



## Carbon sequestration as an integral part of watershed management strategies to address climate change issues

### Policy brief

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#### Summary

*The widespread deterioration of watersheds around the world is a threat to agricultural and livestock production, livelihoods and ecosystem health, strengthened by climate variability and change. Large-scale restoration of degraded watersheds may require 10 to 20 years for full benefits to be realized.*

*In this perspective watershed management and sustainable land and water management are key development areas which present a multiple win potential synergy between food security, climate adaptation and climate mitigation. This paper analyses the current context in which carbon sequestration could be both a proper agri-environmental indicator to assess different strategies of sustainable development in watershed approach and a mean to access to carbon funding. Project examples are provided to show how far carbon sequestration is linked to watershed management and sustainability. It drives to the question "how to facilitate the use of carbon sequestration project estimates to mobilize funds and build carbon-funded Payment of Environmental Services (PES)?"*

*It highlights the fact that protecting watersheds may be one of the most suitable strategic actions for managing climate change risks. It also describes briefly the different roles of carbon sequestration and the link between mitigation and adaptation. The last part compares carbon sequestration performances of different projects, using carbon balance indicator to select best watershed scenarios.*

*This paper is targets the national agriculture sector, forestry and food security policy makers, institution-based, agency and donor decision-makers.*

# **Carbon sequestration as an integral part of watershed management strategies to address climate change issues**

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## **1. Introduction**

The world's watersheds face a wide variety of stresses that threaten to degrade their biological value and their ability to provide ecosystem services (World Resources Institute, 1998 and Millennium Ecosystem Assessment, 2005). Prominent among the pressures faced by watershed include high population growth, expansion of irrigated cropland, high deforestation and acute water scarcity. The stresses are particularly severe in watersheds that are already substantially modified or degraded by human activity in India, China, and Southeast Asia. Other major watersheds that are less degraded, such as the Amazon and the Congo, are nonetheless beginning to experience rapid transformations that threatens livelihood. The accelerating pace of climate change is an additional challenge to the sustainability of global watersheds. Climate change has the potential to damage irreversibly the natural resource base, on which agriculture depends, in many watersheds, which aggravate the consequences for food security. There is a consensus among climate change scientists that major watersheds in Africa and other tropical regions will be impacted to varying degrees by changes to the frequency, intensity and timing of rainfall within seasons, shifts in seasons with wet seasons becoming shorter, dry seasons longer and more uncertain timing in the transitions between them and warmer temperatures increasing evapo-transpiration and impacting on soil water balance (Dangerfield, 2010<sup>1</sup>). These climate fluctuations necessitate increased attention to addressing human and climatic stresses on watersheds in order to conserve their ecological and economic functions.

Working at watershed or landscape level allows to anticipate the impacts of climate change from upstream to downstream. Indeed climate change is expected to intensify extreme weather events such as floods and droughts whose impacts especially depends on land use. This is expected to make communities both from upstream and downstream even more vulnerable. Because of poverty, many local communities live on degraded watersheds placing them at the center of a vicious circle: degraded ecosystems are more sensitive to erosion and further degradation, which are enforced by frequent floods and droughts. Topsoil erosion degrades water quality downstream, decreases agricultural productivity and further impoverishes the rural communities.

Interest in and awareness of the multiple environmental, economic and social benefits provided by watersheds has greatly increased in recent decades. This is particularly true in developing countries where the economy depends predominantly on agriculture. Besides, most of the developing countries are experiencing degradation of land and water resources at an alarming rate, whereas the need for these resources is vastly increasing. Sustainable use and management of land resources can only be achieved by adopting a system of improved land and water management based on an integrated approach to land resources development, and with the direct involvement and participation of the different actors.

Carbon sequestration refers to the capacity of agricultural lands and forests to remove carbon dioxide from the atmosphere in a manner that is not immediately remitted into the atmosphere. Carbon dioxide is absorbed by vegetation through photosynthesis and stored as carbon in biomass and soils. Forests and grasslands are carbon sinks because they can store large amounts of carbon in their vegetation and root systems for a relatively long period of time. However, soils are the largest terrestrial sink for carbon and the ability of agriculture

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<sup>1</sup> <http://africawatershed.org/>

lands to sequester carbon depends on climate, soil type, vegetation cover and land management practices (see Box 1).

