Demand for Soil, Water and Forest Conservation in Burkina Faso

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Abstract

The objective of this thesis is to investigate how different household characteristics and policy-relevant variables affect individual household demand and willingness to engage in natural resource conservation activities in Burkina Faso. The thesis is based on four individual studies that examine Burkina Faso, a country rich in natural resources such as soil, water, and forests. The four studies use household data within each of the country's four regions: north, south, central and west. The data set contains information about actual choices, as well as household characteristics, socio-economic variables, and subjective perceptions concerning, among other things, long-term land use rights and soil degradation. Our different models estimate the effects of these variables on the probability of engaging in soil and forest conservation. We also estimate the demand of resource products such as non-timber forest products (NTFPs), and drinking water. The results of the statistical analysis indicate that forest and soil conservation activities by households are mainly determined by four policy-relevant variables: membership in community-based forest management associations, security of land use rights, training and education. Age and gender do not seem to have an effect on willingness to engage in natural resource conservation, although migrants are less likely to participate in forest surveillance. Further, an increase in household size decreases the participation in community work. Household size is shown to have a significant effect on the demand for NTFPs in the sense that larger households prefer imported or substituted products instead of NTFPs. Moreover, the analysis of the effects of price and income show that the two products that we expected to be substitutes are normal and complementary goods. Concerning the demand for drinking water, the price elasticity derived from the regression analysis shows that water demand is rather inelastic. Furthermore, the results also show that the income elasticities are positive, but smaller than one, implying not surprisingly that water seems to be a necessary good in Ouagadougou.

Keywords: Natural resource conservation, Logistic regression, AIDS model, Instrumental variables, Burkina Faso.

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Dedication

To the Lord, my Family in Sweden (Ingrid and Gunnar) and Burkina Faso;
Runar Brännlund, Peichen Gong, Xavier De Luna and Monica Phillips I don't know how to… It is only unforgettable!

Contents

List of Publications

This thesis is based on the work contained in the following papers, referred to by Roman numerals in the text:

I Amadou Sidibe (2005). Farm level adoption for soil and water conservation techniques in northern Burkina Faso. *Agricultural Water Management* 71, 211-224.

II Runar Brännlund, Amadou Sidibe, Peichen Gong (2009). Participation to Forest conservation in National Kabore Tambi Park in Southern Burkina Faso. *Forest Policy and Economics 11, 468-474.*

III Amadou Sidibe (2003). Determinants of rural farm-level demand of non timber forest products in Burkina Faso. Translated from french: Déterminants de la demande des produits forestiers non ligneux en milieu rural au Burkina Faso (manuscript).

IV Amadou Sidibe, Runar Brännlund, Peichen Gong (2010). Residential water demand with a non linear tariff in the urban city of Ouagadougou (manuscript).

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Abbreviations

AIDS	Almost Ideal Demand System
CEDRES	Center for Economic and Social Research and Documentation
CW	Community Work
FS	Forest Surveillance
IBT	Increasing Block Tariffs
INERA	Environmental and Agricultural Research Institute.
KTNP	Kabore Tambi National Park
NEAP	National Environmental Action Plan
NGO	Non Government Organization
NTFP	Non Timber Forest Product
PNLCD	National Plan for the Struggle against Desertification
RAF	Land Reform Act
SES	Social-Ecological Systems
WAEMU	West African Economic and Monetary Union

1 Introduction

The most challenging problem Burkina Faso faces is the alleviation of poverty. The results of two surveys of household living conditions in 1994 and 1998, as well as other studies on poverty, indicate that poverty is a widespread phenomenon. According to the findings, nearly one-half of the population lives below the poverty line of approximately 110 euro per year. Poverty is particularly prevalent in rural areas, although it also affects 16% of the urban population MEF (2000). In the light of these data, the Government is committed to the objectives established in the (henceforth "Letter"), which sets out a vision for the country's development. This vision is based on the concept of human security, which guarantees that every Burkinabe national will enjoy economic security (access to training and employment), health security, food security, environmental security, and individual and political security. The key quantitative objective stated by the Government is to reduce the incidence of poverty from 45 percent to 30 percent by the year 2015.

The new poverty reduction strategy for Burkina Faso is in line with the above-mentioned Letter and is based on seven key principles: (i) re-defining the role of the State; (ii) sustainable development of natural resources; (iii) promotion of a new partnership between the State and donors; (iv) promotion of good governance; (v) participation of women; (vi) consideration of regional disparities; and (vii) continuation of the process of integration within the West African Economic and Monetary Union (WAEMU).

To implement the poverty reduction strategy, the State will focus on the social sector (basic education, health, drinking water, and sanitation) and rural development (agriculture, livestock breeding, irrigation, sustainable natural resource management and rural roads). This thesis will contribute to

the State's goals by developing improved knowledge of the effects of household characteristics and policy-relevant variables on the utilization of key natural resources involved in theses social sectors, including soil and water conservation in agriculture; drinking water, forest and NTFPs in the food security and income-generating activities for the poor.

2 Objectives

The main objective of this thesis is to investigate how household characteristics and policy-relevant variables affect the conservation of key natural resources such as soil, water and forest in Burkina Faso.

Specifically the four attached studies aim to:

1. Identify and analyze the factors leading to the adoption of soil and water conservation practices, in particular zaï [1] and stone strips.
2. Investigate how household characteristics, household perceptions about the security of land use rights, and household proximity to forests affect household willingness to engage in activities that are meant to promote sustainable forest management.
3. Analyse the determinants of the demand for the key non timber forest products (NTFPs) used in the feeding of rural and urban households. In particular, the study focuses on the importance of NTFP use and the change in use related to economic and demographic characteristics of the household.
4. Analyze how the current drinking water pricing mechanism used by water utility operators affect consumer behaviour concerning water consumption in the city of Ouagadougou.

