.5866	0	15

Independent Variables

In this study, explanatory variables are classified in four distinct categories: household’s demography, the household’s economics, the Institutional frame and the biophysical features (Table C). These regressors represent characteristics observed either at household or plot level.

In the demographic category, the household head age (years), the number of household member and whether the household head is religious or not, are found. Variables considered in the household economic category are the following ones: the number of tasks for which the household has at least hired outside labor, whether the household has one or more oxen, the number of plot cultivated, the total area of land cultivated (ha), the square root of the total farm area, and wealth indicators, those are whether the household roof is a metal one and whether the house is built with bricks. The Institutional factors category group together the access to advice through either visit of DAs or attending of a training, the distance in hours to market for farm input and whether aid was the initiating element in the implement of SWC techniques. The bio-physical group includes the average distance from plot to homestead and the distance to water source, because the regression is constrained with soil erosion and slope gradient for technique's suitability reason as explained in the next subsection.

Table C. *Description and Summary Statistics of the Independent variables used in the probit estimation of farmers' adoption decision*

Variable	Type	Description	Freq	Mean	Std. Dev.	Min	Max	Exp-ected effect
HH Demography								
HHHEADAGE	*Continuous*	*Age of the Household Leader(unit = years)*	1000	45.08	13.68	14	92	+/-
HHSIZE	*Continuous*	*Household Size (unit = persons)*	1000	6.168	2.24	1	15	+
RELIGION	*Binary*	*Whether the Household Head is religious*	1000	.868	.338	0	1	+/-
TRAINING	*Binary*	*Whether a HH member has attended a training*	1000	.348	.47657	0	1	+
HH Economics								
HHHIRELABOR	*Continuous*	*Number of Task for which Labor was Hired at least once*	1000	62.49	13.665	22	107	+/-
OXENTBin	*Binary*	*Whether the household owns or not at least one oxen*	1000	1.13	.863	0	2	+/-
HHNUMBERPLOT	*Continuous*	*Number of Plot*	1000	6.03	2.83	1	19	+/-
LANDHOLDINGTOTAL	*Continuous*	*Total ha of land owned*	1000	1.899	1.284	0	10.9	+/-
LANDHOLDINGTOTAL SQU	*Continuous*	*Squared of Total ha of land owned*	1000	5.255	9.695	0	119.618	+/-
METALROOF	*Binary*	*Primary Residence with Metal Roof*	1000	.457	.4983	0	1	+
CONCRETEHOUSE	*Binary*	*Primary Residence concrete stone/bricks*	1000	.13	.336	0	1	+
Institutional								
VISITAGG	*Continuous*	*The number of visit on crop production and livestock*	1000	4.967	10.58	0	100	+
ACCESSTOADVICE	*Binary*	*Whether the household has received visit on crop production or livestock activities and whether they have attended a training on either two focus*	1000	.558	.4968	0	1	+
MARKETINPUT2	*Continuous*	*Distance to Market for Input*	680	3.37	8.916	.05	60	-

		(unit = hours)						
SOILCONSERVAIDBIN	*Binary*	*Soil conservation aid*	130	.569	.5419	0	2	+
Bio-Physical								
AVERAGE DISTANCEPLOT HOMESTEAD	*Continuous*	*The average distance from plot to Homestead*	1000	1.38	2.112	0	25.075	-
DISTANCE	*Continuous*	*Distance in estimated km to Water source*	1000	8.7214	23.897	0	100	+

Bio-physical Restrictions

The NBDC approach to soil and water conservation problem is interesting in its use of integrated rainwater management approach. The spatial and physical characteristics are taken into account when considering the adoption of one technique or the other. In fact, the adoption of a technique is considered as desirable if its consequences on the others household downstream for example are taken into account. The purpose of taking a watershed approach is to consider the complementarity of implementation of soil conservation techniques at different level. Indeed, depending on the slope, for which erosion degree is a possible indicator, the type of technique to use to mitigate the best erosion varies. This study was intended to take part in a broader project, the developing of a methodology that allows identifying locations within a landscape that have similar bio-physical, infrastructure, socio-economics, and institutional characteristics relevant to Rainwater Management Strategies.

In that line, bio-physical sustainability criteria were provided by scientists and field experts advices in an intern project report. Restrictions were set accordingly to the respective physical performance of each technique. The adoption of a pump is feasible if at least one plot of the household is said flat. The performance of planting specific[20] tree techniques is best for conserving soil when erosion is moderate or severe. Finally, the adoption of some SWC techniques such as Soil bunds, Stone bunds, Grass Stripes and Plouhging contour are best when slope is inclined or steep on at least one plot. A description of these restrictive factors can be found below (Table D).

Table D. *Description and Statistical Summary of Control Variables.*

Variable	Type	Description	Freq	Mean	Std. Dev.	Min	Max
Adopting of Pump							
SLOPEFLATBin	*Binary*	*Whether the HH has at least one Flat Plot*	1000	.818	.3860	0	1
Adopting Planting tree							
EROSIONSEVEREB	*Binary*	*Whether the HH has at least one Plot with Severe Erosion*	1000	.22	.4145	0	1
EROSIONMILDBin	*Binary*	*Whether the HH has at least one Plot with Mild Erosion*	1000	.652	.4766	0	1
Adoption of SC Techniques							
SLOPEINCLINEDB	*Binary*	*Whether the HH has at least one Plot Inclined*	1000	.642	.4796	0	1
SLOPESTEEPBin	*Binary*	*Whether the HH has at least one Steep Plot*	1000	.117	.3216	0	1

[20] Planting eucalyptus and mango oranges, apple, banana, avocado and coffee controls for erosion.

D. RESULTS

Table E. presents the results of the probit estimation of the determinants of farmers' adoption of a pump, planting tree practice, and SWC techniques. Overall, between the probabilities of the dependent variables and the set of explanatory variable included in the model, significant relationships are observed. The range of factors influencing adoption of each of the three different SWC techniques was similar to the one expected.

Pump

The adoption of a pump for SWC purpose is influenced by several variables according to the probit analysis. Variables observed to have a positive influence are the number of member in a household (HHSIZE), the number of tasks for which an household has at least once hired external labor (HHHIRELABOR), whether they own an oxen (OXENTB), the number of DA's visits on crop production or livestock (VISITAGG) and the distance to water source (DISTANCEW). The sole variable having a negative impact is the distance to market for inputs in hours (MARKETINPUT2).

The oxen might be an indicator of the wealth, of the available drought power as it eases the ploughing and other productive tasks thereby reducing the need for additional labor. Whether the household has oxen or not might give information on either one of these indicators or on a combination of those. It can be hypothesized that one owning oxen is likely to be a productive farmer. It might indicate a willingness to invest in improving farm yield. This postulated explanation makes sense with the Hire Labor variable impact. If the farmer is an investor type, he will see scenarios in which hiring external labor is advantageous. The number of visit from the DA might be a proxy for the extent to which the household has received advice from the DA. This variable matches pretty well the postulated explanation. The household size informs on the lack of labor. The nearer the household is to the input market, the most likely they will own a pump. Indeed, space part of such pump perhaps may be found at the market. The market for input is found to be fully correlated with the output market. Therefore the best access one has to the market, the easiest it is to be supplied pump part at the installation or in case of reparation, and furthermore the easiest it is to sell their output surplus.