Box 1. Some management practices that sequester carbon in the soil

**Box 1: Some management practices that sequester soil carbon**

Conservation tillage  
Mulch farming or plant cover  
Composting  
Integrated nutrient management  
Organic farming  
Biochar application  
Fallows  
Crop rotation  
Water management  
Afforestation  
Agroforestry  
Set-aside land use (placing land into conservation program)  
Restoration of organic soils (rewetting/abandonment)  
Restoration of degraded soils  
Grazing land management  
    Livestock grazing intensity  
    Fertilization  
    Fire management  
    Species introduction  
    Use of legumes

Soil carbon sequestration allows for the replenishment of soil organic matter and, provides several other benefits including improved soil structure and stability that leads to reduced soil erosion, improved soil biodiversity, increased nutrient holding capacity, increased nutrient use efficiency, increased water holding capacity, increased crop yields and profitability and potential marketability of the sequestered carbon. Soil carbon sequestration is good for the soil quality, both at short-term and long-term. It is a cost-effective and environmentally-friendly process that can be achieved through land management practices adapted to specific land uses. Once sequestered, carbon generally remains in the soil as long as the sustainable land management practices are followed.

## **2. Carbon sequestration and watershed management**

### **2.1. Carbon sequestration at the heart of Climate Smart agricultural policies**

Global surface temperatures have increased by 0.8°C since the late 19th Century with an average rate of increase of 0.15°C per decade since 1975<sup>2</sup>. The Earth's mean temperature is projected to increase by 1.5°C– 5.8°C during the 21st Century<sup>3</sup>. Future global warming will exacerbate hydrologic scarcity and variability such that crops will have to grow in warmer and drier conditions. Higher temperatures and shorter growing seasons will reduce the yields of most food crops, and promote the spread of weeds and pests. Changes in precipitation patterns will also increase the likelihood of short-run crop failures and long-run productivity decline. Although there will be productivity gains in some crops in certain regions of the world, the overall impact of climate change on agriculture is expected to be negative, threatening global food security.

Climate-smart agriculture (CSA) policies aim at sustainably increasing agricultural productivity, increasing resilience (adaptation) to climate change, reducing greenhouse gas emissions (mitigation) and enhancing the achievement of national food security and development goals. CSA helps policy makers face up with the inevitable challenge that agriculture must undergo a significant transformation in order to meet the related challenges of food security and climate change. Maintaining and improving food security require the transformation of agricultural production systems in the direction of higher productivity and lower output variability in the face of the risks of climate and macroeconomic changes.

In this perspective land management practices that sequester carbon are at the heart of CSA because they reduce greenhouse gas emissions and prevent climate change by enhancing carbon storage in soils; conserving existing soil carbon; and decreasing carbon dioxide, methane and nitrous oxide emissions. An increase in soil carbon storage will lead to an increase in soil fertility, land productivity, and reduced soil erosion.

### **2.2. Value of Soil carbon sequestration as a public good?**

Non climate benefits of improved carbon balance in soil are known and valued in agriculture development. They are linked with many environment objectives targeting agriculture and natural resources, e.g. watershed management, water management, drought management, sustainability of cropping systems, erosion control, flood risk management, water quality management and eco-tourism.

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<sup>2</sup> IPCC (2007). *Climate change 2007. Climate change impacts, adaptation and vulnerability. Working Group II.* Geneva, Switzerland

<sup>3</sup> IPCC (2001). *Climate change 2001: the scientific basis.* Cambridge University Press, UK.

Someway it could be considered that soil carbon sequestration provides a triple win situation as **public good**:

- **Value to farmer** : C sequestration improves agriculture performances (yield increase, input saving, water saving) and incomes (additional production),
- **Value to community**: C sequestration increases cropping systems and watershed climate shocks resilience (adaptation, PES),
- **Value to society**: Large mitigation potential of agriculture arises from C sequestration (local and global carbon value), fight against erosion of soils and sedimentation in reservoirs, reduction of flood risks.

