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Improving Governance for Scaling up SLM in Mali

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ABBREVIATIONS AND ACRONYMS

AEZ	Agro-ecological zone
ANICT	Agence Nationale d'Investissements dans les Collectivités Territoriales
BSI	Special Investment Budget
CDM	Clean Development Mechanism
CMDT	Compagnie Malienne pour le Développement des Textiles
CNRA	Comité National de la Recherche Agricole
CPS	Cellule de Planification et de Statistiques
DNA	Direction Nationale de l’Agriculture
DNCN	Direction Nationale de la Conservation de la Nature
DNPD	National Directorate of Development Planning
GDP	Gross Domestic Product
GoM	Government of Mali
FAO	Food and Agriculture Organization of the United Nations
IER	Institut d’Economie Rurale
ISFM	Integrated Soil Fertility Management
MoA	Ministry of Agriculture
MoLF	Ministry of Livestock and Fisheries
MoEP	Ministry of Economic Planning
MoES	Ministry of Environment and Sanitation
MoEW	Ministry of Energy and Water
MoF	Ministry of Finance
MoIT	Ministry of Infrastructure and Transport
MoHLU	Ministry of Housing, Land Affairs and Urban Development
MIS	Ministry of Health
MoLMUH	Management Information System
MoT	Ministry of Transport
MoTL	Ministry of Territorial Administration and Local Collectives
MRV	Measurable, Reportable, and Verifiable
NAP	National Action Plan
NAPA	National Adaptation Program of Action
OHVN	Office de la Haute Vallée du Niger
ON	Office du Niger
PTI	Program Trienne d’Investissement/Triennial Investment Program
SLM	Sustainable Land Management
SLWM	Sustainable Land and Water Management
STP	Secretariat Technique Permanent
USAID	United States Agency for International Development

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ABSTRACT

Introduction

A benefit-cost analysis (BCA) was undertaken to assess the returns to land management practices of major land use types, namely forests, rangelands, and selected crops (rice, maize, cotton, and millet). Also the public expenditure on sustainable land management (SLM) was reviewed and an assessment carried out how the expenditure is aligned to land policies and how it is targeted to land degradation hotspots.

BCA results

The results show that, without some form of incentives for communities around forests in Sikasso, farmers will continue to clear the forest and plant maize. This underscores the importance of providing payments for ecosystem services for communities in the proximity of forests in Sikasso.

Rotational grazing increases the average forage biomass by 7% to 20%. However, even for rotation grazing, forage biomass shows a declining trend, underscoring the severe overgrazing problem. This suggests rotational grazing alone may not be able to fully address the area's declining pasture quality. BCA of crops shows that for maize, rice, and cotton, land management practices that combine fertilizer, manure, and crop residues are more profitable and competitive than those which use any of the three practices alone.

Impact of climate change on production risks and crop yield

An analysis of the impact of climate change on production risks and returns to land management practices showed that, between 2000 and2050, yield is expected to decrease by 3% to 39% depending on type of crop and climate change scenario used. Rainfed millet yield will decrease the least due to its resilience to dry conditions while irrigated rice yield will decrease the most due to decreased irrigation water supply. Production risks – measured using yield variability – of land management practices that combine crop residues, fertilizer, and manure are lower under climate change than those which use any of the three practices alone. This suggests that integrated soil fertility management (ISFM) practices reduce production risks under climate change. Returns to land management practices under climate change were lower than without climate change but revealed the same pattern, i.e. even under climate change, ISFM practices have greater returns than other practices analyzed in this study.

Despite its high returns, adoption rate of ISFM is low. One of the major reasons for the low adoption rate of ISFM is its high labor intensity. In all treatments using manure, labor costs amounted to 50% to 80% of total production costs. Thus, investment in the development and promotion of animal power and mechanization using simple and affordable equipment and machines needs to be increased. It was also observed that access to extension services, higher education, and vocational training increase the propensity to adopt ISFM practices. Ownership of livestock has also been shown to increase adoption of ISFM, since livestock ownership provides on-farm production of manure and provides draft power for hauling organic matter to crop plots.

Impact of land degradation on Malian economy

The results show that the annual cost of soil nutrient depletion from maize and rice plots in Mali is equivalent to about 4.4% GDP. The country also annually loses about 0.8% of its GDP due to deforestation and 0.6% due to overgrazing. Assuming that the impact of

degradation on the case study crops is comparable to other crops not included in this study, the total loss due to land degradation in Mali is around 8% of GDP annually. This demonstrates the seriousness of land degradation in Mali and the need for the efforts to address this problem.

Review of SLM public expenditure

Mali spent 15% to 18% of its budget on SLM in 2004 to 2007. The budget allocation to SLM declined in 2006-2007 despite a governmental SLM budget increase. The downward trend was due to the decrease in donors support for SLM, who contributed about 70% of the total SLM budget. Food security, implemented through the Ministries of Agriculture, Livestock and Fisheries, and through the Commission for Food Security, accounted for the largest share of the SLM budget allocation (45%). This allocation underscores the priority the Malian government and development partners give to agriculture, which is the biggest economic sector, and to food security.

Allocation to other policies (conservation of natural resources and biodiversity, combating desertification, climate change mitigation and adaptation, land tenure, decentralization, etc.) is quite low - less than 8% - suggesting that such policies do not receive high priority. However, overall, the country's policy on protecting its fragile environment and degraded lands is well aligned with public expenditure. Regions in the Sahelian and Sudan zones – which experience the most severe land degradation – received the largest share of SLM budget.

What can be done in the future to improve returns to SLM expenditure?

Each of the three major agro-ecological zones (Sahelian, Sudanian, and Sudano-Guinean) with significant economic activities has a comparative advantage. Livestock production and irrigated crop production are the main activities with a comparative advantage in the Sahelian zone. For the livestock development pathway, one approach for increasing livestock productivity is rotational grazing, which was found to increase forage biomass production and profit up to 20%. Since water for livestock in the Sahelian zone will become more scarce with climate change, investment in water harvesting technologies will also help to increase livestock productivity.

Promoting the planting of horticultural crops in rotation with rice could increase returns to irrigation investment and improve soil fertility. To increase their adoption, extension services that promote ISFM need to be increased significantly. Current extension advisory services tend to focus on improved varieties and fertilizer.

The development pathway in the Sudanian zone is rainfed crop and irrigated crop production. The zone also has a comparative advantage in crop-livestock production systems. All investments discussed under the Sahelian also apply to this zone, with some modification to suit the specifics of the Sudanian zone.

A development pathway unique in the Sudano-Guinean zone is forest management and reforestation. Investment in forest protection and reforestation would be attractive for communities surrounding forests if there were mechanisms for payments for ecosystem services. These include the permission to harvest non-timber forest products, proceeds from ecotourism, and, if possible, participation in carbon markets. This would require collaboration of the Malian government with the international community to develop Measurable, Reportable, and Verifiable (MRV) indicators of carbon sequestration and strong local institutions to organize farmers to participate in the carbon market.

Different types of non-farm activities have a comparative advantage across all zones. They also provide an opportunity to reduce poverty and reduce pressure on land. Improving access to credit, roads, electric power, and provision of vocational training will enhance non-farm activities in rural areas.

Executive summary

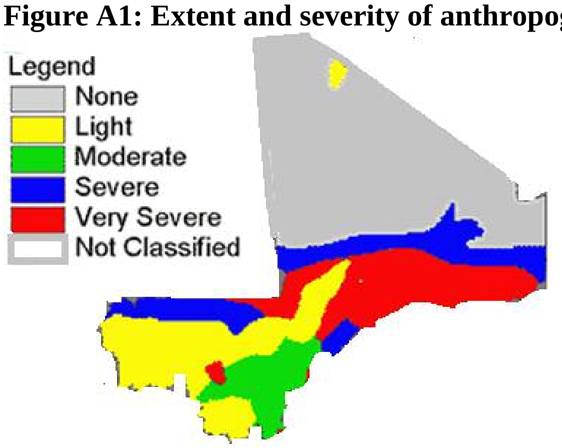
Introduction

About 37% of the Malian Gross Domestic Product (GDP) of US$8.74 billion (in 2008) is contributed by land-based sectors (crops, livestock, and forest) and fish (FAO 2007; World Bank 2009). About 80% of the population in Mali is dependent on the land-based sectors. Thus, investments in land-based sectors are expected to have a significant impact on the livelihoods of the Malian population. **Even though Mali has designed a number of policies and strategies to address land degradation** and is one of only eight sub-Sahara African (SSA) countries which have achieved or surpassed the Maputo Declaration target of allocating 10% of the government budget to agriculture (Fan et al., 2009), **land degradation – whose cost is estimated in this study to be about 8% of the GDP – remains a major problem in the country**.

Land degradation is most severe in the central and southern regions of the country (Figure A1), where population density is high and agricultural activities contribute more than 90% of the food requirement. As this and other studies show, **sustainable land management (SLM) practices are more profitable than land degrading practices and have a large potential to achieve Mali's pillar objective of sustainably reducing poverty. However, adoption rate of SLM practices is low.** For example, this study shows that in 2004/05 only 18% of farmers used a combination of inorganic fertilizer and manure.

Climate change and its consequent effects on production risks and uncertainties is adding new challenges to the livelihoods of the people of Malia who depend heavil on land-based sectors. A large area of Mali lies in the Sahelian and the Sudan zones, both of which are predicted by global circulation models to experience reduced precipitation, greater rainfall variability, and higher temperatures (Butt et al., 2006). SLMs are being increasingly recognised as important for both climate change adaptation and mitigation, thus investments in SLM will contribute to increasing food security and the sustainability of livelihoods in the face of increasing climate variability and change.

Figure A1: Extent and severity of anthropogenic land degradation



Source: FAO.

This study was conducted with the broad objective of identifying policies and strategies for simultaneously addressing land degradation, adapting to climate change and reducing poverty. This is achieved by exploring the drivers of adoption of SLM practices, their returns with and without climate change and what can be done to enhance their adoption. The study also analyzes the targeting of SLM public expenditure to prevention and/or mitigation of land degradation. Furthermore, this study also analyzes the alignment of public expenditure to policies and the types of investments that could lead to higher returns and optimal prevention and/or mitigation of land degradation across different development domains in Mali.

The target audience for the study is policy makers, donors and other stakeholders supporting land-based sectors and rural development in Mali and also in other SSA countries. This study willalso be valuable for other developing countries with comparable socio-economic characteristics to Mali. Additionally, the study is also relevant to scholars conducting research on sustainable development in developing countries.

In this report, integrated economic, environmental, and hydrological modeling is used to estimate the impact of a variety of SLM practices on outcomes, including livestock and crop productivity, carbon sequestration, and Mali's economy. Benefit-cost analysis (BCA) has been used to consider why households adopt SLM practices, the effect of increased sedimentation and off-site effects from land degradation, and the crop-specific effects of a variety of land management practices. Also, a review was carried out of public SLM expenditure, the institutional landscape of SLM budgeting, and the alignment of SLM expenditure to policies and degradation hotspots. Furthermore, SLM benefit-cost analysis results were used to evaluate the areas where public SLM expenditure could lead to higher returns.

BENEFIT-COST ANALYSIS (BCA)

Forest, rangelands, and croplands are the major land use types in Mali. Benefit-cost analysis (BCA) was used to assess returns to forest protection, reforestation, rotational grazing, and different sustainable land management practices for rice, maize, cotton, and millet.

Forest management

The benefits were evaluated that farmers draw from clearing forests and planting maize or keeping the forests and harvesting non-timber forest products (NTFP). Assuming that the value of NTFP is US$ 20/ha[1], **communities in Sikasso area surrounding forests have a high incentive to replace forests with maize if they do not participate in the carbon markets or if they are not given other incentives to protect forests**. However, as the net benefit from maize declines over time, the incentive to clear forests declines. **If farmers were able to participate in carbon markets and were compensated US$ 20 per CO_2-equivalent sequestered, the simulation results show that farmers would have a strong incentive to keep the forest, starting in the fourth year**. These results show the importance of providing payments for ecosystem services to communities in the proximity of forests in Sikasso.

Rotational grazing

The impact of rotational grazing was examined on forage biomass and livestock productivity in the Tombouctou area. **Rotational grazing increases the average forage biomass by 7% to 20%. However, even for rotational grazing, forage biomass shows a declining trend**. On average, continuous and rotational grazing cause a decline at a rate of 14 kg/ha and 7 kg/ha each year, respectively, underscoring the Tombouctou area's overgrazing problem. This suggests that rotational grazing alone may not be able to address the area's declining pasture quality and that other rangelands management practices, such as planting leguminous pasture, rainwater harvesting, etc., are needed to address the declining forage yield. Analysis of returns to rotational grazing showed that **a farmer with a 50-cattle herd will realize an**

[1] Amount includes fuelwood, fodder, fruits, herds etc – derived from past research and verified during study tour in 2009

average net present value (NPV) of XOF 260,000 (West African CFA) per year due to rotational grazing.

Returns to maize, rice and millet land management practices

Overall, the results show that **for maize, rice, and cotton, land management practices that combine fertilizer, manure, and crop residues are more profitable and competitive than those which use any of the three practices alone**. These results are consistent with other studies (e.g. Doraiswamy et al., 2007). Main results of the BCA can be summarized as follows:

Maize: The land management practice with the highest *net present value* (NPV) is the one combining 5 tons/ha manure, 100% crop residue, and 80 kg N/ha, which is the recommended practice.

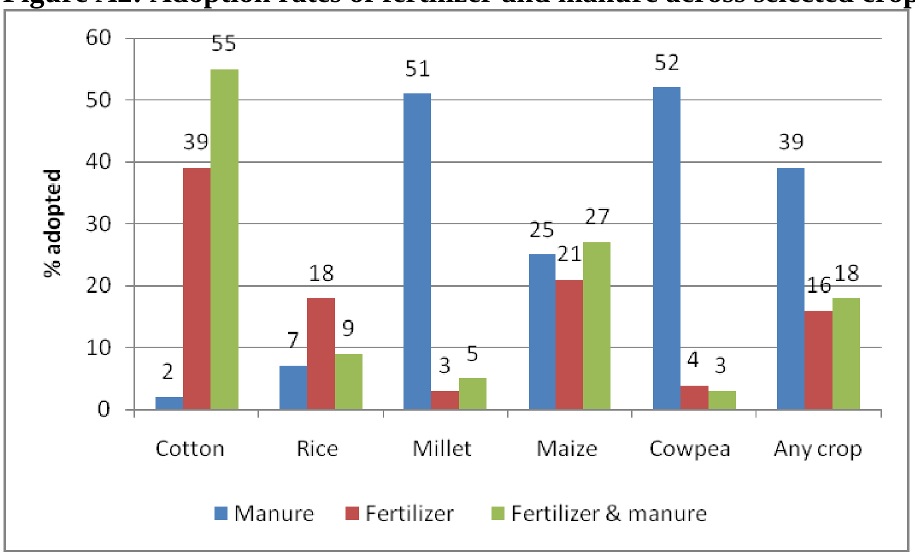
Rice: As is the case with maize, the treatment with the highest NPV is the practice combining 80 kg N/ha and 5 tons/ha manure, followed by a treatment of 40kg N/ha, 1.67 tons/ha manure, and 100% crop residue. Rice production was the most profitable among the five crops considered in this study.

The impact of salinity on a rice-onion crop rotation was evaluated. Simulation results showed that **desalinization increased rice yield by an average of 23% and onion yield by only 1% for the treatment that combined fertilizer, manure, and which incorporated 100% of crop residues. The NPV results show that desalinization is highly profitable compared to no desalinization**.

Cotton: As is the case with maize and rice, the highest NPV is obtained for plots with a practice combining 80 kg N/ha, 5 tons/ha of manure, and which incorporates 100% of crop residue. The NPV for plots receiving 80 kg N/ha and 100% of crop residues is less than zero. It is not surprising that use of manure on cotton in Mali is the highest (Figure A2) among all crops included in this study.

Despite the high returns to practices that combine fertilizer with organic soil fertility management, their adoption rates are very low. Only 18% applied a combination of fertilizer and manure (Figure A2).

Figure A2: Adoption rates of fertilizer and manure across selected crops



Source: Data obtained from the 2004/05 agricultural census.

Millet: Only organic soil fertility management practices have a positive net benefit. The net benefit for any treatment receiving 40 kg N/ha or greater is negative, suggesting that higher rates of fertilizer use are not profitable for millet. This could be due to the low response to fertilizer for the varieties that farmers use. Only 3% of farmers applied fertilizer on millet (Figure A1), highlighting the low returns to fertilizer from millet plots.

Climate change and its effect on yield and returns to land management practices

The impact of climate change on three selected crops was evaluated: maize, rice, and millet. Since climate simulation models produce uncertain results, we use two models with fairly different predictions. The National Center for Atmospheric Research (NCAR) predicts greater precipitation (10% increase), while the Commonwealth Scientific and Industrial Research Organization (CSIRO) model predicts drier climate (2% increase in 2050) (Nelson et al., 2009).

Results show that, **between 2000 and 2050, maize and rice yields are projected to decrease by 4% to 39%**, with NCAR showing the largest decline (Table A1). The yield for millet decreases the least, implying its higher resilience under climate change. Under the CSIRO model, millet yield increases on average by 2%. Rice yield decreases the most due to its high water requirement. Maize and rice yields for the land management practice combining 80 kg N/ha, 5 tons/ha manure, and 100% crop residues remain much higher than with treatments that do not involve fertilizer or manure. The millet yield across land management practices under climate change does not change significantly.

Table A1: Change in yield due to climate change, 2000 – 2050

	All zero	100% crop residue	Manure 1.67 tons/ha, 50% crop residues	40 kg N/ha, manure 1.67 tons/ha & 50% crop residue	80 kg N/ha, 100% crop residue	80 kg N/ha, 5 tons/ha manure, 100% crop residue
			% yield change due to climate change			
Difference: NCAR- no climate change						
Maize[a]	-17.6	-4.3	-15.7	-20.3	-23.7	-24.2
Rice[b]	-35.8	-38.4	-39.3	-41.6	-37.4	-35.2
Millet[c]	5.3	2.0	-3.8	-0.8	-14.6	-13.6
Difference: CSIRO – no climate change						
Maize[a]	-9.0	-1.1	-8.3	-12.4	-15.0	-14.1
Rice[b]	-4.6	-23.6	-28.5	-32.9	-33.8	-32.8
Millet[c]	7.4	2.2	2.1	12.3	7.4	9.9
Average difference: (NCAR &CSIRO – no climate change)						
Maize[a]	-13.3	-2.7	-12.0	-16.3	-19.3	-19.1
Rice[b]	-20.2	-31.0	-33.9	-37.3	-35.6	-34.0
Millet[c]	6.3	2.1	-0.8	5.7	-3.6	-1.9

Sites: [a] Sikasso, [b] Segou, [c] Cinzana.

Notes: Pixel level (10km) 2000 climate change data obtained from Worldclim. Future climate change data (2050) obtained from CSIRO and NCAR.

A comparison of yield variability with and without climate change shows that land management practices that combine crop residues, fertilizer, and manure have lower variability than those which use one of them alone. Thus, integrated soil fertility management practices reduce production risks under climate change.

Analysis of returns to land management practices under the projected climate change scenarios shows that land management practices that use manure and fertilizer for

maize and rice have higher NPVs than the land management that only incorporates crop residues. Under climate change, land management practices that use either manure or fertilizer for millet production are not profitable (NPV <0) compared to the baseline practice (100% incorporation of crop residues). The results for maize and rice further demonstrate that sustainable land and water management (SLWM) will help farmers achieve higher returns to their investment and lower production risks. The millet results indicate opportunities and challenges. While yields show a slight yield increase for most land management practices and declining yield variability as manure and fertilizer application increase, the land management practices that include the application of manure or fertilizer are not profitable under climate change. These results suggest that there is a low response of millet yield to manure and fertilizer application and they therefore highlight the need to invest in the breeding of higher-potential millet varieties. Such varieties would help farmers adapt to climate change.

Impact of land degradation on GDP:

Land degradation causes losses of the country's income. The results show that land degradation, by causing declining yields for maize and rice crops, accounts for a 4.4% reduction in the GDP of Mali. The country also loses about 0.8% of GDP due to deforestation and 0.6% due to overgrazing. **Assuming that the impact of degradation on the case study crops is comparable with other crops, the total loss due to land degradation in Mali is around 8%. This demonstrates the seriousness of land degradation in Mali and the need for the efforts to address the problem**.

OFF-SITE COSTS OF LAND DEGRADATION AND BENEFITS OF SLM

Watershed simulations show that, without soil erosion control, a total of 19,400 tons/ha of sediments are deposited into 18 small reservoirs located on the Banifing river. The dredging costs per ton of sediment are estimated to be US$ 18. The total off-site annual cost of sediment deposition without SLM is US$ 344,453. **Use of contour ridges reduces sediment accumulation in reservoirs by 19%; this leads to a total off-site benefit of US$ 37,252.**

Malian maize, rice, millet, cowpea, and cotton farmers provide significant ecological services through carbon sequestration. Results show that the value of carbon sequestered by maize, rice, millet, cotton, and cowpea farmers is about 2.3% of GDP. The results demonstrate the large contribution of agriculture to carbon mitigation.

WHAT COULD BE DONE TO INCREASE UPTAKE OF SLM PRACTICES?

Agricultural household surveys show that the adoption rate for SLM techniques is quite low. Therefore, the factors were examined that determine the adoption of SLM practices. **Results show that increasing access to labor saving technologies, agricultural extension, vocation training and higher education will increase the likelihood that land users adopt SLM practices.** For all practices using manure or compost, labor costs amount to 50% to 80% of total production costs. Thus, there is need to focus on efforts to reduce the high labor intensity of currently used SLM practices in order to enhance their adoption rate. Investment in the development and promotion of animal power and mechanization[2] using simple and affordable equipment and machines needs to be increased. This could include demonstrations

[2] The term "mechanisation" is used to describe tools, implements and machinery applied to improving the productivity of farm labour and of land; it may use either human, animal or motorized power, or a combination of these.

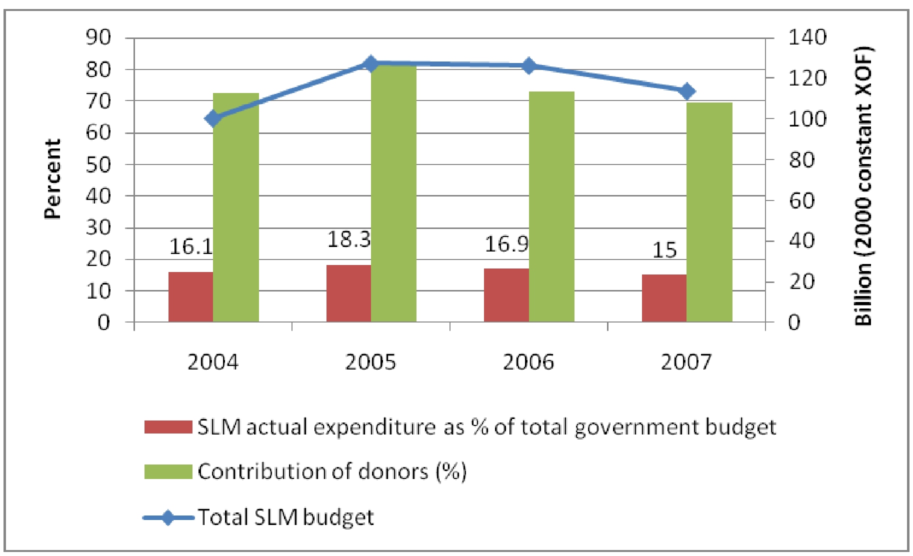
of the benefits of small animals (e.g. donkeys, mules) and hand held motorized devices, also development of systems whereby draught animals and motorized tools can be available for hire. This will increase the likelihood of labor-intensive SLM practices (such as manure and compost) being adopted and their effectiveness. Extension services that promote animal power and appropriate mechanization technologies[3] need to be enhanced, especially in the rural areas where they are weak. This should include encouraging development of small-scale non-farm agribusinesses making / supplying tools to farmers.

The analysis illustrates how education impacts the adoption of SLM practices, especially the use of organic fertilizers. Vocational training increased fertilizer and manure use in tandem, while training in a rural center increases manure use by 17%. Household heads with formal education in the form of post-secondary education were 15% more likely to have used fertilizer. Household heads with secondary education were 6% more likely to use manure and 7% more likely to use chemical fertilizer. Primary school education had no statistically significant effects on the adoption of SLM practices.