[1] "zaï" is a traditional technique for restoring degraded soils by creating a micro-environment favourable for crops by digging and sowing in holes in which manure or compost has already been deposited

3 Background and previous research

3.1 Soil conservation

Land has always been perceived as a "natural asset" that is self-renewing, often as a result of leaving it fallow for certain periods. However, population pressure has led to shorter fallow periods, which are often inadequate for ensuring renewal of soil fertility. Land degradation and loss of fertility through shortened fallow periods are increasing in some areas of Burkina Faso. Signs of soil depletion are visible in the north and central regions. There are also pockets of fairly severe land degradation in the west and southwest regions (including the cotton growing area), where most of the country's agricultural land reserves are located.

In severely degraded areas, soil depletion, poverty, and food insecurity have created a vicious cycle. Food insecurity and poverty lead to depletion not only of the soil, but of other natural resources as well, such as forests, wildlife, and fish stocks.

This calls for the implementation of long-term strategies focusing on restoring, conserving, and managing land and water resources sustainably, by restoring soil fertility and protecting and renovating ground cover.

To help to improve soil fertility in Burkina Faso, various studies have examined how best to restore soil fertility and protect and renovate ground cover (see INERA (2000), Kambou et al. (1994), Robins et al. (1994) and Ousmane (1995)). A joint study by the Ministry for the Environment and the Center for Economic and Social Research and Documentation (CEDRES) at the University of Ouagadougou shows that soil restoration and fertilization with the Zaï technique, stone cordons, and organic manure has a positive impact on agricultural productivity and therefore on poverty

reduction. However, there is a lack of knowledge about the driving forces influencing human behaviour toward these practices. This thesis hopes to improve fertility restoration by identifying the key determinants of adopting soil and water conservation techniques in Burkina Faso.

3.2 Forest Conservation

The land area of Burkina Faso is 274,000 square kilometers (km^2), including 154,200 km^2 natural forests, 87,680 km^2 crop land and fallow, and 32,120 km^2 of land used for other purposes. The current Forest Act recognizes three categories of natural forests: public, community, and private. A community or private forest does not mean that a community or a private person owns the land or the forest; rather, each of them have the use right. Regarding the management regime, the public and community forest lands are generally classified in a manner that restricts certain user rights. The total protected forest area of the country is 3,815 km^2, of which 77% are located in national parks and wildlife conservation areas. Despite the increase in forest conservation since the colonial period in 1935, the country still faces continuous deforestation.

There are many global studies devoted to deforestation, in particular the determinants of deforestation. According to FAO (2001), over 1,200 articles on tropical deforestation have been published since 1980, of which 825 contain findings related to deforestation processes. Kaimonowitch et al. (1998) reviewed over 150 quantitative models dealing with the causes of tropical deforestation. They found that many modelling results should be interpreted with caution because of poor data quality and methodological weaknesses. Household-level models that link to farmer characteristics include Pichón (1997), Munòz (1992), Jones et al. (1995), Holden et al. (1997), Godoy et al. (1996), Godoy et al. (1997), Godoy (1997), and Foster et al. (1997); Cooke et al. (2008); Emtage et al. (2004); Scherr (1995). Studies that have dealt with afforestation determinants in tropical countries include, among others, Schelhas (1997); Owubah et al. (2001); Guthiga, (2008); Guthiga et al. (2008); Mekonnen (2000) and Gebreegziabher et al. (2010). Owubah et al. (2001) and more recently Gebreegziabher et al. (2010) use a logistic regression model to analyze the determinants of household tree planting and explored the most important tree attributes or purpose(s) that enhance the propensity to plant trees. Both find land right security and education to be important determinants for planting trees. However, Owubah et al. (2001) find that the number of farmers engaged in

sustainable forestry practices is small. In the study of forest conservation in this thesis we use a similar model to analyze the engagement of the local population in forest conservation practices, which can provide useful insights for improving the relevant policies. Studies in this field in Burkina Faso are limited to Compaore (1997), Yelkouni (2004), Nguiguiri (1999) and Sambore (2001). Compaore (1997) shows that neither the age of the head of the household nor the proximity of the household can help to explain the degradation of the Ziga protected forest. On the other hand Yelkouni (2004) find indications that the older the farmer, the less likely his/her participation in community works. In addition, the author notes that the degradation of the forest is largely related to the expansion of agricultural and grazing land. Nguiguiri (1999) note that the current adoption of the participatory approach is based on the global political context dominated by democracy, sustainable development and the defeat of centralized models of development. According to Sambore (2001), the surrounding population of the protected forest area of Tissé could be better involved in conservation if they are better trained and granted more decentralized management of these resources.

3.3 Demand for Non Timber Forest Product

Non timber forest products (NTFP) are essential for the people in Burkina Faso. The rural population (90% of total population) most commonly relies on meals of thick porridge made from cereal (millet, sorghum or maize) and soup, both of which lack well-balanced nutrition. NTFP are, among other things, used as a supplement, contributing with essential vitamins and minerals.

Despite the fact that NTFPs in developing countries are often used as supplemental food, a source of income, or traditional medicine, few studies have examined their role in these societies or key factors determining their demand. Such knowledge is needed to assess the importance and the dynamic uses of these products which, in turn, are essential inputs for tropical forest management policy. Most of the studies concerning NTFPs in Burkina Faso are ethno botanic studies (Guinko, 1984 and 1985; Bognounou, 1987 et 1988; Kéré, 1998) providing detailed information about the rural population's use of, and reliance upon, NTFPs. Previous studies have have investigated the factors that determine the demand of NTFPs (Angelsen and Kaimowitz, 1999; Mamo et al., 2007; Coulibaly-lingani et al. 2009). In Burkina Faso, Coulibaly-lingani et al. (2009) used a

logistic regression model to investigate determinants of access to forest products in southern Burkina Faso and found that individual characteristics such as age, ethnicity, occupation, sources of income, gender, household size and education level were statistically significant.