The model can be considered as not bad for a first trial of such regression on this dataset. Pumps for water management and indirectly targeted at soil conservation measure, are more likely to be "adopted" when one has a good market access and if peasant is either wealthy or productive. The former is stated based on a large supply of intern labor, on owning animal for production process, on the openness in hiring labor and on the farmer's knowledge through DA's advice.

Correlation test were also made between each explanatory variable and the dependent one, and for each pair of independent variables. All turned out with nothing to be concern of. For example, one may have wondered if owning a pump is correlated with the number of DA visits; it turned out to be not correlated (r = .0971). Two correlation requires attention, those are the link between the distance to input market variable and the distance to water one (r = .2245) and between the household size and whether holding an oxen or not (r = .2068). Those two may be expected with the previous explanation.

Planting Tree

The variable influencing the implementation of tree planting as SWC purpose are organized along the direction of their relation. Among the variable influencing positively the planting of tree, whether the household has hired, at least once, labor (HHHIRELABOR), whether the DA has visited the household once or more (VISITAGG), the total area of land cultivated (LANDHOLDINGTOTAL), whether one member has attended a training on farming (TRAINING) and whether the household head is religious or not (RELIGION) are found.

The negatives influence's variables on adoption of tree planting include, the mean distance plot to homestead (AVERAGEDISTANCEPLOTHO), the household head age (HHEADAGE), the squared total land hold (LANDHOLDINGTOTAL2) and whether aid has implemented soil conservation technique on farm (SOILCONSERVAIDBIN).

The logic is coherent in-between Planting tree and the distance to the plot. Since, tree's most common uses are heating and cooking, the nearer the tree plot are, the less labor is required to carry it to homestead. The religion variable perhaps captures in addition of the dogma, traditions and lifestyle promoted by the former. However, attention is needed as it can also reflect spatial information, i.e. in the case of Ethiopia, regions boundaries were drawn according to religious criteria. Nevertheless, the religion variable has been computed not according to whether one is Muslim or Christian but rather as one's adherence to a dogma or not. The age of the household head might be associated with the farmer's willingness to test innovation, the oldest one gets, the less flexible or the more doubtful he becomes to innovation. Regarding the opposite sign of the total area of land holding and the former squared one, the bigger one farm gets, the less likely the peasant is found to plant tree. This can be interpreted as a stronger concern of securing a maximum share of the land when the farm is small while when a farm is larger, the concern is relaxed. These two variables were computed to see the impact of being a very big farm as such farm is not necessarily present in the available dataset. The turning point beyond which this partial effect sign change is 2.47 ha. The dataset includes this type of household (min-max .00-10.93).

It is interesting to notice that the training variable is found relevant for planting tree while in the pump adoption probit estimation, solely the number of visit accounting for advice access variable is found significant. This difference is hypothesized to be due to the fact that planting tree requires practicing and advices while pump turns out to be a purchase.

Correlation test were also made between each explanatory variable and the dependent one, and for each pair of independent variables. All turned out with nothing to be concern of. The interesting correlation includes the one between the number of DA's visit and the number of training (r = .2047), the one between the household head age and the adherence to any religion (r = .1556), the one between the attending of a training and the adherence to a religion (r = .1423) and of course the one between the total area of land holding and its squared version (r = .8958).

SWC techniques

The explanatory variables of SWC measures are distinguished accordingly to the impact sign. The negative influence variables include whether the household has an oxen or not (OXENTB), the number of task for which the household has once or more hired labor (HHHIRELABOR) and the total surface area of land owned (LANDHOLDINGTOTAL). The following variables have a positive relation with the adoption of SWC techniques: the distance in hours to the input market (MARKETINPUT2), the squared landholding (LANDHOLDINGTOTAL2), the number of plots (HHNUMBERPLOT), whether the household has either received at least one DA visit or if one has attended a training (ACCESSTOADVICE), whether the house has a metal roof (METALROOF), whether the house is made of bricks (CONCRETEHOUSE), and whether soil conservation measures have been implemented by aid program (SOILCONSERVAIDBIN).

A household owning oxen is less likely to implement techniques, this variable is an indicator of the household welfare. Therefore a poorer farmer is more likely to implement such techniques. Moreover, the less one household has hired labor, the more likely they will implement SWC practices. Household having not much wealth are more likely to be concern mainly about their very own subsistence. While they do not have much capital available to invest in expense techniques, the improving of their crop yields is a survival issue for them. In addition, the concrete house or the metal roof variables were first considered as indicators of the household welfare but do not follow the same pattern as the oxen variable. This counter-intuitive result requires further investigation.

Regarding the opposite sign of the total land holding variable, the smaller area of land one owns, the more one will implement such conservation measures. However to a certain extent, if the surface area is big enough, it becomes very interesting to implement such practices. When dependence on a small area is not crucial, it is rather about the marginal crop yields gained from these conservations measures. The point of turnaround is found at 5.89 ha. Household with this specific landholding are present in the data sample, those are above the mean size observed, which is of 1.9 ha.

The further away from the input market, the more likely one will implement SWC practices. This variable might reflects in this case, indirectly the household wealth. Indeed, the one living further away from market are the one having to spend more time to sell their output as the distance to cross to get to the market is larger. Thus, the present assumption is that poorer peasants are further from the market. However, the correlation between living in a concrete house and the distance to the input market is negative and equals -.0779.

The more fragmented the landholding is, the more likely one will implement SWC techniques. Indeed, on the one hand, having more plots, it is more likely that at least one of the field falls into conservation practices; on the other hand, according to the Similarity Analysis produced by the NBCD, fragmentation of land associated with plots spread all around, is found to be highly correlated with population dynamic of the area. Therefore it is likely that this variable refers to the specificity of the area and not to the land fragmentation. Since dense areas are the more fragmented one; the more people implement conservation, the more collective action makes sense. The implementation of SWC practices through aid program is probably, here also, reflecting a locational variable. Indeed, only 71 households satisfy this variable and aid program maximized their impact by targeting highly dense area.

Correlation tests were also made between each explanatory variable and the dependent one, and for each pair of independent variables. All turned out with nothing to be concern of. The interesting correlation includes the one between SWC practices and access to advice (r=.2445), SWC practices and distance to input market (r=.1733), SWC practices and land fragmentation (r=.3853), access to advice and fragmentation (r=.2261), fragmentation and soil conservation technique through aid (r=.0752). Attention has to be drawn to the following correlation: SWC practices and concrete house (r=.2063), labor hire and fragmentation (r=-.1777).

In conclusion, the data set assessed turns out to be very extensive on household and community information. The sample is well documented and appears to be adequate for the study conducted within the econometric framework. However, in this sample, not much households have adopted either, pump technology, soil conservation practices or planting tree practices. Therefore, econometric analysis on these variables is found to be rather limited by the minimal sample size requirement.