ALIGNMENT OF PUBLIC EXPENDITURE TO SLM POLICIES AND SEVERITY OF LAND DEGRADATION

The Mali government has shown strong commitment to SLM, evidenced by an elaborate institutional framework that supports the objective to protect fragile natural resources. The country spent 15% to 18% of its budget on SLM during 2004 to 2007 (Figure A3). **Budget allocation to SLM declined in 2006-2007 despite the governmental SLM budget increase**. **The downward trend was due to the decrease in donors' support for SLM, which contributed about 70% of the total SLM budget.**

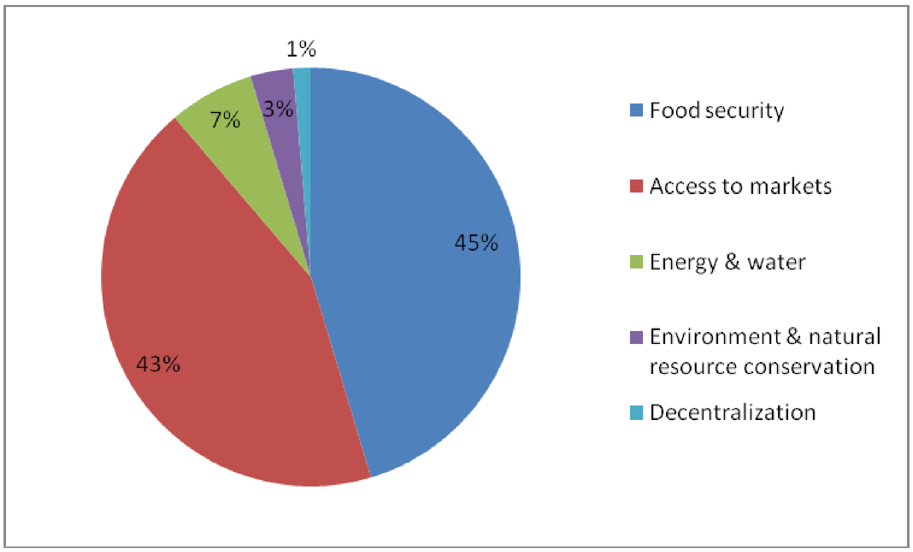
Figure A3: Total government- and donor-funded actual SLM expenditure



[3] Mechanisation should increase land users ability to transport materials, where possible avoiding the propensity to use tools for **primary tillage to open up the soil, which results in moisture loss and greater weed infestation.**

Public expenditure allocation is carried out by different technical ministries, which are the major institutions implementing government policies. Hence, **analysis of the main policies implemented by each ministry and comparison with the corresponding ministerial budget allocations provides an indication of the alignment of SLM expenditure to policies**. **Food security, implemented through the Ministries of Agriculture, Livestock and Fisheries, and through the Commission for Food Security, accounted for the largest share of total SLM budget allocation (45%)** (Figure A4). This allocation underscores the priority the Malian government and development partners give to agriculture, which is the biggest economic sector, and to food security. Mali is among the eight Sub-Saharan African (SSA) countries to achieve the Maputo Declaration, which requires countries to allocate at least 10% of its budget to agriculture (Fan et al., 2009).

Figure A4: Allocation of total SLM expenditure across land management policies



Notes: Food policy (Ministries of Agriculture, Livestock & Fisheries & Commission for Food Security); Access to market (Ministry of Infrastructure and Transport); Energy & water (Ministry of Energy Mines & Water); Decentralization (Ministry of Territorial Administration and Local Collectives).

The Ministry of Infrastructure and Transport, which is the major implementing institution for government policies aiming to improve market access and to commercialize agriculture and other rural sectors, accounted for the second largest share of government-funded SLM actual expenditure (43%) and the second largest share of total SLM expenditure (Figure A4). The two policies are in synergy, since access to markets enhances agricultural productivity and other rural development programs. This study shows that the share of the **allocation to other policies (conservation of natural resources and biodiversity, combating desertification, climate change mitigation and adaptation, land tenure, decentralization, etc.) is quite low -- less than 8%, suggesting that such policies do not receive high priority**.

Distribution of budget allocation to food security policy could be improved by reallocation to poorly funded yet important rural services such as extension services, where these are delivered efficiently and effectively. **Allocation to the livestock sector remains low despite the acknowledged current major deleterious impacts of the sector on the environment (Steinfeld *et al*, 2006), the scope for using SLMs (plus other parallel infrastructure improvements) to improve the sector, opportunities for PES (Neely *et al*, 2009) and it's**

large market potential in and outside Mali. The country has given the livestock and fishery sector greater priority by establishing a separate ministry and by increasing budget allocation to reflect the sector's importance. This needs to be accompanied by greater investment into the sector to fully exploit its potential.

Evaluating SLM expenditure allocations by the severity of land degradation could be used to analyze the alignment of government policies to SLM expenditure. **The study's findings suggest that SLM expenditure is well targeted to land degradation hotspots.** The increasing government-funded SLM expenditure also reflects the government's improved understanding of the challenges arising from increased land degradation, climate change, and other national and global trends that impact the environment.

DEVELOPMENT PATHWAYS, INVESTMENT REQUIRED TO PROMOTE THE WIDER ADOPTION OF INTEGRATED LAND AND WATER MANAGEMENT, AND ENTRY POINTS

Each of the three major agro-ecological zones (Sahelian, Sudanian, and Sudano-Guinean) with significant economic activities has a comparative advantage in an economic activity (development pathway). Based on the results of this study, potential investments were evaluated to support each development pathway. These investments were linked to existing and not-yet-existing programs that could serve as an entry point for such support.

Sahelian zone

Livestock production and irrigated crop production have a comparative advantage in this zone. **For the livestock development pathway, one approach for increasing livestock productivity is rotational grazing.** This study shows that rotational grazing increases pasture biomass by between 7% and 20% and is highly profitable. **Increasing the adoption of rotational grazing will require enhanced extension services to promote the technology.** Research will also help to develop the best rotational grazing regimes appropriate in the Sahelian zone. Other pasture management practices are required to reverse the downward trend of forage biomass --even for grassland under rotational grazing. Such management practices include: (i) planting leguminous pastures, which are well-adapted to the dry conditions in the Sahelian zone; (ii) strengthening local institutions to improve bush fire management; and (iii) reducing current stocking rates through improvement of livestock markets (Turner and Williams 2002) rather than forceful destocking campaigns.

Investment in breeding and veterinary services could also enhance the Sahelian zone's low livestock productivity. This should be built into the current livestock research programs for cattle ("programme bovin" in Sotuba), small ruminants ("programme petits ruminants" in Kayes), and others. Given the increasing livestock product demand, the livestock sector provides an opportunity to reduce poverty in the Sahelian zone and to sustainably increase the sector's contribution to GDP. Current governmental efforts to put greater emphasis on livestock and fisheries are the right steps toward enhancing livestock productivity.

The irrigated crop production development pathway calls for investments to improve access to irrigation; improve the water use efficiency (which is currently low, largely due to the over 40% loss of water from leakages), and address the salinity problem. The returns to investment in rice with and without climate change are high. Benefits can be reaped by improving irrigation and drainage infrastructure and addressing the salinity problem.

Promoting the planting of horticultural crops in rotation with rice could increase returns to irrigation investment and improve soil fertility. The promotion of this investment calls for improved agricultural research and extension services to increase the uptake of such technology. **Current efforts by rice irrigation schemes to promote rice-horticultural crop rotations serve as entry points and should be enhanced.** Because farmers use organic inputs for horticultural production, rice-horticultural rotations improve both soil fertility and increases farmer income.

This research shows that integrated soil fertility management (ISFM) practices, which combine fertilizer and organic soil fertility management practices, are profitable. To increase their adoption, extension services that promote ISFM need to be increased significantly. Current extension advisory services tend to focus on improved varieties and fertilizer, yet farmers will not reap the full benefits of these more costly (financially and environmentally – production of inorganic fertiliser is very environmentally damaging as is its mis-use) until environmental issues such as land degradation, increased rainfall infiltration / storage etc are achieved . Few advisory services are related to ISFM. This is largely due to the low capacity of extension agents to provide advisory services on ISFM, which is a fairly new paradigm. Thus, efforts to increase the capacity of extension services staff to provide ISFM advisory services are required. This can be achieved through short-term training and the printing and distributing of extension messages on ISFM.

To respond to climate change, which will affect the Sahelian zone the most, investment in agricultural research on climate change responses and other new environmental challenges is required. This includes investment in irrigation, improvement of existing irrigation infrastructure to increase its efficiency, research and development to develop drought- and heat- resistant varieties, and construction of roads (Nelson et al., 2009; Butt et al., 2006). This would reduce vulnerability of the local communities and help farmers better adapt to climate change. For example, **Butt et al., (2006) estimated that breeding heat-resistant crop varieties in Mali could reduce the share of the population under hunger risk to as low as 28%. They also showed that soil fertility management could reduce climate change-related economic losses by 66% and undernourishment by 17 percentage points if soil fertility management practices are adopted.**

Sudanian zone:

The development pathway in the Sudanian zone is rainfed crop production and irrigated crop production in areas with access to irrigation water. The zone also has a comparative advantage in crop-livestock production systems. All investments discussed under the Sahelian zone are also relevant in this zone, with some modifications to suit the specifics of the Sudanian zone.

Sudano-Guinean zone

A development pathway unique in this zone is forest management and reforestation. Investment in forest protection and reforestation will become attractive for communities surrounding forests if mechanisms can be put in place that allow them to benefit from forests, including the acquisition of non-timber forest products, proceeds from ecotourism, and, if possible, participation in carbon markets. Farmers currently have an incentive to clear forests and plant maize and other crops with higher returns. However, if communities surrounding the forests were able to participate in carbon markets, protecting forests would be more remunerative than cutting forests.

This would require mechanisms for measurable, reportable, and verifiable (MRV) carbon sequestering investments of participating farmers. It would also require aggressive creation of awareness and capacity building of potential carbon market participants (Winkler 2008). Improving local institutions that manage forests would be required to organize the participation of farmers in carbon markets. This would require revising the Decentralization Act to allow villages to enact and enforce regulations. Developing alternative energy sources and improving the efficiency of cooking stoves would also enhance forest management by reducing fuelwood demand. **Entry points for this include the National Action Plan (NAP) and the National Adaptation Program of Action (NAPA), which are promoting alternative energy sources**.

The Sudano-Guinean zone also has a comparative advantage in the production of horticultural crops, largely due to its high market access, which allows the production of highly perishable crops. The investment required to promote the zone's horticultural production includes additional improvements in market access, the promotion of production and marketing groups that will help farmers to connect to markets, and the reduction of transaction costs. **Entry points for this development pathway include the current efforts by the government and private companies to promote high-value crop production.**

Investments that cut across development domains

Non-farm activities: **Non-farm activities are important in all development domains since they enhance livelihood diversification and are associated with higher income in Africa** (Reardon 1997; Barrett, et al., 2001). Non-farm activities are more attractive if forward and backward linkage sectors are available. Such non-farm activities include agricultural processing activities and agricultural input marketing activities. These and other non-farm activities also reduce land pressure. **Investment in rural credit services, formal education, rural electrification, and rural roads and other communication infrastructure and institutions have been shown to promote non-farm activities** (Haggblade et al., 2007). **Furthermore, rural vocational training enhances non-farm activities. This should be targeted to youth so that they can develop their vocational skills.** The targeting of such vocational training to the agricultural sector will greatly strengthen the linkage between agriculture and non-farm activities.

MAIN FINDINGS AND RECOMMENDATIONS

1. Integrated soil fertility management (ISFM) practices, which are a combination of organic soil fertility management practices (such as manure, agroforestry, etc.) and judicious quantities of chemical fertilizers, is the most profitable practice for maize and rice. However, only 18% of farmers used both fertilizer and manure, while about 40% used manure and 16% used fertilizer. The major drivers of the adoption of ISFM were access to vocational training, tenure security, higher education, and livestock ownership.
2. Without adaptation, climate change is predicted to reduce crop yields by between 2% to 37%, with millet yield decreasing the least and rice yield decreasing the most. SLM technologies reduce yield variance and maintains the highest returns, further highlighting its importance to poor farmers facing climate change (adaptation).

3. Contour tillage in the Banifing river basin (with an areas of about 12,000 ha) could reduce sedimentation in reservoirs by 19%, with an off-site benefit of about US$ 37,000 per year. The dredging cost of sediments without contour tillage is about US$ 0.34 million per year, highlighting the large costs of soil erosion in the watershed.

4. Desalinization of irrigated rice could increase yields by 23% and is therefore profitable. So far, however, desalinization efforts to control salinity in the rice production schemes remain limited, despite their significant impact on rice yield.

5. The adoption of SLM practices would sequester more carbon per annum -- equivalent to about 2% of the GDP -- than the current standard practice that incorporates only crop residues. This exemplifies the large ecosystem services that could potentially be provided by SLM and the need for exploring incentives for farmers and livestock keepers to use SLM.

6. The annual cost of land degradation due to deforestation -- estimated at 0.6% per year -- is about 0.8% of the GDP. The comparison of benefits from maize production and non-timber forest products shows that farmers who live near forests have an incentive to clear forest for planting maize unless they are compensated for the protection of forests such as through carbon credit or other programs (PES).

7. Overgrazing -- common in the Sudanian and the Sahelian zones -- leads to a fodder biomass reduction of about 12% compared to rotational grazing. The annual cost of overgrazing, resulting in a loss of livestock carcass weight, is equivalent to 0.6% of the GDP and likely to be greater if other ecosystem services are considered. Given the large role that livestock plays in the Malian economy, there is need to promote rotational grazing, which is profitable, and other livestock production practices.

8. Mali has designed several policies for directly improving land management practices. The major policies with a direct impact on land management include food security, the prevention of land degradation, the rehabilitation of degraded lands, and the strengthening local institutions. Given the strong emphasis of these policies on natural resource management, this study's results suggest that the allocation of more resources to land-based sectors will help achieve Mali's objective of sustainably reducing poverty. This study also identified several weaknesses of the policies that, if addressed, will increase their effectiveness.

9. The Malian government spends about 11% of its budget on agriculture, which is above the 10% goal set by the Maputo. However, expenditure on land-based sectors is not commensurate with the large economic role they play and the large costs resulting from land degradation.

10. Between 2004 and 2007, Mali spent 15% to 18% of its budget on SLM, of which donors contributed about 70%. This share is higher than Nigeria's federal budget SLM allocation (5%). The budget allocation to SLM declined in 2006-2007. There was a decrease in the support of donors, while the governmental SLM funding increased.

11. The SLM budget allocation was well-targeted to the most-degraded areas in the Sudanian and the Sahelian zones, but funding for the prevention of degradation in the Guinea-Savannah's forested areas was limited.

12. While the SLM budget allocation is well-aligned with the food security policy, policies on natural resources, environmental conservation, and decentralization are less well supported.

13. Based on the results of this study, the comparative advantage of each agro-ecological zone, and the investments that will give the greatest returns in each zone, were identified. The main comparative advantage in the Sudanian zone is rainfed and irrigated crop production and livestock production. However, investment in irrigation is required to address production risks, which are being augmented by climate variability and change. This includes the promotion of ISFM and irrigation investments. The comparative advantage in the Sahelian zone is livestock production and irrigated crop production. Rotational grazing and other improved livestock production systems are required to enhance the low livestock productivity. The Sudano-Guinea zone's comparative advantage is rainfed agriculture and forest production. Improvement of the local institutions to enhance participation in the carbon is required.

14. A holistic approach is required to effectively promote the adoption of SLM practices. An effective coordination of many ministries, departments, NGOs, and other stakeholders involved in rural development is also required.

Chapter 1: Context and Problem Identification

THE ROLE OF LAND FOR THE RURAL POOR, AND THE IMPLICATIONS OF ITS DEGRADATION FOR ECONOMIC GROWTH

Mali's economy is heavily dependent on natural resources, and the majority of the population depends on land-based economic activities. About 80% of the Malian population is dependent on agriculture (including crops, livestock, fish, and forest) (FAO 2007), and the sector contributed 37% of Malian US$ 8.74 billion GDP in 2008 (World Bank 2009). Employing 30% of the labor force (FAO 2007), livestock is the second largest sector (after crops) and contributed 15% of the Malian GDP and 41% of the agricultural GDP (FAO 2005). Forestry accounted for 1.9% of the GDP in 2006 (FAO 2006). Therefore, investments in land-based sectors (agriculture, forestry and other natural resources) have a significant impact on the livelihoods of the Malian population.

The Malian government spends about 11% of its budget on agriculture (Fan et al., 2009). Even though the country is only one of the eight in Sub-Saharan Africa (SSA) to have achieved the Maputo declaration of spending at least 10% of its budget on agriculture, expenditure on agriculture and other natural resource management programs is not commensurate with large role that land-based sectors play in the economy and their potential to contribute to economic growth and poverty reduction. Investment in land management is also not commensurate with the challenges facing land-based sectors.

Mali is among the countries to have experienced severe land degradation in the past due to climate change, overgrazing, deforestation, and other land-degrading land management practices (RDM 2000). As this and other studies show, sustainable land management (SLM) (Box 1) has significant potential to help Mali address these issues and to achieve its pillar objective of sustainably reducing poverty. For example, a long-term experiment in Mali showed that integrated soil fertility management (ISFM), which involves a combination of organic soil fertility management practices (such as manure, agroforestry, etc.) and judicious quantities of chemical fertilizers can increase rice yield up to 167% (Kamissoko et al., 2008). Another experiment showed that improved maize and rice varieties could increase yield three to four times (Butt et al., 2006). Similarly, soil and water conservation (SWC) (Box 2) practices, such as tied ridges, could increase cotton yield by up to 6%, while dry scraping could increase cotton yield by up to 36%.

Box 1: Definition of Sustainable Land Management

> **Sustainable Land Management (SLM)**
> SLM is the crucial entry point for improving land resources resilience and productivity, increasing yields and reducing yield variability. SLM can make a significant and lasting difference, as it is the critical merger of agriculture and environment, with the twin objectives:
>
> 1. Maintaining long term productivity and ecosystem functions (land, water, biodiversity);
> 2. Increasing productivity (quality, quantity and diversity) of goods and services (including safe and healthy food).
>
> Of most immediate importance to people across SSA (from individual land users to national governments) are the opportunities which SLM practices offer in adaptation to climate change, as SLM practices can improve soil structure and function - increasing the amount of rainfall which infiltrates, also it's capacity to store water.
> Many SLM practices also have significant potential for mitigating climate change - sequestering carbon; reducing emissions of carbon dioxide, methane and nitrous oxide; also reducing use of fuel and agrochemicals.
>
> TerrAfrica (2009)

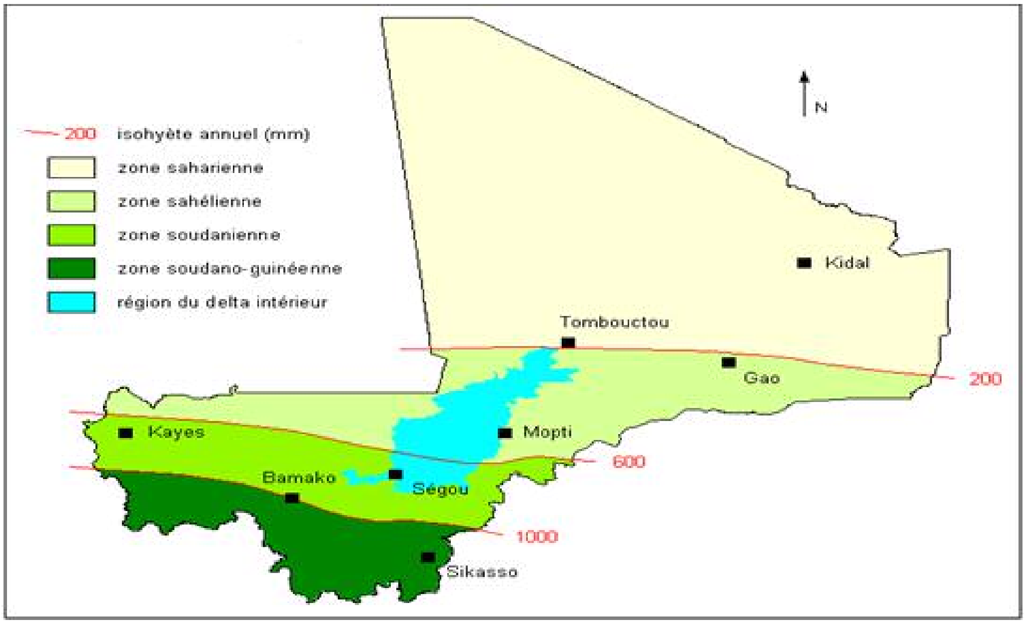
Box 2: Definition of Soil and Water Conservation

> **Soil and Water Conservation (SWC**) is defined as activities at the local level that maintain or enhance the productive capacity of the land in areas affected by or prone to degradation. SWC includes prevention or reduction of soil erosion, compaction and salinity; conservation or drainage of soil water; maintenance or improvement of soil fertility, etc.
>
> Source: www.wocat.net

A study in Mali also showed that ISFM practices have higher profitability than practices using fertilizer or organic soil fertility alone (Doraiswamy et al., 2007). Despite their high returns, this study shows that only 18% of farmers used ISFM in 2004/05. Hence, this study explores the drivers of ISFM adoption and what can be done to enhance it. It also addresses drivers of land degradation, targeting, and alignment to policies of public expenditure on SLM. The study also analyzed benefits and costs of land management practices for selected land-based enterprises and how public SLM expenditure should be revised accordingly.

Since a large area of Mali lies in the Sahelian and the Sudan zones (Figure 1), both of which are predicted by global circulation models to experience reduced precipitation, greater rainfall variability, and higher temperatures (Butt et al., 2006), there is need to quantify the possible impact of climate change and strategies required to address it (Box 3).

Figure 1: Mali agro-ecological zones



Source: Labo/IER, 2000.

Box 3: Climate Change in Mali

Climate change and its impacts on agricultural productivity and food security

Studies have shown that climate change in Mali will lead to reduced agricultural productivity since the country is in the drier areas, which are predicted to experience drier conditions (Christensen, et al., 2007). Butt et al. (2005) predict that climate change will reduce forage yield by 5% to 36%. This will consequently reduce livestock live weight by 14% to 16% (Ibid). Loss of livestock live weight is also due to loss of appetite due to heat stress (Adams, et al 1999). Yield of most crops (e.g. maize, cowpea, millet, sorghum and peanuts) will decrease by up to 17% while yield of some crops (e.g. cotton) will increase by up to 6%. Accordingly, climate change will have a negative impact on food security and economic growth. Butt et al. 2005 estimate that climate change will lead to a 70 to $142 million, loss and the percentage of population at risk of hunger will increase from 34% to 64% to 72%. Breeding programs and land management practices could reduce the negative impacts of climate change. For example Butt et al. (2005) showed that breeding heat resistant crop varieties could reduce the share of population under hunger risk to as low as 28%.

Butt et al (2006) also showed that soil fertility management will reduce climate change related economic losses by 66% and undernourishment by 17 percentage points if soil fertility management practices are adopted.

IFPRI (2010)

Definition of SLM

The definition of land and of SLM for this work builds on definitions provided by the U.N. Convention to Combat Desertification (UNCCD), TerrAfrica, and other sources. Consistent with those definitions, land is defined broadly as encompassing rangelands, woodlands or forest, and agricultural lands, and including the soil, vegetation, other biota, and the ecological and hydrological processes operating within the system. Hence, land management encompasses more than just cropland management or soil management. A tentative definition of SLM, according to TerrAfrica (2005), is the "adoption of land systems that, through appropriate management practices, enables land users to maximize the economic and social benefits from the land, while maintaining or enhancing the ecological support functions of the land resources." TerrAfrica advocates a country-specific approach to defining SLM that considers two major criteria: (i) SLM should maintain the productive potential of land resources, and (ii) it involves sectors for which land sustainability is critical (usually agriculture and forestry). An important consideration in defining SLM will be to make the concept sufficiently operational to be useful in defining and assessing public sector SLM expenditures.[4] Consultation with the SLM committee in Mali showed that this definition reflects Mali's land resource problems and needs.