Box 2. Incentive for action

*“There is ample evidence that many of the resulting agricultural and land uses and management practices will themselves generate significant financial and subsistence benefits to farmers in the short or medium-term. But large-scale restoration of degraded watersheds may require 10 to 20 years for full benefits to be realized. Moreover, many interventions require significant up-front costs that cannot be easily financed, even for well-off farmers. Short-term sources of income are needed, as well as financing. And some types of investments in watershed management benefit only downstream users, not farmers”* (Scherr S, 2010, Africa Watershed Web debate).

### ***2.3. Watershed management and Climate resilience building***

Watershed and land degradation are compromising the capacity of ecosystems to provide, maintain, and regulate critical functions and services, including resilience to climate variability and natural hazards, e.g. regulating floods and preventing droughts. Upstream land degradation reduces the capacity of ecosystems to retain water and regulate water flows, thus preventing excessive runoff during the rainy season. Downstream sedimentation and siltation reduces the water storage capacity of water bodies, thus reducing their **capacity to retain excessive water flows** during the rainy season i.e. preventing flooding, and their **capacity to store water** for the dry season i.e. coping with possible droughts.



**Carbon assets to manage as investment portfolio** *“Terrestrial carbon accumulation should be pursued via a what I would call a portfolio of carbon assets in the landscape (soil, trees on farms, forest, grasslands, and more rational and planned land use changes). This is similar to how someone might put together a retirement investment portfolio of stocks, bonds, cash etc -- to manage risk, re-balance assets periodically, etc. This portfolio of carbon assets -- "landscape carbon" if you will -- together make up many of the constituent parts of a watershed system. Properly managing these carbon assets as a unified natural resources portfolio has positive benefits on water resources, yield rates and variability, resilience, and all the other good local benefits”* (Steve Danyo, World Bank 2011)

The climate-change-smart land management practices for crop production are those that integrate land and water, enhance soil carbon, and use crop varieties adapted that address

climatic variations. Additionally, a combination of organic and inorganic soil fertility management practices enhances resilience to climate change and increases crop productivity.

Land degradation can be exacerbated by climate variability and climate change that further increase the vulnerability of agricultural production systems. Sustainable agriculture and watershed management can **break the downward cycle by reducing vulnerability** to climate change and increasing people's ability to become more resilient—and in many cases contribute—to the mitigation of climate change through improved carbon sequestration and reduced GHG emissions.

Mitigation efforts through carbon sequestration can also enhance adaptation strategies. The policy-driven divide between adaptation and mitigation may blur as some adaptation strategies also serve to mitigate climate change and vice versa.

#### *2.4. Convergence of watershed impacting actions within National Appropriate Mitigation Actions (NAMA)*

Within the 42 National Appropriate Mitigation Actions prepared by countries for UNFCCC and which provide country-based priority mitigation actions, it appears clearly that most of forestry, agriculture and land use change linked actions are profiled so that they can contribute to overall improvement of watershed situation at country level. In this line we have the following actions:

- Heavy engagement in reforestation planning by over 80% of countries with specific NAMA
- Request for sustainable land use planning, SLM , watershed plans and of wide anti-erosive land protection actions in 60% of the Countries with a specific NAMA
- Extension of forest reserves, protected areas , green cover or improvement of pastures in 50% of the countries

### **3. Watershed management, human factor, governance and institutions**

#### **3.1. Watershed management and governance**

Ecosystem services provided by watershed are used by different groups at multiple spatial levels. Watershed governance challenges range from ecosystem-based land and water use decisions to institutional and legal procedures for ecologically-based water allocations. Different communities approach these governance challenges in a variety of ways including spatial planning, rules, protected areas, forest/watershed classification (schemes), participatory land use planning, property rights, logging concessions, logging restriction/banning, certification, and incentives including payment for ecosystem services. A summary of governance approaches by Lebel and Daniel (2009) indicate that while planning has conventionally been led by government bureaucrats relying on neat physical and institutional separation into conservation and use, regulations important for managing watershed ecosystem services can be top-down, self generated or more frequently a combination of local informal rules and national formal regulations.