This analysis consisted of running first trials adoption model. Thereby, three types of soil conservation adoption behavior have been studied. Based on these findings and on literature, drivers of conservation techniques adoption are specific on the type of technology. Indeed, pump technology appears to be more commonly used by wealthier or more productive farmers. Soil conservation and planting tree practices rely more on knowledge access and labor availability and are mainly implemented by less wealthy peasants.

Table E. *Estimated coefficients and their significance for the three soil and water conservation Adoption Probit Equations using STATA 10.0*

Explanatory Variable Name	**Computation**	**ADOPTING PUMP AS SWC**			**ADOPTING PLANTING TREE AS A SWC**			**ADOPTING SWC**		
		Coeff	**S.D.**	**P>|z|**	**Coeff.**	**S.D.**	**P>|z|**	**Coeff.**	**S.D.**	**P>|z|**
HHSIZE1	*Household Size (persons)*	.1102	.0493	.026						
MARKETINPUT2	*Distance to Market for Input (hours)*	-.059	.0124	.000				.01917	.008	.021
HHHIRELABOR	*Number of Task for which Labor was Hired*	.0237	.0079	.003	.0170	.0046	.000	-.0108	.0052	.037
OXENTBin	*Whether the household owns or not at least one oxen*	.3789	.1705	.026				-.3836	.1733	.027
VISITAGG	*The number of visit on crop production and livestock*	.0221	.0061	.000	.0094	.0054	.084			
DISTANCEW	*Distance to Water Source (estimated km)*	.0152	.0048	.002						
HHHEADAGE					-.0194	.0052	.000			
LANDHOLDINGTOTAL	*Total ha of land owned*				.9923	.2618	.000	-.4386	.1327	.001
$LANDHOLDINGTOTAL^2$	*Squared of Total ha of land owned*				-.2008	.0558	.000	.03724	.0159	.019
AVERAGEDISTANCEPLOTHO	*The average distance from plot to Homestead*				-.1492	.0461	.001			
TRAINING	*Whether a HH member has attended a training*				.2962	.1329	.026			
RELIGION	*Whether the HH head is religious or not*				.8392	.2853	.003			
ACCESSTOADVICE	*Whether the household has received visit on crop production or livestock activities along if they have attended a training on either two focus*							.46308	.1451	.001
METALROOF	*Primary Residence with Metal Roof*							.5644	.1491	.000
CONCRETEHOUSE	*Primary Residence concrete stone/bricks*							.65596	.2305	.004
HHNUMBERPLOT	*Number of Plot*							.08169	.0304	.007
SOILCONSERVAIDBIN	*Soil conservation aid -binary*							.4366	.244	.074
Constant		-4.69	.7636	.000	-3.119	.519	.000	.5284	.3999	.186
Spatial Restrictions		SlopeFlatBin>0			ErosionSevereBin>0 or ErosionMildBin>0			SlopeInclinedBin>0 or SlopeSteepBin>0		
Nber of Obs.		**555**			**724**			**417**		
PSEUDO-R2		**.2063**			**.1386**			**.2177**		
Log Likelihood function		-73.475			-255.104			-222.867		

3. PERSONAL EVALUATION

This first experience in a professional environment enabled me to gain a great number of competences in a variety of domains. First of all, being intern immersed in the international research community took me to another level of interaction in a foreign language. Indeed, recently graduated from Clemson University, I had been improving my academic English for over a year. Living in South Carolina was very stimulating language-speaking. Yet, while the international scientific community enhanced the practicing of my professional English, it required me considerable self-learning during the acquaintance phase. Indeed, an advanced professional English level was being called upon during meetings, assembly, random colleagues' interactions, informal lunches, and many more opportunities. The sharpness of the debates either professional or informal was very demanding both intellectually and linguistically. My professional English improved toward an advanced level.

In this cross-disciplinary environment, the communication was trivial neither at the English level nor at the intellectual level. Fortunately, with the sequence of two somehow different topics, I experienced even more this multidisciplinarity. These varied insights taught me a lot. While working with mainly agronomists, understanding of the required tasks was not always easy. I found it very demanding to apply the academic theory learned at University to this complete new domain. Not only the terms were different and new in many domains, the logic behind the expression of an idea was very unfamiliar. Working with colleagues with different experience did not facilitate the mutual understanding. Indeed, each discipline has its own referential vocabulary. It tends to lead in various interpretations. The comprehension of an agreement, of a meeting agenda or of a task objective is sometimes interpreted along individual's referential domain. Specific tasks requirement were not always trivial. Nonetheless, the rich career of my colleagues taught me a tremendous amount of skills.

I learned about agricultural domain through the collaboration with field investigators, Ethiopian local and international experts. The interaction with a sociologist specialist when designing the field trip discussion with Nekem'te peasants, was extremely interesting as her numerous experiences made vivid the different theories on the subject. Working for a spatial economist was one of the highlight of the internship as it closed the buckle of the application of economics in this agricultural development field. The integration of spatial component in the economic analysis came completing my academic knowledge.

Furthermore, the necessity to combine different taught subjects in working toward meeting multidisciplinary objectives, offered me great opportunities to test my knowledge and to learn furthermore. When executing a task, trivial application of knowledge was not sufficient and additional research and initiation had to be done. Moreover, the integration of the economic knowledge with other disciplines was the most subtle exercise. Indeed, the permanence of inter-disciplinarily required a continuous adaptation.

Economics knowledge were essential in understanding household level management and also when soliciting econometric knowledge. Both the exploration of bio-physical household management model and the merging of the data set required programming competences. My training in sociology was very useful when exploring method of qualitative group discussion and understanding the various relevant issues. The cleaning, re-organizing and designing of a database, along with the analysis once the restructuring was done, got me to review in details relevant econometric theory. I learned a lot in doing so under the supervision of a PhD holder. Throughout the diversified task, I had the opportunity to call upon many different competences learned and to educate myself furthermore.

Since each task formed a whole by itself, I could feel the responsibility of that well-defined project on my shoulders. This responsibility was enhanced by the understanding of future interaction of my tasks with others project's segment. However, as noted above, the expression of the requirement level was not always very explicit. The degree of responsibility was therefore difficult to perceive.

In addition, there was a significant recognition of the intern work among the institution. A public presentation of my intern work (Annex B - d) planned from the beginning was organized to inform the NBCD team and other colleagues I got to know throughout my time spent at ILRI Center. Finally, due to the projects' collaboration across multiple jet lags, flexibility of one another, perceived as dedication to the project, was the crucial glue to this latest.