PROXIMATE CAUSES OF LAND DEGRADATION IN MALI

Factors causing land degradation are divided into two major groups: proximate and underlying causes. The proximate causes are the direct causes of land degradation, which include biophysical factors and unsustainable land management practices**.** The two relate in a complex way, and their effects are equally complex. The underlying causes of land degradation are the socio-economic and policy factors that indirectly cause land degradation:

(a) **Biophysical factors**: Land cover, topography, soil erodibility, and other factors are examples of the biophysical factors that lead to land degradation. The Sahara desert, which covers the Tombouctou, Gao, and Kidal regions, has poor or no vegetation, and consequently the rate of wind erosion is severe. The topography in Mali is relatively flat compared to other countries, making water-induced soil erosion minimal. It is estimated that only 11% of the land area is prone to erosion due to rainfall, however, much of that erosion takes place in the Sahelian and Sudanian zones, where 80% of the population is located (Bott et al 2000). Recent climate variability and change have also contributed to land degradation. Projections of climate change from 2000 to 2030 by the Hadley coupled model and the Canadian global circulation (CGM) model predict that the average temperature in Mali will increase 1^{o} to 2.75^{o}, and precipitation will decrease slightly (Butt et al., 2006). Decreased precipitation in the northern regions will lead to further loss of vegetation, which in turn will accelerate water and wind erosion. The erratic onset of rainfall during dry periods, an increasing issue due to climate change, could also lead to more severe erosion, since rain could come during the dry season when land cover is minimal.

(b) **Unsustainable land management practices**: Unsustainable land management practices directly cause land degradation (IFPRI, 2010). Bush fires, common in the savannas of Mali (Laris 2006; Laris and Wendell 2006), deforestation, and tree cutting all contribute to a reduction in land cover, leading to water- and wind-induced erosion. It is estimated that 25%-50% of the Sudanian zone burn every year (Delmas et al., 1991). However, some regimes of

[4] More details on this are given in the section discussing public expenditure review methods.

bush burning are meant as firebreaks, and the Malian forest policy allows controlled burning. Villagers are required to obtain a permit before setting fire (Laris and Wendell 2006).

The low adoption of inorganic fertilizer and organic soil fertility management practices are leading to soil nutrient depletion and loss of carbon in arable areas. As shown below, only 17% of farmers in Mali use inorganic fertilizer, but a much larger share (39%) use manure. Cotton accounts for the largest share of fertilizer use. Due to the limited use of fertilizer, soil nutrient depletion is one of the most serious land degradation problems in Mali. About 49 kg NPK/ha is lost annually in Mali (Baanante and Henao 2006).
Overgrazing is also a problem in Mali (FAO 2005), in common with the bushlands of the Sudanian zones across West Africa (Savadogo et al., 2007).

UNDERLYING CAUSES OF LAND DEGRADATION IN MALI

The underlying causes of land degradation in Mali are the factors that affect the proximate causes of land degradation. These include socio-economic and policy-related issues *inter alia* land tenure, access to inputs, population pressure, poverty, agricultural and natural resource policies.

In the following, the underlying causes of land degradation are discussed, and it is shown how these have affected the state of the land in Mali.

(i) **Population**: Only 2% of Mali population live in the Sahara desert, 5% in the arid zone, 30% in the semi-arid zone and 51% in the dry humid zone (Bott et al 2000). Areas of high population density in southern Mali have experienced rapid deforestation and agricultural expansion in fragile lands. However, even in the northern zones, where population density is low, wind-induced soil erosion is severe due to poor land cover. This demonstrates the complex human-environment interactions and the relationship between the driving forces of land degradation.

(ii) **Poverty**: The linkage between land degradation and poverty is ambiguous. Some studies have observed that poor people deplete natural resources as their livelihoods are heavily dependent on natural resources (e.g. Cleaver and Schreiber, 1994). However, others have observed the contrary (e.g. Kazianga and Masters, 2002, in Burkina Faso). A study in Mali showed a high incidence of poverty (above 50%) and loss of biodiversity in all regions (Wong et al., 2005). Similarly Pol and Traore (1993) observed a strong correlation between poverty and land degradation in southern Mali. However, empirical evidence from other countries has shown more severe land degradation in affluent areas. For example, controlling for population density, Madu (2009) observed more severe degradation in affluent southern Nigeria than in poorer northern Nigeria. Even though this model does not control for a number of other factors that drive degradation, it reveals the potential impact of affluence on degradation if institutions enforcing conservation are weak. Similar results were observed in Uganda by Woelcke (2006). This could be due to the wealthier population's greater ability to harvest natural resources (e.g. bribing their way into protected forests, using vehicles to transport cut timber, etc.). Affluent land users may also use such land-degrading practices as mechanical equipment or water polluting chemicals. However, affluent land users are able to invest in SLM practices such as buying fertilizer and owning livestock that could produce and transport manure, etc. (Swinton, Escobar, and Reardon, 2003). Poor farmers cannot afford such inputs and are more dependent on natural resources -- leading to the famous downward spiral in which poverty leads to more degradation and degradation leads to more poverty (Cleaver and Schreiber, 1994).

(iii) Access to markets. Like affluence or poverty, market access has an ambiguous impact on land degradation. Low market access leads to higher transaction costs, expensive inputs, limited access to information critical for improving land management, and lower prices, which do not give incentives to farmers to adopt inputs that may lead to sustainable land management. As was the case in Machakos, Kenya (Tiffen et al., 1998), Boyd and Slaymaker (2000) have shown that in areas with good market access and conducive natural resource policies, land users are likely to use SLM practices. However, access to roads and urban areas could offer exit options and lower the probability of adopting sustainable land management practices. Access to markets could also increase the opportunity costs of labor --hence lower the probability of adopting labor-intensive practices. Based on these studies, the net effect of market access on land management is complex and ambiguous.

(iv) Rural finance: This includes access to liquid assets, including credit and savings. Access to financial capital is expected to increase the ability of farmers to buy inputs. For example, Akramov (2009) showed that in Nigeria access to credit increases the likelihood of farmers to adopt inorganic fertilizer. However, other studies have shown the weak or negative impact of credit on land management practices as farmers tend to use borrowed money for non-agricultural enterprises with higher returns (e.g. Nkonya et al., 2008). These results suggest that the favorable impact of credit on improved land management practices depends on the competitiveness of agricultural enterprises and that other factors that influence agricultural competitiveness should be taken into account. For example, farmers are likely to use credit on high-value crops with higher returns if access to markets is improved and if other policies supporting the agricultural sector are designed and implemented.

(v) Land tenure. Since many land management practices involve long-term investment, tenure security is an essential prerequisite to the adoption of SLM practices. Tenure insecurity decreases the likelihood of farmers adopting long-term land improvement investments such as soil and water conservation structures, planting trees, and others (Feder et al., 1988; Place and Hazell, 1993). However, tenure security is not necessarily achieved by having a title deed. Studies have shown that farmers with customary land tenure with no formal titles invest in long-term land management practices (Toulmin and Quan, 2000), suggesting that they perceive security. Land in Mali is under government control; land users are given user rights only. The government also gives leasehold tenure for those who prefer to have formal titles. The majority of plots in Mali are under customary land tenure. Data from the household agricultural census of 2005/06 show that 62.5% of plots were acquired by inheritance, while only 16.7% were acquired by customary law. The major problem facing customary land tenure holders in Mali is occasional land grabbing carried out by chiefs and the government (Benjaminsen et al., 2008). Additionally, the cost of obtaining a formal title is high and cumbersome. Benjaminsen et al. (2008) estimated that the cost -- which includes a cadastral survey, annual taxes and fees, paying bribes, and other costs -- is approximately US$ 3000, well beyond the means of the majority of smallholder farmers.

(vi) Farmers who can afford it can justify the attainment of formal land titles. Farmers with legal land titles are protected from occasional expropriation by chiefs and the government. When this happens, usually only under very special circumstances, landholders are compensated at a much higher rate than those without a formal land title (Benjaminsen et al., 2008). Additionally, customary land tenure holders may not be able to access credit because they cannot use land as collateral. However, farmers may not see the need for land titling if they do not feel that their tenure is insecure or if they do not value land titles. This suggests that land titling efforts that attempt to cover all untitled land may not realize the desired SLM and higher economic returns and thus, in some cases, may not be necessary. Areas where the demand for titles may be high include urban and peri-urban areas, or where high-value agriculture is being pursued, leading to a high demand and potential return to formal credit (Deininger 2003). In Mali, areas close to urban areas, such as Koutiala, have seen significant land titling (Benjaminsen et al., 2008).

(vii) **Local institutions and extension services:** Strong local institutions have been shown to enhance effective natural resources management (Agrawal and Ostrom, 2001; Anderson et al., 2006). These results suggest the need to strengthen local institutions as part of government efforts to ensure SLM practices. Mali is among the countries that have decentralized natural resource management (Benjamin 2008). However, fiscal decentralization is weak. A study by Ndegwa and Levy (2004) showed that Mali ranked 15th on the overall performance of decentralization among the 30 SSA countries included in the study.

Extension services have been shown to increase the adoption of SLM practices. Beyond the extension services provided by CMDT and Office du Niger, extension services for livestock and other crops in Mali are generally weak. The provision of extension services are also mainly focused on improved varieties, fertilizer, and plant protection. Extension services on ISFM remain weak in Mali and other countries in SSA.

(viii) **Policies and strategies**. Government policies have a large impact on the adoption of land management practices. A detailed discussion of the Malian major policies that directly affect land management follows below.

LAND MANAGEMENT POLICIES IN MALI

Mali has designed several policies that directly aim to improve land management practices. Below, key policies are reviewed and their limitations identified.

Agricultural Development Act, 2006. The Agricultural Development Act was passed in 2006 with an objective of ensuring food security and transforming agriculture into an engine of growth. The Act provides guidance and the coordination of actions and resource mobilization. The Act also aims to modernize agriculture beyond the subsistence level and to make it more competitive both domestically and internationally. It remains to be seen how this visionary Act will be transformed into action.

National Action Programme (NAP). A large share of Tombouctou, Gao, and Kidal is located in the Sahara desert, and the Sahel zone lies on the Sahara desert margin. The Sahelian zone is threatened by desertification. Due to this, Mali ratified the United Nations

Convention to Combat Desertification (UNCCD). The NAP spells out nine actions for combating desertification in the country (RDM 2000). The NAP program has helped to increase awareness in Mali of desertification in particular and land degradation in general. An UNCCD requirement to involve local governments in implementing NAPs has also helped strengthen the government commitment to decentralization (Bruyninckx 2004). As is the case in other countries that have ratified NAP in Africa, these actions constitute short-term projects, and their budgets remain small and largely donor-funded.

National Adaptation Programme of Action (NAPA). Mali ratified the United Nations Framework Convention for Climate Change (UNFCCC) in 2005. The National Adaptation Programme of Action (NAPA) designed several actions to help farmers and other land users to adapt to climate change. Actions include land and water management, some of which are similar to the NAP actions discussed above. Limitations of the NAPA are similar to above-discussed NAP.

Other International Conventions on the environment and nature conservation. Mali has ratified over 20 global and regional conventions related to environmental and natural conservation. Other notable conventions include the Convention on Biological Diversity (CBD) and the Ramsar Convention on the protection of wetlands. These conventions reveal Mali's political will to address its fragile environment and its readiness to cooperate with international organizations on environmental and natural resource management. However, these conventions' actions remain largely donor-funded, and most of them have not yet been formed to operate on a programmatic, long-term approach.

National Forestry Policy, 2007. In response to deforestation, Mali established the national forestry policy in 1982 and revised it in 2007. The policy strongly advocates the decentralization of forest management and the empowerment of the local communities to manage and benefit from forests (Konate 2009). The policy also promotes the protection of, and investments in, forest, wildlife, and biodiversity conservation. The policy is linked to the above-discussed NAP, NAPA, and CBD. The forest policy aims to involve local communities to manage forests and provide opportunities for rural communities to benefit from global initiatives for climate change mitigation and carbon trading. However, a lot remains to be carried out to make this happen. Konate (2009) identifies the following weaknesses of the national forest policy: (a) multiple laws and regulations, some of which are conflicting and unclear; (b) the national forest policy also includes fisheries, which do not fall directly under forest and are administered in a different ministry (Ministry of Livestock and Fisheries); (c) the policy does not have a monitoring and evaluation system to determine its progress, opportunities, and challenges; (d) there are inadequate human and financial resources to implement the policy. The policy also does not clearly spell out the benefit that communities will draw from forests. These and other weaknesses have contributed to the limited achievement of the policy to address current deforestation.

Fertilizer subsidy: The Government of Mali provides subsidies to cotton and rice producers through CMDT (for cotton), the Office du Niger, and other offices. CMDT accounts for 80% of fertilizer imports in Mali. Fertilizer is subsidized and provided on credit to farmers. The Office du Niger also provides fertilizer subsidies to rice farmers. A discussion with key informants revealed that fertilizer use among rice farmers is mandatory. If a farmer does not apply fertilizer, she/he is likely to lose the farm. At the farm gate, the price of urea was

17,500 CFA[5] per 50 kg bag, but the subsidized price is 12,500 CFA/50kg bag, suggesting a 29% subsidy. Farmers of other crops do not receive subsidies, even though cotton and rice farmers apply subsidized fertilizer to other crops as well. For example, even though the subsidy is not targeted to maize, the crop receives a significant amount of subsidized fertilizer. Additionally, a small portion of fertilizer consumption in Mali (approximately 20%) is imported by private companies and sold in the open market. Fertilizer subsidies do not target poor farmers, and since fertilizer is scarce, it leads to shortages that end up benefiting the rich. Additionally, the private sector is not involved directly in distributing subsidized fertilizer. This has negatively impacted the development of private fertilizer dealers since the prices in the open market are higher, making it difficult for private dealers to sell fertilizer. Even though the fertilizer subsidy has led to significant increases in demand for fertilizer, other rural services -- such as roads, marketing services -- are required in order to provide synergies for improvement of production and marketing.

Irrigation programs. Mali is among the few Sub-Saharan (SSA) countries to have invested significantly in irrigation. About 235,791 ha or 42% of the irrigable area is under irrigation (AQUASTAT 2007). To address the increasing demand for rice and the consequent high price, the government has established the Rice Initiative, which aims to enhance rice production. Irrigation is becoming increasingly important due to increased climate variability and the increasing demand for rice. However, the efficiency of water use is low. Office du Niger staff estimate that 45% of water intake from the Niger River is lost through leakage. Additionally, farmers in the Office du Niger pay area-based rather than volumetric annual fees. This makes the volume of water irrelevant when farmers are making irrigation decisions, which leads to reduced incentives to invest in irrigation canals that save water. Additionally, water leakage contributes to salinity, which is increasingly becoming a major problem.

Decentralization. Mali’s government is divided into 8 administrative regions, which are further divided into 49 districts (cercles). The districts are further subdivided into arrondissements, which are further subdivided into 703 communes, each comprising of 11–45 villages (Benjamin 2008). Local governments are responsible for providing primary education, health, sanitation, public transportation within their area of jurisdiction, and security. Local governments generate their own funds from taxes and economic activities. However, only about 15% of the local government budget is funded from local government sources, while the central government and donors contribute the remaining share of local government budget (Gotlieb 2010). A parastatal agency, ANICT (Agence Nationale d'Investissements dans les Collectivités Territoriales), was formed in 2001 to build the capacity of local governments to prepare economic projects required for receiving central government and donor funding and to manage economic activities (Ibid). ANICT also facilitates transfer of funds from the central government to the local governments (Ibid). The small share of locally-generated funds for running local governments highlights the limited fiscal decentralization in Mali.

Regarding legislative authority: it is the 703 communes which have legislative, administrative, and financial autonomy. A commune has the mandate to enact and enforce by-laws that affect all local communities in its jurisdiction (Ibid). For example, due to the Forest Code, which gives power to the Villages have no legal mandate to enact or enforce by-laws. The villages also have no direct mandate to manage natural resources independent of

[5] US $ 1 = 513 CFA francs / XOF

the communes to manage forests, a commune could delegate this management to lower villages or institutions, such as customary institutions, as part of natural resource management (Ibid). This discretion has given local communes significant powers to manage natural resources and to use the village leaders or customary institutions, which are more acceptable in the rural communities.

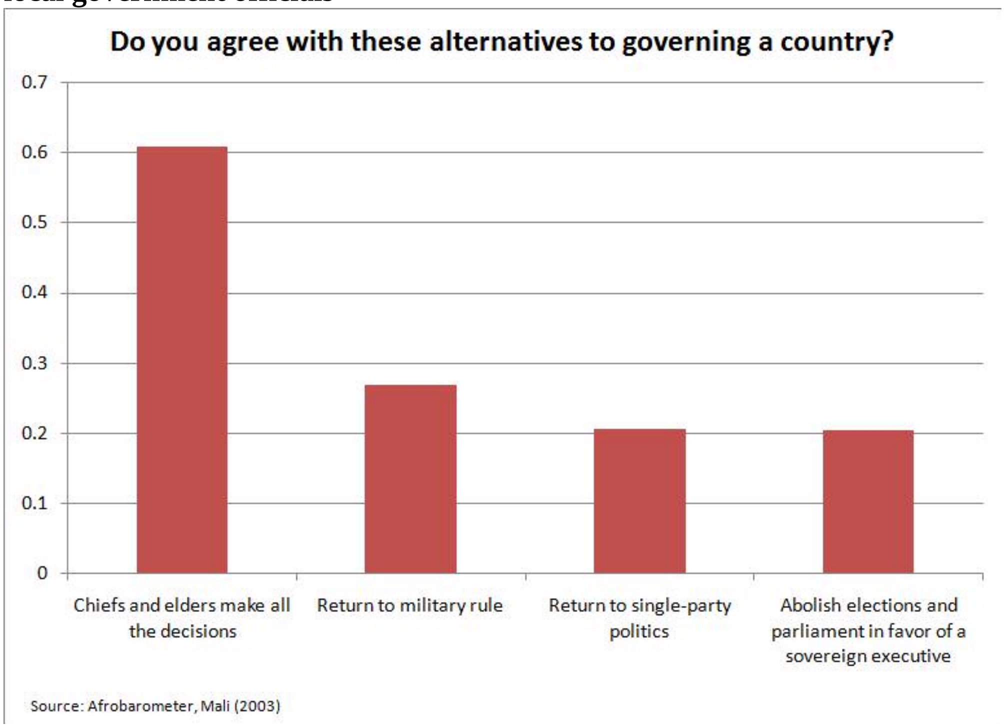
The weak central and local governments have given customary institutions room to enjoy significant influence over natural resource management. Under Mali's decentralization system, the customary institutions are regarded as extra-legal when they do not contravene the central government statutes and illegal when they do (Benjamin 2008). Mali ranks 15th in the 30-country ranking of decentralization performance (Ndegwa and Levy 2004). A recent Afrobarometer survey showed that about 60% of respondents prefer customary institutions (local chiefs and elders) to democratically-elected central and local government officials (Figure 2). Mali suffers from the common problem with decentralised institutions across Africa, where their formal responsibilities are substantial, but this is not well aligned to their budget and capacity. The results show that the country still has a lot to do to improve its decentralization policy, which has been shown to improve natural resource management in developing countries (Agrawal and Ribot 1999).

The review above shows a wide range of policies that touch on all aspects of land management; all of the key policies are in place. Additionally, Mali has surpassed the Maputo Declaration of funding of allocating 10% of its budget to agriculture. However, funding of other ministries important for land management is limited, and the large cost of land degradation calls for greater budget allocations to SLM to prevent land degradation and rehabilitate degraded lands.

Chapter 2: Benefit-cost analysis of SLM practices

In order to address land degradation discussed above, land investments are required. For such investments to be attractive to land users their returns must exceed their costs, and they also need to meet other conditions. In this study, costs and benefits of land management practices were estimated in order to identify profitable land management practices. The analysis covered land management options for production systems that include livestock, crops, and forests. The off-site impacts of land degradation and the ecological benefits of land management practices were also assessed. To understand the impact of climate change on the analysis, benefit-cost analyses of land management practices with and without climate change were undertaken. Subsequently, the drivers for the adoption of sustainable land management practices were analyzed in order to draw policy conclusions on steps that need to be taken to increase the adoption of such practices. Forest, grazing land, maize, rice, cotton, and millet were used as case study enterprises. The main results are summarized below; for details see the technical BCA report. Annex 2 discusses the BCA methodology.

Figure 2: Perception of Mali voters on alternatives to democratically-elected central and local government officials



BENEFIT-COST ANALYSIS OF FOREST RESOURCES

Forests occupy about 10.8 percent of the land area (13.2 million hectares). The main forest problems are the spread of cropping on cleared land, also heavy pressure from grazing, bush fires and overexploitation of fuelwood resources (92 percent of the wood harvested is used as fuel), leading to forest degradation.[6] Consequently, deforestation in Mali is 0.6% per year (Figure 3) which is among the lowest in West Africa (FAO 2003). However, this has reduced the area under forest by 1.4 million ha from 1990-2008 (Figure 3), which is equivalent to a ~~5~~10% loss of forest cover over the 18-year period. Conversion of land to agriculture is the

[6] (source http://www.fao.org/forestry/country/57478/en/mli/).

most common cause of deforestation (RDM 2009). It is estimated that at least 30,000 ha are converted to agriculture every year (Ibid). The probable costs of deforestation across Mali were estimated, using results from this and other studies conducted in similar agro-ecological zones. Communities weigh the incentive to clear forest by comparing it with the value of alternative land use (VALU). If the value of clearing the forest is greater than VALU, then communities will clear the forest or keep the forest if otherwise, i.e.

$$\sum_{t=0}^{T} \rho^{t}(NTFP + OV + PES + NUV > VALU)$$

Where: NTFP = non-timber forest products; OV = Option value, which is equivalent to the value that people attach to future use value of forests; NUV = Non-use value, which includes bequest value and existence value, which is the utility attached to the existence of the forest, regardless of present and future value; ρ^t = discount rate of farmers, t = time in years and T = planning horizon of farmers; and PES = payment for ecosystem services, which is one of the indirect value of forests.

The carbon biomass from planted forestry trees was estimated using EPIC simulation model for Sikasso area (see Box 4 and 5).[7] Due to data constraints, the focus was on tangible benefits (NTFP, PES, and VALU) in this study, and OV and NUV were ignored. An NTFP was determined which would give an incentive to the farmers surrounding forests in Sikasso not to clear the forest, and with and without participation in the carbon market. The NTFP was evaluated against alternative land use of forest land (maize production using the common land management practice, i.e. 50% crop residue and 1.67 tons/ha manure). Using US$ 20 as value of NTFP per ha, Figure 4 shows that, without participation in the carbon market, communities will clear the forests since the net benefit from maize (VALU) -- which is represented by the breakeven line in the graph -- is greater than the value of NTFP over the entire 15-year period. However, the net benefit from maize declines, reducing the difference between VALU and NTFP.

[7] For details also see the Benefit-Cost Analysis report for Mali (IFPRI, 2010).

Box 4: Computer Models Used in Analysis

DSSAT-CENTURY (Gijsman, et al. 2002) and EPIC and SWAT Simulation Models

Computer models were used to assess the potential benefits (or losses) of adopting a range of SLM scenarios (also see Appendix 1 of IFPRI, 2010).

DSSAT (Decision Support System for Agrotechnology Transfer) is one of the most popular crop modeling software packages in the world. DSSAT combines crop, soil, and weather databases for access by a suite of crop models enclosed under one system. The models integrate the effects of crop systems components and management options, to simulate the states of all the components of the cropping system and their interaction. DSSAT crop models are designed on the basis of systems approach, which provides a framework for users to understand how the overall cropping system and its components function throughout cropping season(s), on daily basis. DSSAT model has been widely used in various types of cropping systems all over the world, including low-input subsistence ones in sub-Saharan Africa. The DSSAT cropping system model was modified by incorporating a soil organic matter and residue module from the CENTURY model. The combined DSSAT-CENTURY model used in this study was designed to be more suitable for simulating low-input cropping systems and conducting long-term sustainability analyses.

The EPIC (Erosion-Productivity Impact Calculator/ Agricultural Policy/Environmental extender) simulation model was used in order to simulate scenarios that DSSAT-century model cannot. This includes the impacts of salinity, rotational grazing and forests biomass.