Watershed can be managed only if the local leadership is involved. In rural communities, the local Chief has the strongest voice. Local leadership should be empowered and supported with initiatives which have far reaching results, which can be:

- Develop community based watershed management initiatives, empower the local leadership to manage and prosecute investors who are bringing “harmful” investment to watersheds in their chiefdoms,
- Develop statutory instruments to charge responsibility of these chiefs to demand mitigation measures whenever there is developmental initiatives near or on the watershed,
- Government/international community to reward communities/countries with the best practices in watershed protection and management

#### **3.2. The human factor**

Notwithstanding the importance of recent initiatives in carbon trading to address the threats of climate change in sub Saharan Africa, the most common failure in natural resources conservation has been the scant regard that is given to the so called “human factor”. Wherever there exists a human population, it’s certain that there exists a complex interrelation of ethnic, biological, and social influences which unless they are understood and incorporated into natural resource management plans, it is difficult to predict with certainty the consequent outcome of planned natural resources management interventions (LUSIK W,2010, Africa Watershed Web debate).

## **4. Watershed Management and Payment of Environment services**

### **4.1. Watershed management and incentives**

Payment for ecosystem services has emerged as a substitute or supplement to spatial planning and regulatory schemes in the governance of watersheds (Engel & al, 2008). Society generally attaches a high value to the positive externalities of watershed landscapes and will take action to guarantee that they are well kept and conserved. This is the primary justification for the public funding of watershed management programmes. Command and control approaches to protecting the flow of benefits from watershed landscapes have often failed, therefore efforts have recently been made to create markets for these externalities. Under such payment for environmental services (PES) mechanisms, the beneficiaries of externalities or services pay the providers. This transforms an externality into a tangible income for service providers. When providers and beneficiaries are located in the same watershed, most environmental services of interest are water-related, and depend on the type of water use, the hydrological regime and geological features of the watershed, and climatic factors (FAO<sup>4</sup>, 2006).

### **4.2. Example of Carbon sequestration and cooperation through watershed management**

Box 3. Example of the Cooperation between national government, NGO and private company in Costa Rica

In 1990, the Government of Costa Rica opened the market of electricity generation to the private sector. The company La Manguera SA planned to develop a small hydropower plant in a watershed covered by 98% of forest. This land use results in the conservation efforts of the Monteverde Conservation League (MCL) NGO. Because of an overlap in two different official entitlements, in which both sides appeared to own the same interested parcel of 1.5 ha; there was a conflict between the company and the NGO.

The ministry of Environment was responsible for the water concession of the hydropower project but also the enforcement of PES scheme to create incentives for conserving forest and to compensate those whose land use generates environmental services. Thus, the conflict was solved through the implementation of a PES scheme contract between sides, the downstream water user and the upstream conservator. The payments contribute to about 25% of the NGO's annual budget whereas it increases the costs of the power plant by 21%. In case of delayed payment, the NGO can revoke the use of the land and the entire infrastructure it contains.

The company could provide electricity because the forestry land use allows a guarantee for regular water flows. If the conflict remained, the communities could have suffered from electricity shortage since the NGO could refuse to give the land to produce energy, or water quality shortage and the company could do whatever they wanted on the land, maybe leading to deforestation.

If this case represents one link between land and water use, it also reflects that the key of this link is carbon sequestration. This is the presence of the forest that allows landscape and water management. The carbon sequestered by forestry soils allows the regulating of water flows and cleaning water, which is another issue that also have to be considered in the resolution of the

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<sup>4</sup> FAO, *The new generation of watershed programmes and projects*, FAO Forestry Paper 150, ICRAF ICIMOD, EOMF, REDLACH, 2006

conflict.

It underlines the importance of paid environmental services as an incentive to lead a watershed management strategy. Indeed the many goods and services provided by watersheds such as e.g. the maintenance of water quality and carbon sequestration, don't have expressed value in monetary terms.

#### Box 4. Definition of Payment for Environmental Services

A payment for environmental service is a scheme in which the environmental services providers are going to be paid for their practices by the direct or indirect beneficiaries of environmental services. The purpose is to highlight the provision of indirect environmental services.

