THE ECONOMICS OF LAND DEGRADATION

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Study of the Economics of Land Degradation in Burkina Faso

Neutrality gains and economic gains from sustainable land and soil management in three provinces of Burkina Faso

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A report for the Global Programme “Rehabilitation and protection of degraded land and the reinforcement of the local institutions in land issues in the rural areas of Burkina Faso” of the initiative “One World – No Hunger”, implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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Acronyms and Abbreviations

ANR	Assisted natural regeneration
BAU	Business as usual (status quo)
CBA	Cost-benefit analysis
CL	Conditional logit
CSI	Strategic Investment Frame
CSR	Corporate social responsibility
DPSIR	Drivers, pressures, state, impact and response model
DTR	Discounted time of return
ELD	Economics of land degradation
FAD	Fight against desertification
FAO	United Nations Food and Agriculture Organisation
FCFA	African Francophone Community Franc
Ha	Hectare
INERA	National Institute for the Environment and Agronomic Research
INSD	National Institute of Statistics and Demographics
IRR	Internal rate of return
Kg	Kilogramme
LDD	Land degradation and desertification
LDN	Land degradation neutrality
MAHRH	Ministry of Agriculture, Hydraulics and Fishing Resources
NGO	Non-governmental organisation
NPMG	Network of producer-manager groups
NPV	Net present value
NRDP	National Rural Development Programme
PAS	Permanent agricultural survey
PATECORE	Land development and resource conservation project, Plateau Central
PMG	Producer-manager group
R&D	Research and development
SDG	Sustainable Development Goals
SLM	Sustainable land management
SNRCS	National Soil Recovery and Conservation Strategy
SPI	Science-policy interface
T	Tonne
TEV	Total economic value
UNCCD	United Nations Convention to Combat Desertification
WOCAT World	Overview of Conservation Approach and Technologies
WSC/DRS	Water and soil conservation/Defence and restoration of the soils
WTP	Willingness to pay
WTR	Willingness to receive

Key results

The study evaluates the ecosystem services resulting from the development of 60,000 ha in three provinces in the centre of the country, between 1988 and 2004, through the PATECORE project. It also measures their contribution to food security.

Having highlighted the services identified as priorities by the beneficiaries, the gains in terms of cereals, the availability of water of straw for the livestock, the improvement in biodiversity and the strengthening of mutual social aid, we conducted a survey of a sample of producers representative of the three provinces with a view to estimating the monetary value of the non-market services (experimental choices method).

A cost-benefit financial analysis enabled us to examine the rates of return (IRR and DTR), based on cereal production gains and the investments made.

The total economic value of the services is estimated by aggregating the calculated values and using the result obtained for the value of the situation without developments (BAU). We ultimately obtain the average annual gain per hectare of land developed. This gain is the minimum annual gain in neutrality linked to the developments within this territory. It corresponds to the (minimum) cost of the degradation avoided.

Key result 1: In this study, the total economic value of the services provided by the developments carried out on farmed land is FCFA 3,303,000 for 10 years (theoretical service life of the development), representing an average annual value of FCFA 330,300/year/ha.

Representing twice the initial investment necessary to develop one hectare of land, this sum illustrates the social, economic and environmental importance of the developments beyond the financial aspect.

Key result 2: The average gain in neutrality linked to the developments within the context of the PATECORE project is between FCFA 162,000/year/ha and FCFA 330,300/year/ha of developed and fertilised land.

The lower figure corresponds to the sum of the values of the specifically calculated ecosystem services. Across the theoretical 10-year service life of the developments and for one hectare of land developed, the willingness to pay (WTP) relating to the context of an abundant supply of water is FCFA 361,500 while it is FCFA to 297,000 with regard to strong mutual aid; the availability of livestock fodder creates a WTP of FCFA 264,000, with a WTP value of FCFA 168,000 for assisted natural regeneration.

Key result 3: In terms of food surplus linked to the existing developments in the study zone, we obtain an annual surplus of over 11,016.7 T of cereals in 2017. This could cover the annual food requirements of about 58,000 people. If all land in the zone dedicated to cereals were developed, this surplus would cover the annual requirements of an additional 219,195 people.

Key result 4: Sustainable land management is a profitable sector of investment: at a discount rate of 10%, the profitability rate of the developments reaches a maximum of 35% for millet and a minimum of 8% for corn.

Over a period of 10 years, this makes it possible to generate a global net cash flow of almost FCFA 400,000 for one developed ha of millet and more than FCFA 270,000 for one developed ha of corn.

Summary tables for the economic results:

TABLE

Monetary value of average gains in terms of ecosystem services linked to developments on the farmed land and the average loss of the situation without developments. Per year and per ha (2017)

Service	Calculation method	Values in FCFA/year	In
Harvesting gain	Cost-benefit analysis on a representative sample, CBA	52,250[1]	
Medium migrator	Experimental choice method, evaluation of producers' willingness to pay on a declaratory basis, WTP	27,400	
Large migrator	Experimental choice method, evaluation of producers' willingness to pay on a declaratory basis, WTP	36,100	
Biodiversity	Experimental choice method, evaluation of producers' willingness to pay on a declaratory basis, WTP	16,800	
Mutual aid	Experimental choice method, evaluation of producers' willingness to pay on a declaratory basis, WTP	29,700	
total		**162,250**	
Situation without developments		**-330,300**	

TABLE

Results of the financial evaluation of the cereal production gains

Discount rate	Speculations	Indicators		
		Cum. Act. Income (FCFA)[2]	IRR	DTR (years)
10%	Sorghum	330,436	22%	3 à 4
	Millet	387,271	35%	3 à 4
	Corn	273,280	8%	4 à 5

[1] This amount was calculated by multiplying the surplus by the average price of cereals in 2018 (250*209=52250)

[2] Cumulated Actualized Income

Recommendations

A dynamic land development policy is required in rural areas in order to improve, simultaneously, the environmental situation of land degradation and the socioeconomic situation relating to the issues of food security.

Key recommendations intended for land users

The developments provide land users with significant advantages with an estimated value of between FCFA 162,000/ha/year and FCFA 330,300/ha/year. It is therefore in land users' interest to follow a training course in development techniques and to put these into practice within in a locally concerted framework.

Recommendation 1: users are major stakeholders in the process of disseminating developments.

The contextual elements presented illustrate the importance of local participation in land development actions – upstream to downstream – in ensuring their success and sustainability over time. This involves pursuing capacity building actions with land users; training and sensitising lands users should furthermore guarantee a better level of dissemination, training and sensitisation of other users. Within the scope of our survey in the PATECORE project zone, this cascade training process was not, however, shown to be operational: it should be rethought, for example with incentive schemes designed to facilitate a scaling-up of activities.

Users participate in experience-sharing exercises at local, regional and national levels. Through their knowledge of the local territories, they must contribute to the planning of developing needs, the organization and monitoring of the provision of materials and the construction and maintenance and even the monitoring-evaluation of the developments according to efficient organizational methods. The structures that these users might represent, such as groups, associations, local authorities and decentralized bodies responsible for managing the territories, are key partners in these processes.

Key recommendations for the private sector

Sustainable land management is an interesting sector of investment for the private sector as the developments are profitable in the long term.

At a discount rate of 10%, the profitability rate of developments reaches a maximum of 35% for millet and a minimum of 8% for corn. Over a period of 10 years, this makes it possible to generate a global net cash flow of almost FCFA 400,000 for one developed ha of millet and more than FCFA 270,000 for one developed ha of corn.

Recommendation 1: the private sector can be a financier (through corporate social responsibility, voluntary offsetting, etc.) and a co-investor in land development projects.

The private sector is already a provider and partner in the implementation of developments: its role primarily relates to the provision of materials for the developments and the capacity building of the players involved. We were unable to collect information on the existence of a developments value chain in Burkina Faso, but in the assumption of its structuration, it is clear that the private sector would find its place and benefit from the situation. Its role may extend to co-financing actions through corporate social responsibility, carbon compensation mechanisms, etc. The private sector is a key potential investor in certain fields of action.

Key recommendations for policy-makers/public decision makers

At the end of the study, the average increase in the neutrality of land degradation linked to the developments within the context of the PATECORE project is between FCFA 162,000/year and FCFA 330,300/year per ha developed and fertilised land. This annual gain in neutrality represents the cost of degrading the areas developed that has been saved. Furthermore, we obtain an annual food surplus linked to our study zone of over 11,016.7 T of cereals for 2017. This could cover the annual food requirements of approximately 58,000 people.

Recommendation 1: Promote concerted, multi-level land development policies and actions which generate synergies between sustainable developments objectives 2 and 15.

The study provides tangible advocacy elements justifying the interest in funding soil protection and restoration projects offering multi-dimensional, environmental, social and economic benefits accompanied by financial returns.

Recommendation 2: Work with the local authorities, associations and scientists on the gradual implementation of the flexible land regulation systems to remove the brakes on the dissemination of certain development practices, in particular those relating to tree management (ANR, agroforestry, plantations).

In the region of the study, the forests have disappeared and trees are increasingly rare. The proximity of the city of Ouagadougou is a constraint with regard to restoring tree cover. The data collected within the zone and the country as a whole demonstrate that, even through ANR, agro-forestry remains the least popular development technique, despite the fact that the producers surveyed express a strong need to increase the tree population, even in developed areas. Particular attention should be paid to the question of trees in discussions and in planning of land development.

Recommendation 3: Draw on the achievements of the PATECORE project in terms of capacity building and structuring of the players in preparation of a scaling-up, and accompany the implementation of the SNRCS by reinforcing the empowerment actions aimed at local stakeholders.

PATECORE succeeded in working on the organisation of stakeholders in three provinces; the PATECORE report (PATECORE, 2004, p26) presents its relay structure model; with the help of a steering committee bringing together public stakeholders from the national and local level and the partners involved in implementing the developments, the project succeeded in (PATECORE, 2004, p.14):

- organising needs identification and output planning; this work was subsequently decentralised to the local entities with the support of the project (the local population became the project owner);
- organising provision of the raw material with the support of the private sector (the private sector became the project manager);
- coordinating the monitoring and maintenance of achievements. This work was subsequently decentralised to the local entities with the support of the project (the local population became the project owner);
- monitoring the effects of the developments.

Recommendation 4: To open up greater financing perspectives, in particular through the private sector, it would be useful to complete this study by means of an evaluation of carbon sequestration.

01
Introduction

This ELD study relates to the economics of land degradation in Burkina Faso: it aims to quantify the economic and financial benefits linked to land developments implemented to prevent land degradation, maintain the quality of the soil and restore its fertility affected by the processes of degradation and desertification. Burkina Faso is known for having developed numerous projects relating to the restoration and maintenance of the land since the 1960s, initially through development NGOs and subsequently by means of co-operation projects and rural developments policies: numerous projects have been implemented in the geographic regions of the North and Centre of the country calling on the knowledge and know-how of the local populations. This experience makes Burkina Faso a particularly relevant field of study with a view to evaluating and quantifying the value of the gain in services rendered by the ecosystems resulting from these investments in fighting land degradation. In this ELD study, the timescale of more than 30 years facilitates an analysis founded both on the perceptions of the beneficiaries, and agricultural producers and on the results of objective measurements taken from the different monitoring-evaluation and capitalisation reports which endeavoured to identify and quantify the returns linked to these developments within the framework of the projects implemented.

Photo 1: Murals

Most economic studies in this field estimate the value of land degradation using approaches which quantify the losses in terms of ecosystem services More often than not, these studies are limited to measuring the losses in supply services (in terms of productivity and annual production, biomass or crops). In our case, the literature review targeting the scientific evaluations of projects designed to combat land degradation in Burkina Faso enables us to go beyond simple food losses in cereal production to address the other types of ecosystem services directly linked to the condition of the soil and land.

This ELD study therefore focuses on promoting the financial and economic returns linked to the development of farmed land in a regional that is historically affected by desertification and land degradation: the Nakambé basin. The specific area studied covers the three provinces in which the PATECORE project was carried out between 1988 and 2005; the provinces of Bam, Kourwéogo and Oubritenga straddling two administrative regions, the Centre and Plateau Central. **The aim is to establish and quantify the average annual monetary value of the main service ecosystems linked to the development activities undertaken on farmed land within the scope of the project.** In the field, the study is hosted and coordinated by partners of the GIZ PROSOL project.

To complete this economic evaluation of the ecosystem services rendered through soil protection and restoration, the method employed adopts the six-step generic framework of the economics of land degradation (ELD), which beings by identifying these services. The economic evaluation approach adopted is that of avoided costs, enabling us to view these benefits as avoided costs compared to a situation in which no land development project or action is implemented. In reality, the approach refers to minimums avoided costs, as we implicitly assume a constant land quality in the situation with no projects, an assumption which is somewhat optimistic in light of the contextual data. This approach calling on the avoided costs of degradation will lead us to address the question of land neutrality in tangible terms – goal 15.3 of the sustainable development goals (SDG, 2012). The study will specify and estimate the gains in neutrality generated by projects such as PATECORE. Finally, through this evaluation, we will link gains in neutrality of SDG 15.3 to goal 2 "zero hunger" (SDG, 2012) within the country: the results obtained will be presented in terms of the contribution to rural food security[3].

The desire for neutrality in terms of land degradation means that, from the standpoint of natural resource economics, land degradation must be offset exactly by an equivalent improvement in the health of land. When these effects cancel each other out, a situation of equilibrium exists between the value of the impacts linked to degradation and that of the beneficial impacts linked to the investments dedicated to sustainable management and to the land development by all the stakeholders concerned. This equilibrium is a minimum objective as the neutrality gains are, in reality, a major objective to be achieved by pursuing this sustainable development goal.

For 2008, the annual cost of the degradation of the environment in Burkina Faso is estimated at 21% of the GDP, representing a total of FCFA 780 billion, or FCFA 53,000 per capita (SBA UNDP UNEP, 2011). The inefficiencies or avoidable losses when using natural resources, materials and energy inputs represent 6 to 7% of the GDP. With regard to the category of soils and forests, the cost of damage represents 4.7% of the GDP on a national scale (SBA UNDP UNEP, 2011). Against this backdrop, neutrality gains should total approximately 5% of the GDP annually to "offset" this damage.

[3] The following sustainable development goals will be addressed in the section contextualising our work: "SDG 2, or zero hunger. Eliminate hunger, ensure food security, improve nutrition and promote sustainable agriculture (...). SDG 15 on terrestrial life: preserve and restore land-based ecosystems ensuring they are used in a sustainable manner, ensure sustainable management of forests, fight desertification, eliminate and reserves the process of soil degradation and put an end to the biodiversity depletion (...)". And specifically for the study:
"SDG 15.3 By 2030, fight desertification, restore degraded land and soils, in particular land affected by desertification, drought and flooding, and strive to achieve a world with neutral land-degradation (...)
SDG 15.9: By 2020, incorporate the protection of ecosystems and biodiversity into national planning, development mechanisms, poverty reduction strategies and accounting."
https://www.un.org/sustainabledevelopment/fr/objectifs-de-developpement-durable/

Our study therefore aims to verify the following two hypotheses:

Hypothesis 1: developments in use that are both functional and maintained promote a lasting improvement in the ecosystem supply services, in particular yield, and enhance food security.

Hypothesis 2: developments in use that are both functional and maintained promote a lasting improvement in the ecosystem regulatory and cultural services.

