Green Water Credits

Farmers' adoption of soil and water conservation: potential role of payments for watershed services

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ISRIC - World Soil Information

Green Water Credits is a mechanism to pay rural people for specified land and soil management activities that determine all fresh water resources at source. These activities are presently unrecognized and un-rewarded. This proof-of-concept program is supported by the International Fund for Agricultural Development (IFAD) and the Swiss Agency for Development and Cooperation (SDC)

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MAIN MESSAGES

The need for soil and water conservation is well known; there is a wealth of experience in the farming community, research and extension agencies have significant capacity, but there is an implementation deficit. Erosion of arable land is widespread and maintenance of existing conservation structures is poor. Downstream, siltation of reservoirs is severe, water supplies are inadequate and, increasingly, unreliable.

Farmers are aware of their private benefits from soil and water conservation but see this as a means to an end - crop production and income generation - not an end in itself. They demand tangible benefits from the land, labour and capital involved in conservation activities. Data on economic benefits of soil and water conservation are equivocal. Farm-gate prices and price fluctuations affect the likelihood of adoption of technologies; costs often outweigh benefits. The benefits are highly specific; yields may be increased by, for instance, green manure, but may be depressed by agro-forestry. On the other hand, the costs of constructing and maintaining structures like terraces can be substantial.

Poverty is a severe constraint on good land husbandry and the ability of downstream water users to pay for it. The Upper Tana is occupied by many smallholders who are usually poor, with limited access to markets and low prices for their produce. Poverty drives a preference for short-term benefits; in economic terms it means high real discount rates, at which the cost conservation measures outweighs the benefits to the farmers. Linked to poverty is the need for diversification of livelihoods. Solutions are needed to balance poverty alleviation and investment in sustainable management. There is also poverty in cities; if payments from downstream users mean higher water charges, these could further disadvantage already-vulnerable groups; many slum-dwellers already pay high charges for water purchased from vendors.

Further incentives such as Green Water Credits, which are payments for watershed services, are essential if there is to be wider uptake of conservation practices. This does not necessarily mean cash for conservation. Rewards may include secure access to markets, revolving funds or favourable terms of credit, farm implements, and community benefits such as better roads, schools or clinics, and capacity building. There are advantages and disadvantages to all of these methods. Some are gender-biased and it is difficult to enforce on-going compliance with contracts in the case of up-front in-kind benefits.

Implementation of Green Water Credits depends on cooperation among farmers; good examples are already in operation. Control of soil erosion depends mutually reinforcing practices on neighbouring plots, and the tasks of construction and maintenance of mechanical structures is often too great for one individual or family. Also, it will be easier to arrange and monitor contracts with groups of neighbours rather than with every individual; groups can be self-policing in matters of compliance. Farmers' groups linked through business objectives have already established cooperative arrangements, usually related to marketing which demands quality control, group cooperation and implementation of sanctions – because non-compliance affects the quality of the produce and the competitiveness of the group. Groups have systems are in place for collecting and administering payments, decision-making, monitoring, and dealing with breaches of rules – they can serve as models for Green Water Management groups.

National institutions that carry out research, capacity-building, and training in soil and water conservation have valuable experience and capacity. However, at present they are uncoordinated and do not necessarily reach the most vulnerable farmers.

Green Water Credits is predicated on the delivery of better water availability and reduced flooding, soil erosion and siltation. Given the variability of rainfall in the area, the mechanism must be able to disentangle the risk of non-delivery due to failure of rains, from farmers' failure to deliver watershed management services.

Main studies and results

Sources of information	*Results*
Modelling and livelihoods study *Theoretical models to understand linkages between private land use and externalities in the Tana Basin*	• Labour costs are a big part of the costs of SWC • The costs of constructing and maintaining mechanical structures can be substantial • Several studies have found that the private costs often outweigh the private benefits – in the absence of rewards such as Green Water Credits Models build a supply-response curve for environmental services (in this case increased water supply) linked to biophysical model results
Focus groups *Objective: exploration of farmers' views on soil and water conservation, markets, organisational capacity and institutional settings* *Sample: Eight focus groups with rain-fed farmers and irrigators in 4 agro-ecological zones*	• Knowledge and capacity in soil and water conservation has been built up over decades but there is much room for improvement; mechanical structures are poorly maintained • Farmers are aware of the potential, private, on-site benefits from conservation but demand tangible benefits for the substantial inputs required • Many farmers participate in groups and associations (marketing, benevolent, cultural, etc.) • To ensure farmers' ownership, the Green water Credits process should take into account their feasible suggestions about incentives and modes of payment • Most farmers would prefer contracts of 3-5 years, the longer period being more preferred • A group contract is preferred which, in turn, enforces the contract obligations upon its members A clear channel is required for periodic monitoring and feedback on progress of activities

Sources of information	*Results*
Choice experiment *Objective: to determine the policy components or attributes that would make Green Water Credits more attractive to farmers*	Variables that tend to *increase* attractiveness by > 10%: • Incentives, specifically: - In-kind incentives - Tied cash - Access to revolving funds • Ministry of Agriculture in charge of management • Medium- to long-term benefits
Sample size: 128 farmers in 4 agro-ecological areas	Variables that tend to *decrease* attractiveness by> 10%: • Number of labour-days required • Contract length (years) Variables with low predicted effect (<10%) • Private managing institution • No of household members working regularly on the farm • Current soil and water conservation efforts • Access to external markets Threshold level

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Acronyms and abbreviations

CGMS	Continuous Growth Monitoring System
FAO	Food and Agricultural Organisation of the UN
IFAD	International Fund for Agricultural Development, Italy
IIED	International Institute for Environment and Development, UK
ISRIC	ISRIC – World Soil Information
IWRM	Integrated Water Resource Management
KARI	Kenya Agricultural Research Institute
KenGen	Kenya Electricity Generating Company
LEI	Agricultural Economic Research Institute, Netherlands
MDGs	Millennium Development Goals
MONQI	Monitoring for Quality Improvement Methodology
MoA	Ministry of Agriculture, Kenya
MWI	Ministry of Water and Irrigation, Kenya
NWC	Nairobi Water Company
PES	Payment for Environmental Services
SDC	Swiss Development Cooperation
SEI	Stockholm Environment Institute
SWAT	Soil and Water Assessment Tool
TRPNR	Tana River Primate National Reserve
Wageningen UR	Wageningen University and Research Centre
WRMA	Water Resources Management Authority, Kenya

1 Introduction

1.1 Green Water Credits

Green water is the water held in soil and available to plants. It is the largest fresh water resource but can only be used *in situ*, by plants. *Blue* water is groundwater and stream flow that can be tapped for use elsewhere and which, also, provides environmental services and supports wetland and aquatic environments.

Green Water Credits is a mechanism for payments to rural people in return for specified water management activities that determine the supply of fresh water at source. As a shorthand, we shall call these activities *green water management.* This embraces the well-established technical concept of soil and water conservation but looks at the issue from the point of farmers' field activities. Farmers' water management activities are presently unrecognised and un-rewarded. Green Water Credits will enable them to better manage land and water resources to improve their own resilience to economic, social and environmental change by asset building (stable soils, improved local water resources, shortening the hunger gap, diversified rural incomes); to deliver enhanced *blue* water flows downstream and to reduce the hazards of floods and landslips; and, thereby, improve food security, water security and public health. Green Water Credits is not a poverty alleviation scheme but poor rural people will benefit directly.

The objectives of the proof-of-concept are:

a) Assess the feasibility of Green Water Credits as a practical mechanism to improve water resources and diversify rural livelihoods
c) Develop a business case
d) Identify potential areas for the application
e) Engage international and regional partners, including the private sector, and leverage funding.

This reports deals with the engagement of potential providers of water management services - the farmers. It is the result of an extensive literature review, ten focus groups conducted by ETC East Africa in the Upper Tana, a choice experiment designed to explore the farmers' trade-offs, and a preliminary analysis of potential on-site benefits from Green Water Credits. Farmers' willingness to participate in a Green Water Credits scheme is judged by historical mapping of incentives for soil and water conservation, the social and economic profile of potential suppliers, estimation of willingness to participate, and identification of barriers to participation. Assessment of local benefits and costs of implementation of specific soil and water conservation practices takes account of crop yields, the potential improvement of local water supplies, the reduction of environmental hazards, and the costs to the farmer of required adaptations of the farming system.

This report includes:

1. *Institutional and stakeholder mapping*: Assessment of the existing institutions working in the area, and their potential for managing and monitoring Green Water Credits
2. *Profile of service providers:*
   - Livelihoods in critical areas of the catchment
   - Within these communities, who are the poor and why are they poor?
3. *Upstream costs and benefits of green water management*
   - Costs and benefits of the desired land use changes from the farmer's viewpoint
   - Incremental cost of green water management
   - Benefits, in terms of farm production, household water use, and mitigation of environmental hazards
4. *Farmer willingness to participate in a Green Water Credits scheme:*
   - Choice experiment
   - Likelihood of participation under different design options
5. *Proposed design for most effective supplier participation*

1.2 Methodology

1.2.1 Target areas

The target areas are identified in Report 3 (Kauffman and others 2007) by hydrological studies according to the potential for improvement of *green* water resources, regulation of stream flow, arrest of soil erosion, and mitigation of reservoir siltation.

1.2.2 Data collection

The focus areas are:

a. Population, livelihood strategies and assets, income distribution, education, sources of household income;
b. Farm production: crops, technologies, yields, access to markets, intermediaries, prices;
c. Experience of incentives for soil and water conservation and current activity;
d. Barriers to green water management.

Data are derived from review of existing sources, focus groups, and a choice experiment survey of farmers' preferences. Eight focus groups were conducted with farmers (both those practising irrigation and those not) to explore:

- *Organisational capacity:* A key component of successful implementation. Focus groups embraced existing farmers' or water-users' groups that may serve as models for local organisational and management units for Green Water Credits.