Moreover, I had an, albeit minor, insight within agricultural research reality. Thanks to the short fieldtrip I caught a glimpse on the fuzzy link between theory and its application. Modeling has its boundary, the gap perceived between model and reality could be described as follow. Through simulations, researchers are aiming to representing the reality as closely as possible. Over my field experience, I gained a better understanding of the model I was working on. I became aware of the model's bottom line and its limited applicability. That is to say spreading, through the DA, simulation model in the different villages for farmers' use quiet overlooked the rural livelihood reality[21]. In fact, the wider project's goal would be to implement the software at local level to assist farmer's decision making by enabling the impact's visualization of a change in the management techniques through scenarios. Thereby, to lessen the inherent uncertainty risk linked with the change in practices. The implementation would perhaps be one of the most challenging parts.

Indeed, for some region of the world, where farmers manage their farm as a business and as a maximization of assets and where electricity facilities are well spread out, they can gain from these tools. However, when we talk about subsistence agriculture, where traditional roles are not questionable there are additional issues that come up when considering implementing these tools in these areas. Thereby, these rising issues comes under sociological/anthropological dimensions such as why would a farmer believe this computer will model his farm (what does modeling means for him ?) given the likelihood that he may not be able to read or write, that electricity may be very scarce. He will perhaps see only a new kind of light. There is no a priori reason for him to trust blindly what the system will advise him to do. Moreover, it requires beforehand to have some management concepts. In some situation such as food shortage and dry season, the management logic cannot be applied as it is a matter of survival. Rationality has limits, i.e. the survival of oneself obviously dominates the maximization of input into output. Moreover, cultural traditions are well established for some historical reasons and have consequences, i.e. the accumulation of livestock regardless of the animal health. Indeed, livestock is considered as asset indicator of one's wealth, in that logic, it is rational that everyone intent to keeping alive most animals possible. Focus is not always turned to one's livestock's health and productivity.

In conclusion, I am very thankful for this experience for two reasons; it challenged me both at the intellectual level and the practical one through various professional jobs in a very stimulating context.

[21] Ethiopia is considered as one of the few low-income countries with 39% population living on less than USD 1.25 a day (UNDP, 2010). Their livelihoods, for the majority in rural areas, is far from being accustomed with IT technologies such as software and computer; moreover, they are even further away from being convinced by these type of model as it questions the practices they have inherit and implemented for generations.

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ANNEX A. *Impact of various SWC techniques (Items Selected from the intern NBCD data base).*

Practice	Hydrological purpose	Bio-physical purpose	Socio-economic purpose	Bio-physical characteristics	Socio-economic condition	Institutional condition	Linkage
PUMPS	Water distribution		Access water for supplementary irrigation	Access to water	Access to input market = spare parts and pumps	Access to credit	With water storage
					Access to fuel	Access to information and awareness	
					Male headed household	Access to subsidies	
					No off-farm employment		
LEVEL SOIL BUNDS	Soil and water conservation in moisture stressed area	Erosion reduction	Increased crop yield	Rainfall < 1400 mm	No off-farm opportunity	No land tenure is ok	Soil fertility
	Storage of water in the trenches			Slope 3-15% on cultivated land, slope up to 5% for graze land	Few livestock	No access to credit, access to credit	
				Not suitable on sandy, shallow, poorly drained, or stony soils	Education	Access to information	
					Labor availability		
				Not suitable on degraded land	Male headed household, farm income	Small holding size per active household member	
STONE BUNDS	Soil and water conservation	Erosion reduction	Increased crop yield	Slope 5-35%	No off-farm opportunity	No land tenure is ok	Soil fertility
	Storage of water in trenches			Rainfall < 1400 mm and rainfall >1400 if deep and well drained soils	Few livestock	No access to credit, access to credit	Gully rehabilitation
				Medium texture, stony soils	Farm size	Access to information	Tree planting
					Education		
					Male headed household, farm		

					income		
				Proximity to homestead	Labor Availability	Small holding size per active household member	Grass strips (cut and carry)
GRASS STRIPS ALONG CONTOUR	Soil and water conservation	Soil fertility	Forage for livestock	Not suitable if rainfall < 900 mm and if altitude <1500 m			
		Erosion reduction		Slope < 15%			
STRIP CROPPING		Soil fertility	Crop diversification	Slope < 50%	Access to input market	Enough land	Mulching
		Erosion control		If slope > 5% needs to be combined with terracing or bund			Bunds
TREES IN FIELDS	Ground water recharge	Erosion reduction	Timber, fruit and fodder	Degraded land for maximum impact on livelihood	Young farmer	Land tenure	Multi-store gardening
	Water recharge	Control erosion	Animal feed (strip planting, grazing land management)		Small land size	Land fragmentation	
		Rehabilitation degraded land (trees)	Minimize risks		Household size	Land certification	
		Moderate micro-climate (trees)	Increased productivity		Capital intensive	Awareness	
					Labor intensive	Land ownership	
					Land size		
CONSERVATION TILLAGE	Soil and water conservation	Undisturbed soil	Increase crop productivity	On cultivated land	Labor intensive	Access to extension service and farmer organization	Soil fertility

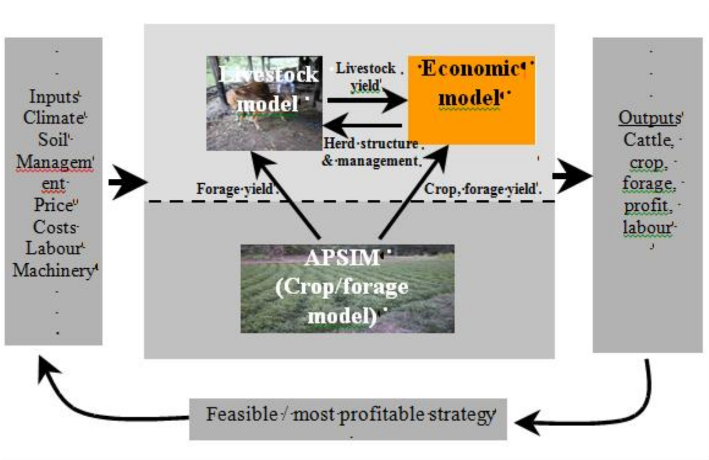
ANNEX B - a. Addis Ababa, 18/06/2011

Bio-Farm Model Review:

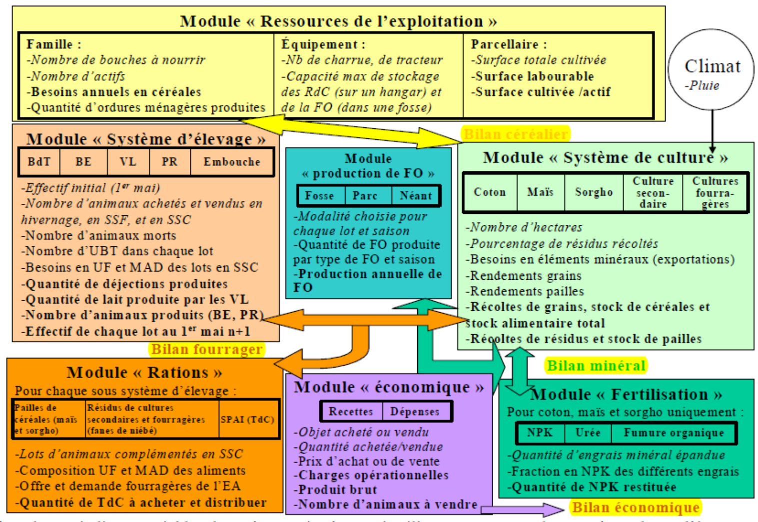
A Comparison of two the IAT model (CSIRO) and the Cikeda model (CIRAD)

Outlook

IAT Cikeda



ure 1. Structure of the Integrated Analysis Tool (IAT)



.égende : en italique, variables d'entrée renseignées par l'utilisateur ; en normal, paramètres du modèle ou variables intermédiaires de calcul ; en gras, variables de sortie.