The evaluation undertaken in this study focuses exclusively on the development of land farmed by private producers[4]. The financial returns linked to cereal harvest gains are first measured before other non-market, economic, environmental and social benefits linked to the development of farmed land are identified and quantified in order to obtain a global value of the gains generated by these developments: to carry out this economic evaluation, a representative survey was conducted in September and November 2018 among 301 producers in the three provinces of the PATECORE project. The regions in the centre of the country are densely populated[5] and are always subject to chronic food deficits: the question of food security here is linked to the issue of land degradation.

The first section (chapter 1) is a bibliographical review focusing on the context of this study: public policies, food security and the neutrality of land degradation are specifically developed. The benefits linked to sustainable land management are presented along with the available measurements of economic rates of return of the developments resulting from several projects. This leads us to address the question of upscaling in two ways: by exploring the organisational dimension of projects such as PATECORE and presenting the recently adopted national strategy for soil recovery and conservation (SNRC), the study reasserts upstream considerations of stakeholder organisation as the prerequisite for the successful implementation of sustainable land management actions, and in particular the multi-dimensional nature of the returns.

The second section (chapter 2) presents the approach, implementation and results of this evaluation. The approach adopted for this second section of the study follows the six stems of the methodology developed by the "*Economics of Land Degradation* (ELD)":

1. Initialisation: organisation methods and methodological choices
2. Geographic characteristics of the study zone
3. Identification of the ecosystem services linked to the developments and to be evaluated
4. Role of ecosystem services communities' means of subsistence and in global economic development
5. Determination of the evaluation method: the damage costs avoided approach, thanks to the presence of developments, is adopted; the evaluation techniques used are the cost-benefit analysis and the experimental choices method *(discrete choice model)*
6. Cost-benefit analysis and decision-making: the results concerning the value of ecosystem services provided by the developments are presented and discussed.

The third and final section (chapter 3) returns to the key results of the study, their operational scope and their limitations.

Please refer to the French version of this study for the Annex, available at:
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[4] Developments on collectively-owned land have not been taken into account in this evaluation.

[5] The 50 villages closest to Rissiam (one of the villages in the survey focus group) lie within a radius of less than 32 km (*https://elevationmap.net/rissiam-kongoussi-bam-bf-1011089040*).

02

Study Context: Food security, neutrality of land degradation and review of the results of sustainable land management in the country

In this section, the main conditions of the study are defined and put into context with regard to Burkina Faso in order to highlight the proximity between the objectives of food security and land degradation neutrality in the country's rural areas. A detailed review of the economic returns of investments dedicated to restoring and maintaining the soils in Burkina Faso will enable us to justify the methodological choices made for this evaluation.

2.1 Food security in Burkina Faso

Food security is the second sustainable development objective adopted by the international community following the Rio +20 summit in 2012: the "zero hunger" objective is presented as follows, clearly linked to the environmental issues in the approach to sustainable development objectives[6].

"It is time to rethink how we grow, share and consume our food. If done right, agriculture, forestry and fisheries can provide nutritious food for all and generate decent incomes, while supporting people-centred rural development and protecting the environment.

Right now, our soils, freshwater, oceans, forests and biodiversity are being rapidly degraded. Climate change is putting even more pressure on the resources we depend on, increasing risks associated with disasters, such as droughts and floods. Many rural women and men can no longer make ends meet on their land, forcing them to migrate to cities in search of opportunities. Poor food security is also causing millions of children to be stunted" (Sustainable Development Goals website, Goal 2)[7] .

The last report on the state of food security and nutrition in the world (FAO-IFAD UNICEF WHO WFP 2017a p30) indicates a continued upward trend of hunger worldwide: after a period of improvement, a return to negative trends can unfortunately be observed; on a global scale, the state of food security in 2017 corresponds to the level recorded in 2008. Africa is by far the continent the most affected by food insecurity, with 22.7% of the population suffering from malnutrition in 2016 (FAO-IFAD UNICEF WHO WFP 2017b, p.10). In West Africa, the percentage of the population affected by malnutrition rose from 10% in 2014 to 11.7% in 2016 (FAO-IFAD UNICEF WHO WFP, 2017a, p. 6), while in Burkina Faso, the prevalence of malnutrition in the total population was 24.9% over the period 2004-2006 and only 20.2% for the period 2014-2016, although in absolute terms, the number of malnourished people rose from 3.3 million to 3.7 million in relation to these two periods (FAO-IFAD UNICEF WHO WFP, 2017a, p. 86 et p.96). The report specifies that *"Cereal availability was globally satisfactory for the period 2003-2012. The average value of apparent consumption of cereal products per capita was 243 kg/person/year during the period. The change in consumption of cereal products per inhabitant adopted a saw-tooth pattern over the period but remained above the consumption norm of 190 kg per person per year"* (FAO-IFAD UNICEF WHO WFP, 2017a, p. 30).

Generally speaking, exposure to change and climate shocks erodes the progress made in terms of food security, and even reverses the favourable trends observed until 2010 and beyond (FAO-IFAD UNICEF WHO WFP, 2017b). Hunger remains a problem that is far more present in countries where the agricultural system is highly sensitive to the variations in precipitation and temperature as well as to drought and in countries where the majority of the population derives its livelihood from agriculture.

[6] As our study focuses on the links between food security and land degradation, this section is limited to the analysis of the cereals available and does not address the issues of nutrition.

[7] *https://www.un.org/sustainabledevelopment/hunger/*

The Sahel region and Burkina Faso in particular display these two characteristics.

Food insecurity is also linked to poverty, especially in rural areas: in 2007, the INSD submitted a report on poverty in Burkina Faso (INSD, 2007, quoted by Traoré, 2012): it illustrates that poverty is higher in the rural areas than in urban areas and, more particularly, points to soaring poverty rates in the Centre region (7.3%) compared to the national average (5.1%). In 2014, more than 47% of the country's population was living below the poverty threshold (Kambou S.H. and Zida, Y., 2014), with a poverty rate of 54.0% in rural areas compared to 23.7% in urban areas. In the rural Nord region, most exposed to climate constraints, 70.4% of the inhabitants live in poverty compared to less than 10% in the capital.

In Burkina Faso, the farming and rural population accounts for the majority of the country's population: in 2017, the agricultural sector accounted for 86% of the population (2017, Burkina Faso, population data) while in 2008, the rural population represented almost 78% of the total population (Bikienga and Lompo, 2017). The agricultural sector in Burkina Faso is characterised by a large proportion of family or subsistence production: on average, more than 80% of cereal production is consumed by the country's farming households themselves. The main constraints encountered by the households in their agricultural activities are a lack of agricultural equipment (43% of households), a lack of fertilisers and pesticides (40%), poor soil quality (41%) and a lack of water (30%) (WFP, 2014 p26) (*box 1*).

BOX 1

Characteristics of agriculture in Burkina Faso

The main source of income of households in rural areas, agriculture accounts for more than 80 percent of the country's active population. Agriculture is extensive, has low levels of mechanisation, uses few inputs and is dominated by small-scale family farms the production of which is essentially intended for the food consumption of the household members (WFP, 2014 p25).

The increases in cereal production observed are primarily linked to an extension of farming land and not to a significant or regular increase in cereal yields.

At the national level, approximately 40 percent of agricultural households farmed land covering less than 3 hectares during the 2012/2013 agricultural season, half of which had a plot of between 1 and 2 hectares. The national average was 4 hectares. Almost 60 percent of agricultural households farmed an area of land covering less than the national average (WFP, 2014 p37).

The availability of cereals was globally satisfactory over the period 2003-2012. Taking the country's foreign trade into account, the cereal balance sheets were in surplus between 2003 and 2012. The country's level of dependence on suppliers of cereal products is 9 percent (WFP, 2014 p25). While agricultural production was globally in surplus during the course of the previous five years (cf. final cereal balance sheets 2008 to 2012) at the national level, production levels among agricultural households were low, due in particular to the small scale of family farms. A non-negligible proportion of agricultural households (54% on the occasion of the last food security forecasting committee in Burkina, 2013) are unable to cover their cereals needs with their own production. This situation results in a high level of dependence of agricultural households on the markets to complete their food supplies (WFP, 2014 p34).

Source: WFP, 2014

BOX 2

Food security in the regions of Burkina Faso in 2012

- Moderate food security: 18% of households. Indicates that these households display insufficient food consumption or cannot meet their minimum food requirement without resorting to irreversible adaptation strategies.
- High food insecurity: 1%
- Borderline food security: 43%. Indicates adequate food consumption without resorting to irreversible adaptation strategies, nevertheless combined with an inability to cover essential spending such as that on health, education and housing.
- Food security: 38% of households.

The highest prevalence of food insecurity can be observed in the regions of Plateau Central (43% of households), Centre Sud (36%), Centre-Ouest (33%), Centre (28%) and Centre-Nord (26%). In Plateau central, these figures are as follows: Plateau Central had a population of 807,444 in 2011-2012:

- Food security: 14%, representing 114,448 people
- Borderline food security: 43%, representing 349,611 people
- Moderate food security: 38%, representing 304,975 people
- High food insecurity: 5%, representing 38,410 people

Households living in a situation of food insecurity are the most economically vulnerable and figure among the most disadvantaged groups. Households where subsistence farming is the main source of living are generally more exposed to food insecurity (26% of households), followed by informal traders (21%) and individuals depending on livestock farming (19%) as well as craftsmen, day labourers and people dependent on aid, donations and remittances (18%).

Household food security is linked not only to their level of poverty but also to the level of education of the head of the household, the area of land farmed and the number of livestock owned.

Source: WFP, 2014, pp9-10

According to the WFP (WFP, 2014), Burkina Faso was 91% self-sufficient in cereals every year during the period 2003-2012 (*box 2*). The 2014 WFP report specifies that *"the country's highest self-sufficiency rates in terms of cereal products are observed in 2005 (97%), 2008 (96%) and 2012 (95%) due to a large increase in national cereal production during those years"* (WFP, 2014, p 31).

The level of annual cereal availability generated by national production varies from one year to another and contributes to the instability of food security: in a year with normal rainfall, the country has just enough potential to satisfy its domestic demand for cereals (millet, sorghum and corn) (Embassy of Burkina Faso in Rome, 2011).

Between 2005 and 2010, the national harvest was between 2 and 2.6 million tonnes p.a. with between 1.7 and 2.2 million tonnes of cereals available to the population. The variation in food coverage displayed a saw tooth pattern over the period 2002-2013, ranging from 90% to 130% depending on the years (Bikienga and Lompo, 2017). Over the same period, the share of cereal imports in total imports of food products increased dramatically from 46% to 86%.

The final cereal balance sheet for the 2010/2011 agricultural campaign indicated a surplus net balance of more than 1 million tonnes[8]. Despite this production, 48.2% of households were considered not to be autonomous (insufficient production

to cover annual cereal requirements) and 21.4% were in a situation of food insecurity (Embassy of Burkina Faso in Rome, 2011). Of the 45 provinces, 24 were in a situation of surplus, with high requirements coverage rates of 120% or more; 13 provinces were in a situation of equilibrium, with coverage rates of between 90% and 120% (including the provinces of Bam and Kourweogo); and 8 provinces were in a situation of low coverage rates below 90% (including the province of Oubritenga) (Bikienga and Lompo, 2017).

The results of the national nutritional survey (2011) illustrated the persistence of food insecurity within the country (INSD, 2007, quoted by Traoré, 2012) while the four regions most affected were those of Sahel, Nord, Est and Centre-nord. Finally, according to the report conducted by the Embassy of Burkina Faso in Rome in 2011, the highest proportions (more than 40%) of households in a situation of cereal insecurity could be observed in the regions of Nord, Centre and Plateau Central (Embassy of Burkina Faso in Rome, 2011). These elements point to a problem of access to cereals for, when the harvest is poor, the households generally cannot afford to buy the cereals they require due to rural poverty.

The 2011-2012 agricultural campaign recorded a deficit in cereal production of almost 150,000 tonnes representing a fall of 190.6% in relation to the 2010-2011 agricultural campaign and of 5.09% compared to the average of the 5 previous years: 180 of the 302 rural municipalities in Burkina Faso were classified as being at risk of suffering food insecurity (Kambou and Zida, 2014). In 2014, the WFP (WFP, 2014 p. 25) estimated that: *"Despite the relatively good performances in recent agricultural seasons, a non-negligible proportion of farming households (54%) will not manage to meet their cereal needs with their own production"*, noting that *"This situation means that farming households are highly dependent on the markets"*. Improvements over the period 2011-2015 remained limited, with an average increase in total agricultural production falling below growth forecasts at 2% per year and a reduction in poverty rates from 52.8% in 2009 to only 47.5% in 2014. A steady fall in cereal production was observed from 2012 while the contribution of the sub-sectors of agriculture and livestock farming to the economy as a whole increased from 26% to 46% (Bikienga and Lompo, 2017).

Despite key progress in terms of agricultural production, the data available show that Burkina Faso remained vulnerable with regard to the food situation. With rural households almost only able to count on their cereal production, food security in rural zones is directly linked to the state of the land. In 2002, 11% of the land across the entire country was high degraded (Embassy of Burkina Faso in Rome, 2011); in the Sahel region of the country, this phenomenon affected 57% of the land with a figure of 29% recorded for the Nord and Centre Nord regions. The same regions displayed a structural deficit in terms of food availability (Embassy of Burkina Faso in Rome, 2011). Food security in Burkina Faso therefore remains a major issue with regard to development and the quality of life of the country's rural households (*box 3*).

Population growth (natural rate of 3.1%) and land degradation dare two factors exacerbating the risks of food insecurity and the associated migrations. Controlling these factors generally requires increased coordination of national actions to the benefit of agriculture, and in particular the adoption of a sustainable land management approach acknowledged to be a favoured means of achieving target 15.3 of the Sustainable Development Goals (SDGs) relating to the neutrality of land degradation (Chazek et al, 2014; ICON SLM, 2015).

2.2 Neutrality of land degradation and application to Burkina Faso

"The time has come for the international community to commit itself to a land degradation neutral world by setting sustainable development goals on land use, with targets towards achieving zero net land degradation" (Rio+20 Declaration, Africa Consensus Statement, Addis Abeba, 2011).

[8] The forage available is deemed satisfactory (farmed and natural forage). The level of agro-industrial by-product (AIBP) stocks is deemed acceptable in the Nord and Est regions. The fill level of watering points is deemed satisfactory, while nevertheless displaying difficulty of access (Embassy of Burkina Faso in Rome, 2011).

BOX 3

Food security in Burkina Faso – an essential issue for the development of the country

The last national opinion survey conducted by the World Bank in Burkina Faso (WB, 2016) identified the following changes relating to the development priorities as perceived by the people of Burkina Faso for their country since 2013[9].

In 2013, the priorities identified were education (36% of the sample) as well as reforms and governance of the public sector (30%). In 2016, the respondents saw food security as the main development priority (40%), retaining the issue of public sector governance in second place (37%). This change in the players' perceptions coincided with a proven renewed increase in food insecurity worldwide.

In answer to the question relating to the domains contributing the most to poverty reduction, the 2013 interviewees identified education (34%), rural development (31%) and agricultural development (29%) as the three leading factors of poverty reduction. In 2016, agricultural development (30%), followed by employment and job creation (26%), education (26%) and finally rural development (22%) were perceived as being the four main vectors of poverty reduction within the country.