- *Groups' economic aims:* Adoption of green water management is linked to the perceived economic incentives compared to the time, energy and resources required. Groups discussed their economic orientation, and how they feel that green water management will help or hinders their enterprise. Participants also discussed their limitations and strengths as a group. Data were collected on type of production, farming areas, household size, costs of implementing green water management, and income - to be cross-referenced with previous surveys.
- *Experience of green water management:* Existing activities, assistance, pros and cons.
- *Relevance of existing governmental and non-governmental organisations:* Perceived capacity and gaps of local institutions in promoting green water management.

Information from the focus groups was used in the design of a choice experiment to examine likelihood of adoption of green water management (Table 2). The questionnaire is presented as Appendix. Interviews also gathered first-hand information about:

- *Households* - composition, labour availability, education levels, manage-ment of cash flows
- *Group membership* - links within the social network, access to informal sources of credit, group bank accounts
- *Markets*
- *Current green water management activities*

Figure 1: Farmers' group discussion in Maragua, October 2006
Photo, Ina Porras

Table 1: Focus groups

Rain-fed groups	*Location*	*AEZ**	*Group composition(1)*	*Year of inception*	*Group activities*
Rwika FDA	Gachoka, Mbeere	IV Sunflower/maize (transitional zone)	25 committee members (44 women); covers 10 Villages	2005	Revolving credit fund Tree nursery
Mwituria Mamunyi	Mwea, Kirinyaga	III Rice/cotton/ coffee/maize (semi-humid)	18 (72)	2003	Tree nursery Crop trials Cash cropping
Kiunjugi Dairy Self-help Group	Mathira, Nyeri	I Tea/dairy (humid)	107 (60)	2004	Milk collection and marketing
Kawawa Multipurpose Self-help Group	Weithaga, Muranga	II Main coffee zone (sub-humid)	26 (38)	2004	Vegetable and tree propagation Marketing of produce Loans - revolving fund Tree planting
Mariya-ini Reafforestartion Youth Group	Murarandia, Muranga	I Tea/dairy (humid)	25 (24)	2001 (registered in 2006)	Tree nursery Revolving credit fund Tree planting
Irrigators					
Rupingazi Youth Group	Gachoka, Mbeere	IV Sunflower/maize (transitional zone)	23 (15 active; 4 women)	1998	Tree nursery Planting water melon/maize Revolving credit fund
Kimbimbi Youth Horticultural Farmers	Mwea, Kirinyaga	III Rice/cotton/ coffee/maize (semi-humid)	77 (39)	2003 (registered 2004)	Merry-go-round Loans Football tournaments Horticulture
Sagana Irrigation Water Project	Sagana, Nyeri	II Main coffee zone (sub-humid)	450 (3)	1979/80; 1994(2)	Horticulture Irrigation and domestic water supply
Gakaki Small-Scale Irrigation Project	Murarandia, Muranga	II Main coffee zone (sub-humid)	340 (14)	1994	Irrigation water supply Fund raising (monthly contributions

** Source: Jaetzold and Schmidt 1983*

Table 2: Choice experiment interviews

District	Division	Location	Cluster	Sample size	Variables	Readings: First (within Cluster)	Readings: Second (centre of Cluster)	Readings: Third (within Cluster)
Nyeri (AEZ I)	Tetu	Thengenge	Kariguini	16	Elevation (m)	2048	1997	1958
					Latitude	S 0^0 29’ 35.6’’	S 0^0 29’ 23.7’’	S 0^0 29’ 11.6’’
					Longitude	E 36^0 53’ 57.8’’	E 36^0 57’ 14.7’’	E 36^0 54’ 27.3’’
	Mathira	Maguta	Kiamucheru	16	Elevation (m)	1948	1896	1882
					Latitude	S 0^0 25’ 301.4’’	S 0^0 24’ 57.8’’	S 0^0 25’ 29.4’’
					Longitude	E 37^0 06’ 58.4’’	E 37^0 07’ 22.2’’	E 37^0 07’ 19.7’’
Muranga (AEZ II)	Mathioya	Kamacharia	Ihiga Ria Iguri	16	Elevation (m)	1776	1793	1774
					Latitude	S 0^0 35’ 40.0’’	S 0^0 35’ 40.9’’	S 0^0 35’ 27.9’’
					Longitude	E 37^0 00’ 38.7’’	E 37^0 00’ 25.7’’	E 37^0 00’ 12.4’’
	Kahuro	Weithaga	Rukui Wangu	16	Elevation (m)	1706	1700	1700
					Latitude	S 0^0 42’ 11.7’’	S 0^0 42’ 12.3’’	S 0^0 42’ 13.4’’
					Longitude	E 37^0 00’ 17.7’’	E 37^0 00’ 09.3’’	E 37^0 00’ 01.8’’
Kirinyaga (AEZ III)	Mwea	Murinduku	Mugamba Ciura	16	Elevation (m)	1275	1237	1245
					Latitude	S 0o 35’ 30.4”	S 0^o 35’ 10.7”	S 0^o 35’ 02.4”
					Longitude	E 370 28’ 34.6”	E 37^0 28’ 45.5”	E 37^0 28’ 49.5”
	Mwea	Kangai	Kombuini	16	Elevation (m)	1252	1235	1245
					Latitude	S 0^o 36’ 03.9”	S 0^o 37’ 09.7”	S 0^o 37’ 24.5”
					Longitude	E 37^0 17’ 41.4”	E 37^0 18’ 03.0”	E 37^0 18’ 05.3”
Mbeere (AEZ IV)	Gachoka	Mutuobare	Kathari	16	Elevation (m)	791	782	776
					Latitude	S 0o 43’ 33.5”	S 0o 43’ 29.8”	S 0o 44’ 42.5”
					Longitude	E 370 52’ 24.4”	E 370 52’ 39.4”	E 370 52’ 58.9”
		Mbita	Kambita	16	Elevation (m)	1177	1182	1224
					Latitude	S 0o 39’ 05.7”	S 0o 38’ 38.2”	S 0o 38’ 32.8”
					Longitude	E 370 35’ 49.8”	E 370 35’ 21.5”	E 370 36’ 11.5”

2 The Upper Tana catchment

The Tana basin (Figure 2) encompasses 100 000 km^2, and supports more than 4 million people. The whole basin covers some part of 21 districts in Central, Eastern, North Eastern, Rift valley, and Coast provinces.

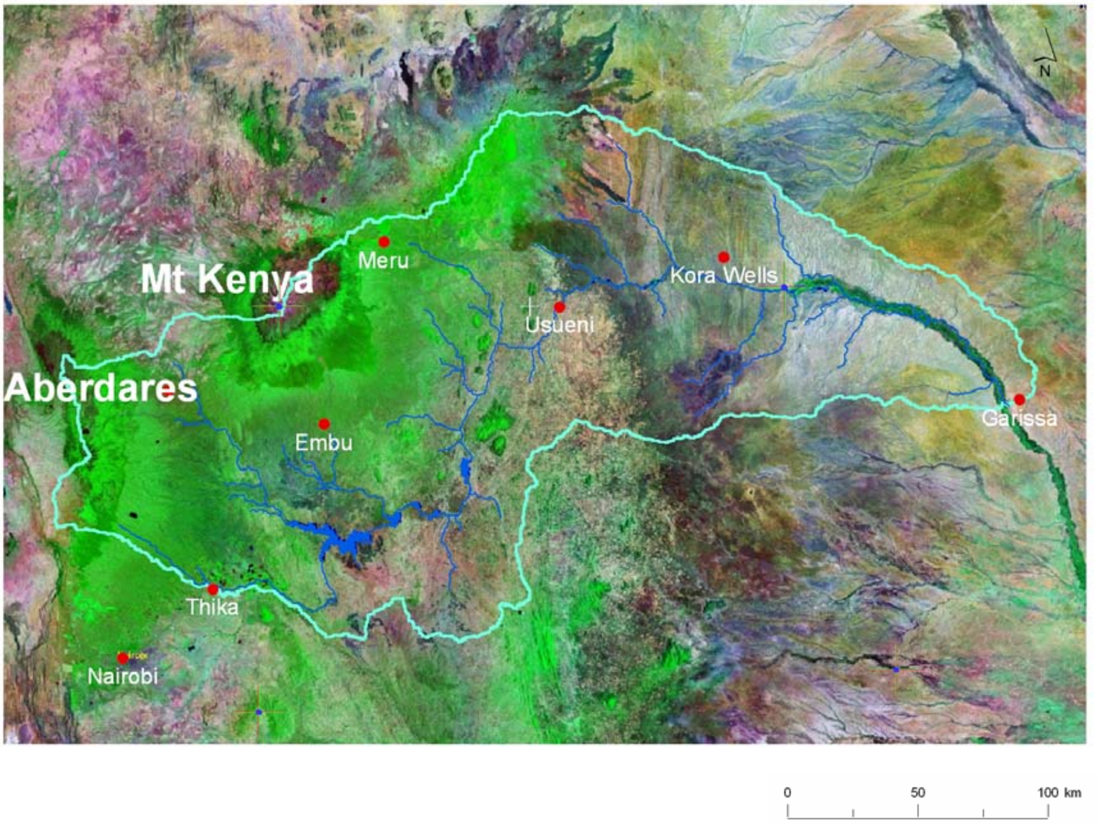


Figure 2: Tana Basin, location
Landsat true-colour image: well-vegetated, high-rainfall areas of Mt Kenya and the Aberdares Range appear green; catchment boundary overlaid in light blue, streams and reservoirs in blue

The upper Tana basin has good rainfall and many farmers, and there is significant potential for improved downstream water benefits. Water scarcity is an emerging issue.There is rich experience of green water management that can inform farmers' participation in Green Water Credits. There are important potential downstream water users who are in a position to pay for water management services over the long term: hydro-electric power, Nairobi municipal water supply, and irrigators. Current reforms of the water sector in Kenya offer a window of opportunity for the introduction of Green Water Credits.