Integrates data and output from 3 separate models: a pre-existing farming system model (APSIM), and 2 new models for predicting cattle growth and mimicking the economic performance of a typical smallholder farm-household enterprise	Made of 7 modules intertwined, 4 BILANS: livestock, soil, cereals, profit

Aim

Opportunities to increase Bali cattle production in eastern Indonesia within the existing constraints of land, labor and cultural cropping practices IAT is suitable for analyzing most rice and cattle based smallholder systems in south-east Asia. So long as estimates of crop and forage production and	Advice platform for multi cropping and livestock feeding.

quality can be provided, along with commodity prices, labor demands and availability, representative analyses of farming systems should achievable.	

Inputs Requirements

Grain/food crop information

Annual for 10 yrs
- Grain yield (kg/ha)
- Stover yield or total biomass (kg/ha)
- Date of harvest (day of year counted from start of wet season)
- N content of stover (%)
- Priority (1 to 4)

For each crop
- Selling price (per kg)
- Home consumption (kg/adult/year)
- Seed input requirements (number of units/ha, bags or kg)
- Seed cost per unit
- Fertiliser input requirements (number of units/ha, bags or kg)
- Fertiliser cost per unit
- Pesticide input requirements (number of units/ha, drums or litres)
- Pesticide cost per unit
- Labour (man days/ha) for each of
  - cultivation/ploughing
  - planting
  - maintenance/weeding/irrigation
  - harvesting
  - post harvest activities

Fixed input (**)

In each season Proportion of labour
- ByProduct-1 (Yield, Price, Season of harvest, amount kept)
- ByProduct-2 (Yield, Price, Season of harvest, amount kept)
- Other costs (Bags, Transport, Storage, Irrigation, other)

Forage information

Harvest information for each of 10 years
- Stover yield or total biomass (kg/ha)
- Date of harvest (day of year counted from start of wet season)
- N content of stover (%)
- Priority (1 to 4)

Fixed inputs (**)

In each season Proportion of labour
- ByProduct-1 (Yield, Price, Season of harvest, amount kept)
- ByProduct-2 (Yield, Price, Season of harvest, amount kept)

Tableau 6 : Variables d'entrée et de sorties du module "ressources"

	Sous module	Description de la variable	Nom de la variable	Unité
ENTREES	Famille	Nombre de bouches à nourrir	Nbouch	
		Nombre d'actifs	Nact	
	Equipement	Nombre de charrues	Nchar	
		Nombre de tracteurs	Ntract	
		Capacité maximale de stockage de la fumure organique dans une fosse	StockmaxFOchar	*en charrettes petit plateau*
		Capacité maximale de stockage des résidus de culture	StockmaxRdCchar	*en charrettes petit plateau*
	Parcellaire	Surface cultivée	Scult	*en ha*

Tableau 11 : Variables d'entrée et de sortie du module "fertilisation"

		Description de la variable	Nom de la variable	Unité
ENTREES	NPK	Quantité de NPK épandue /ha de culture fertilisée	$QNPK_{Cult}$	*en kg/ha*
	Urée	Quantité d'urée épandue /ha de culture fertilisée	$QUree_{Cult}$	*en kg/ha*

Tableau 10 : Variables d'entrée et de sortie du module "production de fumure organique"

	Description de la variable	Nom de la variable	Unité
ENTREES	Devenir des déjections des animaux à chaque saison	$ModFO_{Anxi}$	*Variable qualitative*

Les seules cultures fertilisées sont le coton, le maïs et de façon marginale le sorgho. Les autres cultures ne reçoivent ni engrais minéraux, ni FO, ou alors les quantités sont très limitées Fertilization en fonction du type de sol cfr marine.Annexes p58

Tableau 8 : Variables d'entrée et de sortie du module "système de culture"

		Description de la variable	Nom de la variable	Unité
ENTREES	Assolement	Nombre d'hectares de chaque culture	S_{Cult}	*en ha*
	Récolte des résidus de culture	Proportion de résidus de maïs récoltés	PropRecmais	*en %*
		Proportion de résidus de sorgho récoltés	PropRecsorgho	*en %*
		Proportion de résidus de cultures secondaires récoltés (fanes de niébé)	PropRecCultSec	*en %*

Other costs (Bags, Transport, Storage, Irrigation, other) [22]

Plantation and fruit tree information- **and** Vegetable, spice and other crops

Yield (kg/tree)

Harvest season (R, D1 or D2)

Fixed inputs (**)

In each season Proportion of labour

ByProduct-1 (Yield, Price, Season of harvest, amount kept

ByProduct-2 (Yield, Price, Season of harvest, amount kept

Other costs (Bags, Transport, Storage, Irrigation, other)

-Assolement 5 sous modules : **coton ; maïs ; sorgho ; cultures secondaires à cycle court** (représentées par le niébé)**; et cultures fourragères**
-Paramètres fixes :
- les exportations en éléments minéraux N, P, K des cultures par tonne produite
- les rendements moyens des cultures pour la région des Hauts-Bassins (1996-2006) :paramètre servant à calculer les exportations des cultures en éléments minéraux par hectare, à partir des besoins connus à la tonne,
- les rendements grains du coton, maïs, sorgho et cultures secondaires, pour les trois scénarios climatiques définis (favorable, moyen, défavorable),
- les rendements en pailles des cultures, de même pour les trois scénarios climatiques.

Rendements par années, ordre de grandeur des rendements de la région pour les années climatiques « type » (données DRAHRH, 2008) corrigés à dire d'experts (paysans)
⇔ prise en compte influence du climat sur rendement

Animal information (*)

For each animal (**)

Feeding (for cattle, labour other than for cut & carry)

Herding

Transporting

Veterinary supplies

Manure (for cattle only, labour and costs, per kg)

Mating fees (costs only)

Supplements (for cattle only, and these can be edited from an input form)

Other animal costs (costs only)

Ruminants

Number of animals of each class starting age and size,

Weaning age (months)

Maximum age (before culling old cows, in months)

Selling age (months)

Selling price (per kg liveweight) for each class

Non-ruminants

Reproduction rate (per breeding animal per year)

Sale price of female animals

Tableau 7 : Variables d'entrée et de sortie du module "système d'élevage"

		Description de la variable	Nom de la variable	Unité
ENTREES	Effectifs des animaux au début de l'hivernage	Nombre de bœufs de trait	NBdT05	
		Nombre global de bovins d'élevage (sauf bœufs de trait et d'embouche)	NBE05	
		Parmi le nombre global de BE : nombre de VL mises à la reproduction (variable facultative)	NVL05uti	
		Nombre de petits ruminants	NPR05	
		Nombre de bovins d'embouche	NEmb05	
	Achats / Ventes	Nombre d'animaux achetés à chaque saison	$N_{Anx}ach_i$	
		Nombre d'animaux vendus à chaque saison	$N_{Anx}vend_i$	

) : Variables d'entrée et de sortie du module "rations"

	Description de la variable	Nom de la variable	Unité
ENTREES	Lots d'animaux recevant une complémentation de leur ration en SSC	AnxCompl	*Variable qualitative*

Utilisé qu'en SSC, hypothèse que les pâturages sont épuisés.