The PES works on collaborative watershed management as reflected here, allowing resolving the conflict about resource allocation and establishing a link between different stakeholders. Yet the success of the PES depends on a sufficient demand (the estimated users' demand must be higher than the amount needed to compensate service providers), the understanding that land use is linked with water quality, sustainable financing arrangements, land tenure security, cultural acceptance of PES, and legal framework.

The growing role of the PES approaches today reflects underlying changes in environmental policy and the private sector worldwide. *“From a situation dominated by centralized regulatory approaches to environmental governance, there is now a greater emphasis on decentralization, flexible mechanisms, the private sector as a provider of public services, corporate self-regulation, consumer sovereignty, and civil regulation. Greater flexibility opens opportunities for PES mechanisms, with both the public and the private sectors taking advantage of this flexibility”* (B. Swallow, personal communication, 2007). Hundreds of PES schemes are now being implemented, in both developing and developed countries, primarily for forest based environmental services. But it is important to emphasize that PES are only one of the potential tools for increasing the provision of environmental services. Others include information provision, policy reforms to reduce market distortions, command-and control regulations and taxation.

#### 4.3. Multifunctionality on Cuba Watershed management planning

In this case, carbon sequestration should improve the environmental pillar of sustainability as the watershed project aims at preserving soils, water and possibly biodiversity. It also considers social and cultural issues as an integral part of watershed management planning. The change in adopting sustainable practises should also more or less in a long term allow for generating economical benefit for stakeholders i.e. more incomes due to better or secured production, PES, carbon assets, better access to water, and thus improving their social way of life, i.e. access to water in quality and quantity, empowerment, decentralisation and dedicated responsibility.

This source of income may also prevent rapid or excessive urbanization as well as natural resource degradation through overexploitation. Launching such a project has both benefits for uplands and downlands but it should be noticed that rural people have to gain more user rights, land tenure and crops rights in order to guaranty the durability of what was implemented.

## Box 5. The Cuba case of Watershed management

The relationship between social and environmental issues is implemented in national development policies in Cuba, based on the belief that improved social conditions are a precondition for effective natural resource management. However mountain zones which cover 18% of the Cuban territory and which have symbolic significance for population were not included in programs reflecting these policies. Because the area was left behind, the rural depopulation began and as a result the maintenance of the zone became compromised. To face the issue, the government launched programs to stabilize the mountains populations to make them as independent of the urban centres as possible. Farmers have been trained to change their agricultural practices and public infrastructures have been built. If the plan is managed from the central government, it is also decentralized to the municipal level for local projects which aim at promote sustainable use of local natural resources.

### 4.4. Carbon trading to fund PES in watershed management

Carbon trading offers opportunities for the rehabilitation of degraded lands and watersheds through different practices. Tree planting on degraded lands that cannot support crop production can contribute to carbon sequestration and have local benefits in the form of reduced erosion and water use efficiency, and off-site benefits such as water quality improvements. It demonstrates the synergistic relationship of watershed, land and water management that should be consciously promoted in climate change and carbon market negotiations and cooperation. Payment for Ecosystem Services in the form of carbon sequestration could also be integrated into transboundary basin cooperation efforts. However, the costs of participation of smallholders in such schemes and markets need to be successfully addressed (SOLAW, 2010, IFPRI).

Reinforcing the connection between sustainable land & water management and climate change would be an obvious and needed step to enhance the adoption of these practices, which only increase in importance under the threat of climate variability and change. While there is awareness of climate change and what is required to effectively adapt to it, it is important to bear in mind that farmer management practices are driven by incentives and the prevailing biophysical and socioeconomic conditions that are highly linked.

### 4.5. Sustainability, replicability and up-scaling of watershed management experiences / projects

There is uncertainty about the sustainability and replicability of the activities that projects implement among watershed strategies. Watershed management have proven to be effective for mitigating erosion on sloping land, stabilizing landscapes, providing clean water, and stabilizing – and in some extent improving – agrarian production systems on the small to medium scale. The degree of success of watershed management interventions is primarily a matter of the will of the people and the scale of the activities.

Regarding the *upstream* effects, examples exist throughout the world where upland resource conservation activities have been successful on the micro and macro scales (FAO,2005). Regarding the effects *downstream*, the impact of upland watershed management activities on downstream water quantity and quality remains a controversial issue, partly because of economies of scale, and partly because of difficulties in predicting with reasonable accuracy the results of these activities.