2.1 Biophysical description

The Tana and its tributaries rises in the highlands of the Aberdares Range and Mount Kenya in central Kenya, The Tana River then runs through the eastern part of the country to enter the Indian Ocean; it is the only perennial stream in this dry region. Its a mean annual flow of 178 m^3/sec constitutes more than a quarter of the total mean discharge from all the country's rivers. The Mt Kenya catchment produces 49 per cent of the discharge of the Tana, the Aberdares 44 per cent, and 7 per cent comes from other catchments. The flow is highest in April-June and November-December and lowest in March and October. Flow has been declining; this may be attributed in part to land degradation in the upper catchment, associated with cropping, resulting in increased run-off at the expense of river base flow.

Land degradation is a decline in the land's actual or potential productivity. By any standards, land degradation is serious problem in the Central Highlands of Kenya: Bai and Dent (2006) present long-term satellite measurements of key biomass indicators of land degradation. Soil erosion, in particular, threatens food security and the sustainability of farming, and contributes substantially to rural poverty. It is associated with declining *per caput* availability of cultivable land without technologies for intensification of land use, which drive rural people to extend farming into marginal land and the remaining forest and woodland. It is also associated with increased runoff and declining river base flows because the regulating capacity of the soil is lost. Green Water Credits Report 3 (Kauffman and others 2007) demonstrates that improved land use and management can significantly reduce soil erosion and reservoir siltation and, at the same time, improve river base flow.

Agro-ecological zones, defined according to rainfall, temperature, evaporation, soil properties and length of growing period, encompass regions of different potential for crop and water production (Table 3 and Figure 3).

Table 3: Tana Basin, agro-ecological zones

Agro-Ecological Zone	*Altitude, m above sea level*	*Mean annual temp, ^{0}C*	*Mean annual rainfall, mm*	*Land use potential*
Tropical Alpine (TA)				National Park
Upper Highlands (UH)				
UH0				Forest reserve
UH1				Sheep and dairy
UH2	2440 – 2740	13.7 –11.7	950 – 1600	Pyrethrum-wheat
UH3	2230 – 2900	14.9 – 10.5	700 – 1000	Upper wheat-barley
UH4				Upper Highland ranching
Lower Highlands (LH)				
LH1	1830 – 2200	17.4 – 14.9	1700 – 2600	Tea-dairy
LH2	1890 – 2130	17.0 – 15.4	1200 – 1800	Wheat, maize, pyrethrum
LH3	2070 – 2220	15.8 – 15.0	700 – 1400	Wheat-maize, barley
LH4	2070 – 2210	15.8 – 15.1	600 – 850	Cattle-sheep-barley
LH5				Lower Highland ranching
Upper Midlands (UM)				
UM1	1520 – 1800	19.2 – 17.6	1500 – 2400	Coffee-tea
UM2	1280 – 1680	20.6 – 18.2	1500 – 2400	Coffee
UM3	1280 – 1520	20.6 – 19.2	1400 – 2200	Marginal coffee
UM4	1520 – 1770	19.3 – 18.0	750 – 1600	Sunflower-maize
UM5	1520 – 1770	19.3 – 18.0	500 – 1100	Livestock-sorghum
UM6				Upper Midland ranching
Lower Midlands (LM)				
LM3	910 – 1280	22.9 – 20.6	1000 – 1600	Cotton
LM4	760 - 1220	23.7 – 21.0	800 – 1200	Marginal cotton
LM5	700 – 910	24.0 – 22.9	600 – 900	Livestock-millet
LM6				Lower Midland ranching
Inland Lowlands (IL)				
IL5	610 – 700	24.7 – 24.1	500 – 850	Lowland livestock-millet
IL6				Lowland ranching

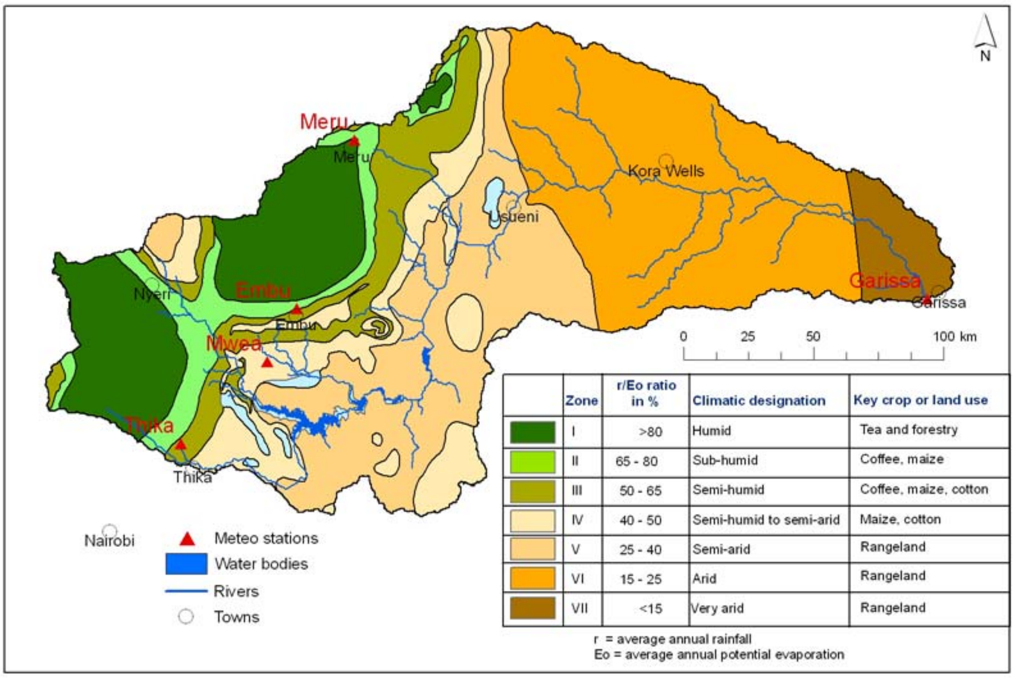


Figure 3: Tana Basin, agro-ecological zones
Source - Jaetzold and Schmidt 1983

2.2 Socio-Economic characteristics

The Tana basin supports more than four million people within the catchment while many more depend on services linked to the Tana. The Upper Tana is one of the most densely populated regions of Kenya; livelihoods depend mainly on farm-related activities.

Extreme climatic events bring loss of life and property, damage to infrastructure, disruption of power supply, water shortage, famine and migration. The World Health Organization reported on January 10th, 2006, that the *short rains* are failing and drought are becoming more frequent and prolonged. This year, 17 districts across the country are experiencing severe food shortage. For the Tana basin, the Global Acute Malnutrition index is 19 per cent and the Severe Acute Malnutrition index is 3 per cent (WHO 2006).

Selected household characteristics collected from 86 households in Nyeri, Embu, and Mbeere (Table 4) show that, overall, family earnings are low; the standard deviation shows large variations between the districts and the households. Many household members depend on farming, while farm sizes are small. The dependency on off-farm income is low on average, but varies greatly between households.

Table 4: Tana Basin, household characteristics
Source: MONQI

	Mean	*Standard deviation*
Number of household members	8.8	3.6
Total area per household (ha)	1.8	1.3
Dependency on off-farm income (%)	8.7	15.8
Family earnings (Ksh/yr)	103 057	85 116
Family earnings (US$/yr)	1 874	1 548
Market share (%)	12.8	44.5

2.3 Economic uses of water

The Tana is a vital water resource: for hydro-electric power, supply of water to municipalities including Nairobi, and provision of water for irrigation. For Nairobi, supply is pumped from a distance of 50 km. Following water-source expansion projects in 1984 and 1995, the available supply was increased to a design capacity of 520 000 m^3/day by 2002 but during the 2006 dry season maximum supply was not more than 456 000 m^3/day, compared with a daily demand of 570 000 m^3 (MG Ngari, Nairobi Water, pers. comm. 2007) The supply problem is aggravated by siltation of the reservoirs and the poor state of the distribution system with losses of about 50 per cent from leaks and illegal connection (Foster and Tuinhof 2005).

3 Soil and water conservation in the Tana Basin

Before independence in 1962, soil and water conservation was implemented through strict regulations, prohibitions and coercive communal work; it became linked to colonialism and was largely abandoned after independence. Sustained effort has gone into its re-establishment, in particular with a long-running National Soil and Water Conservation Program. There has been success on individual farms, especially with simpler activities, like agronomic measures, but less with terraces - which require continual maintenance and communal effort. At different stages, government agencies, international donors, NGOs and Church-based groups have been involved.

Table 5: Evolution of soil and water conservation in the Tana Basin
Source: ETC (2007)

Period	*Detail*
Pre-independence (1930-1962)	Local chiefs, headmen and technical assistants enforced soil and water conservation through prohibitions and compulsory community work
After independence (post 1962)	Farmers associated conservation with colonialism; it was rejected
1970-1980	National Soil and Water Conservation Programme , assisted by the Swedish International Development Agency offers various incentives, including subsidies and tools, to promote individual activities. Upon withdrawal of subsidies, many farmers stopped maintaining terraces - partly because of the costs, partly because the project was not effectively owned by the farmers. Subsequently, subsidies (including tools) were perceived to work against private initiative.
1980s	Conservation promoted by NGOs and Church-based groups (especially after the drought of 1984). Many of these projects emphasised individual farm approaches. Many projects were phased out in the 1990s.
1987-1997	Catchment Approach established, concentrating extension efforts in one catchment per year. PLAN International distributed coupons for work in the 1990s to build terraces. Maintenance of these structures was poor due to labour constraints.
Post-2000	NSWCP ended in 2000. Current activities under the National Agriculture and Livestock Extension Program (NALEP) employ a shifting focus approach similar to that implemented in the previous period. Farmers consulted during the focus groups reckon that SWC efforts diminished over the past 20 years because: Enforcement of rules affecting steep slopes and riverbanks (Agriculture, Basic Land Usage Rules, 1965) has decayed; reduced visits from agricultural officers led to less farmers training and monitoring SWC. Increased use of forests for firewood and tea curing/processing, alongside with reduced planting efforts, has led to reduction in tree cover

Structural works have been encouraged by various incentives (subsidies, food coupons, and access to equipment) but most activities ceased when these incentives were withdrawn. Lessons drawn by the focus groups include:

- Using tools as incentive was counter-productive since farmers did not carry out conservation activities unless they received them;
- Subsidies for nursery establishment were counter-productive in promoting private initiative;
- Indirect, intangible incentives, such as competitions and regular workshops for critical assessment were perceived as positive encouragement.