According to the Embassy of Burkina Faso in Rome in 2011 and the WFP in 2014, Burkina Faso is recognised as a country of the Sahel in which its most vulnerable regions are "on the very borderline" of food security. This situation still applied in 2018, as *"From June to September 2018, more than 954,000 people were forced to reduce the number and quality of their meals drastically after having resorted to all other strategies of adaptation. This situation was primarily caused by the poor results of the 2017/2018 agro-pastoral season. Insufficient rainfall poorly distributed across the country led to a major cereal deficit which had a severe impact on the rural populations whose income was dependent on agriculture."*[10]

Source: WFP, 2014; ***https://www.faso-actu.net/annonces-et-communiques/programme-alimentaire-mondial-lunion-europeenne-aux-cotes-des-populations-locales-affectees-par-la-deterioration-de-la-securite-alimentaire-au-burkina-faso****; FY2016, Burkina Faso, Country Opinion Survey Report, the World Bank Group, 2016*

Since the last Rio Summit (2012), the goal of land degradation neutrality has become the major environmental goal with a view to conserving the land and the biodiversity. By 2030, the countries should therefore endeavour to achieve this level of neutrality.

The United Nations Convention to Combat Desertification (UNCCD) has become a pioneer in making this new concept operational among the regions affected by desertification and land degradation. In 2016, as the link between scientists and the policies of the UNCCD, the Science and Policy Interface (SPI) was commissioned to produce a study exploring in detail the scientific definition of neutrality and suggesting operational means for achieving it (SPI, 2016).

[9] The samples used in these two surveys mainly comprised representatives of the central administrations or of the cooperation sector (one-third of the sample in 2016), together with representatives of NGOs, the private sector, the media, local public administrations and the academic world: in total, the 2013 sample incorporated 326 individuals (i.e. 64% of the people targeted by the survey) while the 2016 sample involve 416 people (72% of those contacted).

[10] *https://www.faso-actu.net/annonces-et-communiques/programme-alimentaire-mondial-lunion-europeenne-aux-cotes-des-populations-locales-affectees-par-la-deterioration-de-la-securite-alimentaire-au-burkina-faso*

According to the SPI, neutrality is a state whereby the quantity and quality of land resources required to maintain the functions and services of the ecosystems to achieve food security remain stable or increased within a clearly defined space, ecosystem and time frame.

This definition (Cornet and Escadafal, 2016):

- highlights the idea of net gains (not only stability),
- also highlights the idea of compensatory mitigation: any forecasted land degradation must be accompanied by measures designed to recover the losses caused,
- underlies a logical sequence of actions which can be summarised as "avoid, minimise remedy"
- and enables the UNCCD to adopt a quantified goal and enjoy renewed international legitimacy.

Neutrality is measured on the basis of the ecosystem services framework: monitoring-evaluation methodologies must be developed through research focusing on the measurement of variations in the numerous services provided by ecosystems to societies over time according to the different investments devoted to land conservation, rehabilitation and recovery. Ultimately, this work defends the vision of neutrality implemented through forms of local or territorial planning regulated by the states and relayed, in the countries concerned, by the decentralisation of natural resource management.

BOX 4

Neutrality according to the SPI, analysis model, identification of targets and prerequisites

The SPI document bases its analysis on the "drivers, pressures, state, impact and response" (DPSIR) environmental model to explain the causal relations between ecological and social systems which could serve to inform decisions to invest in favour of neutrality where, in this case:

- D = the shocks (economic, etc.), population and climate;
- P = the changes in land use and management and the degradation process;
- S = the natural land capital;
- I = the operations of ecosystems / provision of services / well-being, food security and poverty;
- R = the policies linked to the LDN, integrated land use planning, interventions and monitoring.

The neutrality mechanism is a binary mechanism which could be measured in terms of gains or losses in land areas terms for a common type of land. In tangible terms, mapping the types of land and how they change enables each country to determine a reference state of land degradation required to define neutrality targets. The subsequent evaluation should then serve to prepare an integrated planning of land use and management by anticipating changes (in surface area) linked to different investment decisions and by forecasting the associated gains and losses over time.

There are numerous prerequisites for identifying the best options including the creation of a buoyant environment to avoid the neutrality goals compromising the local land tenure systems; good knowledge of the potential and stratification of the land; an evaluation of land degradation; an evaluation of the resilience of land use and the use of socio-ecological systems; a socio-economic evaluation and gender aspects; and, finally, the initiation and monitoring of the LDN.

Source: SPI, 2016; ICON SLM, 2015

According to the SPI (SPI, 2016), the principles associated with neutrality are to:

- comply with the balance between economic, social and environmental sustainability. Neutrality intuitively appears as an ecological goal. However, its benefits must also be measurable in the economic and social spheres as the benefits are, by their very nature, multidimensional;
- base land use decisions on numerous preliminary evaluations validated at local level;
- work within the framework of existing planning processes to grasp the temporal reality of the degradation and the cumulative effects of LDN interventions, facilitate long-term LDN planning and regular monitoring. The broad scale of the LDN is therefore that of the ecosystem, the landscape, the basin and even the administrative territories;
- apply the hierarchy of responses: avoid, minimise, remedy. Avoiding and minimising land degradation maximises the benefit in the long term and proves to be more efficient than recovering degraded land. Reversing land degradation implies restoration, rehabilitation or land use reallocation actions. As restoration could create the right to degrade, the creation of degradation should be avoided in one place to offset it through restoration actions on other sites (anticipation of ongoing degradation, anticipated degradation linked to a change in land use);
- quantify the forecast degradation;
- not prioritise specific investments per site but to think on a landscape or ecological scale, for example on the scale of a basin; to integrate land use planning into a contextual mosaic at the level of an ecosystem or a landscape and to define combinations of development and conservation measures or actions;
- call on participatory processes and good governance.

This vision of the notion of neutrality pays as much attention to achieving quantified goals (definition of neutrality targets) as it does to its implementation. The main components of LDN governance are founded on the following key elements:

- good land governance: reference to voluntary directives for responsible governance of land tenure systems, FAO CSA 2012;
- the protection of gains on restored land (adjustments in land tenure);
- good local governance: support for associative networks, organisations independent of the official system, empowerment, associative governance;
- participation of stakeholders, in particular local ones, and capacity building with regard to the aspects of planning sustainable management of LDN land;
- financing of sustainable land management: institutionalisation of a conservation mechanism by creating funds to which numerous public and private donors contribute.

Finally, in tangible terms, the neutrality results to be achieved (SPI, 2016) imply:

- the maintenance and improvement of the supply of ecosystem services;
- productivity gains for food security;
- improved resilience of the land and the populations dependent on it;
- the identification of synergies with other environmental goals;
- a strengthening of responsible governance of the land tenure system.

In 2017, Burkina Faso commissioned a study with a view to determining the neutrality targets to be achieved by 2030 (SPCCD GTT/LDN, 2017). From 2002 to 2013, the study recorded land degradation across 19% of the territory, i.e. 51,600 km² over 10 years and 470,000 ha per year. Using these data, some 5 million hectares should be restored by 2030 while pursuing the goal of conservation and optimisation of degradation on the remaining land.

The specific neutrality targets are to stop the conversion of forests, improve productivity on grazing land (shrubs, grasslands) and farmed land, improve carbon stocks on 798,000 ha to reach a minimum of 1% organic matter and recover 295,000 ha of bare land out of a total of 590,000 ha (SPCCD GTT/LDN, 2017). The document then identifies the performances to be achieved by 2030 in specific land areas by category of indicator (land occupancy, productivity and carbon stock) to be conserved, used or recovered: for example, 855,100 ha of farmed land displaying a negative productivity trend should be treated, with almost 1.5 million ha of shrubs and grasslands as well as 105,200 ha of forests showing a negative productivity trend (SPCCD GTT/LDN, 2017).

These works represent an important reference for future work and dialogue on priority sustainable land management actions within the framework of planning the agricultural and rural development of the country and striving for neutrality.

2.3 Sustainable land management in Burkina Faso and economic returns of land conservation and restoration projects

Implementation of the concept of neutrality primarily focuses on a set of sustainable land management practices in order to improve the ecosystem services and human well-being (Chasek et al, 2014) relating to:

- regulation-support: fertility and the organic carbon stock of the land, the water cycle, biodiversity, plant cover and natural risks;
- supply: increase productive areas and yields, improve food security, resilience to shocks (climate, economic), reduce poverty, generate profits facilitating investments in households and an improvement in consumption levels,
- culture: social cohesion, mutual aid, organisation, knowledge of and familiarity with sustainable land management technologies, knowledge of the sustainable land management approach and planning mechanisms.

The goals of sustainable land management are environmental, economic and social and refer to:

- improved productivity of the land. Sustainable land management practices are known for their efficiency in the use of inputs (fertilisers, chemical fertilisers, etc.). The main aim of sustainable land management is to increase the productivity of the land, food security and the supply of other goods and services: Yield increases achieved though sustainable land management practices reached at rate of 170% (UNCCD-WOCAT, 2011);
- improved quality of life and livelihoods of the populations. The sustainable land management approaches are particularly appropriate for agricultural families: they allow the productivity of their land to be enhanced and make it possible to cope with recurrent problems poverty and occasional food security issues;
- enhanced ecosystems and services provided. Sustainable land management practices are in particular known for their efficiency with regard to water usage;
- organisational and decisional support for the transposition of good land sustainable land management practices on a larger scale.

A distinction is made between sustainable land management techniques on the one hand and the sustainable land management approach on the other. A sustainable land management technique consists of one or more practices belonging to the following categories:

- agronomic practices (e.g.: intercropping, contoured ploughing, mulching);
- biological practices (plants) (e.g.: planting trees, living hedge, grassy strips);
- physical structures (e.g.: embankments or stepped dykes, contoured terracing);
- management method (e.g.: change in land use, fenced land, rotational grazing).

The techniques used in Burkina Faso to combat desertification are:

- mechanical: zaï, stony strips, small dykes or filtering dykes, half-moons, treatment of gullies

and installation of ditches (retention of infiltration). These are labour-intensive;

- cultural: this refers to the management of organic matter in the soil, compost, organic manure, mineral fertiliser, ploughing;
- biological: this refers to the management of vegetation in the zones to be rehabilitated, fallow land, grazing land, mulching, herbaceous vegetation (grassy strips) and woody vegetation (reforestation, plantations) used, herbaceous carpet.

BOX 5

The state of developments in Burkina Faso in 2018

In Burkina Faso, a total of 186,165 ha of anti-erosion measures have been implemented.

"Anti-erosion measures incorporate the use of stony strips (in all their forms), grassy strips, vegetated strips, banquettes, dykes, living hedges, etc. (...). The highest values are observed in the Nord, Centre-Nord, Plateau-Central and Centre-Ouest regions which account for 26%, 16%, 14% and 13% of anti-erosion measures respectively. The lowest area values are noted in the Cascades, Centre and Sud-Ouest regions, each recording less than 1%, as well as the regions of Boucle du Mouhoun (4%) and Hauts Bassins (7%). Of the areas in which the measures are implemented, 19% are of good quality; 7% are of poor quality or are in the process of deteriorating and 36% are of average quality. Furthermore, 39% of anti-erosion measures have no information available concerning quality. pp.6-7

Agro-forestry includes assisted natural regeneration (ANR), reforestation, market gardens and agro-forestry. Agro-forestry covers an area of 12,222 hectares of land across the entire country and essentially consists of the technique of assisted natural regeneration (ANR). The lowest area values are observed in the regions of Cascades, Centre and Plateau Central, with less than 1% while the highest values are located in the regions of Centre-Ouest and Est, accounting for 54% and 13% of AGF measures respectively. p.46

At a national level, 60 476 ha are subject to the first type of agronomic practices and some 524,968 tonnes of organic manure (agronomic practice 2) were produced in 2018. The first agronomic practice comprises areas expressed in hectares (ha) of soil preparation techniques. In the study, only mulching, zaï, half-moons and sub-soiling are examined. The regions of Plateau-Central (42%), Centre-Nord (28%), Centre-Ouest (10%) and Est (10%) practise this technique the most. The lowest area values are observed in the regions of Boucle du Mouhoun (2%), Sud-Ouest (1%), Hauts-Bassins, Centre-Sud, Centre, Centre-Est and Cascades, each recording less than 1%. pp64-65

The second agronomic practice consists of the quantities of manure produced. Manure pits, composting and farm manure are taken into account in the study. This practice plays an important role in the regions of Plateau-Central (18%), Centre-Sud (13%), Centre-Ouest (12%), Est (11%), Centre-Nord (10%) and Centre-Est (10%), while the lowest rate are observed in Boucle du Mouhoun (5%), Sahel (4%), Centre (3%), Sud-Ouest (2%) and Nord (1%).

An evaluation of the combined impact of the different error sources gives a correct surface area of 97,940 ha, exceeding the area announced by the project by 52%. Taking account of the fact that a proportion of the measures (26%) displays failings which reduce their functionality, we obtain a developed area with functional measures covering 72,476 ha and an area displaying sub-optimum measures of 25,464 ha."

Source: Kambou et al, 2018

TABLE 1

The sustainable land management approach (SLM) in Burkina Faso

Source: taken from TerrAfrica, 2011; PATECORE, 2004; PATECORE, 2005; Bikienga and Lompo, 2017.

Principles of the SLM approach	Description and implementation in Burkina Faso
An approach focusing on people	Societies are the main cause of land degradation and must be at the heart of sustainable land management. This implies tangible investment by farmers in sustainable land management. Documents relating to land development projects highlight constant participation of villagers in land development and maintenance work as their necessary contribution. The materials are generally provided by the project
An inclusive approach	It includes all the stakeholders together with their various interests and needs relating to a single resource, incorporating: • local technical and scientific knowledge and mechanisms in order to create multi-stakeholder dialogue platforms relating to priority actions, at different levels, within a context of planning • gender issues as in small-scale farms, women take responsibility of more and more tasks. Multi-stakeholder platforms are currently being defined for the purposes development planning at local level (bottom-up principle) as well as at other levels; particular attention is paid to the situation of female heads of household
A multi-sector and multi-disciplinary approach	It must bring together all available know-how in the different disciplines, institutions and agencies, including government, non-government and private sector entities as well as local beneficiary societies. The multi-stakeholder approach has been developed in cooperation projects combating land degradation since the 1990s in Burkina Faso: involvement of different levels of authority, the civil society and, from the start of the new millennium, the private sector.
A multi-level approach	It must take account of the local, community and basin level in order to converge on a national level: incorporation of local interests in development sites as well as interests and benefits off site. The multi-scale approach is developed in Burkina Faso within the framework of creating local, regional and national platforms which will work on identifying land development requirements
The sustainable land management approach requires integrated planning of land development	Approach which evaluates and attributes the use of resources while taking account of the different users; it includes all the sectors and, as a priority, agricultural sectors (crops, livestock, forests). Integrated planning is currently being implemented in Burkina Faso through the implementation of concerted planning of actions at different levels.

When they complement and enhance one another, the combinations of measures constitute a key component of the sustainable land management technologies[11]. These combinations produce the most significant variations in soil fertility, yields and other associated ecosystem services.

The last report on the state of developments in Burkina Faso (2018) provides a full inventory of anti-erosion developments in the country, the main aspects of which presented in *box 5*.

A sustainable land management approach defines the ways and means employed to promote a more sustainable use of water and the soil. In Burkina Faso, sustainable land management projects have been developed for more than 40 years. *Table 1* presents the principles of the sustainable land management approach and its realities in Burkina Faso.