[22] **Assumed to be specified for which climate zone, soil type and season the data belongs except if (*) means independent //(**) to fill in crop act. Sheet or Animal_act**
Climate zone – to specify a new country or a new region within a country that has a different climate, each can be given a zone number. // Soil type –five different soil types are presently allowed: sand, silt, loam, clay, and heavy clay, but more can be added //Seasons – each year is divided into 3 seasons, with the first season commencing on the 1st day of the first month of the wet season, and each season lasting 4 months. Crops can be grown in any of these seasons, and labour availability is specified according to season. The first season is the rainy season (R), followed by the early dry season (D1) and the late dry season (D2).

Sale price of male animals
Number kept for home consumption (per year)
Cost per young animal (e.g. feeding costs/year, or until sold)
Costs per older animal (e.g. feeding costs/year)
Labour requirements

Trade animals

Supplements

Milk and Manure

General farm information

Areas of different land types (up to 3 allowed: Backyard, lowland, upland) , %Total, %Building,%Bunded)
Feeding method (Grazing, cut & carry, or both)
Daily feed supply (if cut & carry)
Availability of feeding troughs
Areas of each crop or forage grown
Whether seasonal mating is used or not

Labour availability and permitted activities

Total number of days each member of the family can provide in each season
What activities each person is usually permitted to do

Data requirements for Prototype Economic Model

(*) Data based on SPA Case Household 9

Use labor availability and permitted tasks
Crops allocations and work required
And all other input above

Tableau 12 : Variables d'entrée et de sortie du module "économie"

		Description de la variable	Nom de la variable	Unité
ENTREES	Réserves	Quantité de maïs à mettre en réserves (en plus des besoins annuels familiaux)	ReservMais	*en sacs*
	Dépenses liées aux cultures	Nombre de litres d'herbicide total Touchdown achetés	QHerbTDach	*en L*
		Nombre de litres d'herbicide coton Alonet achetés	QHerbCAlach	*en L*
		Nombre de litres d'herbicide coton Galan super achetés	QHerbGSach	*en L*
		Nombre de litres d'herbicide coton CotonDom achetés	QHerbCDach	*en L*
		Nombre de sacs d'herbicide coton Action 80 achetés	QHerbAcach	*en sacs*
		Nombre de litres d'herbicide coton Herbicoton achetés	QHerbHCach	*en L*
		Nombre de litres d'herbicide maïs Altram achetés	QHerbMAlach	*en L*
		Nombre de litres d'insecticides 1er type achetés	QInsect1ach	*en L*
		Nombre de litres d'insecticides 2ème type achetés	QInsect2ach	*en L*
		Montant annuel des dépenses liées à l'achat et au traitement des semences	CoutSem	*en Fcfa*
	Main d'œuvre	Nombre de journées payées à une main d'œuvre extérieure journalière (désherbage, récolte)	NjourMOext	
		Nombre d'actifs permanents employés de l'extérieur	Nactext	
	Elevage	Montant annuel des frais vétérinaires	CoutVet	*en Fcfa*
		Montant annuel des frais de sel pour les animaux	CoutSel	*en Fcfa*
		Montant annuel des dépenses liées à l'achat de matériel	CoutMat	*en Fcfa*

Data requirements for Livestock Model (*)

Information regarding mortality rates, reproduction rates, feed requirements, (etc) are determined by the cattle model.

Fixed parameters relating to growth rates of different cattle breeds stored in the 'Params' sheet, however these should not be changed except by users with an in-depth knowledge of the energy requirements of cattle, buffalo, goats or sheep.

Data requirements for APSIM (*)

The following table provides a brief summary of the proposed data collection from each on-farm trial.

Observation	Required Information	Timing
Geographical and trial Design Information		
Trial design	- latitude, longitude and altitude	At commencement of experiment
	- trial layout	
	- treatments	
	- replication number	
Crop Management		
Planting	- planting method	At time of planting
	- cultivar	
	- established population	
	- row spacing	
Weeding	- weeding date	At time of weeding
	- how weeded	
Fertilizer	- type	At time of application
	- rate	
	- application method	
	- application depth	
Pesticide	- reason for application	At time of application
	- type	
	- rate	
Crop Measurements		
Non-destructiveplant observations	Crop Phenology	- emergence
		- flowering
		- physiological maturity
Destructive Sampling	Biomass	- flowering
		- physiological maturity
	Grain yield	- physiological maturity
Soil Measurements		
Soil Characterisation	- soil type	At start of trial
	- physical characteristics (water holding capacity)	
	- chemical characteristics	

Soil Water	- plant available water	- pre-plant
		- maturity
Soil Nitrogen	- mineral N	- pre-plant
		- maturity
Climatic Measurements		
At trial site	- rainfall	- for duration of trial
At closest weather station	- location	
	- rainfall	
	- max & min temperature	
	- total radiation or sunshine hours	

Process

The IAT does not employ an automated optimization strategy, but rather uses a **creep budgeting approach** to explore the impacts of various options.

Optimization analysis typically require the problem setting to be heavily simplified and the process of actually finding a solution is rarely transparent to anyone other than experienced users.[23]

Blocked

Output

Final model output is then presented in graph or tabular form

(a) **biophysical characteristics of the system**
- Animal live weight gain
-Fodder/forage analysis
- Milk Production
  Total production and Juvenile intake

(b) **labor details**
-labor availability and required per season
-details of which task is perform per season
  - in terms of number of days
  - in terms of which type of person

(c) **economic performance**

Module Système de ressources

SORTIES	Famille	Besoins annuels en céréales pour la famille	BesCerAnEA	*en sac de 100 kg/an*
	Parcellaire	Surface labourable	Slab	*en ha*
		Surface cultivée par actif	Scultact	*en ha/actif*

Système d'élevage

SORTIES	Reproduction	Nombre de veaux produits par an	ProdveauxAn	
		Nombre de petits ruminants produits par an	ProdPRAn	
	Effectifs des lots à l'hivernage n+1	Nombre total d'animaux dans chaque lot au début de l'hivernage suivant	N_{Anx}fin	
	Production laitière	Nombre de litres de lait produits par les vaches laitières au cours de chaque saison	$Prodlait_i$	*en L*
		Total de la production laitière sur l'année	ProdlaitAn	*en L*
	Quantité potentielle de déjections produites	Quantité potentielle de déjections produites par tous les animaux à chaque saison	$QDejpot_i$	*en kg*
		Quantité totale potentielle de déjections sur l'année	QDejpotAn	*en kg*

i = H, F, C pour hivernage, saison sèche froide, et saison sèche chaude ; Anx = BdT, BE, VL, PR et Emb pour bœufs de trait, bœufs d'élevage, vaches laitières, petits ruminants et bovins d'embouche

[23] The creep budgeting approach involves re-**specifying various input and output variables in a systematic manner to explore the system response to these changes**. That is, the decision-maker 'creeps' around the various response surfaces in a systematic fashion to examine whether there is a shift towards or away from a more satisfactory position than some present baseline or starting position. In this way, the use of '**what-if' questions** is able to provide smallholders, researchers and extension specialists with many insights into how the welfare of the farm-household system will respond to different activities, input and output levels and their respective prices.