Several studies show that some NTFPs, especially shea butter and soumbala, are subject to permanent marketing and generate substantial revenues for those involved in the trade (Lamien et al., 1996; Pasgo, 1990; Lamien and Vognan, 2001). Moreover, Lamien et al. (1996) and Ouédraogo, (2002) point out the essential role of women in the harvesting, transformation and transactions of NTFPs in the markets.

This thesis aims to analyse the determinants of the demand for the key NTFPs[2] used in the feeding of rural and urban households. In particular, the study focuses on the importance of NTFPs use and the change in use related to economic and demographic characteristics of the household. The results of this study may provide a basis for tree management within the parkland system and conservation policy in accordance with several studies (Anderson, 1990; Nepstad and Schartzman, 1992). These studies argue that forest management that includes consideration of NTFPs can reconcile economic, cultural and ecological values inherent in a tropical forest. Effective conservation and management of NTFPs has also been shown to improve rural economies and the welfare of indigenous people who rely on NTFPs for subsistence and cash income (Hall et al., 1993; Belem et al., 2007; Kristensen et al. 2003; Mamo et al., 2007; Shackleton et al., 2007 and Taïta, 2003).

3.4 Demand for drinking water

Another challenging problem facing Burkina Faso is water scarcity. As a consequence, water policy is a high priority for the Burkina Faso government. The overall objective with water policy in Burkina Faso is to

[2] Key NTFPs include non-timber plant products subject to a monetary transaction within local markets and being available the whole year. These included the soumbala of néré, the shea butter, the leaves of baobab, the flowers of bombax or kapokier and the leaves and the flowers of tamarin. Other non forest products or industrial products, which are eventual substitutes for the above products, were also selected for the purpose of the study. These include the maggi cube, the soumbala of oseille, the other oils (cotton, peanut, sesame, etc), the fruits of gumbo and the other additive of tô.

contribute to a sustainable development by providing appropriate solutions to water-related problems so as to prevent water from being an obstacle to socioeconomic development.

To achieve these policy objectives Burkina Faso has developed several strategies concerning both the supply and the demand of water. On the supply side, the strategies include the adoption of a watershed approach for water management, capacity-building for the agencies involved in national water policy, implementing a sanitation strategy and building resource protection indicators, providing water quality surveillance systems, and rehabilitating and consolidating hydraulic structures. On the demand side a central strategy is to introduce a pricing scheme that gives sufficient incentives for efficient use of water. Increasing block tariffs (IBT) are often supported as a good tool for achieving the goals of equity and water conservation (Bithas, 2008). The lower prices charged for the first cubic meters of water are meant to favour the consumers with lower incomes and the higher prices for the following consumption blocks are set to induce water savings from more intensive water users, usually associated with wealthier households and with nonessential uses such as sprinkling gardens or filling pools. It is thus seen as a form of cross-subsidization of the access to an essential good by the poorer through the penalization of wasteful consumptions of the richer.

This paper focuses on the demand for water and the role of the price under IBT scheme as a resource allocation tool. Our analysis requires knowledge of consumer behaviour in the water market, including consumer response to critical price and income changes. In many countries, including Burkina Faso, the price of water is viewed as an important policy variable, which in turn requires knowledge of how consumers respond to price changes. Since the 1960s, economists have discussed the management of water demand through theoretical and empirical studies dealing with the estimation of residential water demand; in particular, obtaining price elasticities of water demand under IBT (For examples in Africa see Ayadi et al. 2003 in Tunisia; Jacob et al. 2004 and 2007 in South Africa ; Nauges, et al. 2008; Diakité, et al. 2009 in Cote d´Ivoire). In the latter study, the authors use econometric estimates of residential water demand to find that the Increasing Block Tariff (IBT) already applied in the main cities would be the best practice for the majority of Ivorian communities in most of rural and secondary cities.

The demand models in the literature typically include two types of explanatory variables: non-price and price. The former type includes

variables describing geographical and household characteristics, such as climate, household size, income and other socio-economic variables. Concerning the price variable, there is very little consensus regarding what kind of "price" that should be used. The reason is that in many countries the price of water depends on the quantity consumed according to some block pricing scheme as described above. There is a significant literature on water demand under block pricing (recent examples include Babel et al. 2007; Barberán et al. 2009; Bartczak et al. 2009; Basania et al. 2008; Bithas 2008; Dahan et al. 2007; Diakité et al. 2009; Frondel et al. 2008; Fullerton-Jr et al. 2007; García-Valiñas et al. 2009; Grafton et al. 2007; Kenney et al. 2008; Martínez-Espiñeira 2007; Martins et al. 2007; Nataraj et al. 2008; Nauges et al. 2007; Nauges et al. 2008; Olmstead 2009; Olmstead et al. 2007; Reynaud 2008; Roseta-Palma et al. 2008; Ruijs. 2009; Schleich et al. 2009; Wang et al. 2008; Worthington et al. 2008). As a result, the average price for a consumer may differ from the marginal price. In cases where a block pricing scheme is relevant, some authors have used the average price (Foster and Beatie, 1979; Chicoine et al. 1986; Point, 1993; Nauges et al. 2000, Nauges, C. and Strand, J. 2007 among others), others have used the marginal price (Howe et al. 1967; Hansen, 1996; Höglund, 1999, among others), and some use both price measures simultaneously (Gibbs, 1978; Nieswiadomy, 1992). There are, however, studies that explicitly take the block price schedule into account in the derivation of the demand for water (Hewitt et al., 1995, Rietveld et al., 2000, Nataraj, et al. 2008). To solve the problem caused by price endogeneity inherent in block pricing rates, we use the technique of instrumental variables -- which are assumed to be uncorrelated with the error term but correlated with price -- as a replacement for the observed price.

4 Theoretical Framework

Broadly speaking, the interactions between humans and ecosystems are described in the literature as social-ecological systems, or SESs. (Anderies et al. 2004).