[11] All the scientific, technological and agronomic knowledge on sustainable land use has been brought together under the generic designation "sustainable land management" (SLM), a summary of which was developed in 2008 by the World Overview of Conservation Approaches and Technologies (WOCAT initiative, WOCAT, 2008).

Sustainable land management is based on a bottom-up approach which starts with the populations' needs and facilitates empowerment of small-scale farmers. Sustainable land management practices are implemented in an integrated approach which builds the capacities of the local stakeholders: organisation of experience sharing, training, organisation of dialogue to define needs and plan actions in connection with the local institutional structures. These practices are also designed to guarantee gender equality, as women are strongly involved in agricultural work.

By developing the sector of sustainable land management, it is possible to generate multi-dimensional benefits:

1. promote sustainable resources (land, water, inputs, etc.) which will improve and generate the degraded land and ecosystems;
2. ensure self-sufficiency of the local population with regard to food and drinking water and, subsequently, facilitate investment with the profits of sustainable land management;
3. guarantee jobs for the active population; and
4. reduce migratory movements and their intensity, preserver cultural identity and social cohesion to achieve human stability at both local and regional level.

In the three beneficiary provinces of the PATECORE project, the main measures observed are stony strips, zaï, half-moons, grassy strips, living hedges and ANR. Tree planting and mulching enjoyed less success (problem of land rights relating to the trees and competition with livestock farming with regard to use of the harvest residues). Returns linked to the measures resulting from the projects implemented in the regions in centre and the north of the country have been identified and measured by a series of studies (*Table 2*). Over a period of more than 20 years, the restoration of plant cover is achieved more visibly through the measures (Belemvire et al, 2008). With regard to the vegetation, the landscapes vary according to whether measures have been taken which impact on the diversity of the species and the presence and health of the trees.

The observed effects of the measures are (PATECORE, 2005; PATECORE, 2006; Belemvire et al., 2008):

- an increase in cereal yields of more than 50%;
- increased food security, even among the poor;
- the purchase of livestock: recover of manure, semi-stabling, fattening;
- intensification of agriculture (stabilisation of farmed areas);
- reduction in emigration (rural exodus);
- diversification of agricultural production;
- manure trading;
- raising of the water tables;
- restoration of plant cover (woody);
- modification of the agricultural calendar: development work and maintenance of WSC/DRS developments, as well as composting work is carried out after the harvest and before the off-season crops;
- new activities have been created such as the sale of manure, specialised labour for WSC/DRS work.

Competition for the use of harvest residues continues to be observed.

With regard to rural development, the WSC/DRS measures have proved to be useful to the regions benefiting from them. They have led to increased integration of agricultural and livestock activities including harvest residues, manure, small ruminant breeding and the development of pulses. This change illustrates the predominance of cereal crops, necessary food security, an intensification of agriculture through generalised used of organic or composted manure and an intensification of stock farming through the practice of fattening. Agricultural mechanisation is also gaining ground. The appearance of a production surplus with the use of WSC techniques has made it possible to create additional income, sometimes saved in the form of livestock (Belemvire et al, 2008). The reappearance of certain cash crops is linked to the growing fertility of fields treated by WSC methods (cowpea and sesame on the central plateau of Burkina

Faso). Finally, the introduction of mechanical WSC techniques allows collateral sources of income to be developed such as the labour market for digging (zaï), the organic manure market and the transport equipment rental. These new activities contribute to increasing agricultural income by 25 to 30%.

According to the PATECORE reports, *"one reason for a high rate of adoption of WSC measures lies in the very high "internal efficiency" they display in the eyes of the farmers* (S. Neubert, 2000): the benefit obtained from WSC measures genuinely perceived by farmers outweighs the construction efforts involved (150 md/ha, Kunze, 1988). The cost-benefit ratio of WSC measures is the most favourable of all activities in the region (S. Neubert, 2000)." (PATECORE, 2004, p51).

The minimum service life of the land measures is estimated at 10 years (PATECORE, 2005). However, the measures continue to provide benefits over a long period – more than 30 years – if they are maintained on a regular basis.

"The effectiveness of the measures is best seen during years subject to average rainfall, such as (...)(...). In terms of yield, reducing the difference in performances with the age of the measures is not visible." (PATECORE, 2005, pp6-7).

The *table 2* presents the main agro-economic results measured for the measures implemented in the regions located in the centre and the north of the country. It can be observed that the data relating to the variations in yield are primarily

TABLE 2

Summary of the main agro-economic studies on the benefits of WSC/DRS measures in northern Burkina Faso
Source: taken from TerrAfrica, 2011; PATECORE, 2004; PATECORE, 2005; Bikienga and Lompo, 2017.

Source report, institution	Zone studied	Direct results: production (short and medium term)	Indirect results: rural development (medium and long term)
PATECORE, 2005. Study on water and soil conservation measures (WSC) of the PATECORE PLT and their impacts, in particular on yields, Kfw, 60p. PATECORE, 2004. The experience of PATECORE on the central plateau of Burkina Faso, 17 years alongside producers combating desertification of the Bam, Oubritenga and Kourweogo provinces, capitalisation document, MAHRH, GIZ, KfW, 62 p	Provinces of Bam, Oubritenga and Kourweogo	Yield per area increased by 250 kg/year/ha (FCFA 25,000/year). The project estimates the average cost of one ha of development at FCFA 155,233/ha. ROI time frame: the project investment of FCFA 80,000/ha is amortised after 4 years and the farmers' investment of FCFA 75,000/ha is amortised after 3 years. Total time frame: 7 years The works also allow the farmed areas to be reduced in the farms. 1999, strips: 25 kg (4%), dyke: 149 kg/ha (23%). 2005, strips: 431 kg/ha (58%), dykes: 312 kg/ha (42%). The observed effects on the grain yields are repeated if we examine the straw yield. Every year the measures produce more straw than the control subjects. Two out of three years, production with dykes exceeds that with strips. Across the three years, the strips produce an average of 808 kg/ha more (44%) and the dykes 671 kg/ha (37%).	In the three provinces: reduced emigration; intensification of production systems and enhanced average quality of life of producers; improved replenishment of the water tables. Service life of the measures: improved production observed from the first year after construction of the mechanisms and certain to be maintained for more than ten years. The developed area enables production of an additional 16,000 t of grains per year and 50,000 t of straw (increase in yields in existing fields and extension of farm land by recovering unproductive land). This quantity is enough to feed an additional 84,000 people.

Source report, institution	Zone studied	Direct results: production (short and medium term)	Indirect results: rural development (medium and long term)
Belemvire A., Maiga A., Sawadogo H., Savadogo M., Ouedraogo S. (coord), 2008. Evaluation of biophysical and socioeconomic impacts of investments in natural resource management actions north of the central plateau in Burkina Faso, Sahel-Burkina Faso study.	Study of 20 villages on the central plateau Farmed areas (%) Rissiam (90) Baolin (72) Sankondé (95) Gonsé (7%)	Positive perceptions of yields No clear effect on food security Yields: for the villages in the Bam province, average sorghum and millet yield (1984-1988): 446 kg/ha and 406 kg/ha. Average yield (2000-2004): 736 kg/ha and 660 kg/ha. The grain tassel ratios are higher in developed fields Bam: the developed fields appear to benefit from greater fertiliser inputs. IRR zaï in Rissiam: without WSC, 468 kg/ha with zaï + 2 t/ha of manure: 716 kg/ha, i.e. an IRR of 83.8% for grain and 111.8% taking harvest residues into account (5 years, NPV 10%) IRR stony strips (SS) and IRR stony strips combined with grassy strips (GS) or zaï in Rissiam control, 468 kg/ha SS: 649 kg/ha grains (+39%); straw: from 1,939 kg/ha to 2,426 kg/ha, i.e. +25% SS GS: 992 kg/ha (112%); straw: 2,998 kg/ha, i.e. +55% The IRR of SS is 0.7% (0.9% with increase in straw) The IRR of SS GS is 42.5% (46.1% with straw) Half-moon and 10 t/ha of compost in Rissiam: IRR of 91.6% and 145% if straw included	No definitive migration in the village surveyed: the return of families has been observed in several villages. Seasonal migrations for gold mining. Water resources: 16 villages in 20 claim a positive impact of measures on water supplies, useful to off-season crops. Density of woody plants higher on developed plots; higher rejection rates; presence of old trees on developed plots (larger diameters). Forage resources still insufficient in the dry season. Predominance of cereal crops, intensification through generalised use of organic or composted manure, but mostly organic as cotton farming rarely developed (to a small extent in Bam); 67% of fields are fertilised in the villages of Rissiam. Other factors such as labour and the level of education can explain difference in harvest quality. Natural grazing land: 69 to 82% of the ration; crop residues 35% among cattle and 16.7% among sheep. Draught animals fed by trough. Development of bottomlands
CCP, 2006 Scientific Review of land degradation in Burkina Faso, 2006	Burkina Faso	Increase in sorghum yield: +23% for white sorghum and +15% for red sorghum; +28% white sorghum (bush) Over 3 seasons: +15% production	788 kg/ha (developed) 685 kg/ha (not developed)

Source report, institution	Zone studied	Direct results: production (short and medium term)	Indirect results: rural development (medium and long term)
Hien V et alii, 2004. Research on technologies for combating desertification in the Sahel and study of their agro-ecological impact, CSFD project no. 83, INERA, Burkina Faso	Northern zone of Burkina Faso: this INERA report reviews the research and projects addressing the fight against desertification (FAD) between the 1960s and 2000. These projects were implemented in the northern area of Burkina Faso (provinces of Sourou, Yatenga, Zondoma, Passoré, Lorum, Soum, Namentenga, Bam, Sanmatenga, Oudalan, Gnagna, Yagha).	Yields: + 47% in the case of pearl millet with stony strips + 11% for sorghum with stony strips from 75% to 133% for crops grown with stony strips, small dykes and filtering dykes. Average annual profit (1999, programme Sahel) Millet with stony strips, FCFA 11,600/ha, sorghum with stony strips, FCFA 24,682/ha, Sorghum with filtering dykes, FCFA 45,570/ha.	The cost-benefit ratio indicates that the average time required to derive benefit from the labour is one season while for total investments (strips, dykes, small dykes) the time frame is between three and eight years. The workload for individual stony strips is 97 hours per ha and 673 hours per ha for collective strips financed by development projects. The cost of the stony strips varies considerably: for a community construction: NGO or projects = FCFA 74,300, a family construction = FCFA 40,440 and a family construction with closely spaced stones = FCFA 4,850).
Dabiré A.B. (coord.), 2004. Promotion of local capacities for the decentralised management of natural resources, the PSB/GTZ experience in the Burkina Sahel, GTZ – Ministry of the Environment and Burkinabe living conditions, 81 p.	PSB/Sahel Fight against desertification project focusing on the accountability of the populations in managing natural resources	WSC measures: 20,787 ha (zaï, half-moons, grassy strips, composting The results: yields doubled in zones treated, return of biodiversity, 75% reduction in conflicts linked to natural resource management.	Environmental project and institutional support for decentralised management of natural resources: local environmental conventions.

produced per type of measure or combination of measures. Based on the data presented, it is difficult to estimate to any great degree of precision all the economic impacts of these measures across an entire region and over a long period. This is why a representative survey referring to the relevant clearly demarcated basin or territory will be necessary to calculate the global value of the benefits provided by these measures in terms of gains in ecosystem services.

The results recorded in the studies are unanimous with regard to the economic and financial advantages of the measures and with regard to their environmental and cultural benefits in the fields of collective learning and social cohesion. However, the dissemination of the approach and the development practices remained limited to occasional actions, even when they are incorporated into public development strategies. In the PATECORE region, one of the best developed in the country, 1 million ha still need to be developed (PATECORE, 2004). An upscaling requires the creation of an appropriate environment and the development of specific strategies, such as CSI-sustainable land management (2014) and SNRCS (2016-2017).

CSI-sustainable land management (Hien, 2016) presents the different sustainable land management actions implemented in the national programmes, in particular the National Rural Development Programme (NRDP) and the National Environment Investment Plan for Sustainable Development (NEIPSD), as well as action to facilitate the mobilisation of additional resources. Its aims are also to:

- develop local and regional dialogue platforms on sustainable land management, intended to promote the sharing of experiences and information, as well as building the capacities of sustainable land management stakeholders at different levels;
- strengthen the institutional and organisational bases to organise monitoring-evaluation of sustainable land management actions on a national scale: in particular, the text suggests strengthening the national observatory of the environment and sustainable development for this purpose.

CSI-sustainable land management defines the possible means of coordinating the different actions and programmes concerned by sustainable land management by establishing global strategic areas of focus. The strategic areas of focus and investment priorities relating to sustainable land management are:

- sustainable management of the fertility of agricultural land: good sustainable land management practices, participatory development of R&D technology, promotion of secure land tenure;
- sustainable management of water for production: development of bottomlands, use of water for agriculture, promotion of innovative irrigation technologies, concerted management of water resources;
- the conservation of ecosystems and sustainable management of forest, wildlife and fishing resources: regeneration of degraded land, decentralised management of forest resources, development and participatory management of the forestry and wildlife sector and promotion of agro-forestry, participatory development of R&D technologies in natural resource management, promotion of private or community forest enterprises;

Photo 1: Grasslands

- security and sustainable management of pastoral resources: the most difficult sphere in which to obtain significant results in terms of sustainable land management, as shown by several earlier studies conducted in one or more African countries (TerrAfrica and WOCAT);
- energy-saving and promotion of new energy sources;
- sustainable land management and promotion of sustainable development: procedural focus point incorporating legislative, governance, environmental awareness and education actions as well as the creation of multi-level (municipal to regional) and multi-stakeholder sustainable land management platforms. This procedural focus point is important to the upgrading, replication, adaptation and upscaling of sustainable land management measures in the country.

This document then estimates the necessary investments per focus point and type of action. For the period 2015-2020, it can be noted that the total investment needs are almost FCFA 900 million, with more than 100 million devoted to soil fertility management and almost a further 100 million devoted to sustainable land management and the promotion of sustainable development.

In Burkina Faso, the Ministry of the Environment is responsible for coordinating the partner institutions and stakeholders of sustainable land management at the national level; the local sustainable land management development actions and their organisation are often managed via the NRDP, formulated and implemented under the aegis of the Ministry of Agriculture: the National Rural Development Programme 2011-2015 includes goals linked both directly and indirectly to WSC/DRS measures in the fields relating to the sustainable development of agricultural production, agricultural hydraulics, environmental governance, promotion of rural areas and promotion of forestry, wildlife and fishing production (Bikienga, 2016).

There are numerous benefits of the measures:

- multi-stakeholder (rural population);
- multi-sector: social (food security, social cohesion, human capital or organisational and technical competences) economic and environmental;
- ecosystem multi-resources or multi-services (soils, biodiversity); and
- multi-level (plot, farm, basin).

Upscaling the measures implies:

- ensuring national coordination of WSC/DRS action planning (sustainable land management);
- adopting a basin approach and a bottom-up rationale;
- involving local authorities, producers, their organisations, the CSOs, the research and training entities, the private sector and the technical and financial partners.

The national soil restoration, conservation and recovery strategy for agricultural land and its accompanying action plan (SNRCS) were formulated in 2016. The key issue is sustainable land management, the upgrading of WSC/DRS measures by replicating, adapting and scaling up the successes already recorded. This strategy coordinates the planning and implementation of actions within the country based on the needs identified locally in collaboration with the stakeholders at the ecological level of the basins. Implementing this strategy implies investing just as much in the organisational processes as in achieving the goals, often formulated in terms of surface area or the enhancement of cereal yields and ecosystem services.