The Soil and Water Assessment Tool (SWAT) (Arnold et al., 1998) was used to estimate the off-site costs of water-induced soil erosion and benefits of soil erosion control. SWAT is a comprehensive watershed model. It provides an integrated framework for modeling hydrology, sedimentation, crop/plant

Box 5: Flow diagram showing inter-linkages of simulation models

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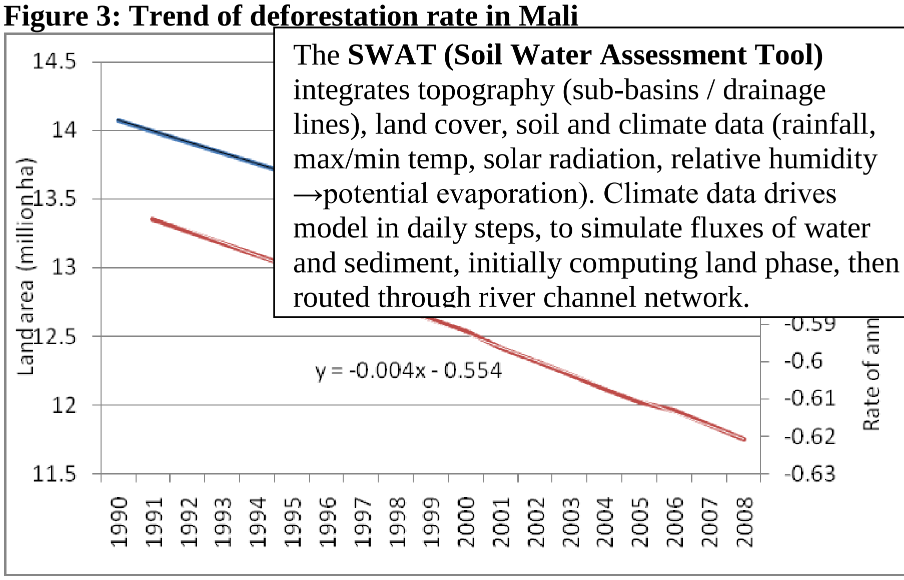
The **DSSAT (Decision Support System for Agrotechnology Transfer)** - uses crop growth information (limited number of main crops), soil and weather data. Different management objective scenarios (over 30 years) are run [application of inorganic fertilizer, organic fertilizer (manure / compost) and post- harvest residue management (100% removed / 50% left + 50% removed / 100% left)] – results show crop yields, above ground biomass and soil organic

The **CENTURY** model is a general model of plant-soil nutrient cycling which has been used to simulate carbon and nutrient dynamics for different types of ecosystems including grasslands, agricultural lands, forests and savannas. CENTURY is composed of a soil organic matter/decomposition sub-model, a water budget model, a grassland/crop sub-model, a forest production sub-model, and management and events scheduling functions. It computes the flow of carbon, nitrogen, phosphorus, and sulphur through the model's compartments. The minimum configuration of elements is C and N for all the model

The **EPIC (Erosion Productivity Impact Calculator)** is a special plant growth model, including ca. 100 plant species (crops / pastures / grasslands / trees). Capable of modelling up to 12 species together (competing for resources (light / water / nutrients) – simulating changes in yields, soil nutrients and carbon – including under differing wind

The **SWAT (Soil Water Assessment Tool)** integrates topography (sub-basins / drainage lines), land cover, soil and climate data (rainfall, max/min temp, solar radiation, relative humidity →potential evaporation). Climate data drives model in daily steps, to simulate fluxes of water and sediment, initially computing land phase, then routed through river channel network.

Figure 3: Trend of deforestation rate in Mali

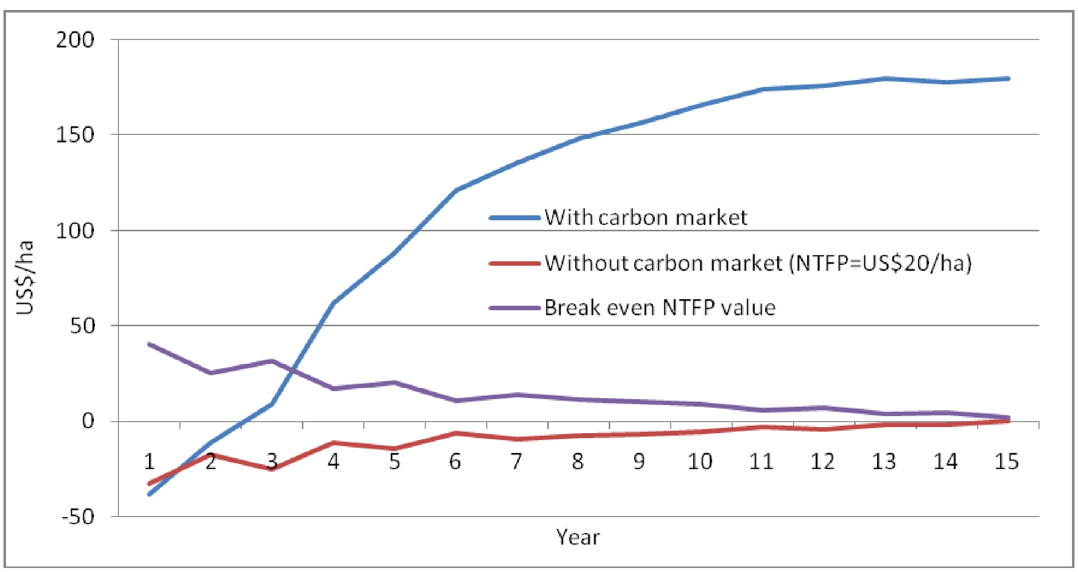


Source: FAOSTAT 2009.

The break-even point is reached when the minimum value required to stop forest clearing is equal to the present VALU. The break-even amount is greater than the value of the carbon market value from year one to year three, during which time the carbon market value and minimum NTFP is lower than the carbon market value. The break-even value of NTFP ranges from US$ 40/ha in year 1 and falls gradually to US$ 2 as the maize yield declines over time.

If farmers were able to participate in the carbon market and if they were compensated US$ 20 per tCO_2-equivalent sequestered, they would have still have no incentive to protect young forests for the first three years. This suggests the need for other incentives for participation in the reforestation program. For example, sharing revenue from tourism with farmers around the forest margins could be one of such incentives. Additionally, assuring farmers that they will receive payment for environment services (PES) could give them an incentive to protect the young trees until the point when the community forest starts paying off in the third year and beyond. The results show the high incentive that farmers have to clear forests and the need for designing methods to give them incentives to protect forests.

Figure 4: Difference between value of alternative use of forest land (maize production) and the value of NTFP per hectare with and without carbon market



This work also evaluated the social cost of deforestation in Mali. A global study by CBD (2001) evaluated the value of tropical forests. Loss due to biodiversity and climate regulations account for the largest loss (Table 1). The largest loss of deforestation is due to climate regulation services, which include carbon sequestration (at the global level), wind barriers, avoided sea rise, crop damage, etc. We assume that the value of biodiversity loss is proportional to the area deforested. To obtain a conservative estimate, the minimum value of each ecosystem service estimated by CBD (2001) was used. However, in cases where data was available in Mali, the actual value was used.

The results show that deforestation alone leads to a social cost equivalent to 0.8% of the 2008 GDP of US$ 8.8 billion (Table 12). This is equivalent to about 4% of the US$ 1.87 billion government-funded 2008 budget or 92% of the government funded SLM budget of US$ 0.08 billion (Table 13). All this indicates the small share allocated to SLM, even in Mali, which has achieved the Maputo Declaration. This is even more striking given that deforestation is only one form of degradation in Mali.

Table 1: Ecosystem services of forests and their marginal values

Ecological service	Beneficiary	Benefit (US$/ha/year	Source
Timber – sustainable harvesting	Government or forest owner	30	CBD 2001
Fuelwood	Local communities/ urban centers	40	CBD 2001
NTFPs	Local community	20	See text above
Recreation	Tourists, government & tour companies	2	CBD 2001
Watershed benefits	Regional inhabitants	15	CBD 2001
Climate benefits	Local, national and global	360	CBD 2001
Biodiversity	Local, national & global	400	CBD 2001
Non-use values	Local, national and global	2	CBD 2001
Total value of forest ecological services (US$/ha/year)		**869**	
Total area deforested each year[2] (000 ha)			79.100
Total cost of deforestation (US$ million)			**68.65**
Cost of deforestation as % of GDP (US$ 8.757 billion, constant 2000=100%)			**0.78**

Source: [2] FAOSTAT 2009.

BENEFIT-COST ANALYSIS OF ROTATIONAL GRAZING

Overgrazing is the most significant cause of land degradation in the pastoral areas located in the northern and north-central regions (RDM 2009). Stocking density in these regions increased by 14% from 14 TLU/ha of agricultural land in 1980 to 16 TLU in 2002 (FAO 2005). Overgrazing is particularly a problem during Mali's dry season, which runs for seven months (November-May) in the Guinea-Savannah and Sudano-Savannah and for 10 months (September-June) in the Sahelian zone. There is no reliable rainfall in the Sahara desert. In the Guinea-Savannah and Sudan-Savannah zones, about 73% of the cattle population is located in the mixed agricultural crop areas (Ibid).

Using EPIC, the impact of rotational grazing was simulated in three sites in the Tombouctou area, where overgrazing is a major problem. Table 2 shows that rotational grazing increases the average forage biomass by about 7% in site 3, 12% in site 2, and 20% in site 1. The change in biomass for rotational grazing was significantly higher (at $p = 0.01$ for site 1 & 2 and at $p = 0.10$ for site 3) than for continuous grazing (Table 2). Forage biomass is decreasing in both grazing practices but the decrease is faster in the continuous grazing (Figure 5). On average, continuous and rotational grazing decline at a rate of 14 kg/ha and 7 kg/ha/year, respectively, underscoring the overgrazing problem in the Tombouctou area (Butt, et al., 2005). Grazing lands in Tombouctou are also highly stressed systems due to water and nitrogen stress and low soil organic matter status. This suggests that rotational grazing alone may not address the declining pasture quality in the area and that other rangeland management practices such as planting leguminous pasture, rainwater harvesting, etc., are likely necessary to address the declining forage yield.

Table 2: Impact of rotational grazing on grassland pasture, Tombouctou, Mali

Site #	Continuous grazing (Tons/ha)	Rotational grazing (Tons/ha)	Change in biomass (%)	Paired T-test
Site 1	0.70	0.84	19.52	0.000
Site 2	0.56	0.62	11.98	0.000
Site 3	1.15	1.23	6.65	0.084
All sites	0.80	0.90	11.62	0.000

Source: EPIC simulation.

Table 3 shows that, with rotational grazing, the profit from livestock of a farmer with a 50 head cattle herd is an average of XOF 260,000 per year. The results suggest that rotational grazing can be profitable, and also increases carbon sequestration by 12%. Consistent with Briske et al. (2008), who observed that rotational grazing leads to lower livestock productivity in South Africa, farmers in site 3 would suffer losses due to rotational grazing. This suggests that rotational grazing may not work in some areas – or that more research is required to determine the length of “rest” periods required for pastoral areas to be restored between grazing phases. It may be necessary to encourage increased livestock off-take (i.e. reduction in herd sizes) in parallel with rotational grazing, for the full benefits to be achieved (Steinfeld *et al*, 2006).

However, despite the generally large profits, the adoption of rotational grazing is still low in Mali.

Various reasons underlie the poor up-take of rotational grazing, including the high cost of fencing “paddocks” and that the system is vastly different from the traditional livestock management practices (maintaining large herds). Increasing up-take will require an increased investment in promoting rotational grazing and other rangeland management practices (*inter alia* reseeding degraded pasture with leguminous seeds, weed / bush control, increased off-take) in Mali, which will be challenging in areas where human populations are highly dispersed and levels of literacy / education are low.

Figure 5: Trend of forage yield (dry matter biomass) with continuous and rotational grazing, Tombouctou

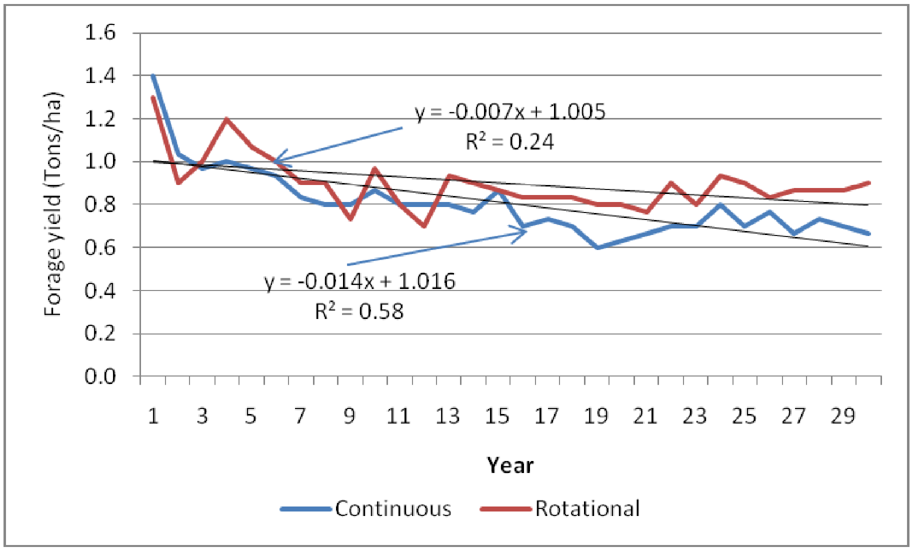


Table 3: Returns to rotational grazing & cost of overgrazing

	Continuous grazing	Rotational grazing
Production costs (000 XOF)		
Enclosures	0	10.13
Veterinary services	30.71	30.71
Transportation	0.11	0.11
Herding labor (1 labor day = 1000 XOF for 365 days) (000CFA)	365.00	456.00
Total production cost (000 XOF)	395.82	496.95
Revenue		
Average marginal cost due to rotational grazing (XOF/kg)[1]		777.92
Carcass weight (average, kg)[2]	130	130
Unit price beef (000 XOF per kg)	1.6	1.6
Net Present Value (XOF Million), 30 years		
Site 1		20.44
Site 2		13.10
Site 3		-1.71
Average (all sites		7.74
Annual NPV average		0.26
Reduction in carcass weight due to overgrazing/year (11.6% reduction of biomass)/TLU (kg)		11.08
Total value of carcass weight in regions with overgrazing (US$ billion)[3]		0.421
Loss of value of carcass weight due to overgrazing (11.6%) (US$ billion)		0.049
Loss due to overgrazing as % of GDP		0.6

Notes & sources: [1] (496.95-395.82)*1000/130[2] FAO (2005); [3] Areas with overgrazing are largely located in the following regions: Segou, Tombouctou, Mopti, Gao, and Kidal (Coulibaly 2004). Note: livestock data obtained from Ministry of Agriculture, Mali.

The cost of overgrazing is equivalent to an estimated 0.6% of the GDP. This cost is lower than in Nigeria, where overgrazing alone led to a 1.7% decrease of the GDP. The reason for the smaller loss due to overgrazing is the small increase in fodder biomass in Mali, probably due to the study site in Tombouctou, which is in a much drier area than is the case in the Nigerian study sites (Niger and Sokoto). The cost of overgrazing above does not include the cost of decreasing biomass, even for pastures under rotational grazing. Pasture biomass under rotational grazing decreased by 31% in 30 years -- from 1.3 tons/ha to 0.9 tons/ha (Figure 5). It also does not include the other ecosystem services provided by pastures, such as soil erosion prevention and carbon sequestration. Hence these estimates are conservative.

There is insufficient data to extend this study to include other SLM practices (agroforestry, silvopastoralism, assisted natural regeneration, reduced tillage etc), nor broader landscape management approaches. However, for future investments, these should be considered, using data for example from TerrAfrica, WOCAT, LADA and FAO resources.

BENEFIT-COST ANALYSIS OF CROPS

Maize

The land management practice with the highest net present value (NPV) for maize is the one combining 5 tons/ha manure, 100% crop residue, and 80 kg/ha, which is the recommended practice (Table 4). The practice gives the second highest returns to labor -- after the 80 kg N/ha only practice. However, the labor intensity of manure and compost could discourage farmers from using such technologies. Labor accounts for 50% of the production costs. The NPV is negative for plots not receiving fertilizer, manure, compost, or crop residues and plots receiving 1.67 tons/ha compost and 50% crop residues. This implies that it is better for farmers to only incorporate 100% of crop residues rather than to apply 1.67 tons/ha compost and incorporate 50% of crop residues. The NPV tends to increase as quantities of manure or compost, fertilizer, and crop residues increase. This means that the more sustainable the land management practice is, the more profitable it is. This is consistent with results by Doraiswamy et al. (2007) who found higher returns to the most sustainable SLM practices in Mali.[8]

The technology with the highest returns to labor is the 80 kg N/ha, which does not use labor-intensive manure and compost. The results suggest the need to improve farming practices and reduce labor intensity. Using appropriate technologies that are suitable and affordable could greatly increase returns to farmer investments. For example, there is need to develop animal power weeding. This alone will reduce the labor cost by about 11 labor days. Use of animal power for the transportation of manure, farm products, and other farm goods could also improve profitability of the technologies.

Table 4: Maize benefit cost analysis, Sikasso

	Net benefit[1] (XOF/ha)	Returns to labor (000 XOF)	NPV (000XOF)
Residue 100% - baseline	9.43	3.16	-
All zero	7.98	2.48	-

[8] However, the study did not consider labor input.

Compost 1.7 tons/ha, residue 50%	7.58	3.34	-
Manure 1.7 tons/ha, 50% residue	11.99	3.19	7
40 kg N/ha, 1.7 tons/ha manure, 50% crop	31.41	10.7	6
80 kg N/ha	75.69	17.2	1
Compost 5 tons/ha, residue 100%, 80kg N	65.10	7.74	1
Manure tons/ha, residue 100%, 80 kg N/ha	76.04	8.44	1

[a] Calculated from cumulative carbon sequestered from all previous seasons.
[1] Net benefit – nets out opportunity costs of on-farm resource use, namely labor.

Rice

Like for maize, the practice with the highest NPV for irrigated rice is the application of 80 kg N/ha combined with 5 tons/ha manure. It is followed by the treatment combining 40 kg N/ha, 1.67 tons/ha manure, and 100% crop residue (Table 5). All treatments also give higher returns to labor than the rural wage rate, further showing that rice production in Mali is highly competitive. The treatment receiving 1.7 tons/ha of manure or compost and 50% of crop residues, as well as the application of 80 kg N/ha along with 100% crop residue had negative NPVs, suggesting they are worse off than the control treatment (100% crop residues).

Table 5: Benefit cost analysis of rice production

	Net margin	NBCR	Returns to labor	NPV
	000 XOF		XOF	000 XOF
All zero	148.74	9.92	12014.17	2163.86
100% residues	76.62	23.17	8055.91	-
Compost 1.7 tons/ha, 50% residues	55.36	9.64	4512.55	-637.52
Manure 1.7 tons/ha, 50% residues	65.47	11.88	6260.24	-334.45
40 kg N/ha, manure 1.67 tons/ha, residue 100%	229.27	28.60	26466.8	6575.21
80 kg N/ha, 100% residue	43.54	10.12	3560.44	-992.15
80 kg N/ha, 5 tons compost,100% residue	295.79	17.98	29258.01	2163.86
80 kg N/ha, manure 5 tons/ha, residue 100%	320.39	18.69	15904.06	7313.17

Salinity problem and returns to desalinization of irrigated rice

The impact of salinity was examined on returns to production of rice during the wet season and onion during the dry season. Simulation results showed that desalinization increases rice yield by an average of 23% for the treatment that receives fertilizer, manure, and 100% of crop residues (Table 6). Desalinization increases onion yield by only 1%. The net present value (NPV) for both rice and onion due to desalinization is about XOF 20 million over the 30-year period simulation. This implies high returns to desalinization.

Table 6: Returns to desalinization and its impact of rice and onion yield

	Yield (tons/ha) with & without	
	Rice	Onion
No desalinization	2.516	0.199
With desalinization	3.086	0.202
% change due to	22.62	1.28

	Yield (tons/ha) with & without	
	Rice	Onion
desalinization		
	Returns to desalinization (rice & onion)	
NPV (million XOF)	19.72	

Source : EPIC simulation.

Cotton

The NPV of all treatments receiving manure is greater than zero, suggesting that such practices are more favorable than the control treatment (100% crop residue) (Table 7). As was the case with maize and rice, the highest NPV is obtained for plots receiving 80 kg N/ha, 5 tons/ha of manure, and 100% of crop residue. The NPV for plots receiving either 80 kg N/ha and 100% of crop residues, or 5 tons/ha of compost, 80 kg N/ha, and 100% crop residues is less than zero, suggesting that farmers would rather incorporate 100% crop residues only than using either of these two practices.

Table 7: Benefit-cost analysis of cotton production

	Net margin	NBCR	Returns to labor	NPV
	000 XOF		000 XOF/day	000 XOF
All zero	2.82	0.0	0.20	-
100% residues	2.06	-0.1	0.18	-
Compost 1.7 tons/ha, 50% residues	3.74	0.3	0.24	50.49
Manure 1.7 tons/ha, 50% residues	7.81	1.0	0.30	172.56
40 kg N/ha, 1.7ton/ha manure	8.06	1.0	0.32	21.39
80 kg N/ha, 100% residue	-7.75	-0.6	-0.05	-294.40
80 kg N/ha, compost 5 tons/ha, residue 100%	-3.20	0.0	0.07	-157.79
80 kg N/ha, 5 tons manure,100% residue	7.92	0.7	0.29	175.89

Millet

Only organic soil fertility management practices have a net benefit greater than zero on millet production. (Table 8). The net benefit for any treatment receiving 40 kg N/ha or greater is negative, suggesting fertilizer use is not profitable for millet. This could be due to the low response to fertilizer for the traditional varieties that farmers use. Only 3% of farmers applied fertilizer on millet, highlighting the low returns to fertilizer from millet plots.

Table 8: Returns to millet production, Cinzana

	Net margin	NBCR	Returns to labor
	000 XOF		000 XOF
All zero	5.31	1.06	1.03
100% residues	5.77	1.30	1.15
Compost 1.7 tons/ha, 50% residues	4.91	0.95	1.06
Manure 1.7 tons/ha, 50% residues	5.92	1.31	1.16
40 kg N/ha, 1.67 ton/ha manure	-4.53	-0.3	-80.2

	Net margin	NBCR	Returns to labor
80 kg N/ha, 100% residue	-4.79	-0.35	-0.11
80 kg N/ha, 5tons compost,100% residue	-6.39	-0.40	-0.09
80 kg N/ha, manure 5 tons/ha, residue 100%	-5.36	-0.28	0.10

IMPACT OF CLIMATE CHANGE ON RETURNS TO SLM PRACTICES

The changes were simulated in maize, rice, and millet yields due to climate change over a 30-year period under the land management practices examined above. Since climate simulation models produce uncertain results, we use two models with fairly different predictions. The National Center for Atmospheric Research (NCAR) predicts greater precipitation (10% increase), while the Commonwealth Scientific and Industrial Research Organization (CSIRO) model predicts drier climate (2% increase in 2050) (Nelson et al., 2009).

Table 9 shows that yield of maize and rice decreases by 4% to 39% under the NCAR model and by 1% to 34% under the CSIRO model. Yield for millet decreases the least, implying its higher resilience under climate change. Under the CSIRO model, millet yield increases on average 2%. Rice yield decreases the most due to its high water requirement. Maize and rice yields for the land management receiving 80kg N/ha, 5 tons/ha manure and 100% crop residues remain much higher than the treatments that do not receive fertilizer or manure (Table 9). The millet yield across land management practices under climate change does not change significantly. This further shows the weak response of millet to fertilizer and other land management practices.

Table 9: Predicted change in yield due to climate change from its baseline level in 2000 to year 2050

	All zero	100% crop residue	Manure 1.67 tons/ha, 50% crop residue	40 kg N/ha, manure 1.67 tons/ha & 50% crop residue	80 kg N/ha, 100% crop residue	80 kg N/ha, 5 tons/ha manure, 100% crop residue
	% yield change due to climate change					
Difference: NCAR- no climate change						
Maize[a]	-17.6	-4.3	-15.7	-20.3	-23.7	-24.2
Rice[b]	-35.8	-38.4	-39.3	-41.6	-37.4	-35.2
Millet[c]	5.3	2.0	-3.8	-0.8	-14.6	-13.6
Difference: CSIRO – no climate change						
Maize[a]	-9.0	-1.1	-8.3	-12.4	-15.0	-14.1
Rice[b]	-4.6	-23.6	-28.5	-32.9	-33.8	-32.8
Millet[c]	7.4	2.2	2.1	12.3	7.4	9.9
Average difference: (NCAR &CSIRO – no climate change)						
Maize[a]	-13.3	-2.7	-12.0	-16.3	-19.3	-19.1
Rice[b]	-20.2	-31.0	-33.9	-37.3	-35.6	-34.0
Millet[c]	6.3	2.1	-0.8	5.7	-3.6	-1.9

Sites: [a] Sikasso, [b] Segou, [c] Cinzana.