Communal work is uncommon in the Upper Tana, even for activities that would clearly benefit from cooperation, such as cut-off drains across farm boundaries and water harvesting; however, it is common practice in parts of Machakos , which has a long history of soil conservation work parties or *mwethya* groups.

4 Payments for environmental services in Kenya

4.1 Payments for environmental services

Environmental services are the goods and services that are provided by nature. These are a public good and market failure is common; governments have usually taken up the responsibility for maintaining them. However, during recent years, there has been serious interest in establishing market-based mechanisms as a more effective and efficient way to maintain these services and to integrate economic growth and ecological integrity. These mechanisms may also address poverty reduction goals.

Payments for environmental services (PES) link the demand for the services (e.g. improved water flows, storage of carbon) with the supply (e.g. forest conservation by local communities, water management by upstream resource managers). By establishing a market mechanism, the suppliers of the services can be rewarded. Green Water Credits is a PES, specifically for land and soil management activities that determine the supply of fresh water at source. Direct payments other rewards will enable better management and, therefore, less runoff, flooding, and siltation of reservoirs, and more groundwater recharge and stream base flow. At the same time, Green Water Credits will diversify rural incomes and help communities to adapt to economic and environmental change.

Payments for Environmental Services are: 1) *Voluntary* transactions on the providers' side *(otherwise it will be regulation)*; 2) Between a minimum of one buyer and one-seller; 3) Conditional on previously-agreed land use that is expected to provide an environmental service. Additionally, it is expected that they will: 4) Promote private sector payment for the provision of (previously considered) public goods; 5) Represent new sources of funding for watershed conservation; and 6) Provide some level of competition, which determines the extent to which individual stakeholders can influence prices. Competitiveness is associated with the number of participants; when there are fewer participants, individuals have more power and the market is less competitive. Effective participation is measured by the existence of barriers to participation.

Source: Wunder (2005) and Porras and others (2007).

4.2 Opportunities and challenges for Kenya

PES approaches are increasingly popular, especially in Latin America, and there are now several proposals for East Africa. Green Water Credits Report 2, *Lessons learned from payments for environmental services* (Grieg-Gran and others 2006) highlights the following opportunities and challenges:

- Green Water Credits addresses the short-term focus of the poverty-reduction by immediate, on-going payments for improved land and water management. However, the inclusion of many smallholders means relatively high transaction costs, reducing the amounts that can be paid to service providers.

- Coordination across institutions and disciplines will require establishment of a multi-stakeholder, multidisciplinary steering group and clear lines of legal and institutional authority.
- A payment system will have to take account of the multiple and overlapping sources of formal and traditional authority for land and water management. Strong customary institutions or well-functioning community development committees may assist the introduction of PES by providing a means for banding farmers together for negotiation, monitoring and channelling payments.
- Success basin-wide will depend on institutional ability to reach smallholders across the catchment. Capacity gaps in existing water management institutions mean that, in the first instance, Green Water Credits will be easier to operate at a local level, or where there are other institutions such as an NGO or a community-based organisation that can provide support or facilitation.
- The prevalence of shared water river basins in Africa does not rule out the introduction of Green Water Credits but makes some of the most significant river basins in the continent more challenging.

Consultations at the October 2006 Green Water Credits Workshop in Nairobi suggest that the concept is broadly welcome. Several related proposals have already emerged that aim at promoting green water management through direct incentives. For instance, the Water Management Board proposes a discount of 5 per cent from water charges to farmers implementing best practice. This would benefit big irrigators but a smallholder paying Ksh 350/year for irrigation (about US$5) would save about the amount paid by a Maragua householder for a jerry can of water from a street vendor (Ksh 15); however, the principle is already accepted. Trust funds, financed by water charges, already exist to support various projects, such as sanitation; however, if a trust fund were to be established for Green Water Credits, it should not be seen as a social welfare kitty.

It was argued that use of the terms “credits” or “payment” may raise expectations that the project may not be able to fulfil; further, that the expectation of payments creates dependency – so the proof-of-concept should develop a range of options including in-kind compensations. On the one hand, it was argued that green water management is for the farmers’ own benefit and their own responsibility. On the other hand, there is clearly a need to tip the financial balance in favour of green water management.

Previous incentives were only partly successful - maintenance fell away rapidly when incentives were withdrawn. Information from the focus groups shows, beyond the simplistic explanation of lack of ownership and interest, that farmers are hard-pressed by short-term issues> Family labour is limited and hired for cash, and there are hardly opportunities for the smallholder to afford even seeds to maintain vegetative measures. The following sections examine the continuing constraints on adoption of green water management, how effectively these limitations can be addressed, and compare the costs of adoption to the resources available.

5 Potential providers of water management services

5.1 The Upper Tana Catchment

The Tana Basin straddles the Central, Eastern and Coast provinces of Kenya but most of the population is in the Upper Catchment, between Thika in the south, Nyeri in the north, and Embu in the West.

5.1.1 Land holding and land use

Arable area per person is highest in the dryer zones of Tharaka (3.9 acres per household) and Mbeere (3.1 acres per household) districts. Pressure on land is highest in the most productive areas: in the tea zone, family holdings range from less than ½ acre to 4 acres; in the coffee zone ½ acre to 5 acres (IFAD 2002).

Land is inherited and subdivided between sons each successive generation. Women do not inherit land, only by men. Unmarried women may be allocated a plot for a dwelling but they may not have access to the rest of the land. Even when widows become household heads, they still cannot inherit. Women own land only by purchase. This has implications for operation of Green Water Credits; contracts with land owners would exclude women. Table 6 shows land holdings according to gender in different districts. In Kirinyaga District, male-headed households had access to much bigger pieces of land (own and operated) compared with female-headed households - a ratio of 3 to 1; in Nyandarua District, male-headed households had twice as much family land as female-headed households; however, for Maragua, Nyeri and Thika districts ratios by gender are similar.

Table 6: Arable land holdings by gender
Source - CKDAP 2006

District	*Mean own land, acres (min., max.)*		*Mean land operated (min., max.)*	
	Male-headed	*Female-headed*	*Male-headed*	*Female-headed*
Kirinyaga	2.9 (0.1, 15)	1 (0.5-1.5)	2.0 (0.1,8)	0 (0,0)
Maragua	1.8 (1,11)	1.9 (1, 8)	1.2 (1,5)	1.1 (1,3)
Nyandarua	5.0 (1,84)	2.8 (3,3)	2.8 (1,42)	1.5 (2,2)
Nyeri	2.8 (1,60)	2.4 (2,3)	1.1 (0.1,8)	1.1 (0.3,8)
Thika	2.9 (0.2,18)	3.3 (0.3,10)	1.4 (0.01,7.5)	1.2 (0.01,3)

The main land use types in the upper catchment are coffee, tea (both in the highlands), and rain-fed cereals (mainly maize) intercropped with beans and vegetables (Figure 4).

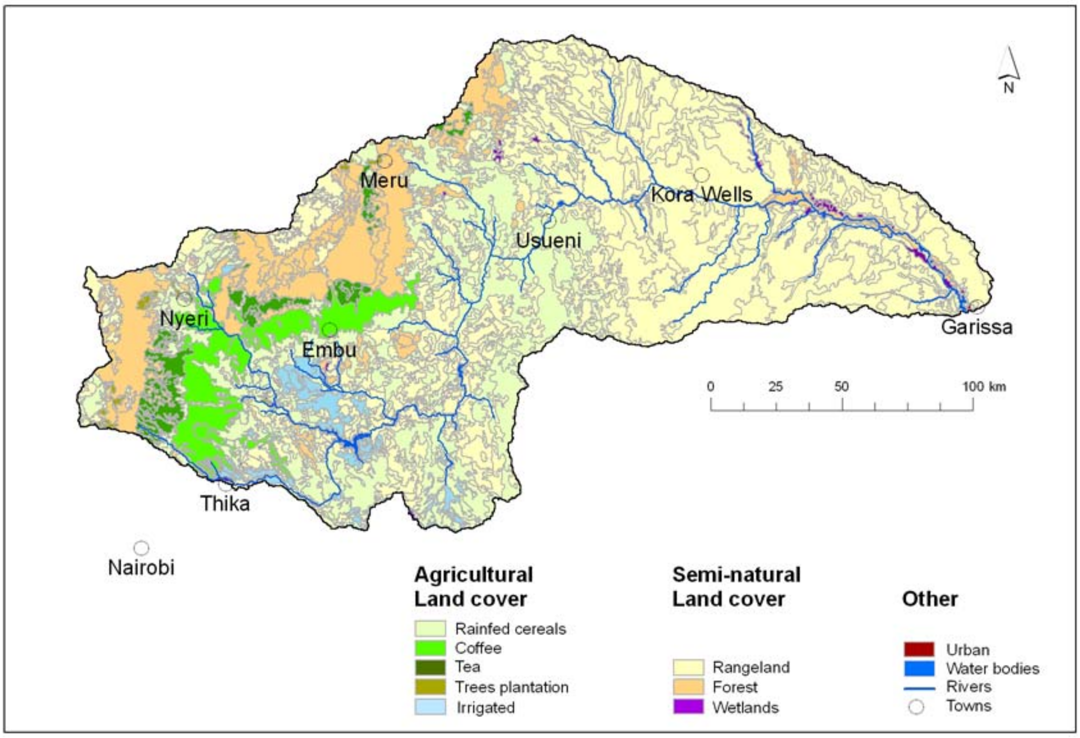


Figure 4: Upper Tana, land use
Source: FAO 2000 - East Africa Module Land Cover

Tea: In the highland tea zone, three quarters of the land is under tea, managed by the Kenya Tea Development Agency which also operates the tea factories. Tea is perennial; under good management, it covers the ground entirely, except during establishment and after pruning, and so provides good soil protection. Other crops in the tea zone include a variety of horticultural crops, maize, beans, bananas, and fruit trees.