Many interventions at the community, household and farm levels have continued after the project terminated. FAO have already provided evaluation of some activities that were still being managed after projects ended concerning for example woodlots, simple low-tech water supply interventions, terracing works that have stabilized hillsides and improved agriculture production and biophysical gully erosion control treatments.

Throughout the world, the contexts in which successful practices can be applied are very diverse and highly variable. No single practice must be considered as a panacea. Every practice must be evaluated and monitored in relation to a wide range of factors that influence adoption, and at multiple scales, also relative to the agro-ecological and geographical context (Bakarr M., 2010, Africa Watershed Web debate) .

The development of low-tech and low cost upland interventions was shown to be increasingly replicable and sustainable on the large scale, especially because technical skills are available and people are willing to implement the activities, than high-tech, high-cost ones which require more technical skills and investment.

Important scale factors for upscaling from site, to watershed, to basin, to region include institutions stability, finances, and cooperation and coordination of all concerned parties. Important factors for out-scaling from plot or demonstration site to local farms and communities include biophysical considerations, finances, and the capacity of local institutions. In any case, the “tragedy of the commons” continues to be a problem. Experience has shown that the political, social and user rights issues must be solved on common lands before interventions are sustainable.

## **5. Use of Carbon appraisal to analyse and monitor watershed projects and policy scenarios**

Since carbon is a proxy for ecosystem functions in general, a carbon balance is a powerful indicator to appraise the impact of watershed projects since it can be calculated on a wide set of indirect land use data i.e. EX-ACT, while keeping data resolution needed for monitoring project results simple (land use based). Data needed for carbon finance would require higher degree of resolution e.g. direct soil analysis or remote sensing information.

Building watershed strategies with carbon sequestration require assessing the present situation and then the impacts and performance of watershed management interventions that could be implemented with a development project or programme.

This is why The FAO decided to develop recently the EX-ante Carbon-balance Tool (EX-ACT) (Bernoux & al., 2010). It aims at providing ex-ante estimates of the impact of land use and land use change on GHG emissions and Carbon sequestration, indicating its effects on the Carbon-balance. This could help the decision process on implementing different options that could have the best benefits in terms of mitigation, natural resources protection, and economy. The carbon balance appraisal could also be used in land-use mitigation policy and economic analyses to anticipate the manifestation of risk by erasing its destructive effects, by finding the proper funds to make the area more resilient.

### **5.1. Application of the EX-ACT tool: the example of Madagascar**

In 2000, the World Bank started a watershed development and management project (PGBV) in Madagascar with the support of FAO.

Land degradation is one of the most serious and widespread problems for the agricultural sector in Madagascar whose three quarters of the population depends on. Upper watershed land use is often based on unsustainable management practices which affect the lowlands. The deforestation for agricultural purposes also contributes to land degradation. Upland soil erosion and water surface run-off also causes sedimentation for downstream infrastructure, contributing to the reduction of cultivated area under irrigation, local flooding of rice paddies in the rainy season and water shortages in the dry season.

#### **Box 6. Watershed and management project in Madagascar**

The project was designed to comprise three technical components covering major strategic orientations: (i) Development of Commercial Agriculture, (ii) Irrigation Development and (iii) Watershed Development. It proposes to address productivity of agriculture in both irrigated low lands and rainfed watersheds, while capturing the environmental externalities associated with more sustainable land use and management. It should tackle the goals of climate risk prevention and environmental protection as well as the economic objectives of productive development.

The rough result directly provided by the software includes a presentation of carbon balances of every project physical component; components are then summed within an aggregated

Carbon Balance for the whole project showing either a carbon source or sink. The balance is divided by the total area. In this case the project creates a sink, the carbon sequestered rises 0,9 tons of eq-CO<sub>2</sub> eq/ha/year. There is a Net Balance of almost 2.4 million tons of eq-CO<sub>2</sub>. The project shows a mitigation potential generated at over 86% by watershed management (forest management, afforestation and grassland, land use change).