Table 10: Maize, rice, and millet yield in 2050 under different climate change scenarios

	All zero	100% crop residue	Manure 1.67 tons/ha, 50% crop residue	40 kg N/ha, manure 1.67 tons/ha & 50% crop residue	80 kg N/ha, 100% crop residue	80 kg N/ha, 5 tons/ha manure, 100% crop residue
				Yield (tons/ha)		
Climate change: NCAR						
Maize[a]	0.34	0.48	0.63	1.43	2.72	2.87
Rice[b]	0.45	1.19	0.91	1.77	4.65	5.01
Millet[c]	0.39	0.38	0.32	0.37	0.32	0.39
Climate change: CSIRO						
Maize[a]	0.38	0.50	0.69	1.58	3.03	3.25
Rice[b]	0.67	1.48	1.07	2.04	4.93	5.20
Millet[c]	0.40	0.39	0.34	0.42	0.40	0.50

A comparison of yield variability with and without climate change shows that yield variance for rice is not significantly different, since the crop is simulated under irrigation conditions in both cases (Figure 6). For maize, the variance for the treatment with no input is lowest. For the rest of the treatments, maize yield variance of treatments with a combination of fertilizer, manure, and crop residues is lower than the treatments using one of the three practices alone. The pattern for millet is more consistent with the variance falling from treatments with no input to the ISFM treatments. This suggests ISFM practices reduce production risks under climate change.

Figure 6: Impact of land management practices on production risks

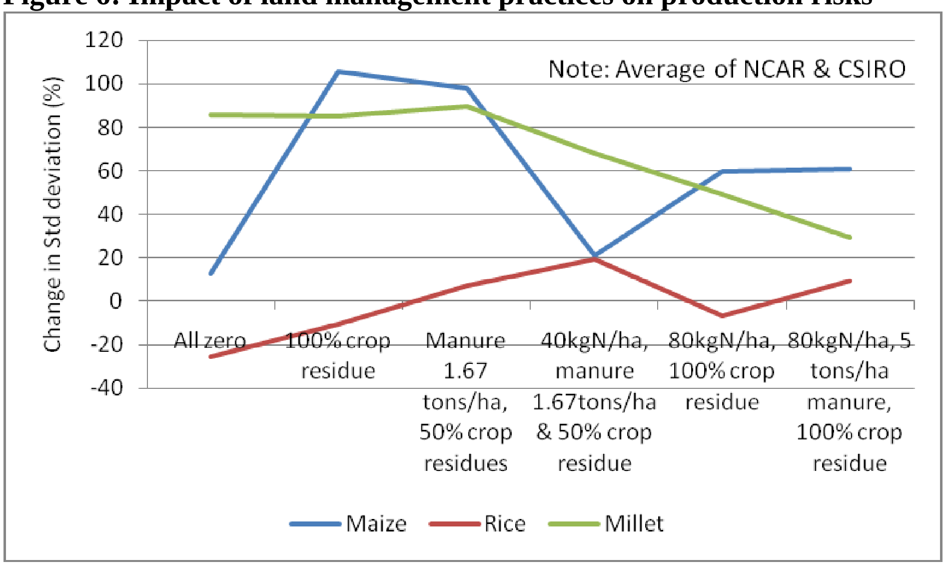


Table 11 reports the NPV of different land management practices under climate change. For maize and rice, land management practices that use more manure and fertilizer have higher NPV than land management that incorporates crop residues only. Under climate change, land management practices that use either manure or fertilizer for millet production are not profitable (NPV<0) compared to the baseline practices (100% incorporation of crop residues).

The results for maize and rice further demonstrate that SLM will help farmers have higher returns to their investment and lower production risks. The millet results provide opportunities and challenges. While yields show a slight yield increase for most land management and declining yield variability as manure and fertilizer application increase, the land management practices applying manure or fertilizer are not profitable under climate change.

These results suggest the low response of millet yield to manure and fertilizer application and therefore can be interpreted as the need to invest in breeding for higher potential millet varieties. Such varieties would help farmers to adapt to climate change. However, the alternative view is that the traditionally genetic variability of millets grown provide farmers with a low cost means to reduce their vulnerability to climate change, as they can save seed and need not invest in inorganic fertilisers.

Off-site costs of soil erosion and benefits of soil and water conservation practices

Although the importance of the off-site effects of land degradation is widely recognized, most studies focus exclusively on on-farm effects, largely due to the difficulties of quantifying and valuing off-site effects. The cost of externalities/off-site effects are calculated using a variety of methods depending on the type of off-site effect, data availability, and reliability of estimates. The method used in this study was largely determined by availability of data.[9]

Table 11: Net present value of maize, rice, and millet in 2050 under two climate change scenarios

	Manure 1.67 tons/ha, 50% crop residue	40 kg N/ha, manure 1.67 tons/ha & 50% crop residue	80 kg N/ha, 100% crop residue	80 kg N/ha, 5 tons/ha manure, 100% crop residue
		‘000 XOF		
	NCAR			
Maize[a]	38.86	638.80	1383.66	1539.61
Rice[b]	-194.05	454.18	2386.96	2601.00
Millet[c]	-70.14	-109.83	-618.42	-657.31
	CSIRO			
Maize[a]	93.86	816.65	1805.33	1996.46
Rice[b]	-257.55	485.99	2362.47	2560.80
Millet[c]	-59.12	-65.44	-543.83	-561.68

Note: The baseline land management practice used is 100% incorporation of crop residues.
Sites: [a] Sikasso, [b] Segou, [c] Cinzana.

The Soil and Water Assessment Tool (SWAT) (Arnold et al., 1998) was used to estimate the off-site costs of water-induced soil erosion and the benefits of soil erosion control. SWAT is a comprehensive watershed model. It provides an integrated framework for modeling hydrology, sedimentation, crop/plant growth, and nutrients/pesticide transport at a river basin scale and under various specified land and water management scenarios.

The SWAT model was calibrated using various data sets containing region-specific information. The SWAT model was calibrated and validated using limited observed river discharge data from Banifing River basin (Figure 7). The discharge data were used to estimate annual water and sediment inflow of 18 small reservoirs with and without contour ridges in the basin.

Estimating the off-site costs of soil erosion and benefits of erosion control

[9] Data was not available regarding impacts on smaller water storage tanks, rainwater harvesting facilities, nor on the impacts on replenishment of aquifers.

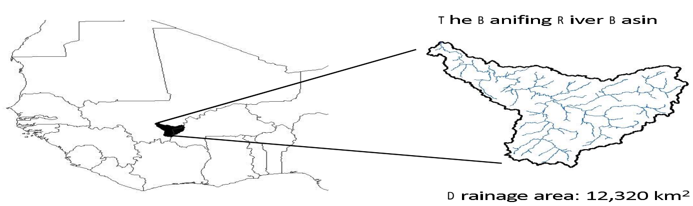
According to Grohs (1994), there are three alternative methodological approaches for calculating the off-site costs of sedimentation of water reservoirs:

(i) Increased operational and maintenance costs and/or change of productivity. These include the cost of dredging water reservoirs, irrigation canals or other waterways, higher operation costs of irrigation pumps and other water machinery, water purification in the case of potable water, etc. The change in productivity of off-site farms is measured by assessing the loss of productivity due to sedimentation in water storage structures, leading to reduced water volume and consequent loss of productivity.

(ii) Replacement costs, i.e. the costs of replacing the live storage of the reservoir lost annually[10]; and

(iii) Preventive expenditures, i.e. the costs of constructing dead storage to anticipate the accumulation of sediments.

Figure 7: Banifing river basin



The choice of methods depends on data availability and the study's objectives. For this study, information on productivity loss, replacement cost, or preventive expenditure could not be obtained. Hence, the off-site costs of soil erosion were estimated using the dredging costs. The off-site benefits of land management practices used to prevent erosion are the avoided dredging costs. Using dredging costs data of reservoirs in Nigeria with the comparable AEZ of southern Mali, the dredging costs per ton of sediment were estimated to be US$ 18.
SWAT simulation shows that land conservation has little effects on stream flow. The total annual cost of sediment without contour ridges is US$ 344,453 or US$ 0.30/ha. The reduction of sediment due to contour ridges ranges from 0% to as high as 100% with an average of 19% (Figure 8). The total off-site benefit due to the reduction of sediment is US$ 36,860. This reflects the limited impact of soil erosion in the Malian flat terrain. However, the river basin considered in this study is small and not representative of other river basins.

WHAT ARE THE DRIVERS OF ADOPTION OF ISFM?

Despite the high returns to ISFM, only 18% used both manure and fertilizer, while about 40% used manure (Figure 9). Fertilizer was mainly used on cotton, whose farmers receive a subsidy from the Cotton Development Authority (CMDT).

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[10] The storage capacity of reservoirs is divided into live and dead storage capacity (Grohs, 1994). The dead storage capacity lies at the bottom of the reservoir and the live storage capacity on top; the latter supplies the water for irrigation or hydro-electricity generation.

The drivers of adoption of ISFM were examined using the Malian Agricultural Census 2004/5. Our results illustrate that the adoption of SLM practices by households, especially the use of organic fertilizers, is strongly affected by socio-economic factors. Vocational training, land tenure security, and holding land under customary tenure increased the adoption of fertilizer and manure use in tandem. Household heads with post-secondary education were 15% more likely to have used fertilizer. Household heads with secondary education were 6% more likely to use manure and 7% more likely to use chemical fertilizer. These results suggest the importance of access to vocational training, tenure security, and formal education for the adoption of SLM practices. Investment in education and vocational training will also have co-benefits for other government policies for poverty reduction.

Figure 8: off-site costs of soil erosion and off-site benefits of SLM, Banifing river basin

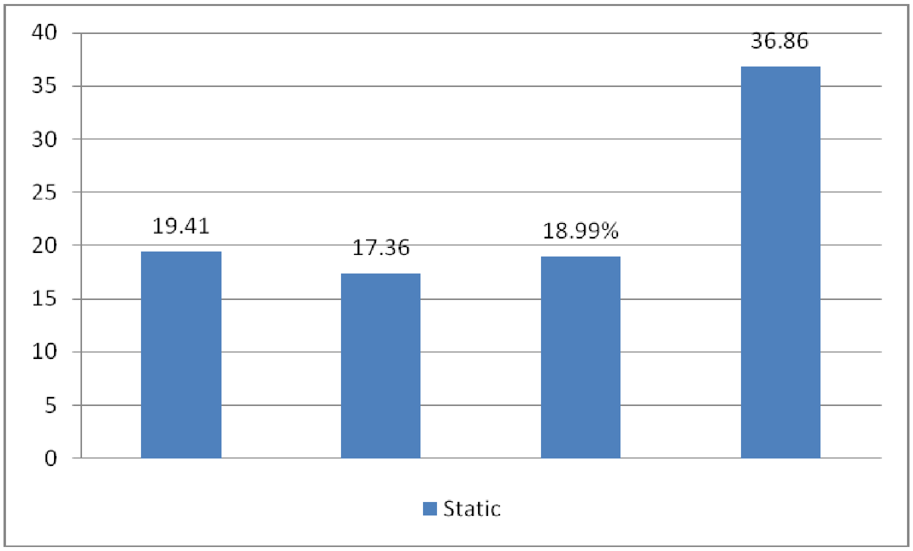
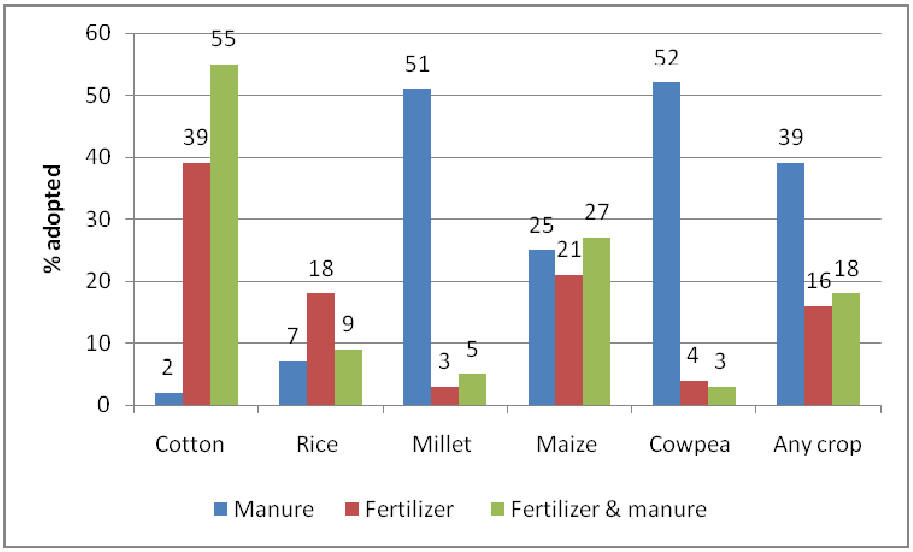


Figure 9: Adoption rates of manure and fertilizer in Mali



Source: computed from raw data, Mali agricultural census 2004/05.

OVERALL IMPACT OF LAND DEGRADATION ON THE ECONOMY AND IMPROVED LAND MANAGEMENT PRACTICES ON CARBON SEQUESTRATION

Table 12 presents a summary of the results of the impact of land degradation on the economy of Mali. Maize, cowpea, millet, cotton, rice, forests, and pasture were used to assess the cost of land degradation on the GDP. This was done by computing the loss due to deforestation and overgrazing and crop yield loss due to land degradation. For crops, the impact of land degradation was analyzed for soil nutrient depletion resulting from incorporating 100% of crop residues only. This was compared with yields under a land management practice that best reflects the improved land management practice farmers are likely to achieve (i.e. 40 kg N/ha, 1.67 tons/ha of manure and 50% of crop residues). However, for cowpea, farmers do not apply nitrogen fertilizer, even though it is recommended as a start-up application before atmospheric nitrogen starts. So it was assumed that the best soil management is the incorporation of all crop residues, which are rich in nitrogen. For cowpea, the baseline scenario is harvesting 50% of crop residues. Degradation due to the use of lower quantities of fertilizer (less than 40 kg N/ha) or manure (less than 1.67 tons/ha) is not considered. For overgrazing, the loss was not considered which stems from the declining forage biomass, neither were the effects of overgrazing on soil erosion and ecosystem services (e.g. carbon sequestration) taken into account. This suggests that the estimates are conservative (i.e., they are at the low end of the actual cost of land degradation for the two scenarios that were compared).

Table 12: Impact of improved land management on carbon sequestration and of land degradation on national income

	Maize	Rice	Millet	Cotton	Cowpea
Prices (XOF/kg)	150	300	100	114	154
Yield with 100% residue (non-adopter of fertilizer or manure) (tons/ha)	0.52	1.41	0.55	0.34	1.27
Yield with 40 kg N+1.67 tons/ha manure	1.62	2.76	0.57	0.79	1.28
Difference in Yields (proportion)	2.12	0.96	0.03	1.3	0.005
Proportion of farmers who did not use manure or fertilizer[1]	0.28	0.66	0.41	0.04	0.41
CO_2-eq 40 kg N + manure 1.7 tons/ha[2]	5.39	83.95	308.32	192.20	0.32
CO_2-eq, for 100% residue (tons/ha)	53.16	82.48	303.41	181.59	0.32
CO_2–eq. gain (kg/ha)	724	1472	4910.5	10609	3.08
Global ecological services due to carbon sequestration (% of GDP) = **2.35%**	0.05	0.05	1.00	1.26	0.00
Crop area('000 Ha)[3]	394.45	425.84	1515.02	540.0	285.64
% of total cropped area = (69%)	8.62	9.30	33.10	11.80	6.24
Loss of GDP due to selected cropland degradation (%) = **4.40%**	0.60	3.72	0.04	0.04	0.00
Loss due to degradation from all crops as **% of GDP**, assuming degradation in crops not included in this study is comparable to the selected crops = 6.4%				6.4%	

Loss due to deforestation as % of GDP	0.78%
Loss due to overgrazing as % of GDP	0.6%
Total loss of crop, forest and pasture as % of GDP[1]	7.8%
Note: [1] Mali GDP (2008) US$ 8.757 (constant, 2000=100%) Exchange rate XOF 350/US$ (constant, 2000=100%)	

[1] Source: Malian Agricultural Census, 2004/05.

[2] For detailed discussion of carbon sequestration, please see BCA report.

[3] Source: FAOSTAT, 2005; IMF, 2009.

About 4.4% of the Malian GDP is lost due to land degradation from the selected crops (Table 12), of which the majority is due to losses in rice. The country also loses about 0.8% of GDP due to deforestation and 0.6% from overgrazing. Assuming that degradation on the case study crops is comparable with other crops, the total loss due to land degradation in Mali is about 8%, underscoring the high cost of degradation and the need to give land management a much higher priority in budget allocation. The results suggest a larger impact of land degradation on the Malian economy than most other past studies (e.g. Barry et al., 2009; Allen and Bishop, 1989) as more sectors and a different estimation method were included.

The Malian farmers also contribute a large share of ecological services through carbon sequestration. Assuming that the farmers who adopted both fertilizer and manure applied 40 kg N/ha, 1.67 tons/ha of manure, and incorporated 50% of their crop residue, the value of the carbon sequestered is about 2.3% of the GDP. This is net of the carbon sequestered by incorporating 100% of the crop residues. Even though it is unlikely that farmers could achieve 40 kg N/ha and 1.67 tons/ha of manure, this estimate demonstrates the large ecological services that farmers provide to the global community (see Box 6).

Box 6: Global benefits of Carbon Sequestration in Mali

> On the global scale, the Malian maize, rice, millet, cowpea and cotton farmers provide significant ecological services through carbon sequestration. Results show that the value of carbon sequestered by maize, rice, millet, cotton and cowpea farmers in Mali is about 2.3% of the GDP. The results demonstrate the large potential that agriculture can contribute to carbon mitigation.
>
> IFPRI (2010)

Chapter 3: SLM public expenditure and its alignment with policies

Mali has designed several policies to support sustainable land management. The budget allocation on each policy is reviewed across ministries. Annex 1 briefly discusses the institutional landscape of SLM expenditure, which discusses the budgeting process and the institutions involved in budgeting process. The annex also discusses the process used to determine SLM expenditure. SLM expenditure is also reviewed by source of funding and geographical location. The major sources of funding for SLM public expenditure are the government and donors (annex 4: Main actors in SLM in Mali). The focus is on actual expenditure.[11]

GOVERNMENT-FUNDED SLM EXPENDITURE

The Ministry of Infrastructure and Transport accounts for the largest share of actual government-funded SLM expenditure (49%) (Table 13). This large share is due to the capital expenditure on roads and other infrastructure. Investment in transport and infrastructure also has multiplier effects in other sectors, and the effectiveness of other policies is affected by transport and infrastructure development. Hence, such a large allocation to policies that improve market access and the commercialization of agriculture and other rural sectors is well justified.

Allocation to food security via the Ministries of Agriculture, Livestock and Fisheries, and the Commission for Food Security accounts for the second largest share of actual government-funded SLM expenditure (36%). This reveals that the priority policies are market access, the commercialization of agriculture, rural livelihoods, and food security. The share of the allocation to other policies is quite low -- less than 6% -- suggesting that such policies are not a high priority. However, some of the objectives of these policies could be accommodated in other ministries. For example, the conservation of natural resources and combating of desertification are addressed through agroforestry, soil erosion control, and the prevention of land degradation programs under the Ministry of Agriculture.

Table 13: Actual Real SLM Public Expenditures by the National Government

Ministry	**2004**	**2005**	**2006**	**2007**	Average	% of total
	Billion XOF (2000 constant price)					
Agriculture	9.40	6.78	9.71	11.89	9.45	31.5
Environment and Sanitation	0.31	0.65	3.73	1.41	1.53	5.1
Livestock and Fishery	0.00	0.96	1.41	2.24	1.15	3.8
Infrastructure and Transport	13.73	11.62	16.49	16.35	14.55	48.6
Energy, Mines and Water	2.34	2.08	1.38	1.12	1.73	5.8
Territorial Administration and Local	1.78	0.94	1.66	0.61	1.25	4.2
Commission for Food Security				1.16	0.29	1.0
Total	27.55	23.04	34.39	34.77	29.94	
National Budget	657.99	782.20	852.51	0.00		
SLM budget as % of total	4.19	2.95	4.03			

[11] See report on Mali SLM public expenditure review for details.

DONOR-FUNDED SLM EXPENDITURE

The actual expenditure priority for donors is similar to that of the government (i.e. the Ministries of Agriculture as well as Infrastructure and Transport receive the largest allocation of SLM actual expenditure) (Table 14). However, under donor funding, the Ministry of Agriculture received more than the Ministry of Infrastructure and Transport. Hence, the SLM expenditure allocated to food security and market access/commercialization as share of total SLM actual expenditure are quite comparable (44% for food security and 43% for market access and commercialization).

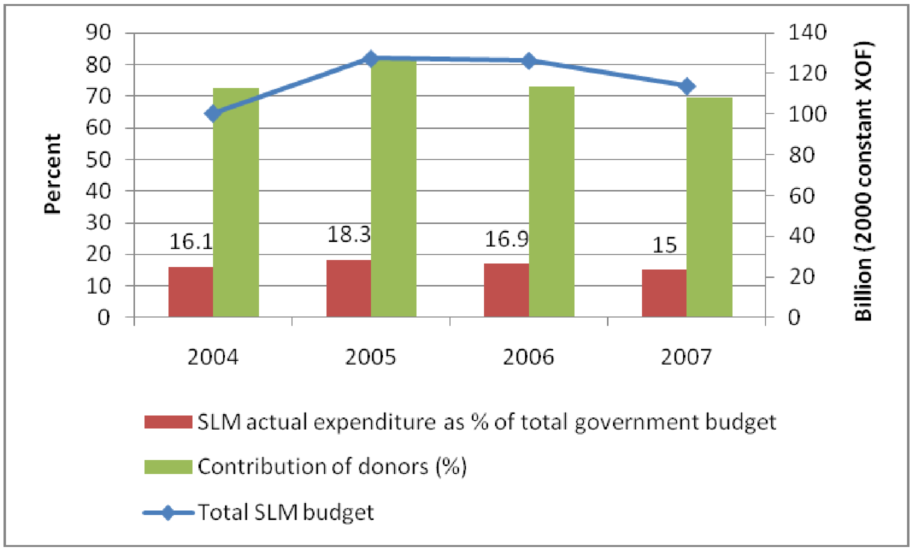
Table 14: Actual SLM expenditures by International Donors

	2004	2005	2006	2007	Average	% of
	Billion XOF (2000 constant prices)					
Agriculture	37.25	44.51	41.44	32.38	38.90	44.6
Environment and Sanitation	1.42	2.10	2.51	3.29	2.33	2.7
Livestock and Fishery	0.00	2.40	3.91	6.99	3.33	3.8
Infrastructure and Transport	26.63	40.94	43.77	33.70	36.26	41.6
Energy, Mines and Water	7.22	14.00	0.26	2.49	5.99	6.9
Territorial Administration and Local Collectives	0.53	0.40	0.10	0.30	0.33	0.4
Commission for Food Security						
Total	73.04	104.34	91.99	79.14	87.13	
National Budget	623.10	694.67	747.16	759.82		
SLM expenditure as % of national budget	11.72	15.02	12.31	10.42		

Total expenditure

The combined government- and donor-funded actual SLM expenditure shows that from 2004 to 2006, total SLM expenditure increased, but declined in 2007 (Figure 10). The 2004-2006 increase is attributed to the increase in funding by both the government and donors. However, the 2007 decrease is due to the donor reduction of SLM funding. The increase of actual government SLM expenditure by 50% from 2006 to 2007 from its 2005 level did not offset the large decrease by donors. The results show the large impact of donor funding on public expenditure and suggest the need for donors to improve their commitment to consistent funding.