In annual term
-Revenue from each activity
-Gross Margin -Living cost
-Home consumption
-Cash Balance
-External Income

Système de culture

SORTIES	Récoltes grains	Récolte grains du coton	RecGcoton	*en kg/ha*
		Récolte grains du maïs	RecGmais	*en sac/ha*
		Récolte grains du sorgho	RecGsorgho	*en sac/ha*
		Récolte grains des cultures secondaires	RecGCultSec	*en sac/ha*
	Bilan céréalier	Stock de céréales	StockCer	*en sac*
		Stock alimentaire total (céréales+niébé)	StockAlim	*en sac*
		Bilan céréalier (stock de céréales - besoins en céréales de la famille)	BilanCer	*en sac*
	Récoltes potentielles de pailles	Récolte pailles des cultures fourragères	RecPCultFrg	*en kg ou charrette*
		Récolte pailles du maïs	RecPmais	*en kg ou charrette*
		Récolte pailles des cultures secondaires	RecPCultSec	*en kg ou charrette*
		Récolte pailles du sorgho	RecPsorgho	*en kg ou charrette*
	Quantités effectivement récoltées = Stocks de pailles	Stock de pailles de cultures fourragères	StockResCultFrg	*en kg ou charrette*
		Stock de pailles de maïs	StockResMais	*en kg ou charrette*
		Stock de pailles de cultures secondaires	StockResCultSec	*en kg ou charrette*
		Stock de pailles de sorgho	StockResSorgho	*en kg ou charrette*
		Stock total de pailles	StockResTot	*en kg ou charrette*

Cult = coton, mais, sorgho, CultSec, CultFrg (coton, maïs, sorgho, cultures secondaires, cultures fourragères)

Système de rations

SORTIES	Bilan en UF pour le nombre d'animaux choisi et pour la SSC	BilanUFAn	*en UF*
	Bilan en MAD pour le nombre d'animaux choisi et pour la SSC	BilanMADAn	*en g*
	Nombre de sacs de tourteaux de coton à acheter pour complémenter le nombre d'animaux choisis pendant la SSC	BesTdCach	*en sacs (50 kg)*
	Dose de tourteau de coton à distribuer par jour et par animal pendant la SSC	BesTdCJ	*en kg/j et animal*

Module Production de fumure organique

SORTIES	Modalité FOSSE	Quantité de FO totale produite par la modalité FOSSE à chaque saison	$Qfosse_i$	*en kg*
		Quantité de FO totale produite par la modalité FOSSE pendant toute l'année	QfosseAn	*en kg*
	Modalité PARC	Quantité de FO totale produite par la modalité PARC à chaque saison	$Qparc_i$	*en kg*
		Quantité de FO totale produite par la modalité PARC pendant toute l'année	QparcAn	*en kg*
	Total	Quantité totale de FO produite sur l'exploitation pendant l'année : fumier de fosse + déjections de parc	QFOtot	*en kg*
		Ratio quantité potentielle de déjections productible à l'année sur quantité de FO effectivement produite sur l'exploitation	TxUtiFO	*en %*

i = H, F, C pour hivernage, saison sèche froide, et saison sèche chaude ; Anx = BdT, BE, PR et Emb pour bœufs de trait, bœufs d'élevage, petits ruminants et bovins d'embouche

Quantité de FO produite, à étaler sur les cultures. Cette quantité est ensuite utilisée dans le module « fertilisation » pour calculer un bilan minéral des cultures.

Module Fertilisation

SORTIES	FO	Quantité totale de FO épandue /ha de culture fertilisée	$QFO_{Cultf}ha$	*en kg/ha et en charrette/ha*
	Fertilisation totale	Quantité totale d'éléments minéraux apportée aux cultures fertilisées	$Q_{E}tot_{Cultf}$	*en kg N,P,K/ha*
	Bilans minéraux pour chaque culture	Bilan minéral (N, P, K) sur le coton	$Bilan_{E}coton$	*en kg N,P,K/ha*
		Bilan minéral (N, P, K) sur le maïs	$Bilan_{E}mais$	*en kg N,P,K/ha*
		Bilan minéral (N, P, K) sur le sorgho	$Bilan_{E}sorgho$	*en kg N,P,K/ha*
		Bilan minéral (N, P, K) sur les cultures secondaires	$Bilan_{E}CultSec$	*en kg N,P,K/ha*
		Bilan minéral (N, P, K) sur les cultures fourragères	$Bilan_{E}CultFrg$	*en kg N,P,K/ha*

Module Economie

SORTIES	Charges opération-nelles	Total des dépenses liées aux herbicides	CoutHerb	*en Fcfa*
		Total des dépenses liées aux insecticides	CoutInsec	*en Fcfa*
		Charges opérationnelles liées aux cultures	ChOpCult	*en Fcfa*
		Charges opérationnelles liées à l'élevage	ChOpElev	*en Fcfa*
		Charges opérationnelles totales	ChOptot	*en Fcfa*
	Produit brut	Produit brut lié aux cultures	PBCult	*en Fcfa*
		Produit brut lié à la production laitière	PBlait	*en Fcfa*
		Produit brut lié à la production de viande	PBviande	*en Fcfa*
		Produit brut lié à l'élevage	PBElev	*en Fcfa*
		Produit brut total	PBtot	*en Fcfa*
	Bilan	Bilan économique	BilanEco	*en Fcfa*
		Nombre de BE à vendre en cas de bilan économique négatif	NBEavendre	