Coffee: In the coffee zone, low prices in recent years have driven a shift to alternative cash crops such as French beans, tomatoes, and Asian vegetables. Farmers also maintain the subsistence part of the mix - maize, beans, potatoes and sweet potatoes intercropped with coffee. Other plots are abandoned with poor coffee bushes which cannot legally be grubbed up because coffee is a *scheduled crop.* This provision of the Agricultural Act is not strictly adhered to but farmers may persevere with an established crop, hoping for better times.

Lower cotton/tobacco zone: The major land use systems in this zone are irrigated cropping, rain-fed cropping, and livestock production under rangeland conditions. There are three major irrigation schemes: Mitunguu, in Meru; Nguuru Gakirwe, in Tharaka; and Mwea, in Kirinyaga and Mbeere; as well as irrigated flower production in the lower Rupingazi/Kapingazi Rivers. Most of the land within Mitunguu and Nguuru Gakirwe irrigation schemes is under high-value horticultural crops. Bananas, maize and beans are grown both under irrigation and rain-fed conditions.

Mwea Irrigation Scheme is a major rice producer. Small-scale irrigation includes group horticultural schemes, group food schemes, and individual smallholder enterprises (Onduru and others 2002). In other regions, the proportion of farmers practising irrigation is lower: 13, 12 and 6 per cent, respectively, in Nyandarua, Thika, and Nyeri. Irrigators mainly use bucket application; flooding is mainly practised in rice fields of Kirinyaga, overhead sprinklers only in Nyandarua and Nyeri (CKDAP 2006).

Subsistence rain-fed cropping in the lower zones yields poor returns. Areas like Marimanti, lower Chuka and Mbeere are occupied by agro-pastoralists, with very limited opportunities for rain-fed cropping of maize, beans, sorghum, millets, cowpeas, and green gram; the last three are also grown for cash.

Forage: Livestock are an important asset. Aggregated data for forage crops are shown in Figure 5. Napier grass is grown by more than half of the respondents, Rhodes Grass by one fifth. Forage crops can be used in green water management as grass strips, fodder trees and banana on such strips, and cover crops.

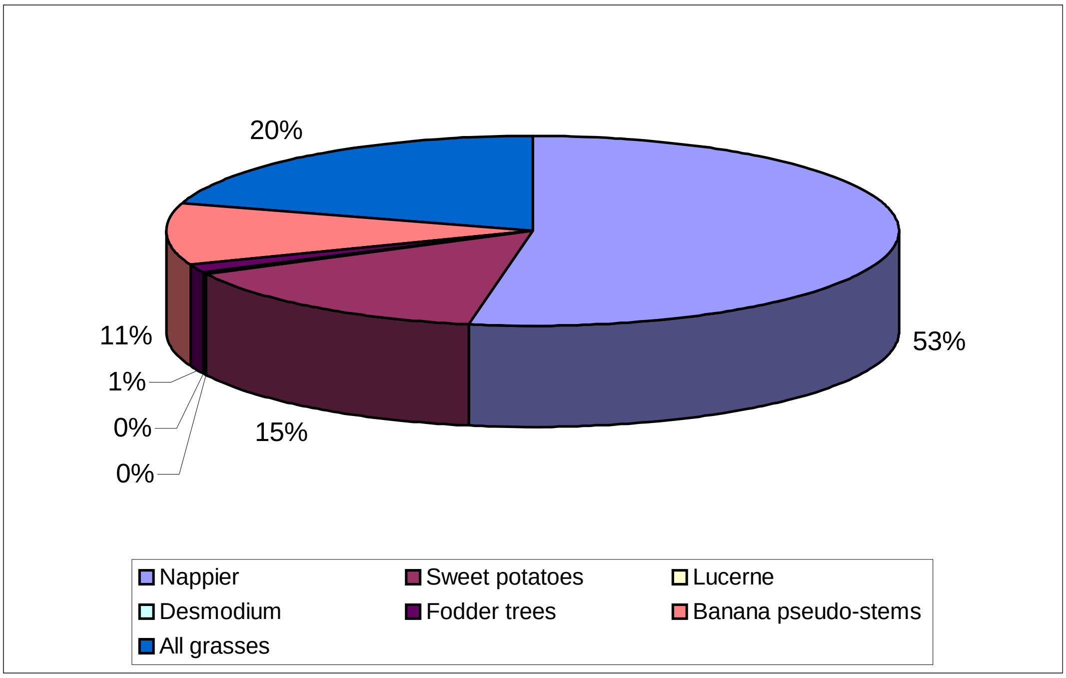


Figure 5: Fodder production in Kirinyaga, Maragua, Nyandarua, Nyeri and Thika
Source: CKDAP 2006

5.1.2 Soil and water conservation

Many farmers practise green water management; many, up to one third, do not; amngst those that do, grass strips is the most popular method. Table 7 illustrates the trends in implementation of specific practices in Mbeere District. Activity also varies between Districts (Table 8).

Table 7: Green water maanagement in Mbeere District, 1996-2001
Source: Siakago Agricultural Office, cited by Onduru and others 2002

Practice	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*
No. farms conserved	1 130	970	1 790	609	1 482	2 200
Fanya juu (m)	39 800	21 000	53 600	86 440	322 760	82 297
Stone lines/bunds (m)	10 500	5 000	15 200	15 730	45 260	6 160
Grass strips (m)	18 000	9 620	47 000	41 900	2 236	5 560
Trash lines (m)	23 500	27 600	17 300	27 900	173 650	196 000
Cut-off drains (m)	5 080	8 400	3 510	995	160	530
Retention ditch (m)	1 070	3 550	2 380	5 200	4 400	1 950
Unploughed strips (m)	5 500	NR	12 500	19 250	16 890	8 645
Riverbank protection (km)	29	8	14.6	15.8	5.5	13
Contour bunds (ha)		20	30	30	2.5	15
Negarims (ha)		1	0.5	4.3	12.5	2
Semi-circular bunds (ha)		NR	NR	0.7	4	3.5
Basins/9-seeds holes (ha)		NR	4	4	2	4.8
Pitting (ha)		NR	NR	NR	8	20

NR: not reported

Table 8: Adoption of green water management (households) by District
Source: CKDAP 2006

	Kirinyaga		*Maragua*		*Nyandarua*		*Nyeri*		*Thika*	
Practice	*Freq*	*%*	*Freq*	*%*	*Freq*	*%*	*Freq*	*%*	*Freq*	*%*
Trash lines	32	13	39	16	3	1	1	0.5	10	4.
Stone lines	6	2	0	0	7	3	2	1	12	5
Fanya juu	28	11	50	20	23	10	47	19	110	45
Grass strips	62	25	135	55	118	50	128	53	46	19
Cut-off drains	19	8	96	39	54	22	30	12	54	22
Bench terraces	13	5	19	8	10	4	64	26	10	4
Semi-circular bunds	1	0.5	1	0.5	0	0	0	0	0	0
Contour farming	34	14	3	1	46	19	1	0.5	1	0.5
Pitting	0	0	5	2	0	0	1	0.5	2	1
Water harvesting basins	2	1	4	2	0	0	0	0	0	0
Road run-off harvesting	2	1	2	1	0	0	1	0.5	1	0.5
None	93	38	31	13	64	27	51	21	35	14

The small sample collected during this study suggests that almost half of the farmers undertake green water management across at least half of their farm (Figure 6). Activities vary markedly between agro-ecological zones (AEZs). Little is done in AEZs I and III (72 and 66 per cent, respectively, report no activity); much more in AEZ II and IV, where 80 per cent of farmers undertake green water management across at least half of the farm. Activity is linked with support provided by Government agencies, in particular capacity building, although some farmers mentioned in-kind support (seeds, tools).