Figure 10: Total government and donor-funded actual SLM expenditure



Actual donor SLM expenditure as a share of total actual SLM expenditure is quite high (over 69% throughout the period under review) though declining. The combination of a large contribution by donors to SLM expenditure and the declining trend is a common pattern in SSA countries (Anon 2006). Based on the contribution of land-based sectors to the GDP (more than 37%), SLM expenditure as a share of total government expenditure is still low and the downward trend is a major concern, given the increasing severity of land degradation, climate change, and other challenges. However, the increasing SLM expenditure from government-funded expenditure is an encouraging trend that underlines the importance that the government of Mali places on SLM.

ALIGNMENT OF SLM EXPENDITURE WITH POLICIES

The allocation of SLM expenditure was analyzed across regions and how they were aligned to these policies relating to desertification and conservation of natural resources and biodiversity. Since the implementation of policies is carried out by key ministries, the allocation of funds across the ministries hosting national policies could help determine the alignment of the SLM budget to specific policies. In the six ministries that directly manage lands, there are a large number of policies with overlapping objectives. Table 15 summarizes each ministry's key policies. The association of the policies with the key implementing ministry will help understand the alignment of SLM expenditure with policies. A major weakness of this approach is that there is a strong interrelationship across policies, which, by definition, are related to land management. Hence, the allocation in one ministry may indirectly affect another policy. For example, the food security policy is directly implemented in almost all six ministries. Likewise, the policy on natural resource and environmental conservation is implemented in almost all ministries that implement programs that lead to SLM. Thus, this analysis should only be treated as indicative rather than a strict alignment of SLM expenditure with policies. Food security policy receives the largest allocation of SLM expenditure (45%) through the Ministry of Agriculture as well as the Ministry of Livestock and Fisheries (Figure 11); the allocation has increased slightly from 2004–2007 (Figure 11). To ensure good market access, the policy on market access receives the second highest share of SLM expenditure through the Ministry of Infrastructure and Transportation. The policy on market access provides complementary services to other policies.

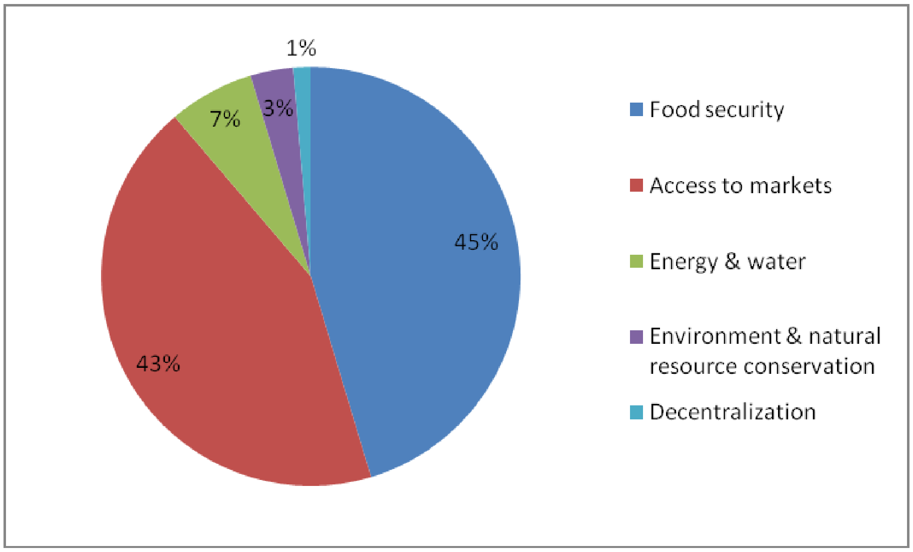
Table 15: Ministries and major policies relevant to land management

Ministry	Major policies relevant to land management
Agriculture	Food security
Environment and Sanitation	(i) Protection of natural resources (e.g. NAP; forestry policy) (ii) Protection of biodiversity (CBD) (iii) Combating desertification (NAP) (iv) Mitigation of, and adaptation to, climate change (NAPA)
Livestock and Fishery	Food security
Infrastructure and Transport	(i) Improved access to markets and services (ii) Commercialization of agriculture
Energy, Mines, and Water	(i) Renewable energy sources (ii) Reduction on dependency on fuelwood (iii) Food security (irrigation water)
Territorial Administration and Local Collectives	Decentralization

Of serious concern is the low allocation of expenditure to natural resources and decentralization, both of which are key to achieving several objectives stated in the NAP, NAPA, CBD, and other policies. Both receive less than 5% of the total SLM allocation. This has severe short-term implications for the level of funding to prevent land degradation and rehabilitate degraded lands. In the short, medium and long-term, strong, well-funded local institutions are also required to manage communal grazing lands and enhance the participation of communities in the carbon credit market. (As it will be seen in the discussion below, providing incentives for communities to stop deforestation will require the provision of such incentives as carbon credits.)

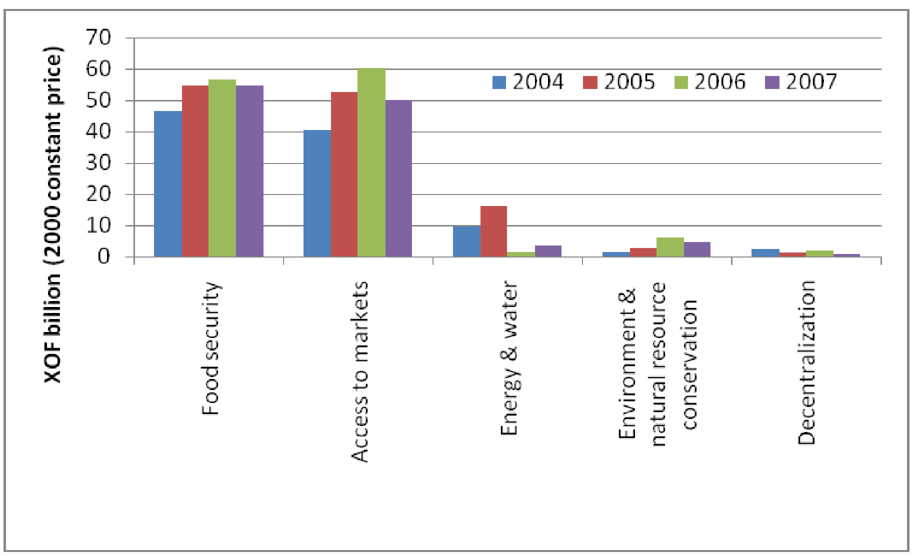
Allocation of expenditure to decentralization is also declining over time, raising doubts on the priority placed on local-level management of natural and other resources. Local governments provide rural services such as rural roads and legislative services for land administration. Additionally, each of the ministries with a significant budget allocation to SLM conducts its local-level management programs through the local governments. Consistent with UNCCD's requirement of decentralization and a participatory approach in implementing activities for combating desertification (Bruyninckx 2004), Mali's NAP implements its activities through the local governments (RDM 2000). Hence, the declining allocation to SLM through local government suggest that, while food security seems to have a resource allocation well-aligned with its importance, policies on natural resources and environmental conservation are not well-aligned with the decentralized budget allocation to SLM.

Figure 11: Allocation of SLM expenditure across land management policies



Notes: Food policy (Ministries of Agriculture, Livestock & Fisheries & Commission for Food Security); Access to market (Ministry of Infrastructure and Transport); Energy & water (Ministry of Energy Mines & Water); Decentralization (Ministry of Territorial Administration and Local Collectives)

Figure 12: Alignment of SLM expenditure with policies – trend 2004 - 2007



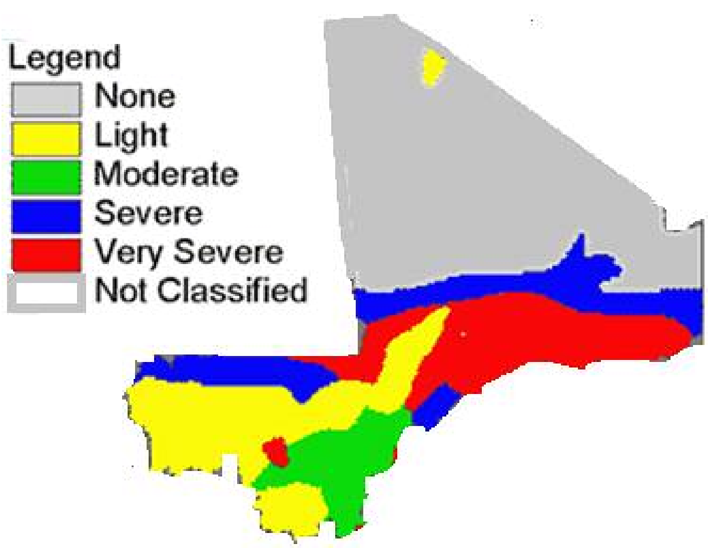
Targeting of SLM Expenditures

In this section, the targeting of SLM expenditures to land degradation hotspots is investigated. Human-induced land degradation is very severe in the middle belt and is also evident in the Sahelian zone, where there is intensive irrigated and rainfed crop and livestock production. Anthropogenic land degradation is moderate-to-light in the Sudanian and Sudano-Guinea zones (Figure 13). Since SLM expenditure is recorded at the regional level, the allocation of the SLM budget is examined along regional boundaries.

The regions covering severe to very severe land degradation areas are: Mopti, Segou, northern Koulikoro and Kayes, and southern Tombouctou and Gao. Table 16 presents real SLM public expenditures by region for 2003-2007. Calculating the average expenditure received by region over this period, Tombouctou, followed by Segou and Mopti, had the highest allocation of SLM public expenditures. The three regions lie in an area of severe to very severe degradation. However, examination of expenditure across ministries showed that Segou received the largest allocation of SLM expenditure from the Ministry of Agriculture (Figure 14). Mopti received the second largest allocation from the Ministry of Agriculture. The two regions are the bread baskets of Mali. Segou accounted for about 40% of millet and 50% of rice production, while Mopti contributed 21% of millet and 12% of rice production in 2005/06 (FEWSNET 2008). The high SLM expenditure in the regions with severe to very severe degradation demonstrates the targeting of expenditure to degraded areas and alignment to policies on combating desertification, natural resource conservation, and biodiversity.

The allocation also reflects well the synergies across policies. For example, combating desertification also improves food security and contributes to natural resource and biodiversity conservation. Hence, even though the policies on natural resource and biodiversity conservation and combating desertification did not seem to have received priorities under the ministry-level analysis, regional analysis reveals the indirect achievement of such policies via the Ministries of Agriculture and Livestock and Fisheries.

Figure 13: Extent and severity of anthropogenic land degradation

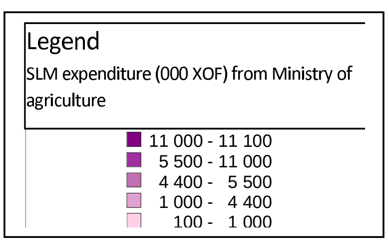


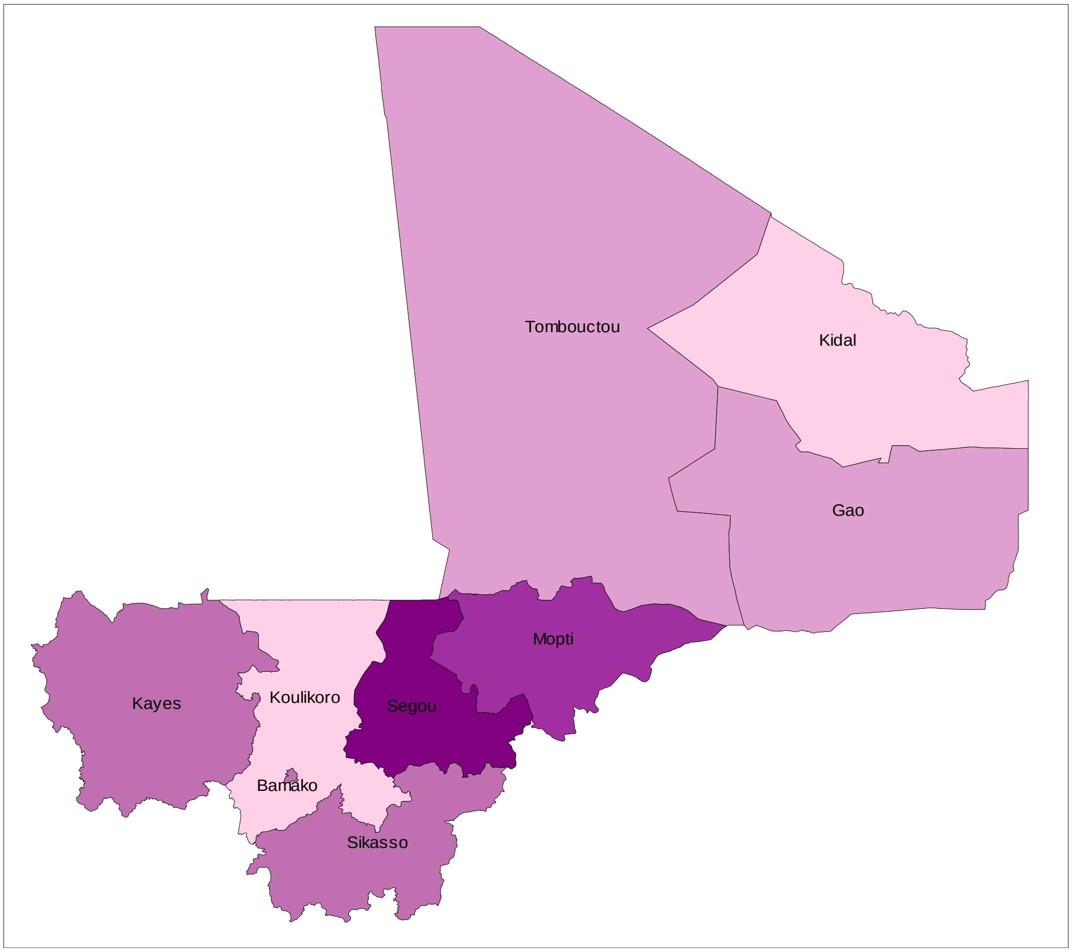
Source: FAO.

Table 16: Public SLM expenditures by region (at constant prices)

	2003	2004	2005	2006	2007	Average
	Billion XOF (2000 constant prices)					
Tombouctou	0.61	0.84	2.98	2.72	2.06	1.84
Ségou	1.04	2.11	2.03	1.94	1.61	1.74
Mopti	0.41	1.52	2.34	1.43	1.38	1.42
Bamako	0.01	2.24	2.12	2.11	0.10	1.31
Sikasso	1.07	0.69	1.21	1.67	1.47	1.22
Gao	0.00	0.31	1.57	1.58	2.60	1.21
Kayes	0.60	0.78	0.18	0.34	0.33	0.44
Koulikoro	0.23	0.28	0.04	0.37	0.36	0.26
Kidal	0.00	0.03	0.03	0.11	0.11	0.06

Figure 14: SLM expenditure in the agricultural sector across regions (2007)





COMPARISON OF THE NIGERIAN WITH THE MALI BACKGROUND STUDIES

Studies on the use of fertilisers (inorganic and organic) in both countries (IFPRI, 2009, Banful et al, 2010) showed that integrated soil fertility management (ISFM) practices are more profitable than practices that use either inorganic fertilizer or organic soil fertility management practices alone. However, it was observed that, in both countries, ISFM adoption rates were lower than those for fertilizer or manure alone.

The factors behind the low adoption rates were similar in both countries, i.e. households with livestock and access to extension services were more likely to adopt ISFM. In Mali, however, a greater proportion of farmers were using manure and compost than in Nigeria. This difference could be because of the traditional organic land management practices in Mali, where composting has been practiced for centuries by farmers as a traditional land management practice. Due to the targeting of inorganic fertilizer in Mali and the non-targeted availability of often subsidized fertilizer in Nigeria, fertilizer use in Nigeria is spread out to more crops than is the case in Mali, where cotton and rice account for the bulk of fertilizer consumption. These differences reflect the impact of national policies on the adoption of production technologies.

In terms of public SLM expenditure, donors in Mali account for over 70%, while the donor share in Nigeria is 5%. The donor contribution to Nigeria's government public

expenditure in other sectors is generally also lower than is the case in many other SSA countries. Decentralization in Nigeria is also much stronger than is the case in Mali. This has affected the SLM budget allocation to local governments. Nigeria allocates a large share of the federal budget to state governments, which, according to the case study states, allocate a much larger share of their budget to SLM expenditure than the federal government.
In terms of the allocation to SLM, Mali provides about 16% of its total national budget to SLM, while Nigeria allocated an average of 1.7% of its federal budget to SLM. Thus, at the national level, the SLM allocation in Mali is 10 times higher than it is in Nigeria. [Note however, these numbers are not directly comparable, since Nigeria has decentralized its expenditure, giving states a role in making budget allocations.]

IMPLICATIONS OF THE BCA FOR INTERVENTIONS IN LAND DEGRADATION AND PUBLIC SLM EXPENDITURE

The analysis above showed that the land management practices that are sustainable are also profitable, while those that degrade lands have lower (and progressively declining) returns. The first question is: what factors drive the adoption of land management practices that are sustainable and profitable? The second important question is: how can current SLM expenditure be changed to enhance the adoption of profitable SLM practices and to more effectively direct public land investments to the prevention of land degradation and the rehabilitating of degraded lands?

Despite the high returns to SLM practices that combine fertilizer and organic soil fertility management practices, their adoption rates were very low. Only 18% of farmers / land users reported the use of both inorganic fertilizer and manure. Labor costs are a large share of total costs of the SLM practices studied; this could be a hindrance to wide-scale adoption of labor-intensive land management practices like manure application.
In order to enhance adoption of SLM practices, efforts need to be increased to reduce the high-labor intensity of SLM practices. Investment in the development and promotion of animal power and mechanization using simple and affordable equipment and machines needs to be increased. Tenure security, vocational training, and higher education also have favorable impacts on the adoption of ISFM, suggesting that improvements in tenure security and increasing investment in education and vocational training will enhance use of SLM practices.

Increasing the adoption of SLM will require simultaneous improvements in the drivers with positive impact. This should **start with the improvement of the agricultural extension services**, in order that they provide advisory services on SLM and animal power. A study carried out in Nigeria and Uganda revealed that the major messages that extension agents provide to farmers are related to improved crop varieties and inorganic fertilizer (Banful et al., 2010). Extension services on organic soil fertility management (e.g. manure use and tree planting – SLM practices) are quite limited in both countries (Ibid). Extension services in Mali are generally supply-driven with little capacity to use the extensive body of indigenous knowledge that farmers have acquired in using organic soil fertility management practices.
Securing land tenure is essential for promoting long-term investments in land. Mali is currently exploring strategies for formalizing the customary land titles, which, according to 2004/05 agricultural survey data, account for about 80% of household plots The ongoing formalization of the customary land tenure system is the right strategy for achieving this, but cheaper methods of conducting cadastral surveys are required to ensure faster, cheaper, and more cost-effective cadastral surveys. For example, Tanzania is currently implementing a

pilot universal land registry using remote sensing data, which has been shown to be cheaper and faster than the conventional cadastral process (Huber et al., 2008; Kironde 2009). Such strategies could also be used in Mali to speed up the registration process. Investment in education will require an integrated approach involving the Ministry of Education, poverty reduction programs, and other development programs.

If these investments are implemented and increase the adoption of SLM, returns will be much greater. For example, the adoption of 40 kg N/ha, 1.7 tons/ha of manure, and 50% crop residues will more than triple maize and rice NPV's from their current levels (Tables 4 & 5). This suggests that the promotion of SLM could have high returns.

Improvements in forest protection could be effectively catalyzed by increasing the economic returns to local people, for example through the provision of carbon credits, which needs to be supported by strong local institutions to ensure compliance with by-laws and government statutes prohibiting the encroachment of forests. Landholders should also be encouraged to plant trees. This requires a significant increase in the current funding of local governments and that several institutional weaknesses discussed earlier are effectively addressed. The current Decentralization Act also needs to be revised to allow villages to enact and enforce regulations. The current Act only allows communes comprising of 11-45 villages to enact and enforce by-laws. Empowering communes will strengthen the local communities to better manage forests and woodlots. For example, the enforcement of regulations prohibiting tree cutting and bush burning is more effective when the communities surrounding forests are involved in the management and benefit from the forests.

Investment in forest extension services is also required. The training of forest technical staff is limited in Mali since the Centre de Formation Pratique Forestier has produced only 25 graduates every two years in the period 1993-2002 (Temu et al., 2005), a level that limits provision of forest technical services.

Likewise, **investment in the livestock sector has a large potential to increase income and reduce poverty among livestock farmers in the country's drier zones.** Improving livestock productivity through the promotion of rotational grazing and other rangeland management methods requires an increase in the budget allocated for livestock production, but also should reap benefits for local people from PES (Neely et al, 2009, Tennigkeit and Wilkes, 2008). Strong local institutions are also essential for managing communal grazing lands and to enforce rotational grazing. This further justifies an increased allocation of resources to local governments to enhance their capacity to manage natural resources. As is the case for crops and forests, livestock extension services are also weak and require significant improvement to increase the adoption of improved livestock production methods. Below, possible investments are discussed.

These investments will help improve the protection of natural resources; this has been shown to be cheaper than the rehabilitation of degraded resources (Schwilch et al., 2009).

Chapter 4: Toward improvements of rural land quality

DEVELOPMENT DOMAINS, DEVELOPMENT PATHWAYS, AND ENTRY POINTS

A development domain is an area with a comparative advantage for producing a certain good or goods or providing a service or services. Development pathways are the economic activities in which each of development domains has a comparative advantage. For example, sparsely populated areas in the Sahelian zone have a comparative advantage for livestock production, while the Guinea-Sudano zone has a comparative advantage for the rainfed crop production. The country's development domains fall roughly along the country's agro-ecological zones (see Figure 15). Below, the development pathways in each of the development domains are discussed; the Sahara zone is not included because it is so sparsely populated and has limited production.

Based on the results of this study, the investments required to support each development pathway are evaluated. These investments are linked to existing or not-yet-planned programs that could serve as an entry point for interventions to support each development pathway. Such entry points help enhance and complement existing programs. Also discussed is the enabling environment that will enhance uptake of each SLM practice. Annex 3 summarizes the development pathways, the SLM practices to be promoted, the investment required to promote SLM adoption, the enabling environment, and the entry points.

Sahelian development domain

The main comparative advantage of this zone is livestock production and irrigated crop production. The regions predominantly in the Sahelian zone account for over 40% of Mali's cattle population (CPS 2004/05). **Given the increasing demand for meat and livestock products, this sector provides an opportunity to reduce poverty in the Sahelian zone and to increase the sector's contribution to GDP.** One approach to increasing livestock productivity is rotational grazing, which increases pasture biomass by 7% to 20%. Studies have shown that rotational grazing leads to an average live weight gain ranging from about 10% to 30%. Investment in improving breed productivity, for example promoting increased off-take and reduced herd sizes (with massive cc mitigation benefits as it reduces methane production) and veterinary services (including training "para"-vets, particularly to help control endemic diseases and advise on improving the genetic quality of stock) could also enhance the Sahelian zone's low productivity. Parallel investments in livestock-related infrastructure *inter alia* shade, markets, cold stores, abattoirs and product processing are also necessary.

The effects of climate change also require investment in water harvesting (e.g. run-off can be used more productively and infiltration increased by pitting / zaï or tied ridges, also by increasing surface roughness, contour furrows / bunds) also moisture conservation technologies (e.g. reduced tillage, use of compost, conservation agriculture) to help alleviate the anticipated reduced precipitation and increased intensity of rainfall in the Sahelian zone (Figure 1). It is estimated that 48% of land area in Mali falls within a water-livestock investment domain, which are livestock-dominated grazing areas or livestock-rainfed crop production systems or mixed livestock and large-scale crop irrigation systems (Peden et al., 2006). This area supports 8.12 tropical livestock units (TLU)[12] and 92% of the population (Ibid). This underscores the importance of investing in the livestock sector.

[12] TLU combines all livestock types into one unit. One TLU = 250 kg of live animal weight (Peden et al 2006).

Irrigated crop production is also important in this zone. **Irrigation addresses erratic rainfall and climate variability, which are most pronounced in the Sahelian zone.** Mopti and Tombouctou each account for 12% and 11% of rice production in Mali, respectively. This underscores the importance of a well-developed irrigation system in the semi-arid zone. Dillon (2009) showed that agricultural production increased by more than threefold when farmers gained access to irrigation in the Sahelian zone. The returns to investment in rice are high. Hence, promoting irrigated rice is expected to achieve a high pay-off. Additionally, promoting horticultural crops planted in the dry season after rice could increase returns to irrigation investment and improve soil fertility.