Sadly the project suffered institutional resistance to the detriment of its watershed components, which were only partially implemented. In addition, the institutional strengthening of users' associations and the local capacities for land-use management are not yet sustainable. In addition, a social "safety-net" dimension which would protect vulnerable communities that are the most likely to deteriorate watersheds through the cultivation of tavy is absent. This illustrates the challenges that exist within current programs that combine carbon sequestration and watershed management.

Yet, the carbon sequestration allowed with the activities of this programme can be of great interest to developing country policy-makers. First, redistributing its benefits to smallholders allows greater access to food, being an important factor in household economies and therefore also in food security. Second, in the face of credit constraints, carbon sequestration activities affect the performance of agriculture by providing farmers with cash to invest in productivity-enhancing inputs. Third, the nature and performance of agriculture, themselves affected by agricultural policies, can have important effects on the dynamism of the redistribution sector to the extent that the latter is linked to agriculture. This sector grows fastest and most equitably where agriculture is dynamic – where farm output is available for processing and distribution, where there are inputs to be sold and equipment repaired and where farm cash incomes are spent on local goods and services.

### 5.2. Land Degradation and use of carbon appraisal (Uganda 2010)

Land is a key strategic resource in Uganda, central to higher agricultural productivity, ecosystem stability, climate resilience, and national and global environmental benefits. Although land constitutes over 50 percent of the value of the "asset basket" of poor Ugandans, current farming practices threaten soil fertility and prevent a significant share of agricultural potential from being realized. The soils of sub-Saharan Africa lose considerable fertility due to poor nutrient management (World Bank, 2010). In Uganda this problem is particularly pronounced. Land degradation hotspots, where soil erosion and infertility are especially rampant, have been identified in the Southwestern Highlands, Lake Victoria Crescent, the Northwest, and the Eastern Highlands, as well as the Cattle Corridor. In these areas it is estimated that nitrogen, potassium, and phosphorous balances are less than 85, 75, 10 kg per hectare annually. Soil erosion is estimated at above 5 tons per hectare per year (World Bank SLM PER 2008).

Uganda's natural forest cover, consisting of tropical high forest, woodlands and forest plantations, has declined drastically from 54% (approx. 13.2 million hectares) in the 1950s to the present 4.9 million hectares representing approximately 20% of the total area of the country (ENR-SIP, 2007; NEMA, 2004/05). A large proportion of the rural population depends on forest resources for basic needs and forestry provides a range of environmental

services and biodiversity values, such as greenhouse gas mitigation, watershed regulation, climate regulation, soil and water conservation, and nutrient cycling (Uganda SLM framework, 2010).

There are opportunities to promote climate change mitigation and adaptation through sustainable land management (SLM) in Uganda using existing mechanisms. In the present context, the opportunities include:

- Increased use of the clean development mechanism (CDM) to finance Afforestation and Reforestation (A/R) projects;
- Increased use of adaptation funds to support SLM priority activities
- Increased funding for climate change mitigation and adaptation through programs promoting SLM; and
- Increased integration of climate change mitigation and adaptation activities, including SLM, into development strategies of the Government of Uganda and donors.

Within this perspective, a first Carbon Balance appraisal was conducted by FAO and World Bank using EX-ACT, for the main Agriculture World Bank programme (ATAAS) which covers over 50% of the whole agriculture sector and targets over 2.1 million households. The project would be able to avoid the emission of 130.1 Mt of eq-CO<sub>2</sub> while emitting about 1.46 Mt of eq-CO<sub>2</sub>. Finally the net effect of the project, according to the previous assumptions, is to create a sink of 129.4 Mt of eq-CO<sub>2</sub> during 20 years.

Since the project works on about 2.9 Million ha, the average mitigation potential of the project is equal to about 2.2 Ton of GHG avoided/sequestered per hectare per year or 44.9 tons of eq-CO<sub>2</sub> on 20 years. Most mitigation potential of the Sustainable land management Programme is related to the avoided deforestation linked to the intensification of agriculture lands, as well as the improvements implemented for annual crops.