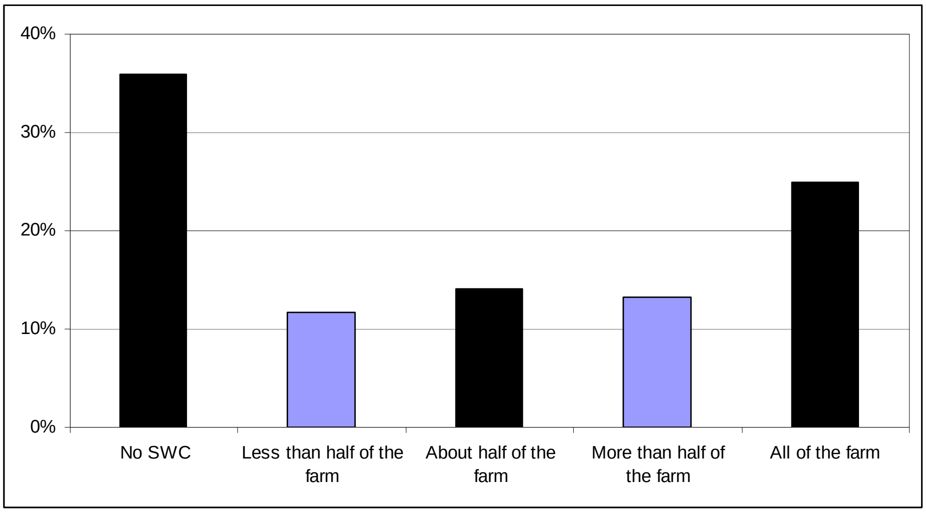


Figure 6: Green water management by farm
Source: Choice Experiment Survey, 2007

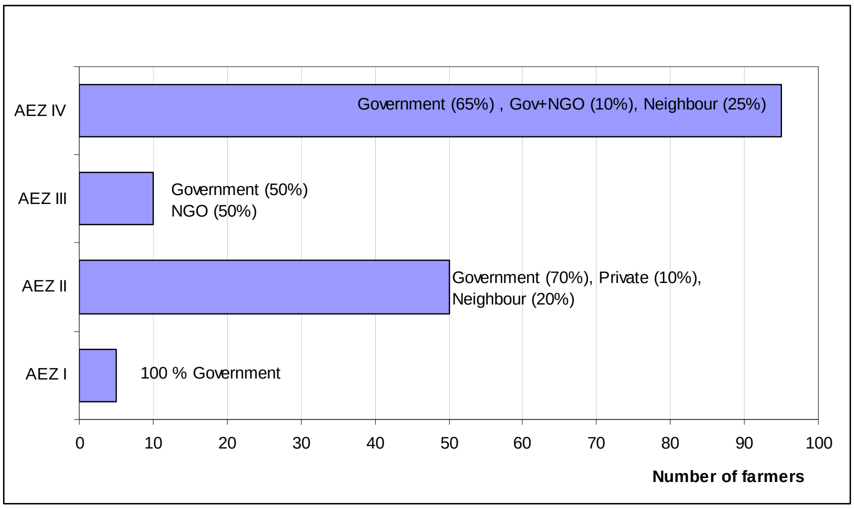


Figure 7: Support for green water management, by AEZ
Source: Choice Experiment Survey, 2007

Crop residues and mulching: The availability of crop residues for mulch and green manure depends on the farming system. In drylands, crop residues come from cereals and pulses, and are mainly used for stock feed - grazed as standing stalks or kept for feeding in the dry season; some maize stover is used as fuel. The residues are rarely incorporated into the soil or used as mulch. Mulching is practised only on high value crops. Green manuring is likewise uncommon; both through lack of knowledge and because farmers consider land too scarce to be used for non-food crops (Onduru and others 2002).

5.2 Costs and benefits of SWC

5.2.1 Cost of conservation measures

The costs and benefits to the farmers supplying water management services is a crucial element in the feasibility of Green Water Credits.

Establishment and maintenance: Giger and others (1999), in a survey of 38 schemes in 15 African countries, calculated a median establishment cost of US$ 150/ha (variance 20-1000) and, for maintenance, a median of $ 20/ha/year (most between $10 and $50/ha/year). Labour is the main cost; for the Tana basin, the estimates of Shiferaw and Holden (2001) in Ethiopia (Table 9) may be comparable.

Table 9: Area loss and labour requirement for conservation measures, Ethiopia

Technology	*Slope, %*	*Area loss [1], ha/km*	*Labour requirement [2], work days/km*		*Labour requirement, Work days/ha*	
			Construction	*Maintenance*	*Construction*	*Maintenance*
Soil bund	5	0.4	70	15	28	6
	10	0.8	70	15	56	12
	20	1.6	70	15	112	24
	30	2.4	70	15	168	36
	50	4.0	70	15	280	60
Stone bund	5	0.4	150	15	60	6
	10	0.8	150	15	120	12
	20	1.6	150	15	240	24
	30	2.4	150	15	360	36
	50	4.0	150	15	600	60
Fanya juu	5	0.4	250	15	100	6
	10	0.8	250	15	200	12
	20	1.6	250	15	400	24
	30	2.4	250	15	600	36
	50	4.0	250	15	1000	60
Grass strips	5	0.4	10	2	4	0.8
	10	0.8	10	2	8	1.6
	20	1.6	10	2	16	3.2
	30	2.4	10	2	24	4.8
	50	4.0	10	2	40	8.0

1 Land occupied by structures having a width of 1m. Unless grass and other products are harvested, this is the area loss due to conservation

2 For level and graded bunds, the average labour requirement for soil and stone bunds were used

Table 10 incorporates data on labour costs and gross margins from MONQI surveys of several sites in the Tana River Basin between 1997 and 2002 to make an indicative estimates of the costs of specific conservation measures. These costs of constructing and maintaining mechanical structures are substantial, especially for steep land.

Table 10: Estimated costs of area loss and labour for conservation measures in the Upper Tana (US$/ha)

Technology	*Slope (%)*	*Max Area loss* [1]	*Min Area loss* [2]	*Labour* [3]	
				Construction	*Maintenance*
Soil bund	5	60	16	32	7
	10	120	32	64	14
	20	240	64	128	27
	30	360	96	192	41
	50	600	160	320	69
Stone bund	5	60	16	69	7
	10	120	32	137	14
	20	240	64	274	27
	30	360	96	411	41
	50	600	160	686	69
Fanya juu	5	60	16	114	7
	10	120	32	229	14
	20	240	64	457	27
	30	360	96	686	41
	50	600	160	1143	69
Grass strips	5	60	16	5	1
	10	120	32	9	2
	20	240	64	18	4
	30	360	96	27	5
	50	600	160	46	9

[1] Calculated by the areas lost * maximum gross margins (US$ 1500)
[2] Calculated by the areas lost * minimum gross margins (US$ 400)
[3] Calculated by taking the rate for hired labour per day (80 KSh), converted to US$

To arrive at the net costs of water management services, the farmers' benefits from green water management should be deducted from the costs. Calculating the benefits is difficult because they depend on the higher sustained yields expected, which, in turn, depend on soil, terrain and weather, as well as crop management and farm-gate prices. The results of many studies are equivocal. For instance, Ekbom (2006) found that terraces and green manure contribute to increased yields but agro-forestry is associated with lower yield of the primary crops. In Kenya, Pagiola (1996) found that higher commodity prices increase incentives to adopt conservation measures on steep slopes, but not on shallower slopes; were terraces to need more land to be taken out of production than assumed in the calculations, then higher commodity prices would tend to discourage farmers from adopting them. Winter-Nelson & Amegbeto (1998) found that increased output prices tend to improve incentives for agricultural investment, but increased price variability damps investment through the effects of risk aversion, credit constraints, or option values.

Winter-Nelson & Amegbeto (1998) cite Kilewe (1987) that yield losses due to erosion on fields with 15 per cent slope in Machakos are constant at 22.2 kg maize/ha and 18.6 kg beans/ha (on base yields of 1000 kg maize/ha and 800 kg beans/ha). With an average maize price of 11.54 Ksh/kg maize (Monqi 2006), this comes down to 256 Ksh/ha or 3.7 US$/ha for maize. For beans with an average price of 19.26 Ksh/kg, the benefit from reduced erosion is 358 Ksh/ha or 5.1 $US/ha. These benefits are small compared to the costs. Shiferaw and Holden (2001) found negative net present values for most soil and water conservation measures under various crops. For semi-arid Kenya, Pagiola (1994) reckoned that it takes 48 years to break even once soil conservation structures are constructed. In short, the incentive of Green Water Credits is essential to overcome the financial barriers to sustainable land management.

5.2.2 Upstream economic benefits of Green Water Credits

Very much as a first step, Table 11 summarises the incremental financial benefits of the green water management practices used for biophysical scenarios in Report 3 (Kauffman and others 2007) - contour strips, mulching, and tied ridges. For the soil loss from erosion, the nutrient nitrogen content was calculated with data from the LEINUTS MONQI survey in the Tana Basin in 1997 (data used was from samples taken in Nyeri) and the cost of replacing this with fertiliser calculated from the price of CAN (a common fertiliser in the region). Prices were not adjusted for inflation.

Calculating the benefits of groundwater recharge is more difficult. Table 11 shows the groundwater recharge calculated with the price of irrigation water. This assumes that the value of water can be equated to the cost of irrigation water which may not reflect accurately the *value* of water; different uses of water may have different prices and values; the value of water may different throughout the season, with a peak in the dry season. Improved crop yields as a result of green water management are not included in Table 11.

Table 11: Incremental financial benefits of green water management (Ksh/ha/yr)

	Contour Strips		*Mulch*		*Tied ridges*	
	1996	*1997*	*1996*	*1997*	*1996*	*1997*
Maize						
Groundwater recharge (Ksh/ha/y)	0.7	3.9	1.3	5.9	1.1	7.2
Runoff (mm/y)	-0.7	-4.0	-0.8	-5.1	-1.1	-7.4
Soil loss (Ksh/ha/y)	-15.4	-130.6	-15.4	-130.6	-15.4	-138.3
Tea						
Groundwater recharge (Ksh/ha/y)	0.5	2.1	1.0	3.3	0.6	3.1
Runoff (mm/y)	-0.4	-2.2	-0.6	-3.1	-0.6	-3.1
Soil loss (Ksh/ha/y)	0.0	-23.0	0.0	-23.0	0.0	-15.4
Coffee						
Groundwater recharge (Ksh/ha/y)	0.3	1.9	0.7	2.8	0.4	2.6
Runoff (mm/y)	-0.3	-1.9	-0.4	-2.7	-0.4	-2.7
Soil loss (Ksh/ha/y)	-23.0	-215.1	-23.0	-215.1	-23.0	-161.3

N content of 1 kg soil	0.0040	Source: MONQI data LEINUTS Nyeri, 1997
CAN fertiliser N content	0.21	"
Price 1 kg CAN (US$)	0.40	Constant prices US$ 1997
Price 1 kg N (US$)	1.90	"
Price of 1 kg soil (US$)	0.0077	"
Price of 1 ton soil (US$)	7.68	"
Price of irrigation water ($US/$m^3$)	0.0021	Source: field data October 2007 Constant prices US$ 2007

5.3 Modelling the supply of *green* and *blue* water

Farmers' land use and management decisions affect biophysical systems through several mechanisms. These links must be explicit and quantified for the development of a Green Water Credits mechanism. The quantification outlined by Report 3 (Kauffman and others 2007) can be built upon by estimating the economic implications - assuming that farmers make management decisions to maximize their economic returns. These economic decisions to supply market goods (crops and livestock) also affect the supply of environmental services such as water supply.