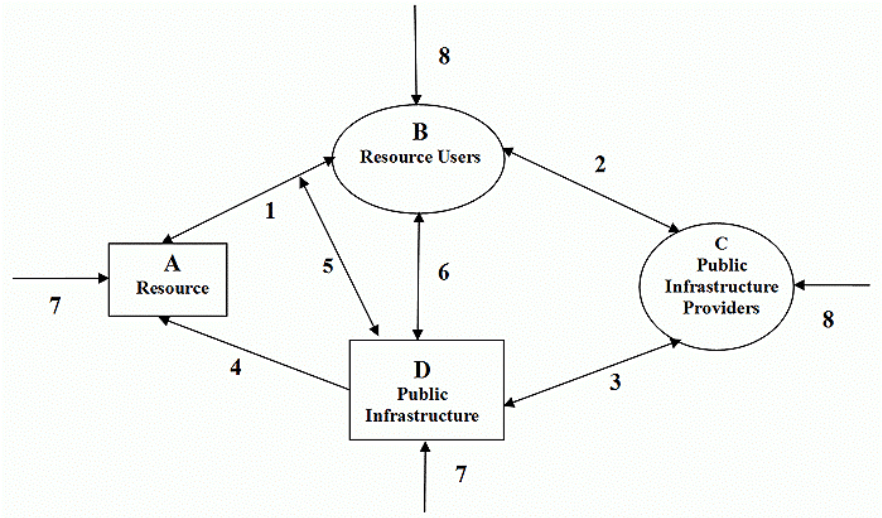

Figure. 1. Conceptual model of a social-ecological system.
Source: Andries et al. (2004).

Andries et al. suggests that a minimal representation includes the elements depicted in Figure 1. *A* is a resource that is used by multiple resource users. The human component of the model has two parts: the resource users (*B*) and the public infrastructure providers (*C*). Public infrastructure (*D*) combines two forms of human-made capital: physical and social. According to the authors, *physical capital* includes any engineered works, such as dikes,

irrigation canals, etc. while *social capital* reflects the rules used to govern, manage, and use the system and those factors that reduce the transaction costs associated with the monitoring and enforcement of these rules (Ostrom et al. 2003). In centrally governed SESs, monitors would be employed and paid by a government agency.

In their examination of robustness, the authors address two types of disturbances: (1) External disturbance can include biophysical disruptions (Arrow 7), such as floods, earthquakes, landslides, and climate change, that impact the resource (*A*) and the public infrastructure (*D*); and (2) socioeconomic changes (Arrow 8), such as population increases, economic change, recession or inflation, and major political changes, that have an impact on the resource users (*B*) and the public infrastructure providers (*C*). Internal disturbances refer to rapid re-organization of the ecological or social system caused by the subsystems of the ecological or social system.

Furthermore, based on this framework, Ostrom (2007) developed a multi-tier framework (Figure 2) that we adapt for this study.

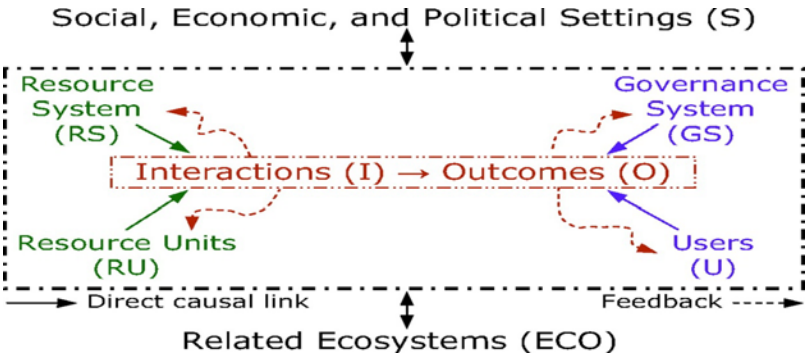

Figure 2. A Multi-Tier Framework for Analyzing a Social-Ecological System.

This framework consists of organizing variables called tier-variables in a nested multi-tier framework as shown in Figure 2. It enables one to organize and analyse how attributes of (*i*) a resource system (e.g., fishery, lake, grazing area), (*ii*) the resource units generated by that system (e.g., fish, water, fodder), (*iii*) the users of that system, and (*iv*) the governance system jointly affect and are indirectly affected by interactions and resulting outcomes achieved at a particular time and place. The framework also enables one to organize how these attributes may affect, and be affected by, larger socioeconomic, political, and ecological settings in which they are embedded, as well as smaller ones.

Humans are an integral part of natural resource use and management. Managing exclusively for the resource without incorporating human behaviour and use may preclude the attainment of management goals. Household characteristics and policies are often good indicators of human behaviour. Impacts to our natural environment may include conversion of forest land to other uses, land cover change, loss of biodiversity, soil erosion, changes in water quality. These can be also economic changes (economic viability of local communities, jobs opportunities etc.) as well as social changes (community relations, access to resources, community security etc.). These changes could have effects on environmental quality, human health and safety and quality of life. For example, it is well known that education as household characteristics leads to good conservation practices. So far, we know these interactions, a variety of management strategies can be adopted to alter human behavior or alter its effects. Some management strategies are quite direct including regulation. Some others are somewhat indirect and include incentive programs, demonstration projects, education etc. All these interactions can be shown in figure 3.

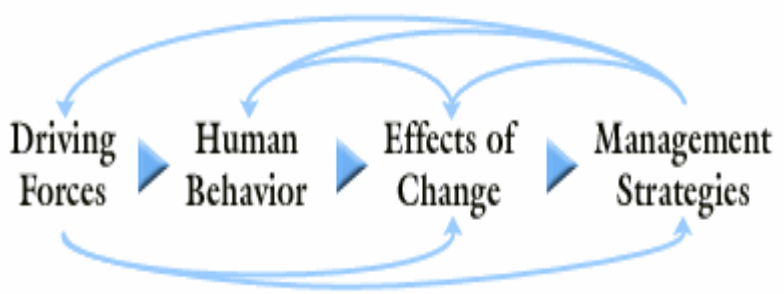

Figure 3. keys interactions of elements of natural resource and management strategy.