In this respect, the PATECORE capitalisation report underlines the fact that the local level of producers is essential and relevant and that it is necessary to organise the development planning "from the bottom up" by means of coordination, relay-consulting and organisation of the supply of inputs required to implement the measures when local labour is available after the harvests.

"The sustainability of the PATECORE project through the population maintaining and servicing the physical WSC infrastructure without the support of the project has been confirmed, as the maintenance efforts are feasible for the target groups. New large-scale WSC works will require stone transport costs to be borne by the external partners" (Belemvire et al, 2008).

The implementation of the measures required organisational and planning structures underpinning these measures. The local structures, farmers' organisation, producer groups and environmental associations have been strengthened and given responsibility for planning the measures. "Since 2001, a reorganisation of PATECORE has transferred planning and implementation responsibilities directly to the farmers organised into groups. At present (2004), approximately 800 producer-manager groups (PMGs) in over 450 villages have been set up and are organised into 44 networks of producer-manager groups (NPMGs). During the 2004 season, the PMGs developed approximately 10,000 ha with the aim of recovering or conserving farming land" (PATECORE, 2004 p 14).

The PATECORE project has emphasised the importance of defining the basic development needs by providing a coordination mechanism to facilitate monitoring and coherence at both basin and national level. At the village level, the WSC measures require organisation and collective choices to be effective.

"The farmers have their own planning rationale based on indigenous knowledge and memory of the land. This was not an illusion for the mental planning of the sole WSC measures on individual plots as it was observed that the constructions are generally (over 80%) well built (evaluation report 2002, 2003 and 2004); the WSC works are installed within the territory to fulfil their role of collecting water and improving the soils." (PATECORE, 2004 p36).

Sustainable upscaling of WSC/DRS measures is covered by the SNRCS but also figures in the international commitment on neutrality. This means promoting awareness among the communities on an incentive basis:

- through training in the techniques and tools available to them to manage their agro-sylvo-pastoral area in exchange for an undertaking to comply with a certain number of rules designed to protect the environment and to adopt fertilisation techniques (PATECORE, 2004);
- through their involvement in the local planning actions;
- through the implementation of local monitoring systems managed by the direct stakeholders in the developments together with their organisations.

In this contract between the state structures, cooperation entities, producers, their families and their organisations, the state has undertaken to assist decentralised rural communities in implementing certain measures programmed for collective land, such as bottomland and pastoral zones.

The state intervenes more broadly by creating the appropriate environment: its role in land tenure security by promoting relative regulation frameworks is, for example, important to the success of the measures.

The final step in making the SNRCS operational is the establishment of reference conditions to be able to plan, ex ante, the results that can be expected from the WSC/DRS development policies. Even though the development projects, and in particular that of PATECORE, are well documented, there is no global evaluation of the long term benefits linked to these developments, and thus no estimation of the possible returns linked to efficient implementation of such a strategy. In this context, the analysis of a sub-basin in which 60,000 ha of land were developed by the PATECORE project (1988-2004) represents a relevant basis for the quantified evaluation of all the benefits obtained in terms of ecosystem services through the implementation of the sustainable land management approach.

03
The 6+1: Approach of the ELD Initiative

3.1 - Step 1: Initialisation

In Burkina Faso, the partner of this evaluation is the PROSOL project, which develops soil protection and restoration actions at a decentralised municipal level with specific building of local land tenure capacities (*box 6*). PROSOL finances, coordinates and support surveys and the institutional organisation of the study in Burkina Faso. In September 2018, it convened a steering committee bringing together the stakeholder institutions and the people involved in the study to take decisions concerning the strategic elements of the study: its spatial scope, its location, its strategic scope and the priority services to be evaluated (appendix 1, composition of the steering committee).

BOX 6

The PROSOL project, host structure of the study in Burkina Faso

The PROSOL project adopts a land-tenure stance to structure the actions and local organisation of its fertility management and soil restoration goals. It observes that:

"Access to land is becoming increasingly difficult for women and young people due to growing demographic pressure. Land insecurity is also increasing for the population from other regions and which sometimes represents more than half of the total population. This has damaging impacts on the consequent and sustainable use of fertility and soil enhancement techniques. At present, no approaches are used on a large scale in Burkina Faso aimed at promoting the integrated management of soil fertility and the rehabilitation of degraded land (central problem).

The causes of the central problem can primarily be ascribed to the insufficient scope of basin rehabilitation projects and programmes and to their lack of coordination at national and local level. Land insecurity is increasing among a large proportion of the population because the decentralised bodies provided for by the land law reform are not yet operational. Not only do small-scale farmers therefore have little incentive to invest themselves in soil fertility management, they also have insufficient knowledge of sustainable production methods." p 6

The project *"englobe three interconnected fields of action: integration of water resource conservation and soil fertility enhancement techniques in the field of agriculture and in the municipal planning of the partial basins that are treated (A), the strengthening of local land authorities (B) and initial and continuing education as well as knowledge management concerning soil fertility and rural land law (C)."* p 12

PROSOL is part of the global action to protect the soils and rehabilitate degraded land in order to promote food security as part of the special UN one world no hunger initiative – SEWoH – and it contributes to structuring the neutrality goals with regard to land degradation (15.3) by 2030.

In Burkina Faso, the fight against land degradation and the protection of soil sin rural areas are both vectors of food security and of the improvement of living conditions and quality of life. The global aim of the study's steering committee is to provide a solid, quantified rational on the financial and socio-economic advantages of fighting land degradation in Burkina Faso. The specific objectives are to undertake the monetary (economic) evaluation of the gains in the ecosystem services generated by the dissemination of developments in a region with a history of benefitting from sustainable land management projects.

Initially, the financial profitability of the investments made in terms of developments is examined over a 10-year time frame; the value of the other ecosystem services provided – supplies, regulation and socio-cultural services associated with the restoration and conservation of the soils – is measured and monetarised on the basis of producer perceptions in the study region in accordance with a quasi-experimental evaluation protocol (Crépon et al, 2012). This approach enables us to address the idea of the total economic value (TEV) of the ecosystem services resulting from the measures deployed. This total economic value of the ecosystem service gains obtained corresponds to the (minimum[12]) value of the degradation costs avoided by the existence and permanence of these measures over time.

To obtain the value of the non-market services provided by the measures, producers' willingness to pay (WTP) for each service must be calculated using the maximum sum that each producer would agree to pay to benefit from each service. This method is based on the record of perceptions stated by the individuals interviewed (calculation of preferences by the choices stated): this is the experimental choices method. It means working on a sample representative of the population of the given territory (or the entire country) and demarcating a clear spatial scope for the evaluation. If positive, the total economic value ultimately obtained represents the annual net gain in neutrality in terms of land degradation resulting from this territory.

In contrast, the financial analysis is based on estimated data of a more objective nature, taken form reference documents or directly from the surveys: it provides the flow of value of the benefits (in terms of cereal production gains) resulting from the measures over time, the internal rates of return of the investments made and the updated return time of the investment, i.e. the period of time necessary to recover the initial value of the investment in the land development works. In this work, the calculations will be undertaken for a 10-year time frame, which is the minimum service life of the developments as estimated by the PATECORE reports (PATECORE, 2005). This approach also enables us to analyse the contribution of the developments to food security.

The framework ultimately chosen for the surveys is that of the three provinces of Centre, Nord and Plateau Central which have hosted different WSC/DRS projects since 1988, including the PATECORE project between 1988 and 2004 (map 1). They are located in the same sub-basin of Nakambé. Nakambé (formerly the White Volta) is one of three sub-basins of the Volta, rising to the east of Ouahigouya and permanently snaking its way south-west towards Ghana, beyond the artificial lake of Bagré and covering an area of 50,000 km^2.

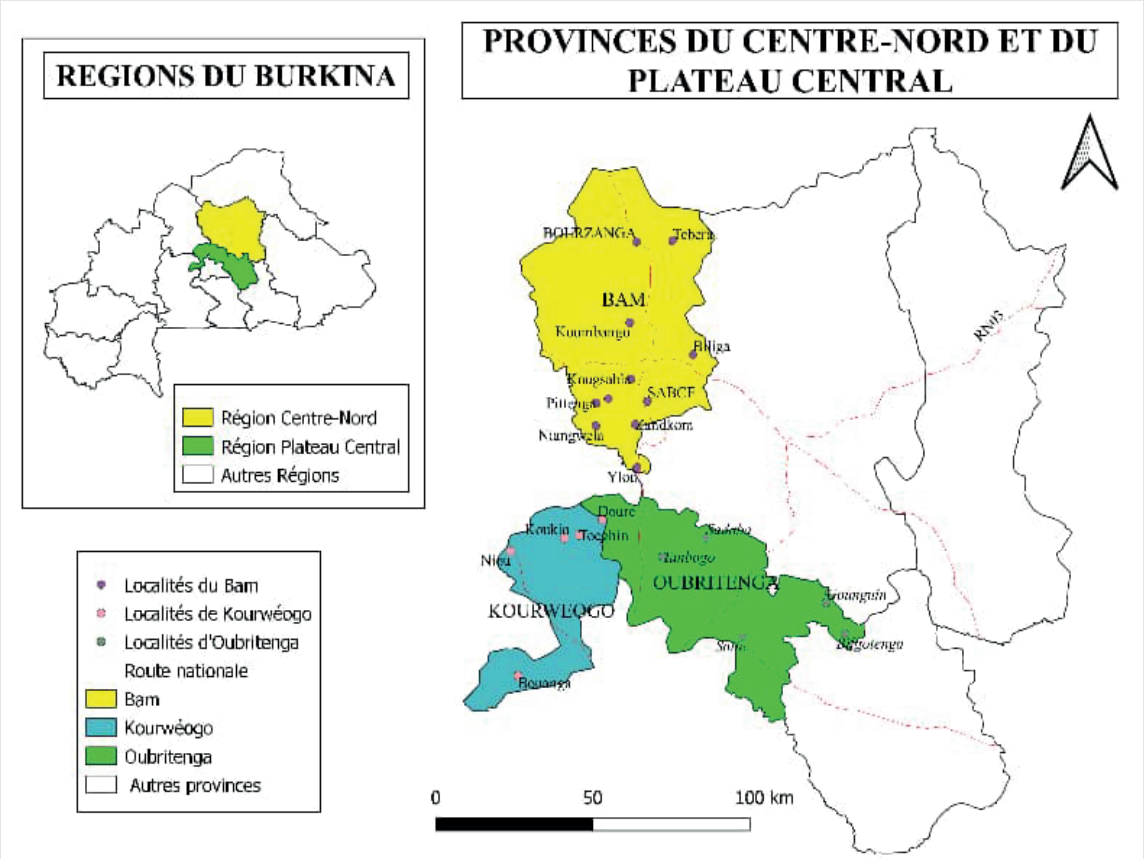
This choice is based on the following criteria:

- a zone historically affected by phenomena of desertification;
- a zone with long-standing sustainable land management measures, densely clustered;
- a zone with quantified data available on the developments undertaken, in particular their costs, their performances and the resulting benefits;
- a densely-populated and accessible zone in which sustainable land management projects are ongoing.

[12] In accordance with the land degradation trend over the same time frame.

FIGURE 1

The PATECORE zone



A review of the documentation available on the PATECORE project and the soil restoration projects in Burkina Faso enabled us to confirm that:

- the techniques employed within the scope of the WSC/ DRS measures (water and soil conservation, soil protection and restoration) and the soil fertility management measures are those of sustainable land management;
- the implementation approach developed by the PATECORE project in particular coincides with the sustainable land management approach by taking account of the forecasts and local needs when elaborating the development planning and the introduction of a coordination mechanism;
- with a view to neutrality, the sustainable land management approach also adopts an approach per basin and favours the coordination of local and regional stakeholder platforms to identify shared opportunities and share experiences between sites.

The methodological choices ultimately adopted for the study are as follows:

- perform a global evaluation of the value of the ecosystem services resulting from the measures implemented in the PATECORE project zone;

- limit the evaluation to the farmed areas developed: build a sample representative of the households in the region studied on whose land developments have been implemented;
- conduct a financial analysis of the flows of benefits in terms of cereal production gains over 10 years, which is the estimated minimum service life of a measure;
- calculate the producers' willingness to pay for each type of ecosystem service the availability of which is linked to the measures and thus obtain the monetary value of these services in the zone studied;
- calculate the total economic value of the gains linked to the measures for 2017 (agricultural season 2017); the agricultural season 2017 is chosen as it is an average year in terms of rainfall and agricultural season;
- use for the generic result of the PATECORE project which indicates an average increase of 250 kg/ha/year in agricultural yields of the developed land throughout the duration of the project, and
- ask the producers to estimate their willingness to pay as a number of man days in the surveys, i.e. in terms of the work effort rather than the financial effort.

To identify the ecosystem services to be evaluated, a series of trips were made to eight villages within the Centre region where focus groups were organised (appendix 2 and 3, sampling and survey questionnaires).

3.2 - Step 2: Geographic/ecological characteristics

Out study zone, the former PATECORE zone in the Nakambe basin, straddles 2 regions: Centre Nord and Plateau Central.

These regions are characterised by a relatively high population, with a growth rate of 2% in plateau central (RGPH 2006) and 3.02 in Centre Nord (PRDCN 2014), and a sub-Sahelian type climate in Centre Nord and a Sudan-Sahel and northern Sudan climate in Plateau Central (RGPH 2006; PRDCN 2014).

Photo 2: Nakambé River

The area is characterised by 2 seasons, one of which is rainy, with spatio-temporal irregularities making the agricultural activities (fishing, market gardening, etc.) and economic activities linked to rainwater resources random and precarious (PRDCN 2014). The level of water is between 414 and 671 mm/year in Centre Nord and 600 and 850 mm/year in Plateau Central. Coverage of cereal needs, for example, is only 76.6% in Centre Nord (PRDCN 2014).

The two regions boast relatively high amounts of surface water, with water courses such as the Nakambe, the Nazinon, the Massili, the Guibga, the Bamboré and the Koulottoko in Plateau Central and lakes Bam and Dem, the Bourzanga, the Siam and other dams in Centre Nord. It should be noted that a large number of these water courses dry up for part of the year. On average, there are 6 types of soil (lithosoils, brown eutrophic, gossanous, hydromorph, gravelly and sodium soils), none of which run deep or are particularly fertile (RGPH 2006) with a gently-sloping peneplain broken by hills in Plateau Central and valleys (Nabambe and Sirba) in Centre Nord.

In Oubritenga, we observe shrub-like vegetation, and forest cover in the Centre Nord region extends to only 0.15%. The vegetation deteriorates quickly due to over-grazing, abusive wood cutting, bush fires and a worsening climate (RGPH 2006). There are nevertheless protected species such as baobab *(Adansonia Digitata)*, shea *(Butyrospermum Parkii)*, néré *(Parkia Biglobosa)*, tamarind tree *(Tamarindus Indica)* and *Acacia Senegalensis*.

Following the droughts of the 1970s and 1980s and the land degradation depriving producers of the harvests necessary to eat, a series of definitive migrations were observed from 1975 to 1990. The arrival of new families from the start of the new millennium is one of the effects of the sustainable land management projects implemented (Belemvire et al, 2008). Dynamic demographics is a factor favourable to introducing and maintaining measures as mutual aid is a socio-cultural component of the collective work organisation; which is in turn a vector of social acceptability and the success of the WSC/DRS techniques.