Efforts to promote SLM practices will also help increase returns to investment and reduce climate change-related production risks. This could be achieved through improving the capacity of extension advisory services and their knowledge of SLM practices (including increasing the range of practices promoted – e.g. silvopastoral and agroforestry, re-seeding degraded rangelands with leguminous species) improved livestock production, and climate change. This can be done through short-term training for extension workers, also the wide-scale distribution of extension messages on SLM (*inter alia* using posters, pictorial guides, newspapers, radio), the school curricula, setting-up of demonstration plots for farmer visits, also through farmer field schools. Further research is also required to develop new technologies that respond the challenges of climate change and to the Sahelian environment.

Sudanian zone

The comparative advantage in the Sudanian zone is rainfed and irrigated crop production and livestock production. Investment for the development of rainfed crop production and livestock requires the enhancement of agricultural research (and also local adaptation of research results from elsewhere) that focuses on responses to climate change and other new environmental challenges / opportunities. Butt et al. (2006) estimated that breeding heat-resistant crop varieties could reduce the share of the population under hunger risk to as low as 28%. They also showed that soil fertility management would reduce climate change-related economic losses by 66% and undernourishment by 17 percentage points if soil fertility management practices were adopted. The suggested improvements to livestock and irrigated crop production systems discussed above also apply to the Sudanian zone.

Sudano-Guinean zone

Forestry and rainfed agriculture have comparative advantages for farmers in the Sudano-Guinean zone. There are currently large incentives for farmers to clear forests and plant maize and other crops, which bring higher returns than they can gain from woodfuel, timber and non-timber forest products (NTFPs). However, if communities surrounding the forests were also able to participate in the carbon market, protecting forests would be more remunerative than clear cutting forests. Other local benefits that communities could draw from forests include more equitable access to non-timber forest products and the proceeds from ecotourism.

Improving the capacity of local institutions to manage forests and the development of measurable, reportable and verifiable (MRV) strategies will also lead to large pay-offs to forest investments. Particularly, existing and new community land management groups (unites de gestation de terroir) which “enjoy local specificity and independence in their decision making process” (Borrini-Feyerabend et al, 2004) should be promoted. These groups need to have the authority to exercise the right to govern common resources as well as financial autonomy, enabling them to eventually share the financial benefits as funding flows from the carbon market to local participants – and particularly have the moral and financial support of decentralised government. The Sudano-Guinean zone also has a comparative advantage for producing horticultural crops, largely due to its better market access than other agroecological zones, which allows the production of highly perishable crops. The investment required to promote horticultural production in the zone includes improvement to market access, the promotion of production and marketing groups that will help farmers connect to markets, and the reduction of transaction costs.

Investments that cut across development domains

Non-farm activities: **Non-farm activities are important in all development domains because they enhance diversification of livelihoods towards activities which have less dependency on crop and livestock sectors, both of which are prone to the adverse effects of climate change and variability.** In order to enhance returns from both non-farm and agricultural (crop and livestock) sectors, it is important to create synergies and forward and backward linkages between the two sectors. Agricultural processing activities and agricultural input marketing activities are examples of non-farm activities that can increase agricultural productivity. Non-farm activities also reduce land pressure. Investment in rural credit services, formal education, rural electrification, and the improvement of rural roads and other communication infrastructure and institutions have been shown to promote non-farm activities (Haggblade et al., 2007). Rural vocational training also enhances non-farm activities. This should particularly be targeted to the youth to develop their vocational skills and reduce the haemorrhaging of youth to urban areas. The targeting of such vocational training to the agricultural sector will strengthen the linkage between agriculture and non-farm activities.

GAPS IN THE STUDY AND FURTHER RESEARCH

Detailed public expenditure data could not be obtained which would have allowed analysis of detailed returns to specific public investments. This is due to the fact that most public expenditure data are recorded at the departmental level, making it harder to determine, for example, returns to specific land management practices such as soil erosion control. Also, expenditure data was only available for the years 2003-2007, which limited trend analyses.

Due to data limitations the study also did not cover all crops, nor all appropriate sustainable land management practices. However, the enterprises selected covered a large share of the land-based enterprises: crops (69%), forests (100%), and rangeland (approximately 70%).

Not all of the off-site effects of land degradation were captured, again due to lack of data. For example, it was important to compute the sedimentation in other river basins but time and data were major limitations.

Future research should investigate these and other aspects (e.g. adaptation of SLM approaches used elsewhere to the Malian situation) in order to better inform policy makers and other stakeholders.

CONCLUSIONS AND POLICY IMPLICATIONS

Mali is one of the few countries in Sub-Saharan African (SSA) that spend a significant share of their budget on land-based sectors. The country has also designed an elaborate institutional landscape for the management of natural resources. As it covers arid and semi-arid areas, the country is also among the few SSA countries that have invested significantly in irrigation. **Our analysis shows that government-funded expenditure on SLM is increasing and is well-targeted to the degradation hotspots in the north.** This suggests an increase in the government's attention to natural resource management. Hence, the important question is what type of future expenditure will lead to greatest pay-offs / benefits? This study provides some insights into the type of public investments that the government and donors should direct their support.

The study's findings include that SLM practices are the most profitable, but that their adoption rates are low. It was also found that rotational grazing and the prevention or addressing of salinity has a high pay-off. Major reasons for the low adoption rates of SLM include their high labor intensity, limited promotion by extension service providers, high price of unsubsidized fertilizer, and household characteristics. Insecure land user rights likely also contribute to the limited adoption of SLM rotational grazing, and control of salinity. The development of labor-saving technologies and the enhancement of widely-used animal power would help increase the adoption rate of SLM. Agricultural advisory services on SLM are also limited in Mali and other SSA countries. This suggests the need to increase the capacity of extension service providers through short-term training and up-scaling SLM information campaigns using tv, radio, newspapers, leaflets, posters, school curricula, adult education, demonstration sites and farmer field schools.

Research needs to be enhanced in the full range of SLMs relevant to Mali, to widenthe range of SLMs used and specifically devise packages of recommended SLM technologies suitable for each agro-ecological zone, particularly to address increasing climate variability and change (adaptation and also mitigatin). This suggests the need for increasing resource allocation for research or adaptation of systems being adopted elsewhere-.

Current subsidies for cotton and rice have contributed to the weak development of the private fertilizer input markets, which could be more efficient and could provide services to growers of other crops. **There is a need for the government to reconsider its current approach of subsidizing fertilizer to ensure that it fosters growth of an efficient private sector.**

Land rights for the majority of landholders with customary tenure are not secured. Government's efforts aimed at improving land user rights through registration is expensive and cumbersome, suggesting the need to use a pragmatic approach that protects the rights of the customary tenure land users without having to register their land. Studies elsewhere have shown that customary land tenure provides land holders with security that allows them to undertake long-term investments. The rights of customary tenure landholders in Mali are, however, at risk, and they have at times been victims of expropriation by the government and chiefs (Benjamin 2008).

Weak local institutions could also limit the adoption of rotational grazing and other SLM that require collective action to implement. **There is a need to devote more resources to strengthen the capacity of local institutions to manage natural resources collectively.** This could be carried out through initiatives such as community action projects that encourage preparation of village development plans and community organization, which are common in other sub-Saharan African countries, which have followed decentralization.

It was observed that farmers' education and vocational training is crucial to the adoption of SLM. Primary education, however, did not have an influence on the adoption of SLM, suggesting the need to introduce natural resource and environmental management in the primary school syllabus. The National Action Plan (NAP) and the National Adaptation Programme of Action (NAPA) both have activities promoting awareness of natural resources and the environment. Such efforts could be an entry point for enhancing land users' knowledge about ISFM.

Uptake of SLM technologies only addresses production aspects and not the marketing aspects. **There is need to improve agricultural marketing in order to provide incentives for farmers to use SLM and other production technologies**. This includes establishing market information aimed at smallholder farmers, developing roads and other rural infrastructure, and other rural market investments. To reduce post-harvest losses and enhance the value of agricultural products, there is also a need to invest in developing agricultural processing and value-addition services.

Regarding targeting of expenditure, there is a need to pay more attention to the conservation of forests in southern Mali. Conservation has been shown to be less costly than the rehabilitation of degraded lands. However, an increase in conservation of lands with moderate or no degradation should not be carried out at the expense of expenditure on degradation hotspots. Rather, conservation expenditure should be drawn from other resources. Efforts to benefit from the Clean Development Mechanism (CDM) and other global ecosystem programs should be increased in order to reward farmers who participate in conservation. Consideration for the development of alternative energy sources needs to be given in tandem with developing and facilitating of carbon market participation. This approach is expected to reduce the demand for firewood from the forests.

Local government involvement is essential to increase up-take of rotational grazing, prevention of deforestation, and support local communities' participation in the CDM and other carbon credit markets. Currently, Mali allocates only 1% of the SLM expenditure to local government. There is therefore a need to direct more resources to strengthen local governments. This will enhance the alignment of SLM expenditure to the Malian decentralization policy and its efforts to implement its NAP and NAPA programs, both of which use local governments to implement their activities. There is also need to revise the decentralization policy, which does not give a sufficient mandate to villages to enact by-laws. Allowing villages to enact by-laws would enhance their compliance. Efforts to increase economic interest groups and cooperatives would also help smallholder land users to work collectively.

Finally, a conclusion of this study is that the **promotion of SLM practices will require close coordination between many ministries, departments, NGOs, and other stakeholders involved in rural development**.

Annex 1: SLM Institutional landscape and determination of SLM expenditure

INSTITUTIONAL LANDSCAPE OF SLM EXPENDITURE IN MALI

There is an elaborate institutional structure in Mali that directly affects land management (Figure 15). First the Ministries are reviewed that manage land directly, followed by an analysis of the institutions that plan and allocate SLM expenditure. There are seven Ministries involved in direct management of land, which in turn allocate budget for land management. A Commission for Food Security has been formed, and it receives a separate budget. There are also NGOs and projects supporting land management. These are discussed below along with their relevance to land management.

Ministry of Agriculture

The Ministry is responsible for crop production. As it will be seen below, the Ministry of Agriculture is the largest Ministry that directly affects land management and accordingly receives the largest share of the SLM budget allocation from the government and donors. The Ministry has five departments or programs that deal directly with land management:

(i) The 'Cellule de Planification et de Statistiques' (CPS) is the statistical and planning department that collects and analyzes data and designs development plans. CPS carries out agricultural household surveys and other types of data collection.

(ii) The 'Comite National de la Recherche Agricole' (CNRA) coordinates research done by national 'Institut d'Economie Rurale (IER) and research done by the Ministry of Agriculture, Ministry of Environment and Sanitation, the Ministry of Economic Planning and university and colleges. The coordination of research of different institutions across ministries under the CNRA is one of the strengths of the SLM institutional structure in Mali.

(iii) The 'Direction Nationale de l'Agriculture' (DNA). The DNA manages and coordinates production of crops other than rice and cotton. DNA also coordinates plant protection, including locust control.

(iv) Office du Niger (ON). ON is responsible for irrigated rice in the Niger River basin. ON manages rice production and marketing. In addition to rice, ON also supports other agricultural systems in the ON area. Realizing the benefits of an integrated approach, ON has increasingly been integrating other crops and livestock.

(v) The Compagnie Malienne pour le Developpement des Textiles (CMDT) coordinates cotton production and marketing. As is the case with ON, CMDT has increasingly integrated other crops and livestock produced in the cotton belt of Mali. Working under ON is the Office de la Haute Vallee du Niger (OHVN), which supports cotton production. It is largely funded by USAID and provides technical support to farmers. OHVN introduced high-input cotton production technologies, which has demonstrated high returns.

Ministry of Environment and Sanitation

The Ministry of Environment and Sanitation manages environmental issues. The Ministry has two major departments that deal directly with land issues:

(i) Secretariat Technique Permanent du Cadre Institutionnel de Gestion des Questions Environnementales (STP/CIGQE) is responsible for land and environmental management. STP coordinates efforts to combat desertification under the NAP and other initiatives. This sets the Ministry in the center-stage of land management. Through the Comité Interministeriel, STP coordinates departments and other ministries to implement land and environment programs.

(ii) Direction Nationale de la Conservation de la Nature' (DNCN) manages broadly defined natural resources. Its overall objective is to sustainably manage natural resources. DNCN has branches at regional and sub-regional level. DNCN works with communities on a variety of natural resource management issues. These provide key support for articulating the local agenda.

Ministry of Housing, Land Affairs, and Urban Development

It is under this Ministry that issues related to land tenure are administered under the cadastral department. Land tenure formalization is quite expensive and out of reach for the majority of poor farmers.

Ministry of Territorial Administration and Local Communities

This Ministry is the centerpiece of decentralization, which is key in natural resource management at the local level. Under each of the eight regions, the Ministries discussed above conduct their local level management issues through this Ministry. The communes – each comprising of 11to45 villages - develop economic plans, which are funded by the local and central governments. As discussed above, the communes also enact and enforce by-laws for land management.

Ministry of Livestock and Fisheries

To give emphasis to livestock and fishery, this ministry was formed out of a department in the ministry of agriculture in 2005. The Ministry has four departments, namely veterinary and public health, fishery, animal production and development, and administration.

Ministry of Infrastructure and Transport

This Ministry also hosts the department of meteorology. The Ministry oversees rural roads and other types of infrastructure development and management, which are key for land investments. However, the Ministry only provides meteorological data and does not deal with issues related to adaptation to climate change. Infrastructure development is also important in land management practices.

Ministry of Energy and Water

This Ministry directly affects land-based production activities. This includes irrigation water. Hydro-electric power, which largely serves urban communities, is also managed under this Ministry. However, the Ministry has also been exploring alternatives to the fuelwood – the most common energy source to the majority of people in Mali. Under the 'Direction Nationale de l'Energie (DNE), the Ministry seeks to reduce firewood consumption and to develop biofuel and energy-efficient stoves.

Commission for Food Security

In response to Mali's long-term objective of achieving food security, the government formed a special commission for food security and started allocating it special budget in 2007.

Non-Government Institutions (NGOs)
More than 1000 NGOs work directly on land and environmental issues in Mali. These provide technical support including extension services, capacity building of local institutions to manage natural resources, rural financial services, and other services.
Donors and External Aid in Land Management
Donors are actively involved in funding and implementing land management programs. As it will be seen below, donors account for the largest share of SLM expenditure. These include projects on combating desertification, water management, afforestation and agroforestry, and climate change. Most of these projects are implemented under the Ministry of Environment and Sanitation which, as seen above, is heavily involved in the land management.
The discussion above shows that Mali has an elaborate institutional structure that provides a reasonable framework for implement land management programs, which is summarized in Figure 15. It is also interesting to note that the Ministry of Environment and Sanitation takes a leading role in land management, an aspect that is dominated by the Ministry of Agriculture in other countries. Coordination across ministries and departments in Mali is also reasonable though still requires significant improvement to address the various challenges such as land degradation, desertification, and other forms of land degradation and climate change.

INSTITUTIONAL LANDSCAPE OF SLM BUDGETING

Several institutions play a key role in the process of planning and allocation of public resources, particularly the National Directorate of Development Planning (DNPD), the Planning and Statistics Departments and projects and programs. The DNPD, under the Ministry of Finance, is charged with budgetary planning to meet the needs of national policies and priorities at the national, regional and local levels with an increased emphasis on decentralized planning. The CPS coordinates budgetary planning within each Ministry and is responsible for the Ministry's planning and coordination with the DNPD. In addition to prioritizing and planning the Ministry's budget request with the DNPD, the Ministerial CPSs also coordinate intra-sectoral projects.

Below the budgeting process is discussed in detail, focusing on the government Ministries, departments and agencies. The budgeting process of donors is not addressed, since they channel their support through the government ministries.

National Directorate of Development Planning (DNPD). Under the supervision of the Ministry of Finance, the DNPD develops elements of national policy planning and development management and their implementation. The DNPD develops broad guidelines for economic, social and cultural development of the national, regional, and local-level medium and long-term economic and socio-cultural development strategies. These guidelines are given to the regional departments to prepare their budgets, which are in turn submitted to the corresponding national Ministries and departments (Diallo, 2009). To develop these guidelines and strategies, the DNPD relies on the statistical departments (CPS) from each ministry for data required for planning. The CPS from each ministry is responsible for data collection, analysis and program planning based on the statistical data and policies. CPS coordinates the preparation of plans, programs, and projects and the analysis of policies and strategies. It also monitors and evaluates plans, programs, and sectoral development projects and to ensure their consistency and intra-sectoral programs. The CPS also develops, forecasts, and monitors environmental conditions. The CPS further tracks records relating to financing and technical cooperation. To ensure that the planning is well-coordinated between the ministries and the corresponding local government departments, the Regional Directorate of Planning, Statistics, Informatics, Spatial Planning and Population – [Direction Régionale de la Planification, de la Statistique, de l'Informatique, de l'Aménagement du territoire et de la Population (DRPSIAP)] – collects data and the corresponding regional and sub-regional plans and strategies. This is one of the key vehicles of the decentralization process.

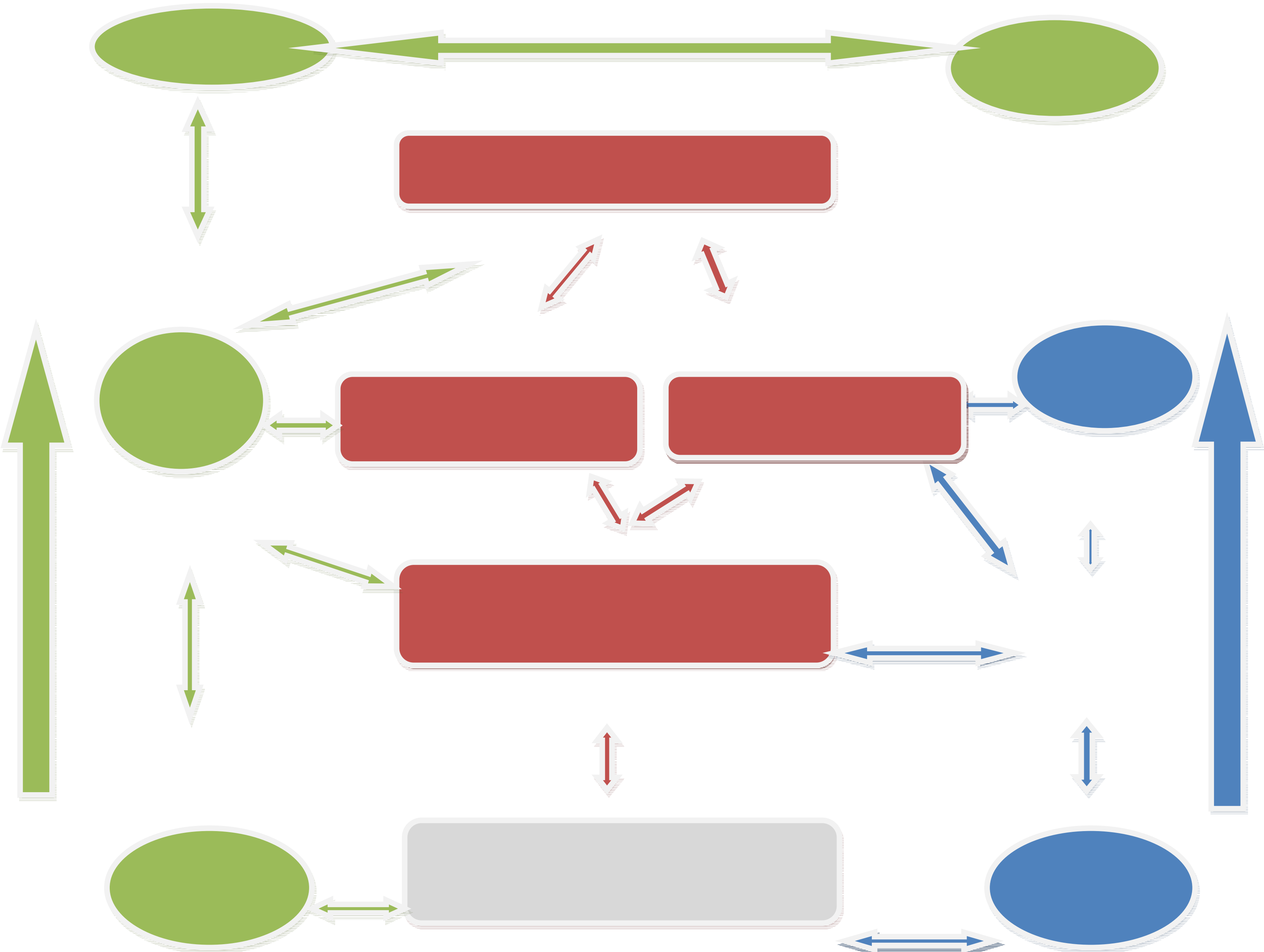
Budgeting process and decision-making bodies. In each ministry, a public investment program is developed in each sector by the sectoral technical department. A corresponding program development is done at the regional level. The aim of the cross-sectoral coordination and integration in each ministry is to ensure that the programs under each sector of the ministry respond to the broad objectives of the ministry. Forums for dialogue are then held within the ministries to ensure there is harmony in the sectoral programs and that the budget suggested by the DNPD is not exceeded. The inter-sectoral integration and harmonization of budgets form the Triennial Investment Program (PTI) and the Special Investment Budget (BSI). The PTI and BSI are used to guide the annual budgets.

The third stage of the budgeting process involves integration of the ministerial PTI and BSI. This is done by the DNPD and involves the following steps:

- CPS / DAF send their PTI and BSI to the DNPD and the corresponding databases;
- DNPD convenes a preliminary technical meeting to discuss the proposed budgets. This meeting is attended by all ministries and departments that prepared the budgets;
- The DNPD compiles the assessment reports on the decisions made in the technical meetings; and
- The DNPD then sends the budgets of all ministries to the Prime Minister's office for approval before the budget is presented to the national assembly for final approval. It is in the national assembly where a strong debate involving representatives of the general public takes place at national level. Participation in the budget process by the general public at a level lower than the regional departments discussed above is limited.

Figure 15: SLM Public expenditure budgeting institutions and processes

Key to Figure 15: Budget Spécial d'Investissement (BSI); Programme Triennal d'Investissement (PTI); Direction administrative et Financière; DNCT Direction Nationale des Collectivités Territoriales; Direction Générale du Budget (DGB); Direction Nationale de la Planification du Développement (DNPD) ; Direction Administratif et Financière (DAF).

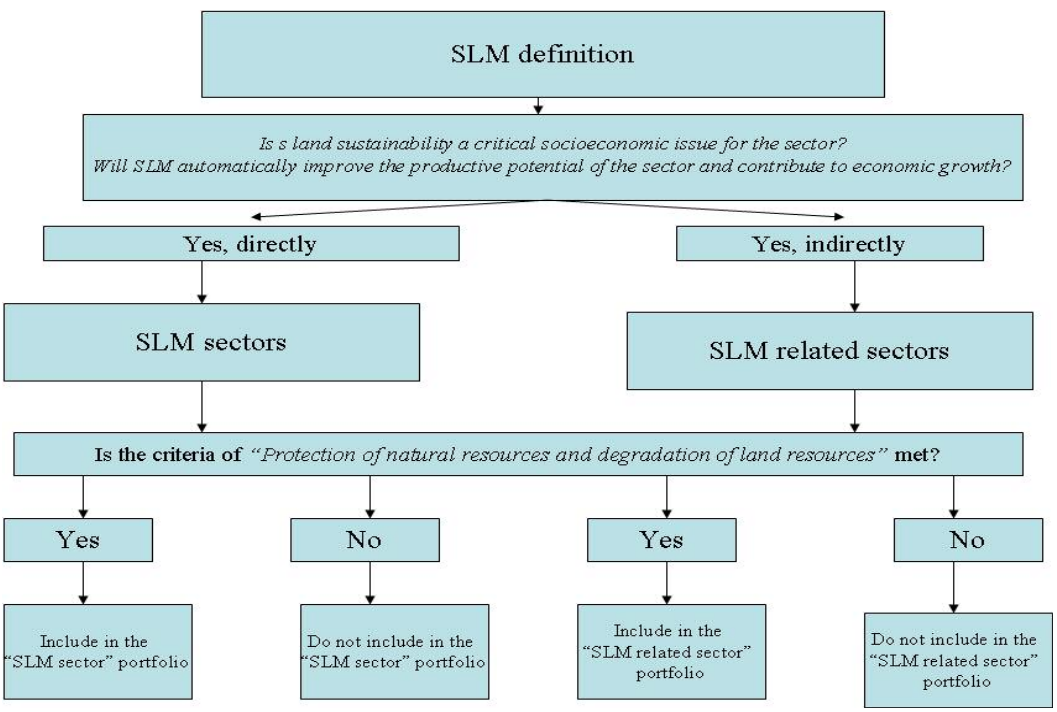


The regional level budget process follows a procedure corresponding to the national procedure described above. The regional assembly approves the final budget. Of interest to note here is that the sources of funding for the regional budgets include central government transfers, which accounts for the largest share, and revenue generated at regional level, including taxes, revenue from economic activities, donor funding, etc.