Green Water Credits aims to support the supply of environmental services by providing long-term incentives. Here we outline a procedure for constructing a supply response curve for *blue* water supply, following the Minimal Data approach (Antle and Valdivia 2006), applied by Immerzeel and others (2007) to estimate the supply curve for environmental services in Tibet. This approach can be implemented in the design phase of Green Water Credits to estimate the supply curve for farmers participating in Green Water Credits.

The first step is to model the farmers' decision about land use. We simplify choice to two options: one without conservation measures (activity *a*); and one where green water management is implemented (activity *b*). The land use decision in each time period is based on the maximization of expected value of the land use, which we denote by $v(p, s, z)$ where p is a parameter (vector) reflecting the output price; s indexes the site and $z = a, b$ indexes the activity at the site. This allows for spatial heterogeneity. The value v can be interpreted in various ways but we will interpret it as expected returns from cropping; this will differ according to AEZ and cropping pattern.

For simplicity, it may be assumed that the adjustment cost associated with changing from one land use to another is nil. With this assumption activity *b* is chosen if $\omega(p, s) = v(p, s, a) - v(p, s, b) \geq 0$ (vice versa for *a*).

Implementing green water management will have several effects. It will lead to reduction of soil erosion, which means there will be more water in the reservoirs because their capacity is not reduced by siltation. It will also increase crop yields (possibly decreasing *blue* water) as well as reducing unproductive evaporation from the soil (increasing *blue* water). Most importantly, better regulation of the water cycle, will increase groundwater recharge and river base flow at the expense of destructive floods

The benefits of the water management services provided by activity *b* consist of:

- Reduction in the amount of water removed from the soil by direct evaporation leading to an increase in *blue* water (mm)
- Reduction in the amount of sediments contributed to the reach (tonnes/ha)
- Reduction of peak flows (and floods) and increase in base flows.

These benefits depend on the weather, which is not known beforehand but which may be forecast statistically. In principle, each of the benefits may be valued although, in practice, this may be difficult. As an example, we may consider just one benefit: reduction of evaporation.

When farmers do not receive any payments, there is an initial equilibrium of ecosystem services. The initial equilibrium (starting point) will be a mix of activities *a* and *b*.

Green Water Credits aims to increase the environmental benefits by a payment p_e to induce farmers to switch to activity *b*:

$$\varpi(p,s) = v(p,s,a) - v(p,s,b) \leq p_e e \qquad (1)$$

$\varpi(p,s)$ can be interpreted as the opportunity cost of implementing green water management. The price p_e paid to farmers must therefore equal the opportunity costs per unit of environmental service provided.

The total supply of environmental services is determined by the joint spatial distribution of environmental services and opportunity cost. If $v(p,s,a) < v(p,s,b)$ and $\varpi(p,s) < 0$ then farmers will implement *b* without payments $p_e e$. If we define the spatial distribution of opportunity costs as $\phi(\varpi)$, then for $p_e(0)$ the area under the negative of $\phi(\varpi)$ represents those land units where farmers use green water management without payments (Figure 8). Define the quantity of ecosystem services supplied in this initial equilibrium as S(p). As p_e increases, the net benefits of green water management increase for additional land units and farmers adopt green water management practices on those land units, increasing the quantity of environmental services supplied.

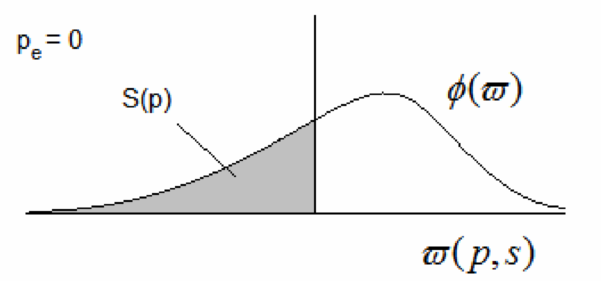


Figure 8: Implementation of green water management without payments (initial situation)

Let $\varphi(\varpi / e)$ be the spatial distribution of opportunity costs per unit of ecosystem (in mm water) obtained by ordering all the sites *s* for a given *p* within a land unit in increasing order, then the fraction of the total number of farmers who undertake green water management without payments is given by:

$$r(p) = \int_{-\infty}^{0} \varphi(\varpi / e) d(\varpi / e) \qquad (2)$$

The initial equilibrium supply of water before farmers are given payments is then given by:

$$S(p) = r(p)He \qquad (3)$$

where H is the total area of the land unit. With payments, the number of farmers switching to green water management *r(p, p_e)* can be found by integrating $\varphi(\varpi / e)$ between zero and p_e. The total supply of environmental services is then:

$$S(p, p_e) = S(p) + r(p, p_{e)}He \qquad (4)$$

There are two options in offering payments: either farmers are paid only for an *increase* in environmental services relative to a baseline, or farmers who undertake green water management before payments were offered are paid for this services –which alternative increases the cost of producing any given quantity of environmental service by the amount $p_e S(p)$.

The supply curve for *blue* water can be derived from the spatial distribution of opportunity cost per mm water using Figure 9. The supply curve exists of three parts. Part 1 includes those land units for which opportunity costs are greater than p_e which will remain in activity *a*. As p_e increases, more land will be put under activity *b*. Part 2 between 0 and p_e corresponds to those land units that have switched from activity *a* to *b* due to payments p_e. Part 3 is the are under the spatial distribution of opportunity cost on the interval $(-\infty, 0)$ equals *r(p)* and represents the land units where farmers implement activity *b* without payments. At the point where $p_e = \varpi / e = 0$ the baseline supply of green water credits equals *S(p)*.

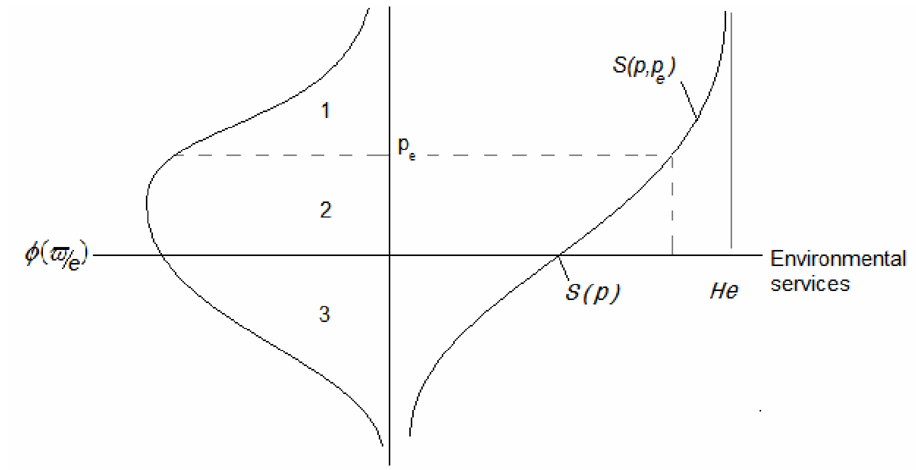


Figure 9: Supply curve for Green Water Credits

Data needs: The data required to simulate land use decisions are the expected values for each competing land use activity at each site. Several models have been developed to integrate physical and economic models; usually these are data-intensive. The Minimal Data approach uses available data to parameterise directly the spatial distribution of net returns to competing activities and, then, simulate land allocation decision using decision rules, such as maximisation of expected returns. For this approach, average or representative costs and returns for a geographical unit are required, and data from secondary sources or quick surveys are used to estimate mean expected net returns to each activity in each region. In addition to these data, the spatial variability in expected returns are required. Several assumptions are made:

- Variable costs of production are approximately proportional to expected output: $c \approx \kappa y$
- Farmers in a region have similar output/price expectations;
- Farmers in a region face similar factor prices (land, labour, capital) and average costs of production.

With these assumptions, net return are $v = py - c \approx (p - \kappa)y$, where y is yields. This implies that the coefficient of variation ($cv_v = \sigma_v / \mu_v$) in net returns v across land units in a region at a point in time can be estimated by the spatial coefficient of variation for y: ($cv_y = \sigma_y / \mu_y$). Available data show that this approach provides an approximation that is well within an order of magnitude. Thus, land use decisions in a region are determined by the spatial distribution of the difference in expected value $E(\Delta v) = E[v(a)] - E[v(b)]$ and the variance of the difference between *v(a)* and *v(b)* is:

$$\sigma_{a-b}^2 = \sigma_a^2 + \sigma_b^2 - 2\sigma_{ab} \tag{5}$$

where the variance in net return of practice is

$$\sigma_i^2 = CV_i^2 \cdot v_i^2 \tag{6}$$

and the covariance in net returns between practice a and b is

$$\sigma_{ab} = CV_a \cdot v_a \cdot CV_b \cdot v_b \cdot \rho_{ab} \tag{7}$$

where ρ_{ab} is the spatial correlation coefficient.

The model constructs this distribution per site; by sampling this distribution at different p_e, the supply curve of blue water of each site is calculated. These supply curves may be aggregated to obtain a supply curve for the whole catchment.

5.4 Livelihoods study

For the design studies for Green Water Credits, general information gathered by the literature review will augmented in the field by a livelihoods study.