3.3 - Step 3: Categories of ecosystem services

The ecosystem services to be evaluated using the inventory of effects resulting from the measures are determined on the basis of:

- the literature on the PATECORE project;
- the focus group organised in September 2018 avec the producers and representatives of the collective decentralised village entities of eight villages in the study's three provinces;
- the presentation of these initial results and their discussion with the study steering committee.

The review of the studies conducted on the impacts of the development projects, and in particular PATECORE and the Sahel study, highlight numerous impacts of the WSC measures and of the soil fertility management, notably:

- an increase in soil fertility (erosion contained): a sustainable response to the maintenance (nutrients) or event improvement (soil structure) of soil fertility;
- an increase in agricultural yields (250Kg/Ha/year on average): for example, +58% for sorghum and + 52% for millet in Bam province;
- an improvement in food security (mitigation of the food crisis);
- agriculture becoming more intensive: the cereal areas were reduced in Bam and Sanmatenga provinces and demonstrated a slight extension in Yatenga, despite population growth in the study zone of 26% across the period 1985 to 1996;
- farms invest an increasing amount in livestock, characterised by the initial transition towards a semi-intensive management;
- enhanced after availability;
- a curb on emigration: limiting of the rural exodus and return migrants the village (with zones maintained ecologically intact and a reduced risk of transmitting illness such as AIDS);

TABLE 3

Summary of different ecosystem services linked to the WSC/DRS measures

Supplies • Cereal production, fruits, straw • Water availability • Raw materials (wood, leaves, organic matter, etc.) • Biological diversity • Medicinal plants	**Regulation** • Increase in quality of air • Carbon sequestration • Regulation of water flows • Water purification • Fight against erosion • Enhanced soil quality
Housing • Maintenance of genetic diversity (reappearance and protection of threatened species)	**Cultural and amenities** • Transmission of cultural heritage (transmission of traditional techniques, etc.) • Consolidation of social capital (solidarity, mutual aid)

- solidarity and mutual aid between producers (increased organisational capacities, extension of practical knowledge;
- increased confidence of famers due to use of traditional techniques);
- regeneration of the forest coverage and its diversity (the number of trees and diversity of species are larger on fields with WSC installations) and improvement of plant cover in general.

Table 3 summarises the different ecosystem services linked to the developments on the Mossi Plateau: these are supply services, regulation and housing as well as cultural and social services.

The aim of the field mission is to identify the direct and indirect ecosystem and environmental services resulting from the WSC/DRS measures on farming soils. The information exchanged within the focus groups highlight the following direct and indirect services linked to the measures: the direct services are:

- regulation of water flows,
- increase in soil quality,
- increase in productivity,
- water availability,
- the presence of trees through ANR, presence of wood, fruit, leaves and shade,
- the presence of straw for roofs and animals.

The indirect services are:

- a curb on emigration (reduced rural exodus),
- a reduction in conflicts,
- the transformation of agriculture (towards a semi-intensive agro-sylvo-pastoral model),
- in the Bam province, the fight against the lake becoming silted up has also been mentioned.

The economic evaluation cannot cover all these directs and indirect services, the ecosystem services to be evaluated were chosen according to the producers' stated preferences and the orientations provided by the steering committee. The services adopted are **food cereal production gains, water availability, livestock feed availability, biodiversity and mutual social aid.**

3.4 - Step 4: Identification of the role of the ecosystem services as communities' livelihoods and in overall economic development

The main ecosystem services identified as major benefits of the WSC/DRS measures are presented in the *table 4* along the method used to calculate their economic value. As shown in the initialisation section, the evaluation approach adopted is that of damage costs avoided thanks to the presence of the measures: two specific evaluation techniques are applied, the costs-benefit analysis for agricultural and food production gains, the experimental choices method to calculate the value of other supply, regulation and cultural ecosystem services identified.

The *table 4* summarises the different elements of total economic value taken into account in the quantified evaluation exercise. The method adopted to estimate the total economic value involves aggregating the values obtained individually, subject to the absence of double counting and the phenomena taken into account. For example, calculating the value of water availability (supply service) and the value of the enhanced water cycle (regulation service) would imply taking similar elements into account. That is why only the water availability is evaluated here. Furthermore, the aggregation of values from the calculation methods or different models must be handled with care (risks of double counting and inconsistencies).

Harvest gains: profitability is calculated using data on the yields of developed lands in the survey at the level of all farms interviewed and without differentiating the types of development. This distinguishes our approach from those focusing on profitability, often conducted per type of development, and enables us to evaluate the impact of developments at the local or regional level of a clearly demarcated territory. The calculations will be made for cereal production (sorghum, millet and corn) in order to highlight the global contribution of the developments to food security.

Photo 3: Bocage

TABLE 4

Ecosystem services provided by the measures and method of calculating their value

Ecosystem service	Method used to quantify (specify if organic, physical, geographic, ecological, etc.)	Method to estimate total economic value: by aggregating individual values, subject to absence of double counting
Supplies		
Harvest gains	Financial analysis based on data available on output and costs (PATECORE project data) and measured data on prices and areas developed	Cost-benefit analysis on a representative sample, ACB Average result for 2017
Water	Economic evaluation on declaratory basis, representative survey	Experimental choices method, evaluation of producers' willingness to pay, WTP Average value for 2017
Straw gains	Economic evaluation on declaratory basis, representative survey	Experimental choices method, evaluation of producers' willingness to pay, WTP Average value for 2017
Regulation		
Fertility	Not calculated as risk of double counting with the supplies service in terms of harvest gains	
Biodiversity	Economic evaluation of assisted natural regeneration (presence of trees) on declaratory basis, representative survey	Experimental choices method, evaluation of producers' willingness to pay, WTP Average value for 2017
Water cycle	Not calculated as risk of double counting with the supplies service in terms of increased water availability	
Cultural		
Mutual aid	Economic evaluation Mutual aid is a necessary condition for the success of the measures, on declaratory basis, representative survey	Experimental choices method, evaluation of producers' willingness to pay, WTP Average value for 2017

The improved agricultural yields relating both to the supply services (harvest gains) and regulation services (fertility) will only be calculated once, in terms of financial flows or net present value (NPV). Once again, the improved water availability, which concerns both supply and regulation services, will only be calculated once using based on the producers' WTP.

The value of the main socio-cultural services, such as mutual aid and a capacity for collective organisation has also been calculated: the collective organisation is presented as a major impact of the implementation of the developments over a period of 30 years. It is also a prerequisite for the success of the developments and their longevity.

The different values will be aggregated in the next section to deduce the total economic value, taking all necessary precautions.

To prepare the survey of producers' willingness to pay, the different levels of attributes must be determined for each service evaluated. The producers are then asked to choose the level of attribute they prefer according to pre-determined amounts

BOX 7

Levels of attribute used to evaluate producers' preferences for ecosystem services and social impacts linked to the developments

We want to establish producers' preferences for a certain number of services and social impacts linked to the WSC/DRS measures. These services and impacts relate to both the cultural aspect and to biodiversity.

To this end, the people interviewed are asked to choose between alternatives where the situation with development is compared to two other situations (alternatives 1 and 2) which differ accounting to the following characteristics:

Biodiversity (definition: concerns the number of species and number of populations within these species)

2 levels:
- Reappearance of tree / shrub species in or around crop fields (bocage)
- No change

Drinking water availability (women wasted a great deal of time collecting water)

2 levels:
- Large quantities available (abundant)
- Little available (as before)

Livestock feed availability (pennisetum, wild straw)

2 levels:
- Presence of herbaceous plants around the fields serving as livestock feed / stubble,
- Nothing (in relation to before the developments)

Strengthening of the social fabric (designates collective mutual aid)

2 levels:
- Yes
- No

Monetary attribute: number of men/day to implement the developments on one ha, at the end of the dry season (May)

4 levels:
- Strips as number of men/day for one ha
- Small dykes as number of men/day for one ha
- Sykes as number of men/day for one ha
- Nothing (no spending)

(se survey choice cards in appendix 3), in this case a value of labour given in man days. It is particularly difficult for the surveys to provide a reliable response as a monetary value due to the rarity on site. The levels of attribute for the evaluation of water, straw, biodiversity (ANR) and solidarity (mutual aid) services are presented in the *box 7*.

The survey was conducted with 300 farmers with access to developed lands in the three provinces in November 2018. To support the economic evaluation exercise, the sample is designed to be statistically representative of the PATECORE zone (appendix 2 sampling and appendix 3, questionnaire). An example of the choice card given to the producers is presented in *table 5*.

The first analyses serve to present the main characteristics of the sample studied in connection with the issue of developments and land degradation: at the time of the survey, (November 2018), 83% of those interviewed were heads of household. Some 66% were members of a PO but 28% did not know of the existence of cooperatives; 25% were members of an association committed to protection of the environment. While 88% of those interviewed

participated in implementing the WSC measures, only 13% trained other producers.

69% of the respondents have implemented measures on at least 69% of their land:

- 92% of the respondents implement zaï,
- 69% implement stony strips,
- 13% implement half-moons
- 10% implement grassy strips.

Numerous producers have combined measures: the most common combination in the survey is that of "zaï-stony strips" (more than 27% of the sample).

Some 56% of producers maintain the measures ever year (and 39% from time to time). This maintenance is primarily carried out by members of the family (99%). On average, this accounts for 4 hours/day/Ha in the household (survey, 2018). Finally, more than 99% make amendments to the developed plots.

For more than 99% of respondents, the measures combat erosion, improve the quality of the soil and increase agricultural yields. For 89%, the measures increase water availability in the zone; for 82%, the measures consolidate links between producers; for 65%, the measures help reduce the level of emigration while for 58%, the measures contribute to reducing their farmed land.

With regard to the WSC/DRS measures, 95% of the respondents find them very important or important (PROSOL ELD surveys, November 2018). More than 96% believe that tress in the fields are important while 87% would like to have more trees on their plot.

TABLE 5

Example of choice offered producers in the survey to calculate WTP

Attributes	Choice A	Choice B	Neither
Biodiversity			
Water availability			
Mutual aid			
Presence of livestock feed			
No. of men per day	0	63	
I prefer	o	o	o

Some 62% and 12% of the respondents have observed a moderate to strong increased in their yields since they began growing cereals while 11% of the sample observed a fall in yields. The two main causes of loss of fertility are the lack of rain (68%) and the lack of trees (16%)

According to the producers interviewed, the two main practices which enhance soil fertility are WSC measures (56%) and the use of fertilisers (30%). More than 99% make changes and take measure to improve the quality of their soil.

With regard to the importance of attributes, the presence of water is ranked first (57%), followed by mutual aid (23%) and the presence of biodiversity (15%).

The following section provides information about the land degradation process in the Sudan-Sahel zone since the 1990s.

3.5 - Step 5: Dynamics of land degradation

In the Sudan-Sahel zone which specifically concerns this study, soil erosion by water is the main factor of land degradation, causing erosive run-off and the loss of arable land. The chemical degradation of soils is due to the loss of nutrients in the soil, the lack of fertiliser inputs (organic and chemical), the unsuitability of the agricultural practices and in particular the disappearance of fallow land. The fertility management dimension continues to be insufficiently taken into account by producers. The physical degradation of the soil occurs by the compacting and degradation of their structure, which depend primarily on work on the soil and overgrazing. The degradation of water is linked to drought, which is a natural phenomenon in northern Burkina Faso, poor use of agricultural inputs and chemical products, in the second case in the developing gold mining sector (providing a livelihood for 700,000 people). Finally, the biological degradation manifested by losses in plant cover as well as the loss of habitats and natural species close to the soil is linked to deforestation and land clearing for agricultural use and fuel wood, bush fires and the use of chemical inputs (CCP-Burkina, 2006).

Several social and institutional factors must be taken into account in order to understand the mechanisms governing the creation and development of degradation processes. First and foremost there are conflicts between users of resources concerning soil and water. These conflicts and the management thereof are linked to the high rates of poverty of land users and to insufficient local security of land tenure rights. More globally speaking, this land insecurity refers to the lack of coherence between modern and traditional laws. With regard to institutional frameworks adapted to sustainable land management, the role and quality of basic development infrastructures should also be highlighted, such as access to education, healthcare or agricultural credit, together with the types of governance and local policy, including the involvement levels and methods of including local stakeholders.

Comparing the available data reveals the following trends for the three provinces in our study:

- in the CCP-Burkina report 2006, which records the state of land degradation and the (physical and anthropogenic) risks of desertification per province between 1992 and 2002, the zones at medium risk are located in the central area of the country where the sustainable land management technologies are the most frequently used. Nevertheless in the Bam province, the risks of degradation are high and affect 92.88% of the land in this province; in Kourweogo, the risk is high to very high across 77.4% of the territory; and finally, in Oubritenga province, 100% of the territory faces a high risk of degradation (SP/CONEDD, 2006, quoted by Belemvire et al, 2008);

- the CCP-Burkina study 2006 also notes that certain provinces of the central plateau experience a stable level of degradation, which could be explained by the already high level of degradation in these areas, or by the results of the soil recovery work;

- the zones at high risk in the country are located in the eastern and western regions of the country where the phenomenon of degradation is more recent;

- the report on the neutrality of land degradation, LDN in Burkina Faso (SPCCD GTT/LDN, 2017) confirms that plots with high plant coverage (the forests) are now only present in the south and south-east; the conversion of the forests, generally into arable or grazing land, is linked to rural demographics; it occurred across the rest of the territory between 2002 and 2012;
- in the Nord, the Sahel and the Centre-nord, the plots of land with very low plant cover (bare land) are extensive. On several occasions, this report mentions the Nakambé basin, which is home to our study area: this territory primarily consists of savannahs and grasslands as well as farmed land. It is located in a stable area in terms of plant cover and was not subject to major degradation stress over the period 2002-2012. This region event displays positive changes in terms of the stabilisation of, or even increase in, soil productivity, despite some sites occasionally being marked by acute signs of a fall in soil productivity;
- the soils in the basin lost carbon stocks over the period 2002-2012;
- with regard to biodiversity, the 2008 Sahel study discusses the quantitative and qualitative decline in wildlife – warthogs, hyenas, deer, etc. "The absence of afforestation does not allow game to recover" (Belemvire et al, 2008, p29). The big game has disappeared. In 2017, the neutrality report only mentions the presence of small game. This disappearance is due to the extension of farmed lands and to the disappearance of forest habitats (SPCCD GTT/LDN, 2017).

These elements point to a relative reversal of land degradation trends in our study zone, between 1992 and 2002. This information enhances the relevance of our choice for the study zone: we want to check and quantify the benefits of the improvements linked to the development of farmed land.

Photo 4: Filtering dyke

3.6 - Step 6: Cost-benefit analysis and promotion of non-market benefits

3.6.1 The cost-benefit analysis (financial)

For this part of the analysis, we examine the economic indicators generally taken into account in the cost-benefit analyses (CBA).

For the needs of the analysis, the cash flows are discounted. Discounting is the method allowing financial flows not directly comparable because they occur at different dates to be understood on a single basis. They can not only be used for comparison but can also be used to performed arithmetic operations. The aim of this process is to take account of the change in value of money. The discount rate facilitates comparison of all costs and benefits currently in euros regardless of the point in time when the benefits were acknowledged or the costs recorded. The value of a sum of money today in a future year, "n", must evaluated by applying a discount coefficient.