Table 1 : Possible value generated per year during 20 years

	Final carbon balance in t of eq-CO <sub>2</sub> (during 20 years)	Value generated per year (during 20 years)		
		2\$/t eq-CO <sub>2</sub>	5\$/t eq-CO <sub>2</sub>	10\$/t eq-CO <sub>2</sub>
<b>Initial scenario</b>	129 447 637	12 944 764	32 361 909	64 723 819

The areas effectively improved by farmers are around 1.3 million hectares. So the equivalent Value generated per ha is around 500 USD on 20 years, or 25 USD /year (5\$/t eq-CO<sub>2</sub> ).

The huge amount of avoided GHG emissions may lead to high potential for financing incentives to work on climate change mitigation. The value generated could be attributed to farmers working on agriculture intensification as well as collective intervention to follow efforts in progress, e.g. payment for environmental services and watershed management.

### 5.3. Carbon appraisal at microwatershed levels (Santa Catarina state, Brazil)

EX-ACT was used to appraise the Santa Catarina Rural Competitiveness project (SC Rural). The proposed SC Rural project, under final preparation stage, focuses on the competitiveness of Family Agricultural Producer Organizations (FAPOs). FAPOs are defined as producer organizations in which 90% of membership consists of family farmers as defined under Brazil's Program to Assist Family Agriculture (PRONAF). Both currently existing FAPOs and others to be established during project execution are targeted.

SC Rural has the objective of increasing FAPOs' competitiveness by: (i) financing capital and related technical assistance in order to encourage technological innovation and diversification, raise productivity, and broaden market access; and (ii) bolstering provision of needed complementary public goods and services (e.g. infrastructure, certification, sanitary, legal and environmental regulatory compliance). The SC Rural project total cost is US\$ 189.1 million, with US\$ 90 million consisting of World Bank loan, using a sector wide approach that includes Government expenditures and activities from different sectors: agriculture, water resources management, environment, infrastructure (rural roads and communication) and rural tourism. Approximately 3.6 million hectares, equivalent to 37% of the state area - where economic activity is lagging and the potential for improvement and the need for support are larger - will be covered by the project which will primarily support rural agricultural and non-agricultural small-scale producers, rural workers and indigenous families, organized in associations, cooperatives, formal (with legal status) and informal networks or alliances. This is equivalent to total area of about 936 micro-catchments, i.e. about half of the 1,683 micro watersheds into which the State is divided. Productive landscape directly targeted by the project is estimated as 200,000 ha but it is estimated that total land receiving support for improved agricultural systems and natural resources conservation and management amounts would total 661,000 hectares.

The overall C-balance, computed as the difference between C sinks and sources over 20 years shows that SC Rural project activities are able to create a sink of 12.2 Mt CO<sub>2</sub>eq, sequestering 14.3 Mt CO<sub>2</sub>eq and emitting 2.1 Mt CO<sub>2</sub>eq. Most mitigation potential of the SC Rural project is in fact related to expansion of agro-forestry systems – with a different level of cropping intensity and biological complexity depending on the ecological conditions of project area – and to the promotion of the integration between woody perennials and crops, shrubs, and/or animals on the same land management unit, with a consequent change in land use.

## **6. Conclusions**

To tackle development challenges effectively in the context of climate change, it appears crucial to properly consider the linkages among land-use change (deforestation and conversion among forest, grasslands and croplands), land resources management (soil, water, vegetation and biodiversity management) and the vulnerability or resilience of local livelihoods.

Soil carbon sequestration integrated to watershed management may serve as a bridge in addressing the global issues of climate change. Even if the threat of watershed degradation strengthens the keen on mobilizing necessary investment to cope with such issues, it remains necessary to provide innovative incentives for carbon sequestration, based on impact and scenarios assessment, as well as demonstrating co-benefits that will encourage and support the adoption of sustainable land and water management in low-income countries. Co-benefits of carbon sequestration also may provide a direct link to the Millennium Development Goals (MDGs) through their effects on food security and poverty (FAO, 2009).

Substantial resources could be mobilized through the implementation of different payments for watershed service, climate change mitigation through carbon sequestration, targeting the providers of those environmental and social services. *“Mechanisms can be put in place through revolving funds, bonds, etc., so that anticipated future carbon revenues can be used to cover the necessary investments. These and other approaches are worth developing”* (Scherr S, 2010, Africa Watershed web debate).

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