PROCEDURE FOR DETERMINATION OF SLM PUBLIC EXPENDITURE

The decision to categorize expenditure as SLM was guided by the definition of SLM given above. The focus was on programs and projects have intended and relatively direct impacts on land management, such as technical assistance programs to promote SLM, establishment and enforcement of protected areas or other land use regulations, and investments to improve rural land tenure security. Figure 16 served as the decision tree for determining the SLM expenditure portfolio. Expenditure data was collected from the following Ministries: Agriculture, Environment and Sanitation, Livestock and Fisheries, Finance, and Local Governments (Ministère de l'Administration Territoriale et des Collectivités Locales).[13] Data from the Commission for Food Security was also collected. Expenditure data for 4 years (2004 – 2007) were collected. This gives the expenditure trends. The analysis also related expenditure trend to the government policies and strategies.

Figure 16: Decision tree of SLM expenditure portfolio



[13] Mali is divided into 8 administrative 'régions', which in turn are divided into 'cercles' (districts). The districts are further divided into 'arrondissements' and each 'arrondissement' is subdivided into 'communes' which are made of several villages.

Annex 2: Benefit-Cost Analysis methods

Benefit-Cost Analysis (BCA) is the key tool for determining SLM investments. This analysis is therefore aimed at providing empirical evidence for advising regarding the type of SLM technology investments for each of the selected case studies. Since land degradation and investment and returns to SLM are long-term processes, time series data are required to effectively conduct BCA of SLM. Additionally, there are both on-farm and off-farm costs of land degradation and benefits of SLM. Assessment of the off-farm costs and benefits is complicated and difficult to measure (Berry et al., 2003; Hein, 2006). Hence, there has been a limited number of studies that have assessed the on-farm and off-site costs and benefits of land degradation and SLM investment. The BCA of SLM is carried out using fairly simple methods and approaches that can be easily replicated in other studies. The approach compares profit of agricultural production with and without SLM practices.

Profit with SLM practices:

$$\pi_t^c = Y_t^c(P_t - Z_t^c \pm \lambda_t^c)$$

where π_t^c = profit with SLM practices in year t;

Y_t^c = crop or livestock yield with SLM practices in year t;

P_t = social price of output in year t;

Z_t^c = social cost of production of one unit of Y_t^c; and

λ_t^c = off-site costs/benefits with SLM practices per unit produced in year t.

Profit without SLM is given by:

(2) $\pi_t^d = Y_t^d(P_t - Z_t^d \pm \lambda_t^d)$

where π_t^d = profit without SLM practices in year t;

Y_t^d = crop/livestock yield without SLM practices in year t;

Z_t^d = cost of production of one unit of Y_t^d; and

λ_t^d = off-site costs/benefits without SLM practices per unit produced in year t.

The social NPV (NPV^s) of adopting SLM practices is therefore given by:

(3) $NPV^s = \sum_{t=0}^{T} \rho^t (\pi_t^c - \pi_t^d)$

where T = the farmers' planning horizon; and

$\rho^t = \left(\frac{1}{1+r}\right)^t$ = the farmers' discount factor, where r is the farmers' private discount rate.

Farmers will find it profitable to adopt an SLM practice if NPV>0. However, a given farmer's decision to adopt SLM practices typically does not take into account the off-site costs and benefits that result from adoption or non-adoption of SLM practices, nor does the decision usually involve consideration of risk, credit constraints, and the size and irreversibility of the investment. The literature on these issues also establishes that a positive NPV may be far from sufficient to induce investment (e.g. Pender, 1996; Dixit and Pindyck, 1994; Fafchamps and Pender, 1997).

TRANSLATING BIOPHYSICAL LAND CHARACTERISTICS INTO CROP YIELD

Since many land management practices have long-term effects, agricultural productivity and on-farm and off-site costs and benefits over time were computed using crop and hydrological models. Crop models mathematically describe the growth of a crop and its interaction with soils, climate, and management practices. When calibrated to local environmental conditions, crop models can help understand the current status of farming systems and test what-if scenarios. To assess the potential benefits (or losses) of adopting a range of SLM scenarios, DSSAT-CENTURY (Gijsman et al., 2002), EPIC, and SWAT simulation models were DSSAT (Decision Support System for Agrotechnology Transfer) is one of the most popular crop modeling software packages in the world. DSSAT combines crop, soil, and weather databases for access by a suite of crop models enclosed under one system. The models integrate the effects of crop systems components and management options, to simulate the states of all the components of the cropping system and their interaction. DSSAT crop models are designed on the basis of systems approach, which provides a framework for users to understand how the overall cropping system and its components function throughout cropping season(s), on daily basis. The DSSAT model has been widely used in various types of cropping systems all over the world, including low-input subsistence ones in sub-Saharan Africa. The DSSAT cropping system model was modified by incorporating a soil organic matter and residue module from the CENTURY model. The combined DSSAT-CENTURY model used in this study was designed to be more suitable for simulating low-input cropping systems and conducting long-term sustainability analyses.

The EPIC (Erosion-Productivity Impact Calculator/ Agricultural Policy/Environmental eXtender) simulation model was also used to simulate scenarios that DSSAT-century model cannot. This includes impact of salinity, rotational grazing, and forests biomass.
The on-farm costs of land degradation will be based on the loss of productivity rather than replacement costs. The simulation results will allow analysis of the long-term costs and benefits of the SLM practices.

Impact of climate change on returns to land management practices

The impact of climate change on returns to the selected land management practices were assessed using two models with fairly different predictions. The National Center for Atmospheric Research, US (NCAR) model predicts greater precipitation (10% increase), while the Commonwealth Scientific and Industrial Research Organization, Australia (CSIRO) model predicts drier climate (a 2% increase in 2050 [Nelson, et al., 2009]).

The weather data solar radiation, minimum and maximum temperatures, and rainfall was generated using stochastic functions based on historical weather data obtained from WorldClim (www.worldclim.org). For the base climate scenario, the WorldClim current conditions dataset was used, which is representative of 1950 to 2000 and which reports monthly average minimum and maximum temperatures and monthly average precipitation. Precipitation rates and solar radiation data were obtained from NASA's LDAS website (http://ldas.gsfc.nasa.gov). The future rainfall data (2000 to 2050) were obtained from CISRO and NCAR. The results from the Variable Infiltration Capacity (VIC) land surface model were used. For shortwave radiation (the sunlight plants make use of) monthly averages at 10 arc-minute resolution were obtained for the years 1979 to 2000. Overall averages for each month were computed between all the years. Rainfall rates were obtained at three-hourly intervals for the years 1981, 1985, 1991, and 1995. A day was determined to have experienced a precipitation event if the average rainfall rate for the day exceeded a small threshold. The number of days experiencing a rainfall event within each month was then counted up and averaged over four years. The monthly values were regressed nonlinearly, using the WorldClim monthly temperature and climate data, elevation from the GLOBE dataset (http://www.ngdc.noaa.gov), and latitude. These regressions were used to estimate monthly solar radiation data and the number of rainy days for both today and the future. All average climate variables were generated at 10km×10km grid scale by IDE (Inverse Distance Weighted) interpolation.

For projected climate scenarios, the results of two GCMs from the IPCC Data Distribution Centre were used to generate 10km×10km grids monthly weather average by IDW (Inverse Distance Weighted) interpolation. The two GCMs are: NCAR (National Centre for Atmospheric Research) and CSIRO (Australia's Commonwealth Scientific and Industrial Research Organization). In order to decrease the simulation workload, only projections under the IPCC SRES scenarios a2 and 2050s (corresponding CO_2 concentration of 599 ppm) are used. The summary of present and future climate characteristics of the countries for each GCM is listed below.

These data were generated and integrated in the DSSAT crop simulation model to predict the impact of climate change on crop yield for the 50-year period (2000 – 2050).

Table 17: Average temperature (T in ^{o}C), annual total precipitation (P in mm), and radiation (R in MJ/m^{2}d)

	Baseline	Changes corresponding to	
		NCA	CSIR

Off-site costs of land degradation and benefits of SLM

Although the importance of the off-site effects of land degradation is widely recognized, most studies focus exclusively on on-farm effects, largely due to the difficulties of quantifying and valuing off-site effects. The cost of externalities/off-site effects are calculated using a variety of methods depending on the type of off-site effect, data availability, and the reliability of estimates. For example, following Grohs (1994), three alternative methodological approaches could be used for calculating the off-site costs of the sedimentation of water reservoirs for irrigation: (i) change of productivity (i.e., evaluating the income foregone due to reduced water availability for irrigation; this might also include increased operation and maintenance costs), which includes the costs of dredging reservoirs and rivers; (ii) replacement costs (i.e., the costs of replacing the live storage of the reservoir lost annually); and (iii) preventive expenditures (i.e. the costs of constructing dead storage to anticipate the accumulation of sediments). The method used in this study was largely determined by availability of data.

The Soil and Water Assessment Tool (SWAT) (Arnold et al., 1998) was used to estimate the off-site costs of water-induced soil erosion and benefits of soil erosion control. SWAT is a comprehensive watershed model. It provides an integrated framework for modeling hydrology, sedimentation, crop/plant growth, and nutrients/pesticide transport at a river basin scale and under various specified land and water management scenarios.

The SWAT model was calibrated using various data sets containing region-specific information. The SWAT model was calibrated and validated using limited observed river discharge data from the study river basin from Sokoto river basin, which are available from Global Runoff Data Centre's database. These data were used to improve the estimate of SWAT model parameters for hydrologic simulation via calibration or model fitting.

***Estimating the off-site costs of soil erosion and benefits of erosion control*:**

(i) Increased operational and maintenance costs and/or change of productivity. The increased operational costs and maintenance costs includes the cost of dredging water reservoirs, irrigation canals or other waterways, higher operation costs of irrigation pumps and other water machinery, water purification in the case of potable water, etc. The change in productivity of off-site farms is measured by assessing the loss of productivity due to sedimentation in water storage structures, leading to reduced water volume and consequent loss of productivity;

(ii) Replacement costs (i.e. the costs of replacing the live storage of the reservoir lost annually[14]); and

(iii) Preventive expenditures (i.e. the costs of constructing dead storage to anticipate the accumulation of sediments).

The choice of methods depends on data availability and the study's objectives. As information on productivity loss, replacement cost, or preventive expenditure was not available the off-site costs were estimate of soil erosion were estimated using the dredging costs. The off-site benefits of land management practices used to prevent erosion are the avoided dredging costs. Using dredging costs data of dams in Nigeria with the comparable AEZ of southern Mali, the dredging costs per ton of sediment were estimated to be $18.

Carbon-related off-site costs and benefits of land management practices

The carbon sequestration of different land management practices was estimated as well as the change in the carbon stock resulting from a change in land use from forest to crop production. In both scenarios, a value of carbon equivalent was imputed related to the carbon market price of the equivalent carbon dioxide (CO_2-eq.).

[14] The storage capacity of reservoirs is divided into live and dead storage capacity (Grohs, 1994). The dead storage capacity lies at the bottom of the reservoir and the live storage capacity on top; the latter supplies the water for irrigation or hydro-electricity generation.

The carbon balance of each land management practice was calculated in order to determine their level of carbon sequestration. Carbon balance is the difference between the total carbon sequestered and carbon emitted by a given land management practice. In this study, the carbon balance was computed by considering only CO_2 sequestered on-farm and carbon emission on-farm and off-farm. The off-site carbon emission is largely from nitrogen application. Nitrogen application increases soil carbon (Cassman, 2004), but its manufacturing is energy intensive. Production, transportation, and application of 1 kg of nitrogen emit 3.875 kg CO_2 (Vlek et al., 2004). Intensification, however, can help reduce conversion of land to agriculture. Vlek et al. (2004) estimated that a 20% increase in fertilizer use in SSA can release l2 million ha of land that can be used for forest regeneration, leading to a net carbon sequestration of 13.3 Mt. To get the area saved by intensification using fertilizer, the land area was computed, which would be required by farmers using no fertilizer to produce the same quantity produced when using 40 kgN/ha. For example, the average yield of producing rice by incorporating only crop residues is 2.79 tons/ha, while rice yield on plots receiving 40kg N/ha, 1.67 tons/ha of manure, and 50% of crop residue is 4.33 tons/ha. When using only 100% crop residue only, a farmer will need 1.55 ha to produce the equivalent quantity achieved by applying 40kg/ha, 1.67 tons/ha of manure, and 50% of crop residues. If the farmer converts shrublands - with a carbon density of 12.7 Mg/ha (Baccini, et al., 2008) – to rice production (with carbon density of 5.3 tons/ha), 11.5 tons of carbon will be lost. Hence we take into account the area saved by using fertilizer but also net out the CO_2 emission due to manufacturing, transportation and applying fertilizer.

Carbon balance for other land management practices was also computed. The DSSAT-CENTURY model takes into account the carbon emission and storage for each practice and reports the balance (Gijsman et al., 2002).

The impact of deforestation and reduction of carbon stock in general is estimated after determining the amount of lost carbon using various silvicultural methods. Other studies usually value the CO_2 emission reduction at US$ 20 per ton of carbon (Smith et al., 2008).

Annex 3: Development domains, development pathways, and major investments required in each pathway & entry points

Development pathway	evelopment omain (AEZ)	and and water anagement practice	nvestments equired	nabling nvironment	ntry points[a]
		Rotational grazing	Enhance extension & research	Stronger local institutions & improved veterinary services	A, B, E & F
Livestock production	Sahelian & Sudano Sahelian	Pasture improvement (introducing leguminous trees & pasture)			
		Manage bush fires			
		Reduce stocking rates	Improve livestock marketing	Improved market information flow	C & D
		Desalinization	Enhance extension & research	Better access to inputs	
Irrigated crop production	Sahelian & Sudano Sahelian	Improved irrigation infrastructure & drainage system		Secure land user rights	A, B, E & K
		Improved water use efficiency		Secure land user rights	
		Rice-horticultural crop rotation		Improved markets;	
		Integrated soil fertility management practices (ISFM)	Enhance extension & research	Improved markets; secure land user rights; better farmer formal education & vocational	
Rainfed & irrigated crop production	Sahelian, Sudano-Sahelian & Sudano-Guinean		Develop labor saving technologies & improve animal power equipment		A, B, E, F, G, K & L
			Promote mixed livestock and crop production		
			Develop efficient input markets	Market-friendly input subsidies; develop marketing skills by private traders	As above

Development pathway	evelopment omain (AEZ)	and and water anagement practice	nvestments equired	nabling nvironment	ntry points[a]
Horticultural crops	All development domains (AEZ)	Climate change-smart crop varieties and livestock breeds	Enhance research & extension on climate change		
		ISFM	As rainfed & irrigated crops above	As above & irrigated crops above	As above & irrigated crops above
			Improve storage & processing		
Forest management	Sudano-Guinean	Protection of forests and reforestation programs	Promote participation in carbon market & payment for ecosystem services	Better linkage with Clean Development Mechanism, REDD+ & other global market initiatives	D,E, F, H & M
Non-farm activities	All development domains (AEZ)	Not applicable	Vocational training & Higher education	Better market access; rural vocational training institutions	C, G, H, I, J & M
			Electricity or alternative power sources		

[a] *Entry points key*

A	ER & other national & international livestock research programs
B	Agricultural extension services by national programs and NGOs
C	Commercialization & improvement of market access programs; CPS data collection
D	Activities to combat desertification & land degradation
E	Land registration for improving land user rights
F	Decentralization & stronger local institutions for natural resource management
G	mprove vocational training & secondary education, targeting the youth
H	Promotion of farmer/economic interest groups and collective action
I	Access to rural financial services (credit)
J	Agricultural processing and value addition

K	mprove irrigation infrastructure by Office du Niger and other irrigation schemes
L	CMDT & rice scheme fertilizer subsidies
M	Alternative energy sources

Annex 4: Main Actors in Sustainable Land Management in Mali

Main Actors	Role and Responsibility for SLM	Strengths	Weaknesses
Central Government			
Ministry of Agriculture	See below	Mali has surpassed the Maputo Declaration of funding of allocating 10% of its budget to agriculture. SLM expenditure is well targeted to land degradation hotspots. The increasing government-funded SLM expenditure also reflects the government's improved understanding of the challenges arising from increased land degradation, climate change, and other national and global trends that impact the environment.	Extension services weak and focus on improved varieties, fertilizer and plant protection – need to re-focus on SLM.
'Cellule de Planification et de Statistiques' (CPS)	The statistical and planning department that collects and analyzes data and designs development plans. CPS carries out agricultural household surveys and other types of data collection.		
'Comite National de la Recherche	Co-ordinates research done by	The coordination of research of different	

Main Actors	Role and Responsibility for SLM	Strengths	Weaknesses
Agricole' (CNRA)	national 'Institut d'Economie Rurale (IER) and research done by the Ministry of Agriculture, Ministry of Environment and Sanitation, the Ministry of Economic Planning and university and colleges.	institutions across ministries under the CNRA is one of the strengths of the SLM institutional structure in Mali.	
'Direction Nationale de l'Agriculture' (DNA).	The DNA manages and coordinates production of crops other than rice and cotton. DNA also coordinates plant protection, including locust control.		
Office du Niger (ON)	ON is responsible for irrigated rice in the Niger River basin. ON manages rice production and marketing. In addition to rice, ON also supports other agricultural systems in the ON area. Realizing the benefits of an integrated approach, ON has increasingly been integrating other crops and livestock.		

Main Actors	Role and Responsibility for SLM	Strengths	Weaknesses
Compagnie Malienne pour le Developpement des Textiles (CMDT)	Co-ordinates cotton production and marketing. As is the case with ON, CMDT has increasingly integrated other crops and livestock produced in the cotton belt of Mali. Working under ON is the Office de la Haute Vallee du Niger (OHVN), which supports cotton production. It is largely funded by USAID and provides technical support to farmers. OHVN introduced high-input cotton production technologies, which has demonstrated high returns.		
Ministry of Environment and Sanitation	See below		Funding of this ministry which is important for land management is limited, and the large cost of land degradation calls for greater budget allocations to SLM to prevent land degradation and rehabilitate degraded lands. Notably, the allocation of funds

Main Actors	Role and Responsibility for SLM	Strengths	Weaknesses
			to policies such as conservation of natural resources and biodiversity, combating desertification, climate change mitigation and adaptation, land tenure, decentralization, etc. is quite low -- less than 8%, suggesting that such policies do not receive high priority.
Secretariat Technique Permanent du Cadre Institutionnel de Gestion des Questions Environnementales (STP/CIGQE)	Responsible for land and environmental management. STP coordinates efforts to combat desertification under the NAP and other initiatives. This sets the Ministry in the center-stage of land management. Through the Comité Interministeriel, STP coordinates departments and other ministries to implement land and environment programs.		
Direction Nationale de la Conservation de la	Manages broadly defined natural resources. Its	These provide key support for articulating the local	

Main Actors	Role and Responsibility for SLM	Strengths	Weaknesses
Nature' (DNCN)	overall objective is to sustainably manage natural resources. DNCN has branches at regional and sub-regional level. DNCN works with communities on a variety of natural resource management issues.	agenda.	
Ministry of Housing, Land Affairs, and Urban Development	Under this Ministry, issues related to land tenure are administered under the cadastral department.		Land tenure formalization is quite expensive and out of reach for the majority of poor farmers.
Ministry of Livestock and Fisheries (including the Departments of Veterinary and Public Health; Fisheries; Animal Production and Development	Current livestock research programs are for cattle ("programme bovin" in Sotuba), small ruminants ("programme petits ruminants" in Kayes), and others.	The country has given the livestock and fishery sector greater priority by establishing a separate ministry and by increasing budget allocation to reflect the sector's importance.	Allocation to the livestock sector remains low despite the acknowledged current major deleterious impacts of the sector on the environment, the scope for using SLMs (plus other parallel infrastructure improvements) to improve the sector, opportunities for PES and the sector's large market potential in and outside Mali. The increased profile of the

Main Actors	Role and Responsibility for SLM	Strengths	Weaknesses
			sector needs to be accompanied by greater investment into the sector to fully exploit its potential.
Ministry of Infrastructure and Transport	Oversees rural roads and other types of infrastructure development and management, which are key for land investments. The Ministry also hosts the Department of Meteorology.	Infrastructure development is also important in land management practices.	Funding of this ministry which is important for land management is limited, and the large cost of land degradation calls for greater budget allocations to SLM to prevent land degradation and rehabilitate degraded lands. The Ministry only provides meteorological data and does not deal with issues related to adaptation to climate change.
Ministry of Energy and Water	This Ministry directly affects land-based production activities, including irrigation water. Hydro-electric power, which largely serves urban communities, is also managed under this Ministry. However, the	Under the 'Direction Nationale de l'Energie (DNE), the Ministry seeks to reduce firewood consumption and to develop biofuel and energy-efficient stoves.	

Main Actors	Role and Responsibility for SLM	Strengths	Weaknesses
	Ministry has also been exploring alternatives to the fuelwood – the most common energy source to the majority of people in Mali.		
Commission for Food Security	In response to Mali's long-term objective of achieving food security, the government formed a special commission for food security and started allocating it special budget in 2007.		Distribution of budget allocation to food security policy could be improved by reallocation to poorly funded yet important rural services such as extension services, where these are delivered efficiently and effectively.
Local Government			
Ministère de l'Administration Territoriale et des Collectivités Locales[15]	This Ministry is the centerpiece of decentralization, which is key in natural resource management at the local level. Under each of the eight regions, the Ministries discussed above conduct their local level management issues through this Ministry. The	Mali is among the countries which have decentralised natural resource management (NRM). Local governments are responsible for providing primary education, health, sanitation, public transportation within their area of jurisdiction, and security. Local	Only about 15% of the local government budget is funded from local government sources, while the central government and donors contribute the remaining share of local government budget. The small share of locally-generated funds for running

[15] Mali is divided into 8 administrative 'régions', which in turn are divided into 'cercles' (districts). The districts are further divided into 'arrondissements' and each 'arrondissement' is subdivided into 'communes' which are made of several villages.

Main Actors	Role and Responsibility for SLM	Strengths	Weaknesses
	communes – each comprising of 11to45 villages - develop economic plans, which are funded by the local and central governments. Regarding legislative authority: it is the 703 communes which have legislative, administrative, and financial autonomy. A commune has the mandate to enact and enforce by-laws that affect all local communities in its jurisdiction. Local governments provide rural services such as rural roads and legislative services for land administration. Additionally, each of the ministries with a significant budget allocation to SLM conducts its local-level management programs through the local governments. Consistent with	governments generate their own funds from taxes and economic activities. A parastatal agency, ANICT (Agence Nationale d'Investissements dans les Collectivités Territoriales), was formed in 2001 to build the capacity of local governments to prepare economic projects required for receiving central government and donor funding and to manage economic activities. ANICT also facilitates transfer of funds from the central government to the local governments.	local governments highlights the limited fiscal decentralization in Mali. Allocation of expenditure to decentralization is also declining over time, raising doubts on the priority placed on local-level management of natural and other resources. Villages have no legal mandate to enact or enforce by-laws. The villages also have no direct mandate to manage natural resources independent of the communes. Local institutions are not yet sufficiently strong to enhance effective NRM, including organizing farmers to participate in the carbon market / benefit from PES.

Main Actors	Role and Responsibility for SLM	Strengths	Weaknesses
	UNCCD's requirement of decentralization and a participatory approach in implementing activities for combating desertification, Mali's NAP implements its activities through the local governments**.**		
Civil Society			
Non-Government Institutions (NGOs)	More than 1000 NGOs work directly on land and environmental issues in Mali. These provide technical support including extension services, capacity building of local institutions to manage natural resources, rural financial services, and other services.		

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