PATECORE reports indicate that the difference in yields between developed plots of land and other without developments is 250 kg/Ha on average for cereals and the average cost of development is FCFA 155,235 FCFA (approx. 237 euros). It is therefore clear that the situation with developments provides more than that without. The question that can be legitimately asked is that relating to the profitability of the developments themselves.

For this study our profitability criteria are as follows:

- NPV (net present value) involves calculating the discounted value of different financial flows across the service life of a project, incorporating the initial investment. In simple terms, it is the gain in money generated by the project throughout its service life.

$$\text{Net present value} = \frac{\text{Net benefit flows during period t}}{(1 + \text{discount rate})^t}$$

- IRR (internal rate of return): this is the discount rate resulting in a zero value of NPV. In simple terms, the IRR corresponds to an investment that can be comparted with the profitability rates of the financial investment.

An IRR worth x simply means that money can be borrowed at a rate x across the duration of the project without losing.

- The DTR (discounted time of return): this is the number years required for the cumulated discounted annual savings to offset the investment or the additional cost of investment.

We do not discount the flows during the first year of implementation as we consider an annual discount that the project provides immediately. Considering a project with a service life of 10 years, the *table 6* presents the indicators for the main products of sorghum, corn and millet.

As with the ELD study in Tunisia, we use a discount rate of 10%, as accepted in developing economies. The European Bank uses this rate in West in the energy sphere[13]. Furthermore, *"... this value corresponds to a compromise between development requirements with short-term returns on investment (typical discount rate of about 17-20%) and the sustainability requirements with longer-term returns (discount rate which would be close to 1%)."* (Quillérou, 2016).

We conduct then the sensitivity study using several discount rates to calculate the NPV, IRR and DTR. For the sensitivity analysis:

- a first rate of 1% is applied as recommended in the Stern report which stipulates that the climate damage facing future generations has a very high current value; rate legitimising strong action today; giving future generation more weight;
- a second rate of 4%: to evaluate natural assets which tend to decrease rather than increase, we use rates varying from 2% to 6% (Garrabe,

[13] *http://www.eib.org/attachments/country/eib_in_west_africa_fr.pdf*

TABLE 6

Results of the financial evaluation of cereal production gains and sensitivity analysis

Discount rate	Product	Indicators		
		Current cum. income (FCFA)	IRR	DTR (years)
1%	Sorghum	484 298	35%	3 to 4
	Millet	567 597	49%	2 to 3
	Corn	400 527	22%	4 to 5
4%	Sorghum	421 379	31%	3 to 4
	Millet	493 856	44%	2 to 3
	Corn	348 492	17%	4 to 5
7%	Sorghum	371 091	26%	3 to 4
	Millet	434 918	39%	3 to 4
	Corn	306 902	12%	4 to 5
10%	Sorghum	330 436	22%	3 to 4
	Millet	387 271	35%	3 to 4
	Corn	273 280	8%	4 to 5
20%	Sorghum	240 152	7%	4 to 5
	Millet	281 458	21%	3 to 4
	Corn	198 612	-10%	5 to 6

2012). This is also the rate recommended by the Lebègue report (Lebègue D. ,2005);

- we then apply a rate of 7% roughly corresponding to the government borrowing rate in Burkina (http://ecodufaso.com/emprunt-obligataire-80-milliards-de-fcfa-mobilises-par-tresor-public-burkinabe-pour-le-financement-du-pndes/);
- finally a 20% rate.

Implementation of these developments displays IRRs which are positive over 10 years, regardless of the product and discount rate. These scenarios show that *aggregate discounted incomes* and the *profitability* rates for each product increase as the discount rates falls. It should be recalled that a high discount rate relates to impatience and a strong preference for the present. One striking fact linked to the value of the discount rate is the negative value associated with the IRR of corn at 20%. This rate is -10%, so it is not advised to borrow for a development project intended for growing corn at a discount rate of 20%.

The discounted time of return is between 3 and 4 years for sorghum, except at 20% when it is between 4 and 5 years. For millet, it is between 2 and 3 years until 4% and between 3 and 4 years above this figure. For corn, the least profitable product, the discounted time of return is between

4 and 5 up to 10% and between 5 and 6 years for a discount rate of 20%.

A discount rate of 10%, as recommended in development economics should be focussed on. In Burkina, this 10% rate is applied to investments in certain sectors, such as energy[14].

Based on this rate after implementation lasting 10 years, sorghum provides a discounted net revenue of FCFA 312,605, with FCFA 258,533 for corn and FCFA 366,373 for millet. It is obvious that millet is the most profitable product in the context of the developments.

The IRR is 35% for millet, 22% for sorghum and 8% for corn at a rate of 10%. It is therefore possible to borrow over 10 years at a rate of 35% to finance the installation of one Ha of millet.

[14] *http://www.eib.org/attachments/country/eib_in_west_africa_fr.pdf*

We know that the developments do not record only one financial flow. The other impacts are numerous. The next section of the study therefore examines the evaluation of certain environmental and social impacts using the experimental choices method.

3.6.2 The experimental choices method

Among our initial estimations, producer well-being does not decrease with an increase in the value of the monetary attribute. This is understandable, as we expressed it in the number of man days and not as a direct monetary value of the developments. To identify a threshold from which the relation would reverse, we tested a quadratic relation, incorporating the cost squared. This quadratic model was ultimately adopted (*box 8*).

We note that the situation without developments is rejected (Business As Usual, BAU). The developments and their impacts considered in the survey

BOX 8

Treatment process and model used

Without having identified any protest responses, we used all the questionnaires to treat the experimental choices section. All the attributes were coded using the "effect coding" model to facilitate treatment and interpretation of the results. The others are quantitative variables, and taken as such.

For a given qualitative level, a corresponding coded variable takes a value of 1 when this level is present, -1 for the reference situation (status quo) and 0 in other situations. The advantage of "effect coding" is that there is no correlation between the level s and the constant representing only the utility associated with the reference situation.

The model used is a conditional logit model which considers a homogeneity of preferences of the producers surveyed. It therefore provides average estimations of the parameters explaining these preferences. The parameters obtained via this model are all significant (at the critical threshold of 1%), with the exception of cost^2, which is significant at 5%.

In the quadratic model adopted, the constant remains significant and negative, indicating that factors outside the models would appear to have a negative impact on utility. The quadratic model adopted is successfully specified if we accept the pseudo-R 2. This indicator has a value of 0.34 which falls within the interval defined by Hensher and Johnson (1981) as signifying successful specification of the model.

Source: Kambou et al, 2018

TABLE 7

Results of the logistic regression

Attributes	Coefficients
BAU	-2.17*** (0.213)
ANR	0.11*** (0.022)
Water availability	0.24*** (0.026)
Mutual aid	0.19*** (0.023)
Livestock feed availability	0.17*** (0.022)
Cost	0.07*** (0.025)
Cost^2	-0.00099** (0.0004)
Obs: 7,224, LL : -1732.39, R2=34.39	-274,000

*** significant at 1% ** significant at 5%
* significant at 10* (standard deviation)

are well received. According to our results (*table 7*), good water availability or strong mutual aid in an option greatly increases the probability of choosing this option.

Table 7 provides information concerning the choice probabilities when the attribute levels figure in the option. It also enables us to calculate the willingness to pay and receive (which we will do in the following section).

3.6.3 Willingness to pay (WTP)

Table 8 enables us to evaluate, in monetary terms, the preferences of producers benefiting from developments on their land for the different attribute levels and thus the willingness to pay or receive.

Willingness to pay is defined as the maximum price a buyer agrees to pay for a given quantity of a good or service (Kalish and Nelson, 1991). In this study, it corresponds to the amount that producers are willing to pay for the improvements to be implemented (presence of services and positive impacts thanks to the developments). Conversely, the willingness to receive represents the minimum amount they are willing to receive if the positive changes are not observed.

Marginal willingness to pay is given by the following formula:

$$WTP_{\alpha} = -\frac{dx_p}{dx_{\alpha}} = -\frac{dV/dx_{\alpha}}{dV/dx_p} = -\frac{\beta_a}{\beta_p}$$

where x_{α} and x_p are the attribute α and the monetary attribute respectively, and β_{α} and β_p are the parameter estimated by the conditional logit.

Referring to the results, the producers are against the reference situation (BAU) with no WSC/DRS measures. The willingness to receive (WTR) for 10 years to retain the other characteristics not taken into account in the present study is on average FCFA 3,303,000 per ha.

TABLE 8

Willingness to pay for the different ecosystem services evaluated

Levels of attributes	Willingness to pay (WTP) or to receive (WTR) (FCFA) /ha
BAU	-3,303,000
Low level of biodiversity	-168,000
Agro-forestry	168,000
Low water availability	-361,500
High water availability	361,500
Low level of mutual aid	-297,000
High level of mutual aid	297,000
Low livestock feed availability	-274,000
High livestock feed availability	274,000

The WTP for the ANR is FCFA 168,000, while the figure for an abundant availability of water is FCFA 361,500, for mutual aid is FCFA 297,000 and for the presence of livestock feed is FCFA 264,000.

Water availability displays the highest willingness to pay, followed by mutual aid. During the survey, we asked the producers to prioritise the levels of attributes considered in this study. The presence of water was ranked first (57%), followed by mutual aid (23%). Producer preferences are clearly oriented towards this attribute.

Status quo: an unattractive situation:

Globally speaking, the situation without developments (BAU) is not appreciated by the producers interviewed as it is systematically accompanied by a reduction in utility. This decrease is demonstrated in the model by the negative value linked to Business As Usual (BAU), which is the utility associated with the other characteristics not taken into account in this study (services not adopted for the quantified evaluation) as well as the positive WTP linked to the upscaling of the situation without developments to the situation with developments for the characteristics (or the ecosystem services) taken into account in the experimental choices study. The WTP linked to the BAU is FCFA -3,303,000, reflecting a fall in utility. In other words, the producers are willing to receive this amount per Ha of development to remain in a situation without any developments (for 10 years).

A preference for biodiversity (ANR effect):

In the wake of recurrent droughts, plant cover had disappeared. Thanks to the developments, the seeds drained by the run-off water are stopped around and within the crop plots. Once they have germinated, these seeds give rise to plants which are maintained and saved (assisted natural regeneration, or ANR). This agro-forestry approach helps increase yields while providing the populations with local and foreign plants used in the medical field, in food and animal feed, in cooking, construction, etc. This characteristic has been evaluated in our study. For one Ha, ANR is subject to a willingness to pay of FCFA 168,000 across the theoretical service life (10 years) of the developments. It should be noted that this WTP represent the lowest WTP in the study, although this takes nothing away from the fact that ANR increases their satisfaction, all the more so as 96% of the individuals surveyed find the presence of tress at least important (76% use them for fuel wood, 43% as medicinal plants, etc.) and 87% would like to have more trees.

Water availability:

The zone of the former PATECORE is located in an arid pedoclimatic region with irregular rainfall unconducive to the replenishment of the water table. This problem is exacerbated by the situation in the basin zone displaying considerable water erosion. Following the droughts of the 1970s and the launch of PATECORE which helped curb water run-off and encouraged its infiltration through the developments implemented, the populations learned to appreciate the presence of this commodity, valuing it accordingly. In this study water availability is appreciated compared to the situation whereby water is scarce and is granted the highest willingness to pay. The quantity of water accumulated thanks to 1 Ha of development displays a willingness to pay of FCFA 361,500 for the entire service life of the measure.

A strong preference for mutual aid:

Social assistance in Africa has a long history. It strengthens ties and maintains social cohesion. Developments are implemented by means of two approaches: the field approach and the basin approach. The field approach involves developing only the individual's land, ignoring everything upstream. This does not, however, take account of spatial externalities linked to the fact that if the upstream areas is not protected, downstream efforts will be in vain. Having understood the benefits of the basin approach, the producers have adopted it, thereby enabling ties to be strengthened not only during the construction of the works but also beyond this. This social characteristic is welcomed and displays the second-highest willingness to pay within this study.

Livestock feed availability:

In the study zone, farmers generally breed small ruminants for the purposes of hoarding. In 2017, for example, producers spent an average of FCFA 25,000 on livestock feed. This confirms that they would have spent approximately FCFA 79,000 if they had to buy all their feed throughout the year. This results in a net saving of FCFA 54,000. In our study, the willingness to pay for livestock feed availability through the developments is FCFA 264,000 per Ha for the service life of the measure.

According to our data, our surveys cover on average 5 Ha of land; each producer's annual willingness to pay for 5 ha would be about FFCA 132,000. This value is twice as much as they believe they would spend if obliged to buy all the feed. This emphasises the importance of this livestock feed service (enabling them to save and to maintain their stock of animals).

Using indicators such as the discounted time of return and the internal rate of return together with the willingness to pay, our cost-benefit analyses have shown the values assigned to the main ecosystem services created by the soil protection and conservation measures. What are these values, and what might be the impact of these measures on food security and land degradation neutrality?

3.6.4 Resume of the economic evaluation results and reflection on the practice (stage 6 + 1 : ACT)

The study consisted in conducting two types of evaluation, one financial and the other economic.

- The financial section illustrated the financial advantage of the situation with development measures in relation to that without from the standpoint of the investments made, regardless of the discount rate considered. This analysis highlighted the profitability of investments in developments.
- The economic section focused on the measurement of the value of ecosystem services resulting from the development measures: the study demonstrates the willingness to pay for the main environmental and social impacts linked to the developments; it also serves to estimate the general loss of utility linked to the situation without any developments.

The work has emphasised the numerous financial and economic benefits in investing in the fight against land degradation and desertification. According to our results:

- the developments are profitable and beneficial to investors;
- the developments are advantageous in economic, social and environmental terms for the territories and agricultural and local communities concerned;
- the developments contribute to achieving the decision-makers goals of land degradation neutrality and food security.

The main recommendation of the report is thus to continue and intensify the land development operations with a view to protecting and restoring soil fertility in the regions affected in Burkina Faso.

Neutrality gains on developed land:

The evaluations carried out illustrate that part of the value of these developments can be approached by adding the revenues linked to the 250 kg surplus and the WTP.

On this basis, the developments would provide a minimum annual value of FCFA 162,250/year/ha (*table 9*). This value exceeds the initial investment, although it represents only a proportion of the total economic value of one developed hectare: it does not, for example, include major benefits such as the reduction in migrations and conflicts or the transformation of agricultural systems into a semi-intensive activity.

This value could thus be incorporated into a much larger entity which would be considered to be the total economic value of the developments. In this study, the full TEV is equivalent to the sum total of willingness to receive displayed by all producers interviewed, amounting to FCFA 3,303,000 for

TABLE 9

Monetary value of average gains in ecosystem services linked to the developments implemented on farmed land, per year per ha (2017)

Service	Calculation method	FCFA/year
Harvest gains	Cost-benefit analysis on a representative sample, CBA	52,250[15]
Straw gains	Experimental choices method, evaluation of a producers' willingness to pay on a declaratory basis, WTP	27,400
Water	Experimental choices method, evaluation of a producers' willingness to pay on a declaratory basis, WTP	36,100
Biodiversity	Experimental choices method, evaluation of a producers' willingness to pay on a declaratory basis, WTP	16,800
Mutual aid	Experimental choices method, evaluation of a producers' willingness to pay on a declaratory basis, WTP	29,700
Total		**162,250**

ten years, giving an annual value of FCFA 330,300/year/ha. At twice the initial investment required to develop one ha of land, this amount shows the social, economic and environmental importance of developments, beyond the financial aspect.