Our goal is to investigate the effect of household characteristics and policy-relevant variables on the key environmental elements in Burkina Faso in order to contribute to sustainable management strategies. I adapt the multi-tier framework to our case, as described in figure 2, by including key determinants household characteristics and policy-relevant variables; and the management strategy as a component of the system. The framework maps in figure 2 and 3 highlights the key interactions of elements of the system including the management strategy.

5 Institutional framework for natural resource conservation in Burkina Faso.

To handle natural resource management and conservation Burkina Faso has developed an action-oriented institutional framework through a National Environmental Action Plan (NEAP). The NEAP has been developed around four programmatic agendas: (1) national resource management, (2) village land management; (3) improving living standards and (4) developing environmental capabilities. The programmatic agendas are complemented by two support programs: managing information on the environmental action plan and coordinating and monitoring the NEAP.

The interactions between the four programmatic agendas are illustrated in Figure 4.

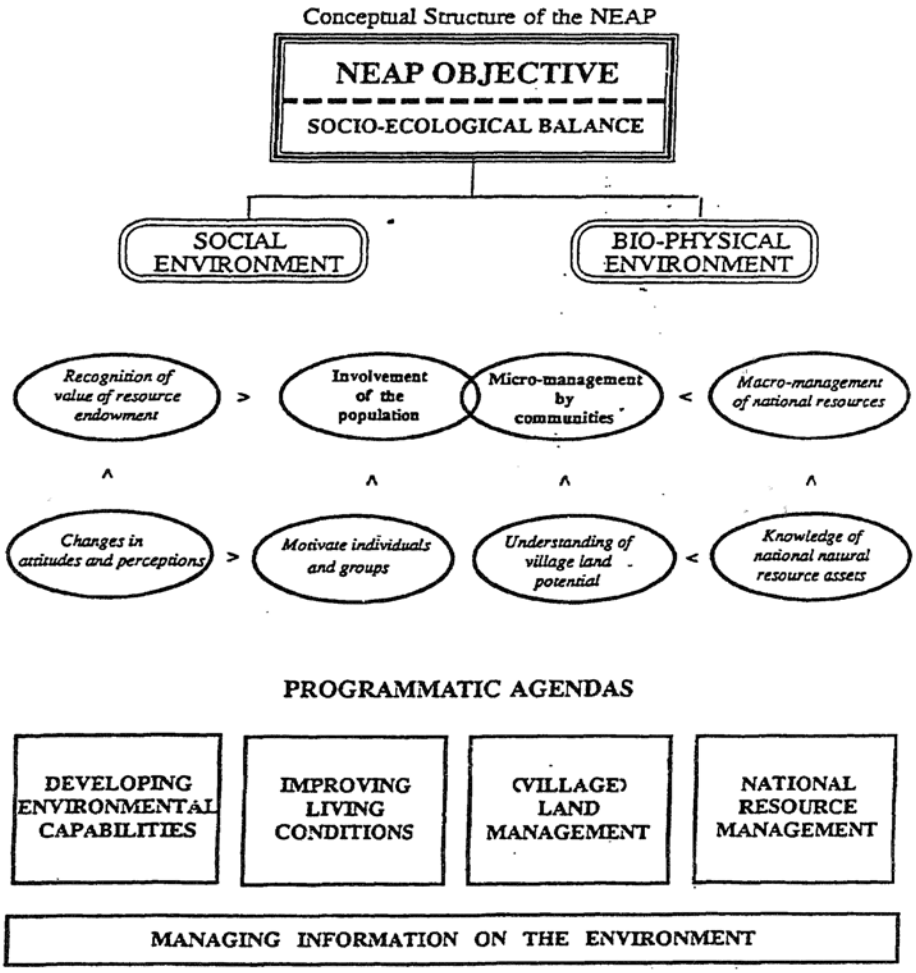

Figure 4: Conceptual Structure of the National Environmental Action Plan.
Source: Ministère de l´Environnement et du tourisme, (1991).

On the physical side, the management task is shared between the State (responsible for macro-management of the natural resources) and the individual (responsible for micro-management of the land to which he/she has a use right). At the urban level, government is responsible for supplying the population with public sanitary infrastructure and drinking water while waste management is the business of private enterprises. The objective of each of the "bio-physical" programmatic agendas is to supply actors with

information and capacity-building through coordination programs or projects.

On the human side, the programmatic agenda for "developing environmental capabilities" is responsible for supplying the population with both the means and the incentives to play their role. An individual who is not aware of environmental management importance or lacks the technical skills may be unable to adopt management practices. The same is also true for individuals lacking education, living in poverty, or experiencing poor health, which makes the programmatic agenda for "improving living conditions" an essential component of achieving the natural resource management strategy.

A population without access to markets is unlikely to participate in environmental management. Thus, it is essential that the decision-makers and the population work together to provide information, education, services, social and economic infrastructure that, together, will change attitudes toward the environment and stimulate voluntary participation in environmental management. This is the short term objective of the programmatic agendas. The two support programs are designed to provide coordination, monitoring and evaluation structure to the NEAP and to initiate the process of developing an environmental database that could eventually be used as a basis for evaluating the system.

Despite that the individual population should be responsible for managing resources at the level of the village or neighborhood, the programmatic agenda for "national resource management" recognizes that the government bears the responsibility for the policies and plans that define the global use of natural resources and for the direct management of parks and wildlife reserves, and lakes that have been designated for special protection based on national heritage characteristics.