Visual, graph	Numbers

Limits

	L'influence de la fertilisation (ni celle du type de sol) sur les rendements n'est pas prise en compte. Les pratiques agricoles sont considérées comme identiques et moyennes au sein d'une même sole (toutes les zones cultivées en maïs reçoivent exactement la même fertilisation par exemple).
10 year period – the IAT is currently limited to run over a 10 year period. However, this is not a limit of design, but a limit of the availability of reliable climate data	le modèle est conçu pour des systèmes de production en culture continue et fait l'impasse sur la jachère, la possibilité de défrichement ou d'extension par achat /location etc.
While APSIM does not handle all yield-limiting constraints, such as weed competition, insect damage, water logging and effects of severe weather on growth and yields. Therefore, simulated yields and resource demands can exceed field results, especially in low input smallholder production systems.	simplifier au maximum (quitte à complexifier dans des travaux ultérieurs) : en se basant sur les décisions d'affourragement, on considère qu'en saison humide, *tous les animaux se nourrissent de fourrages hors exploitation* (parcours collectifs, bords de champ etc.) et que leur production n'est pas limitante, d'où une couverture satisfaisante des besoins fourragers de tous les lots. De même, en SSF, période de vaine pâture, on considère que les *animaux se nourrissent des restes de pâturages disponibles sur les parcours et de la grande quantité de résidus de récolte des parcelles cultivées sur l'exploitation (résidus non stockés par l'exploitant) ou sur les exploitations du*

	terroir villageois. Là encore, on fait l'hypothèse que la quantité disponible de fourrages n'est pas limitante et couvre les besoins fourragers de tous les lots d'animaux. En SSC par contre, on extrapole les décisions d'affourragement décrites en III.1.4 et on fait ***l'hypothèse qu'il n'y a plus de fourrages disponibles***, que ce soit dans l'exploitation ou en dehors de celle-ci : les besoins fourragers des animaux sont alors uniquement couverts par ce que le producteur décide de leurs apporter (résidus de culture stockés). → la simplification proposée car elle nous permet de nous affranchir de la difficulté à prendre en compte les apports de fourrages venants de l'extérieur (parcours collectifs, résidus de culture de parcelles hors exploitation) et les prélèvements de fourrages de l'exploitation par des animaux de l'extérieur (rappelons que les systèmes étudiés sont ouverts, sans clôture, et que les animaux peuvent divaguer où ils le souhaitent).

Validation

Based on a comparison of model output (e.g. predicted yield) with village records and individual household records; which are considered adequate for the purposes of this application.	Une validation à dire d'experts, i.e. Une Validation par confrontation

Field Use

	formation théorique des manipulateurs à l'utilisation de l'outil.

What question does it answer?

It enables rapid analysis of the financial, resource and production impacts of livestock improvement strategies (identified by the farmer) and their sensitivity to key climate, soil, management and farm design variables. Less desirable strategies can be readily identified and discarded, leaving a shortlist of best-bet options that can then be	-Forage supply (forage management and vegetables grown that persists throughout the dry season and quality issues (controlling mating) were often the major or most immediate constraint to improved cattle production +cfr p.35 LPS-2004-005 Part 1.pdf Graph

assessed in the field by participating farmers. This provides a degree of confidence to both project staff and farmers that the actions they are about to undertake are unlikely to have an adverse effect. This screening enables a more efficient and targeted use of limited project resources.	Controlled Mating and forage availability having an effect on animal performance

ANNEX B – b.

Addis Ababa, 27/06/2011

Discussion on potential solutions with farmers from Boneya: Meeting Feedback

Morning: Meeting with WoARD staff (3h)

Ten woreda level experts from crop, cooperative promotion office, livestock, DAs, and office head of agriculture with deputy head attended the meeting

The findings of the research conducted were presented. Then they were asked their opinion on the suggested solutions. The inputs gathered throughout this discussion were broader than the solutions exposed. They brought up the following problems:

- High soil acidity → affects legume growth
- Termites → eat everything
- Low working culture → farmers need more discipline, be harder workers
- Water shed management has to be holistic
- People use sloppy land for cultivation → erosion
- Poor management of natural pasture
- CR used for many purpose but not enough for feed
- Low availability of farming tools → for implement soil conservation techniques
- Lack of labor → not enough time to do what DA advise to farmer (soil conservation)
- Deforestation for grazing land
- Farmer focus more on livestock number than on productivity
- Burning of CR is tradition
- No recommendation for fertilizer use
- No collective action

The discussion was concluded by addressing their inputs in a brief way.

Water problem has to be address by the World Bank as Welega is among the selected region funded.

The lack of lever should be address by the farmers themselves by joining together with the helped by the DA.

It is interesting to report that they seek for results regarding the soil research conducted by Mathieu Crespin, as it would address one of the major constraints mentioned.

Afternoon: Meeting with Boneya farmers (3 women, 20 men and 3 DA,)(3h)

The meeting started out with a Livelihood Appraisal in order to obtain insights on the major challenges they face. They were asked to brainstorm on their major problems related to farming and to agree on a ranking.

Problem ranking:	**Solution:**
1) Land degradation- soil erosion	Terraces, ditches, check dam/ crop rotation, fallow periods
2) Livestock disease	Good feeding, proper housing, get the animal to clinic, clean drinking water, feed storage
3) Increase in fertilizer's price	Compost, corralling, Fallowing, manure & CR management, access to credit
4) Lack of seed →Improved seed are expensive	Access to credit, select locally available good seed

→ often eat the remaining seeds they produced before the end of the dry season	
5) Lack of grazing land =Shortage of feed	Dedicate a piece of land to feed production, requires proper management, management of CR along with storage, planting fodder tree, try out new forage species
6) Climate change → high rainfall, unpredictability	
7) Small land size - scarcity	
8) Lack of assistance, technical support	
9) Lack of access to credit service	

Next, we briefly exposed a simplified problem tree (see attached) along with the suggested solutions from the research.

Afterwards, a feasibility assessment was conducted. In order to explore with the community constrains and strengths regarding the implementation of each solutions, the following table guided the discussion.

Solutions	A		B		C	
	Facilitating factors	Constraining factors	Facilitating factors	Constraining factors	Facilitating factors	Constraining factors
Material resources required						
Knowledge required						
Capacity/ skills required						
Linkages with orgns/actors required						
Who can take the lead?						
Is any collective action required? Who will be involved?						
Who can provide support?						
When is the best period to implement it?						
Where ?						

Time was running out and we unfortunately could go through only one solution (addressing the main problem according to their opinion): soil bunding and planting stabilizing grass.

Therefore, the feasibility assessment could not be complete as planned. Indeed it would have requires to go through the table for a few other solutions to be able to select the most feasible one. Nevertheless, the farmer's interaction was great even though we started to feel they were tired.

Recommendations:

- Meeting with the WoARD staff is very helpful and source of important knowledge (has to be done before meeting the farmers, three hours are enough)
- **Discussion with farmers needs a whole day**
  → Defining existing problems, ranking and defining solutions is actually helpful to make the farmers interact and to prioritize (even if a research is already carried out it is interesting to generate their view on the system they are living in without external influence)
  → In order to wrap up the agenda planned it would have required more or less three additional hours. Hence it should take place in two parts. The livelihood appraisal should take place in the morning and after a lunch break, the feasibility of the solution may be discussed
  → The methods used worked quite successfully (However, it requires one local person to lead discussion and one who writes down in local language)
  → It would perhaps be interesting for the innovation platform being set up in the area to take the lead and implement some of the solutions from the research that are coherent with the farmers and officials insights.

ANNEX B – c.