An average gain in neutrality linked to the developments in the context of PATECORE could total between FCFA 162,000/year and FCFA 330,300/year for one hectare of developed and fertilised land. The minimum value of FCFA 162,000 only incorporates the services evaluated, i.e. the gain in water, livestock feed, harvest, biodiversity and mutual social aide. The ceiling value of FCFA 330,300 includes the value of all services identified by the producers, in particular the reduction in migrations linked to insufficient harvests and the reduction in conflicts over resources. As already mentioned, this average annual gain in neutrality is the avoided cost of degradation in the developed areas.

Estimated impact on food security:

The contextualisation of the study clearly highlighted the link between sustainable land management developments and food security. Based on our results, we calculated the overall gain in cereal production resulting from the developments across all the areas in our study zone developed and sown with cereals - the provinces of Bam, Kourweogo and Oubritenga (*Table 10*).

Considering the total area developed within our study zone in 2017, we obtain a surplus of more than 11,016.7 T of cereals. This could cover the an-

TABLE 10

Areas developed within the study zone in 2018

Attributes	Land developed (Ha)	Total cereal land (Ha)
BAM	34,965	76,343
Oubritenga	6,912	54,342
Kourwéogo	2,190	35,904
Total	44,067	166,589

[15] This amount was calculated by multiplying the surplus by the average price of cereals in 2018 (250*209=52,250)

nual food requirements of approximately 58,000 people (FAO norm = 190 kg/person/year).

Finally, we simulate a situation in which all land sown with cereals (sorghum, millet and corn) in the three provinces is developed. This would represent an area of 166,589 ha. With a surplus of 250 kg/ha, this would provide an additional 41,647 T per year (2017), satisfying the annual requirements of almost 219,195 people.

Limitations of the study and organisational prerequisites for successful developments:

Our study has limitations linked not only to data availability but also to the time at our disposal to conduct it.

The data from the PATECORE report, in particular the average gains of 250 kg/year/ha may seem out of date. It would have been preferable to use recent data linked to the developments and to each product, but we did not have access to all the necessary data.

It should also be noted that in the study, we consider the yields from undeveloped land as constant over time due to a lack of data. This would seem implausible due to the dynamic nature of the degradation of this land and its impact on yields.

Finally, we ignore the impact of the developments in employment, all the more so as labour remains strongly family-based (our study data).

Data such as that relating to the replenishment of the water table or the additional volume of livestock feed harvested was not available to enhance the economic evaluation conducted.

The declaratory and hypothetical nature of the economic evaluation can be seen as a limitation of the study, even if the choice experiment is by far the best non-market evaluation technique.
Thanks to the sampling and the meticulous approach adopted, the results obtained are relevant to the former PATECORE zone in the Nakambe basin. It will nevertheless be difficult to generalise this study to the territory as a whole as each zone has its own geophysical, socio-demographic and socio-cultural characteristics.

The quantified results and values obtained are also linked to the organisational mechanism implemented by PATECORE in order to implement the developments: the developments were correctly implemented and regularly maintained while both the planning and implementation were conducted in a participatory approach. Different results could have been obtained in a different institutional and organisational context.

Upscaling and disseminating the development practices will therefore rely on numerous factors:

- local familiarity with the WSC/DRS techniques by the producers within their organisations to facilitate training and the sharing of experiences;
- bottom-up developing planning:
  - the organisation of raw material supplies, rubble for large-scale developments
  - the organisation of work, and in particular its collective organisation
  - the quality of support consulting during implementation and maintenance;
- contextual conditions, and in particular the availability of labour, prior collective organisation of work, social cohesion, etc.;
- dissemination of know-how, its organisation and effectiveness;
- the use of financial levers for hard investment (rubble, etc.).

The PATECORE reports recommend outside financing of raw material supplies (rubble) and transformation conducted under the aegis of the local communities. Provision of a proportion of the investments by public entities through contract in which the producers undertake to adopt decisive environmental practices is an incentive to finance soil preservation and conservation[16].

The supply of stones is a key logistical and organisational constraint insofar as the material requirements (rubble) need to be determined collectively at village, municipal or inter- municipal level: the

complete development of a plot of one hectare represents close to 40 tonnes for 300 m of stone strips. Upscaling would doubtless require a development stone supply chain to be organised at national level.

Principal recommendations by sector:

Land users:
The developments provide land users significant advantages. Their value falls between FCFA 162,000 FCFA/year/ha and FCFA 440,350/year/ha. It is therefore in land users' interest to follow a training course in development techniques and to put these into practice within a locally concerted framework.

Possible action 1: Land users are major stakeholders in the development implementation process.

The contextual elements presented illustrate the importance of local participation in land development actions – upstream to downstream – in ensuring their success and sustainability over time. This involves pursuing capacity building actions with land users; training and sensitising lands users should furthermore guarantee a better level of dissemination, training and sensitisation of other users. Within the scope of our survey in the PATECORE project zone, this cascade training process was not, however, shown to be operational: it should be rethought, for example with incentive schemes designed to facilitate a scaling-up of activities.

Users participate in experience-sharing exercises at local, regional and national levels. Through their knowledge of the local territories, they must contribute to the planning of developing needs, the organisation and monitoring of the provision of materials and the construction and maintenance and even the monitoring-evaluation of the developments according to efficient organisational methods. The structures that these users might represent, such as groups, associations, local authorities and decentralised bodies responsible for managing the territories, are key partners in these processes.

Private sector:
The developments are profitable in the long term. At a discount rate of 10%, the profitability rate of developments reaches a maximum of 35% for millet and a minimum of 8% for corn. Over a period of 10 years, this makes it possible to generate a global net cash flow of almost FCFA 400,000 for one developed ha of millet and more than FCFA 270,000 for one developed ha of corn.

The contributions of the private sector are of several kinds: supplier, provider or partner of the implementation of the developments in situ; it is potentially a key player in the organisation of a developments value chain, and it is also an important stakeholder capacity building partner. The private sector is also a partner and co-financier (through corporate social responsibility, voluntary offsetting, etc.) and a co-investor in future land development projects.

The private sector is already a provider and partner in the implementation of developments: its role primarily relates to the provision of materials for the developments and the capacity building of the players involved. We were unable to collect information on the existence of a developments value chain in Burkina Faso, but in the assumption of its structuration, it is clear that the private sector would find its place and benefit from the situation.

Its role may extend to co-financing actions through corporate social responsibility, carbon compensation mechanisms, etc. The private sector is a key potential investor in certain fields of action.

Possible action 1: the private sector can be a financier (through corporate social responsibility, voluntary offsetting, etc.) and a co-investor in land development projects.

Policy-makers/Decision-makers:
At the end of the study, the average increase in the neutrality linked to the developments within the context of the PATECORE project is between FCFA 162,000/year and FCFA 440,350/year per ha developed and fertilised land. This annual gain in neutrality represents the cost of degrading the ar-

[16] In Burkina Faso, these developments were financed by projects such as PATECORE, the association Zood-Nooma, the Forests and Food Security (FFA) project, etc. (8 bodies and main projects in northern Burkina Faso); these primarily represent investment in labour for farmers.

eas developed that has been saved. Furthermore, we obtain an annual food surplus linked to our study zone of over 11,016.7 T of cereals for 2017. This could cover the annual food requirements of approximately 58,000 people.

Possible action 1: Promote concerted, multi-level land development policies which generate synergies between sustainable developments goals 2 and 15

The study provides tangible advocacy elements justifying the interest in funding soil protection and restoration projects offering multi-dimensional, environmental, social and economic benefits accompanied by financial returns. These elements can serve as a basis:

- at international level for identifying international funds to finance developments (fields of climate, natural resources, etc.);
- at the national and local level, explore the idea of attractive individual or collective contracts offering support in financing developments in exchange for services linked to the maintenance and monitoring of developments and, more globally, commitment on the part of the beneficiaries to natural resource management.

Possible action 2: Work with the local authorities, associations and scientists on the gradual implementation of the flexible land regulation systems to remove the brakes on the dissemination of certain development practices, in particular those relating to tree management (ANR, agroforestry, plantations).

In the region of the study, the forests have disappeared and trees are increasingly rare. The proximity of the city of Ouagadougou is a constraint with regard to restoring tree cover. The data collected within the zone and the country as a whole demonstrate that, even through ANR, agro-forestry remains the least popular development technique, despite the fact that the producers surveyed express a strong need to increase the tree population, even in developed areas. Particular attention should be paid to the question of trees in discussions on and planning of land development.

Possible action 3: Draw on the achievements of the PATECORE project in terms of capacity building and structuring of the players in preparation of a scaling-up, and accompany the implementation of the SNRCS by building the capacities of sustainable land management operators.

PATECORE succeeded in working on the organisation of stakeholders in three provinces; the PATECORE report (PATECORE, 2004, p26) presents its relay structure model; with the help of a steering committee bringing together public stakeholders from the national and local level and the partners involved in implementing the developments, the project succeeded in (PATECORE, 2004, p.14):

- organising needs identification and output planning; this work was subsequently decentralised to the local entities with the support of the project (the local population became the project owner).
- organising provision of the raw material with the support of the private sector (the private sector became the project manager).
- coordinating the monitoring and maintenance of achievements. This work was subsequently decentralised to the local entities with the support of the project (the local population became the project owner).
- monitoring the effects of the developments.

It is necessary to enhance the players' competences in order to ensure the long-term organisation of requirements analysis and planning of developments at different levels as well as coordinating the monitoring of the developments and their impacts. It is important to involve decentralised entities and local collective organisations to ensure successful implementation of this strategy with a view to the sustainable development of basins and territories.

Possible action 4: To open up greater financing perspectives, in particular through the private sector, it would be useful to complete this study by means of an evaluation of carbon sequestration.

04
Conclusion

La réflexion engagée depuis 2014 par le Burkina Faso dans le cadre des travaux de la Convention sur la lutte contre la désertification (CNULCD) sur la mise en œuvre de l'objectif 15.3 de objectifs de développement durable sur la neutralité en matière de dégradation des terres, consiste à élaborer des états de référence de la dégradation des terres afin de déterminer des objectifs chiffrés raisonnables pour l'atteinte de la neutralité à l'horizon 2030. Par ailleurs, la revue de littérature sur les projets de gestion durable au Burkina Faso montre que les investissements dans la protection et la restauration des sols sont de nature à contribuer sensiblement à l'amélioration de la sécurité alimentaire dans deux au moins de ses dimensions : la disponibilité et la stabilité. Au plan stratégique, le pays s'est doté en 2014 d'un cadre stratégique d'investissement en gestion durable des terres (CSI-gestion durable des terres) et en 2016, d'une stratégie nationale de restauration de conservation et de récupération des terres.

Les données disponibles sur les retours économiques des aménagements de protection et de restauration des sols au Burkina Faso montrent qu'à court, moyen et long-terme, l'adoption de pratiques de gestion durable des terres génère des bénéfices économiques significatifs et diversifiés. Cependant, les informations chiffrées manquent pour estimer le gain de neutralité moyen issu de ces investissements et il est nécessaire de calculer une valeur économique monétaire de l'ensemble des services écosystémiques permis par les aménagements sur les terres cultivées. C'est pourquoi une étude ciblée permettant d'approcher la valeur de l'ensemble des bénéfices induits par les aménagements des terres cultivées est pertinente.

Entre 1988 et 2004, le projet PATECORE est intervenu dans trois provinces du Centre du pays. Les documents du projet fournissent les informations utiles pour mener à bien un travail d'évaluation économique des services écosystémiques rendus par les aménagements. La réalisation d'une enquête représentative sur ce terrain permet, en mobilisant l'analyse coût-avantages et la méthode des choix expérimentaux de mesurer la rentabilité des aménagements au cours du temps et le consentement à payer des producteurs pour les principaux services qu'ils ont identifiés : le gain de récolte, le gain en aliments de bétail, le gain en eau, l'amélioration de la biodiversité et le renforcement de l'entraide sociale.

Le choix de la zone d'étude permet de répondre aux questions suivantes :

- Peut-on parler d'une valeur environnementale liée aux pratiques d'aménagements sur les terres du plateau central et des trois provinces étudiées ?
- Quelles sont les dimensions de cette valeur ?
- Quelle est la valeur nette totale des services éco systémiques liés aux aménagements sur les terres cultivées et sur de longues périodes ?

Les résultats obtenus montrent que :

- La gestion durable des terres est un secteur d'investissement rentable : au taux d'actualisation de 10%, le taux de rentabilité des aménagements s'établit au maximum à 35% pour le mil et au minimum à 8% pour le maïs. Sur 10 ans, cela permet de dégager un flux net global de près de 400 000 FCFA pour un ha aménagé de mil et de plus de 270 000 FCFA pour un ha aménagé de maïs.
- La valeur économique totale des services fournis par les aménagements sur les terres cultivées, est de 3 303 000 FCFA pour 10 ans (durée de vie théorique de l'aménagement) d'années, soit une valeur annuelle de 330 300 FCFA/an et par ha. Cette somme représente si on la ramène

à une année l'équivalent d'un SMIG mensuel (33 130 FCFA en 2020). C'est aussi plus d'une fois et demi le montant l'investissement initial nécessaire à l'aménagement d'un Ha de terre.

- Le gain moyen de neutralité lié aux aménagements dans le contexte du PATECORE se chiffre entre 162 000 FCFA/an et 330 300 Fcfa/an et par ha de terre aménagée et fertilisée. Le chiffre plancher correspond à la somme des valeurs des services écosystémiques spécifiquement calculés. Sur 10 ans de vie théorique des aménagements, et pour un hectare de terre aménagée, le CAP associé à la présence d'eau en quantité abondante est de 361 500 FCFA celui, pour une forte entraide est de 297 000 FCFA ; la présence d'aliment de bétail reçoit un CAP de 264 000 FCFA ; enfin, ce CAP vaut 168 000 FCFA pour la régénération naturelle assistée.
- En matière de surplus alimentaire lié aux aménagements existants de la zone d'étude, on obtient un excèdent annuel de plus de 11 016,7 T de céréales en 2017. Cela pourrait couvrir les besoins alimentaires annuels d'environ 58 000 personnes. Si la totalité des terres de la zone étaient aménagées, ce surplus couvrirait les besoins annuels de 219 195 personnes supplémentaires.

Le rapport sur la NDT au Burkina Faso indique que la zone du PATECORE après avoir subi des stress environnementaux important entre 1992 et 2002, montre un état stabilisé entre 2002 et 2012. Cependant, cette situation stable coïncide aussi avec le constat d'une disparition quasi-totale des ligneux et de la faune sauvage de moyenne et grande taille. La proximité de la capitale est un facteur important pour expliquer le manque d'arbres. Des problèmes de sécurité alimentaire restent ponctuellement aigus dans la zone car les ménages, bien que proches des marchés, n'ont pas les moyens nécessaires pour acheter les céréales manquantes. 300 000 ha restent en effet à aménager dans les trois provinces de notre étude.

Tous ces éléments montrent la nécessité du passage à l'échelle des aménagements y compris dans ces zones historiquement bénéficiaires. Il convient aussi de souligner que si les zones à risque moyen se situent aujourd'hui dans cette zone centrale ou ces technologies sont les plus utilisées, les zones à risques élevés se situent dans les parties est et ouest du pays où l'ampleur du phénomène y est nouvelle et où la diffusion des pratiques d'aménagements est encore peu développée.

Photo 5: Interview with a producer

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