The program agenda for "village land management" is based on the "popular participation approach" to environmental management, which has already been adopted by the country. The RAF (the land reform act) and the PNLCD (National Plan for the Struggle against Desertification) are the principle guides to the program agenda for village land management, which should be carried out through the voluntary participation of villagers. Land security tenure is essential to empower the villagers and secure them for long term environmental investments on their own and on communal land. The government should supply villagers with the technical skills and the social and economic infrastructure needed to achieve these goals. For

example, villagers need to know how to map and survey lands in order to collect basic socio economic statistics for their villages.

The other two programmatic agendas for "improving living conditions" and "developing environmental capabilities" are designed to support the two previously mentioned programmatic agendas. Thus, the programmatic agenda for "improving living conditions" has a rural and an urban component. It aims to alleviate the poverty, which is seen as a prerequisite to active involvement in natural resource conservation. The second programmatic agenda is to build technical capacity of experts and institutions for supporting the other programs.

6 Methodology

In the analysis of the determinants of adoption of forest, soil and water conservation practices, we make use of binary data which motivates the use of logistic regression. The theoretical framework of utility maximization is used to explain the response of the farmer vis-à-vis a choice or a practice.

In the case of one choice, the decision of the farmer is a process of two mutually exclusive alternatives. The suitable model would be logit model and has been applied to estimate the coefficient of variables that might determinate the adoption of zaï and stones strips, which are soil and water conservation techniques.

In the forest conservation process, we have identified four alternative practices for forest conservation. In that case, a multinomial model is more appropriate to analyze the factors that determine whether individuals engage in forest conservation practices, and which practices are most common.

In order to estimate the water demand elasticities for different regions with different water supply types, we must address the estimation problem caused by price endogenity due to block rates. To cope with this problem, we employ a simple regression using the instrumental variable approach, as in many other studies. To do so, we replace the actual average price with an instrument that is uncorrelated with the error term. Our instrumental variables are income, various household characteristics, and the hypothetical block price relevant for each household. Given that the actual marginal price differs from the hypothetical marginal price, the hypothetical block price is exogenous, although we expect that it is correlated with the actual average price. That is, a household with a high consumption level will, on average, be on a higher price segment (although we do not know exactly what segment) and hence the average price we observe will be relatively high.

To investigate the demand for NTFPs, we estimated an Almost Ideal Demand System (AIDS). The AIDS model has been choosen because of its great popularity in applied demand analysis, as well as its flexibility and simplicity, which allow for the incorporation of demographic variables. Given the demand system, the empirical model consists of a system of equations of five groups of commodities: NTFPs, potential local substitutes for NTFPs, rice, other food, and non-food. The household characteristics included in the study are age of the head of household and household size.

7 Study area

As shown in Figure 6, this thesis examines several different regions of Burkina Faso. For each of the studies, investigators were involved in collecting the data and provided training in how to fill in the questionnaire. The information collected from the questionnaires are similar for all studies and include: farmer's socio-economic characteristics, socio-demographic composition of the household and other data specific to each study.

To supplement the questionnaire and to facilitate the interpretation of the results, we held individual and collective discussions with respondents and local institutions (e.g., NGOs and farmers' associations). This helped to familiarize ourselves with the local farming system and the management practices.

To investigate what determines the adoption of soil and water conservation techniques, we selected 230 farms in the northern region (see Figure 5 characterized by both (1) a high degree of soil degradation and (2) the use of some soil conservation practices (e.g., zaï and stone strips).

To investigate how household characteristics and policy variables affect the individual household's willingness to engage in these conservation activities, we selected one of the four protected forest areas in the southern centre of the country. This protected forest, called Kabore Tambi National Park (KTNP), covers an area of 155,500 ha and is surrounded by 12 villages with a total population of 4,300 people (Naturama, 2003). The data were collected from 160 households located in two of these villages.

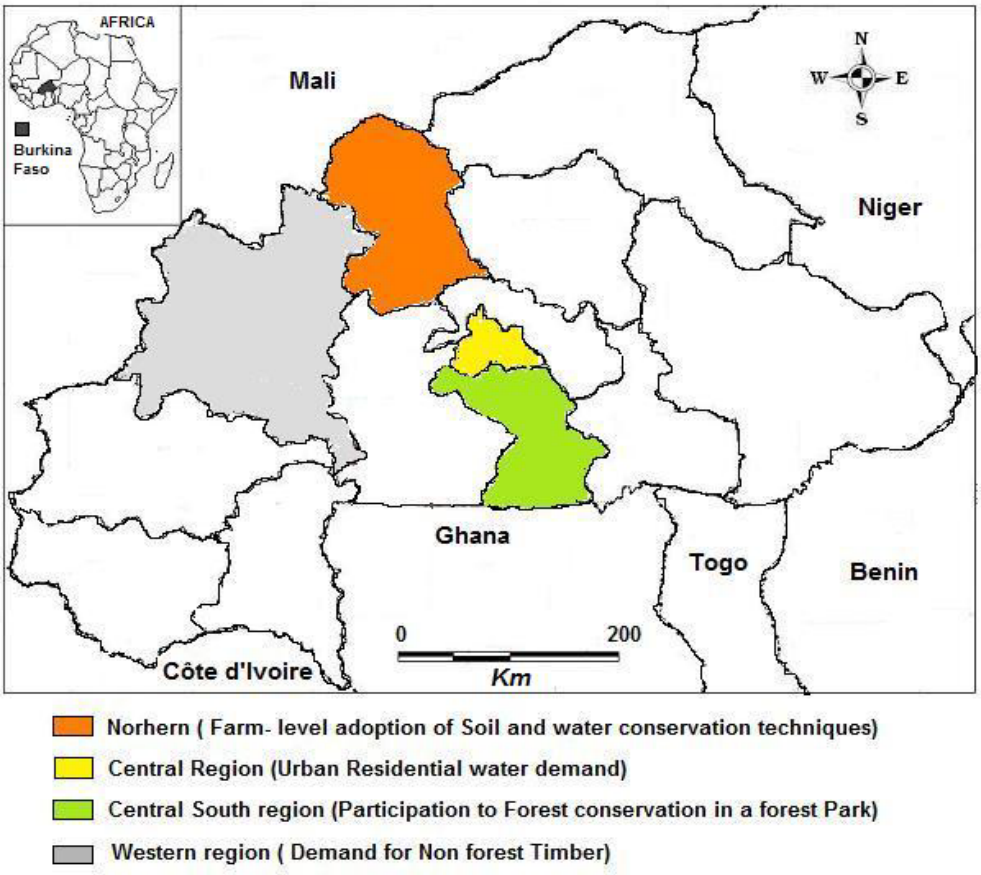

Figure 5. Study areas (Source: Institut Géographique du Burkina, July 2009)

To identify which variables determine the demand for NTFPs, we select the western zone because of the substantial production of NTFPs and the institutional knowledge available from the National Research Institute. The data were collected from a sample of 193 households selected in two villages. Ouagadougou, the capital in the central region, was chosen to investigate how the current water pricing mechanism used by water utility operators affect water consumption in Burkina Faso.

To assess the impact of the water network connection type on household water demand, the city was divided into three regions. Region I includes the urban sectors where a majority of the households are connected directly to the water network. Region II consists of the peri-urban sectors where

relatively few households are connected to the water network. Region III includes peri-urban sectors without connection to a water network. Two urban sectors were randomly selected from regions I and II, while two others slums were also randomly selected among all the slums areas which are all located in the peri-urban sectors. In each area or sector chosen, a random selection of 60 households was made to produce an overall sample of 360 households.

8 Summary of results

Table 1 summarizes the empirical results from different studies according to the topics covered in each study. The four regressions covered include:

- Soil and water conservation techniques (Paper I)
- Forest conservation practices (Paper II)
- Non-timber forest products (Paper III)
- Demand for drinking water (Paper IV)

Table 1: Results of the Demand for Soil, Water and Forest Conservation in Burkina Faso.

	Paper I		**Paper II**			**Paper III**		**Paper IV**		
	Soil and water conservation techniques		Forest conservation practices			Demand for Non Timber Forest Products		Demand for drinking water		
	Zaï	Stones strips	Community Work (CW)	Forest surveillance (FS)	CW + FS	Non Timber Forest Product (NTFP)	NTFP substitute	Region I Water network	Region II Peri urban	Region III Slums areas
Policy Variables										
Education	+**	x	ns	ns	ns	x	x	x	x	x
Training	+*	+***	+**	+**	+**	x	x	x	x	x
Membership	x	+**	+***	ns	+***	x	x	x	x	x
Perception	+*	x	x	x	x	x	x	x	x	x
Land right	x	x	ns	+*	+***	x	x	x	x	x
Income	x	x	x	x	x	+***	-***	+***	+***	+***
Agric. Equipment	+**	x	x	x	x	x	x	x	x	x
Cultivated area size	x	+***	x	x	x	x	x	x	x	x
Livestock small ruminant	+*	+***	x	x	x	x	x	x	x	x
Price	x	x	x	x	x	+***	***	ns	-*	ns
Individual House	x	x	x	x	x	x	x	x**	ns	x
Household characteristics										
Age	x	x	ns	ns	ns	ns	ns	x	x	x
Gender	x	x	ns	ns	ns	x	x	x	x	x
Household size	x	x	-*	ns	ns	-***	+***	+***	ns	+***
Forest proximity	x	x	ns	ns	ns	x	x	x	x	x
Migrant status	x	x	ns	-***	ns	x	x	x	x	x

*Significant at level of 90%; **Significant at level of 95%; ***Significant at level of 99% ; +* positive significance; -* negative significance ; x : data not applied

The results show that most of the significant variables across all four studies are those related to policy. These include education, training, membership in an organization for the conservation of soil and forest, income, and price of the resource (the latter is only relevant for NTFPs and drinking water).

For household characteristics, the variable household size appears to be significant for both conservation practices and resource demand. The variables gender and age appear to have no significant effect on either the management of or demand for resources.

In addition, a number of other variables may influence soil and water conservation techniques or forest conservation (papers I and II). These are soil degradation perception, cultivated area size, livestock capital and agricultural equipment for water and soil conservation techniques, and land right, forest proximity and migrant status for forest conservation.

Education, training and membership.

In general the results in Table 1 show a positive relationship between the frequency of a natural resource conservation practice and an individual's education level, training and membership in a farmer´s association. These findings are consistent with our expectation and indicate that training and educating farmers is likely to lead them to adopt resource conservation practices. A similar positive relationship is found with regard to membership in farmer's organization, i.e., members are more likely to adopt conservation practices compared to a non-member.

Income and Price effects

The demand equations shown in Table 1 indicate that (1) NTFPs appear to be normal goods because their budget share increases when their price or the household income increases and (2) cross price effects between NTFPs and what we have denoted "NTFP substitutes" give no significant support to the hypothesis that they actually are substitutes (i.e., the effect is insignificant). The negative sign indicates that the two goods are complementary to each other. To provide more information for the price and income effects for the demand of drinking water we display the price and income elasticities, evaluated at the mean of the data in Table 2.

Table 2. Price and income elasticities for water demand, evaluated at the mean of the data (IV = instrumental variables, OLS = ordinary least squares).

	Region I (urban connected to water network)		Region II (peri-urban public water connection)		Region III (slum without water network)
	IV	OLS	IV	OLS	OLS
Price	-0.1	-0.04	-0.3	-0.10	0.2
Income	0.5	0.5	0.6	0.6	0.4

The price elasticities derived from the regressions show that water demand is rather inelastic, which is in line with previous studies. Furthermore, the income effects are as expected, i.e., income elasticities are positive, but less than one, implying that an increase in income leads to more water consumption but that the budget share for water will decrease. Not surprisingly, water seems to be a necessary good in Ougadougou.

Household size

Household size has a significant and negative impact on the participation in community work, and migrant status has a significant negative effect on the participation in forest surveillance. The results suggest that the likelihood of participating in community work and forest surveillance is determined mainly by variables other than household characteristics.

Specific variables that determine soil and conservation techniques

Perception of soil degradation

The perception of soil degradation is a determinant for zai adoption but not for stone strips. These findings are reasonable given that stone strips are a collective practice that tends to be implemented even when individual farmers are dubious of their usefulness (i.e., they may be funded by outside sponsors). In contrast, the adoption of zaï is more likely to be an individual, rather than collective, practice. Thus, a farmer who perceives actual soil degradation is more likely to adopt zaï than a farmer who does not perceive such a problem.

Size of cultivated area

The results indicate that farmers who are cultivating a larger area is more likely to adopt stone strips, while those cultivating a smaller area are more likely to adopt zaï. One possible explanation is that zaï requires intensive

input (e.g., manure) that is difficult to supply in the case of large cultivated areas. For stone strips, capital investments are required (e.g., trucks) to transport stones, which would not be profitable in the case of small farms.

Agricultural Equipment

Despite its significance, the coefficient of the equipment variable is very close to zero indicating that it may not be an important variable in determining the use of soil and water conservation techniques such as zaï and stone strips. That is, the need for agricultural equipment may not be essential in the decision to adopt such techniques.

Specific variables that determine forest conservation

Migration status

Migrants have insecure land rights. Their lands are "borrowed" and therefore durable investments such as planting trees are not allowed. Therefore, it is reasonable to believe that migrants are less motivated to care for the forest. They may participate in visible activities, such as community work, to maintain good relationships with the autochthones but may not participate in forest surveillance activities. Moreover, migrants may be reluctant to report illegal use of the forest to the autochthones, who wield political power over them. This may explain the negative relationship between migrant status and the likelihood of participating in forest surveillance.

Proximity of protected forest area

We expected that the proximity of forest area to an individual farmer might be a determinant of that farmer's forest management practices because being close to the protected forest encourages such activities. However the result shows no significant relationship.

Land right security

We assume that a higher level of land use right security -- i.e., when an individual is confident in his land use right -- favors investments in forest conservation. Therefore, we assume that this variable is positively correlated with all forestry management practices. This is confirmed by the result, which indicates that two of the three sustainable forest management activities are positive and statistically significant.

9 Concluding comments and policy implications

The objective of this thesis is to investigate how different household characteristics and policy-relevant variables affect individual household demand and willingness to engage in natural resource conservation activities in Burkina Faso. The thesis is based on four individual studies that examine Burkina Faso, a country rich in natural resources such as soil, water, and forests. The four studies use household data within each of the country's four regions: north, south, central and west. The data set contains information about actual choices, as well as household characteristics, socio-economic variables, and subjective perceptions concerning, among other things, long-term land use rights and soil degradation. The data are used in different models including simple logistic regression with and without the use of instrumental variables, a multinomial model framework, and a demand system framework (AIDS). The latter is used to estimate the effects of the various variables on the probability of engaging in soil and forest conservation, as well as to estimate the demand for resource products such as non timber forest products and drinking water.

The results from the statistical analysis show that the participation by household members in forest and soil conservation activities is mainly determined by four policy relevant variables: membership in community-based forest management associations, security of land use rights, training and education. With respect to the household characteristic variables, the variables age and gender have no effect on an individual's willingness to engage in natural resource conservation. The only significant effects are that migrants are less likely to participate in forest surveillance and that an increase in household size decreases the participation in community work.

For the demand model, the household size is shown to have a significant effect on the demand of NTFP's for which larger households prefer

imported or eventual substitute products instead of NTFP's. Price and income effects indicate that the hypothesis that the two products are substitutes can be rejected. Concerning the demand for drinking water, the price elasticity derived from the regression show that water demand is rather inelastic. Furthermore, the results also show that the income elasticities are positive, but smaller than one, implying that water seems to be a necessary good in Ouagadougou.

A number of policy implications arise from this study given that the effects of several policy relevant variables are significant. First, improving the access to education and training will increase the probability of adopting soil and forest conservation practices. Second, improving land-use right security among farmers and improving a farmer's ability to recognize soil degradation will increase a farmer's willingness to practice forest and soil conservation activities. Thus, particular attention should be paid to the prevailing system of land rights vis-à-vis migrants and its incentives, or disincentives, for promoting sustainable management of the forest resource. Third, the establishment and/or reinforcement of membership in community associations should be promoted. The demand for NTFPs indicates that consumers increasingly prefer substitutes for NTFPs when their family size becomes larger. Given the increasing population of the country, the importance of NTFPs as functional food, and its probable impact on public health,[3] attention should be paid to promote NTFPs consumption. The results on drinking water demand do not provide any clear policy direction. On one hand, the low price elasticity indicates that water can be a substantial and stable source of revenue for the government since a tax on water will not change consumer behavior to any large extent. On the other hand, the implication of a low price elasticity from a resource allocation perspective is that a price increase will not induce any significant increase in water conservation, at least in the short run. However, it is possible that in the long run a tax on water may provide incentives for changing consumption patterns, depending on how consumers react over a long time horizon.

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3 Functional foods can be considered to be those whole, fortified, enriched or enhanced foods that provide health benefits beyond the provision of essential nutrients (e.g., vitamins and minerals), when they are consumed at efficacious levels as part of a varied diet on a regular basis. Link to that definition most of NTFPs are included as functional food. Functional foods represent one of the most intensively investigated and widely promoted areas in the food and nutrition sciences today. (Hasler 2002). According to the author, there is a clear evidence for nutritional prevention of diseases such as cancer and risk of cardio vascular diseases by phytochemicals such as flavonoids and carotenoids has been obtained from a variety of interdisciplinary studies including epidemiological studies, in vitro cell culture studies, and animals and human intervention.

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