5.4.1 Methodology

To understand the direct and opportunity costs of any land use change, information is needed on family income, share of the market, and gross margin per crop and livestock. These costs will directly affect the type and magnitude of incentives required to promote changes in land practices. The following items are estimated using the MONQI Methodology questionnaires:

a. General farm data, including the demographic structure of household, and implements owned or agriculture-related constructions (as a proxy for capital);
b. Dependence on off-farm income, estimated by the share of total income and by type of activity per household member (a very rough estimate, but may be more reliable than estimates per household member, as income is usually a sensitive subject);
c. Crop production and income, determined by assessing the amount of cultivated land, cropping pattern, and crop calendar per season. Then the external inputs in crop production, crop management and the output from crop production (harvesting and residue management) are measured;
d. Livestock production and income, determined by livestock measuring growth and composition of herd, the external inputs, livestock feeding and care and output from livestock production;
e. Household consumption (food and non-food) is not captured, except the external purchases that are made to the stock (e.g. seeds) and sales or use of materials in the stock (excluding home consumption);
f. Use of family labour for agricultural production.

The targeted areas for Green Water Credits should be the areas combining (i) the AEZs relevant for green water management, (ii) the highest erosion rates and (iii) the dominant land use. In the forthcoming design stage of Green Water Credits, this survey, alongside farmers' focus groups, will provide information about present livelihoods, opportunities and constraints, and poverty issues. Specifically, the net returns from agriculture for the farmer, on-farm benefits and costs of specified conservation packages, and the importance of Green Water Credits in diversifying and supplementing family income will be ascertained for the main production units in the target areas.

5.5 Results from the focus groups

5.5.1 Perception of obstacles and opportunities

Farmers' opinions about the main obstacles and opportunities for SWC are summarised in Table 12. Attractive conservation technologies offer short-term, on-site benefits in *large* increments; require only affordable inputs, especially labour; do not take up productive land; have little risk; and are consistent with the farmers' socio-economic environment. When asked about the barriers to green water management, the farmer groups mainly based their responses from experiences in implementing structural conservation measures (e.g. *fanya juu*, cut-off drains etc.) irrespective of agro-ecological zone and farming activities.

Table 12: Obstacles and opportunities for SWC

Factors impeding green water management	*Opportunities for addressing impeding factors*
Labour intensive and expensive	Promotion of conservation measures that will increase income in the short and medium term, to compensate for high labour input Use of labour work parties or hired labour
Lack of incentives and the attitude that terraces are only to be constructed when there is food for work	Awareness of the short and long-term benefits of green water management
Inadequate technical knowledge; agricultural officers no longer visit farmers frequently	Practical training Training of selected community members to instruct others Training in both structural and agronomic methods
Inadequate tools for making terraces and for deep tillage	Provide or improve accessibility and affordability of required tools to farming communities
Inadequate grass/tree seeds for vegetation required to stabilise terrace embankments	Training on appropriate seeds/vegetation/plant types required Establish seed bank

Factors impeding green water management	*Opportunities for addressing impeding factors*
Perception that making terraces reduces available land for crop production, especially on steep land	Integrate terrace construction/conservation activities with the growing of high value crops e.g. using fodder trees and grasses in terrace embankments Promote suitable practices according to climate, soil, and slope and farming system
Urban migration has reduced available on-farm labour	Promote group work and strengthen local institutions for green water management activities

Farmers raised various opportunities for addressing barriers to green water management. In the Upper Tana, where land parcels are becoming small, technologies that are replicable and that fit within small plots were mentioned frequently. Technologies that bring increased yields and income were seen as a possibility for compensating for labour inputs, e.g. conservation practices combined with the production of high-value crops, which bring demonstrable benefits in the short term as farmers wait for the long-term benefits. Practical training and availability of equipment/tools were mentioned as ways of overcoming the slow progress in conservation activities. Awareness creation and training in a basket of appropriate green water management technologies were seen as possibilities for changing attitudes.

Collective action was raised as a possibility in addressing labour constraints. However, collective actions depend on: a direct private stake in community benefits; knowledge about the problem; potential to reap productivity benefits; trans-farm boundary installation of structures agreed by the owners; previous positive experience with informal labour exchange contract; and the household belonging to an active community group.

5.5.2 Recommendations

Knowledge baseline: The need for soil and water conservation is well understood but is equated with physical structures like terraces; the wider concept of green water management with emphasis on agronomic measures such as mulch and cover crops us not well understood. Most groups said that they would appreciate additional training, access to inputs and support.

> *Recommendation:* The conservation measures that are likely to be adopted are those leading to increased income in the short term. Practices should be integrated so that farmers are able to get short-term benefits as they wait for long-term benefits, e.g. fodder grass strips provide an immediate benefit as well as to conserving soil.

Incentives: Various short-term incentives have been provided by various agencies. These have enhanced the adoption of conservation measures in the short-term but some direct incentives like cash and food for work has resulted in weak ownership of the process once the incentives are withdrawn.

Recommendations:

- To ensure ownership by the farmers, communities targeted for Green Water Credits should be involved in the design of the conservation practices and the incentives (time frame, contract obligations and mechanisms for long-term implementation and maintenance)
- Advocacy and awareness-creation need to be linked with enforcement
- Capacity building is needed both within the farming community (e.g. training on conservation measures and tree nursery management, access to tools, equipment and other inputs), and in managing and supporting agencies
- Payment preferences differed from one group to another. Based on current needs experienced by the community and on-going projects, most groups favoured in-kind payments (indirect payments) and, where cash is needed, micro-credit and revolving fund arrangements.

Contract arrangement and monitoring: Groups were willing to enter into contracts for Green Water Credits. Most farmers preferred contracts between 3 to 5 years to provide security and confidence to engage in green water management.

Recommendation: Farmers and/or their representatives should be involved in the design of contracts, especially in determining their duration and obligations. The contractual benefits and commitments should be explained in detail, as there is history of farmers entering in agreements without wholly understanding their consequences. The contract should, preferably, be signed at the group level which enforces the contract obligations on all group members. There needs to be a clear channel for monitoring and feedback on progress of activities.

6 Likelihood of adoption green water management

This section reports on the aspects of green water management packages that may increase the likelihood of adoption by farmers, based on a pilot Choice Experiment for the Upper Tana, information from focus groups conducted by ETC, and lessons from similar experiments carried in Kenya and elsewhere.

6.1 Theoretical framework

Choice experiments help to understand the implicit trade-offs embedded farmer's decision making. For example:

- What are the most significant attributes influencing the likelihood of adopting green water management?
- What levels of these attributes will have the largest impact?
- What are the characteristics of the farmers who are likely to engage?
- Where are these farmers located with respect to the critical areas?
- What are their main economic activities?
- Does likelihood of adoption vary across the basin? Would there be a need for different incentives depending on the areas?

This information will help to understand what will be the potential cost of implementing Green Water Credits from the point of view of the providers, and the approximate investment needed to ensure farmers' engagement. Examples of applications to environmental issues include:

- Willingness to participate in Payments for Environmental Services in the Monteverde area in Costa Rica (Porras and Hope 2005)
- Adoption of organic farming for improved catchment environmental services and poverty reduction in Bhoj, India (Hope and others 2005)
- Domestic water policy trade-offs in South Africa (Hope and Garrod 2004)
- Valuation of groundwater protection options in Massachusetts (Stevens, Barret and Willis 1997)
- WTP of an electricity utility for environmental management of watershed that supplies hydro-electric power in Costa Rica (Alpizar and Otárola 2004)

Stated Choice Methods (SCM) estimate and predict the behaviour of potential and actual participants to proposed or uncertain changes in attributes of goods or services in an existing or hypothetical situation (Louviere and others 2000), based on random utility theory which allows a rigorous modelling framework. The model predicts willingness to accept (or to pay) in terms of probability.

Valuation of non-market goods and services is accomplished either through revealed-preference (studying actual behaviour on a closely related market good) or stated-preference methods (analysing consumers' behaviour in a hypothetical setting when faced with alternative policy scenarios).

Choice methods investigate "what if?" questions; it is important to bear in mind their limitations - their use requires technical design and analysis, command of computing software, and the selection of the right combination of attributes to define the policy package is key; there is a danger of reductionism – it is helpful to keep the number of attributes small to help the respondents' decision making.

The main stages of a choice modelling exercise are: introducing the situation, selection of attributes and levels, choice of the experimental design, construction of the choice sets, measurement of preferences, and estimation procedure.

6.1.1 Introducing the situation: what are the SWC practices proposed?

SWC practices are locality-specific, so generic SWC packages were devised that could be adapted for different sites. For each AEZ, farmers were presented with a card giving a description (photograph or figure) of each SWC management package (Figure 10 and Table 13). These packages are presented and discussed in Figure 10.

Introducing the technological package

Show photographs representing the pre-selected technological package to the farmer.

We would like to ask you to look at the technological package presented here. It represents relatively simple and effective measures for soil and water conservation. Some may even be already in place in your farm.

We would like to ask how likely is it for you to actively enter and keep the activities described.

The group will be divided in two and only one of the following question formats (E2 or E3) is presented to each farmer.

You will be presented with five options representing different characteristics for the technological package.

These characteristics include the approximate amount of labour required to keep the activities, the length of the contracts that need to be signed, the institution that will manage the overall project together with the farmer's group, and the type of incentive that might accompany the package. In all cases, farmers will receive adequate capacity building to understand the practices.

Additionally, for this project to work, group cooperation will be essential in order to achieve minimum threshold levels at the community and at the Tana level. Individual contracts will be processed through local farmers groups, who will represent, monitor and distribute the benefits among its members. The good or bad performance of each individual farmer will be reflected as overall group performance.

Figure 10: Describing the scenario to the farmer

Table 13: SWC management packages

AEZ - main crop	*Management package*	*Comments from focus groups*
I – tea	Contour strips of perennial vegetation Mulch, in young and pruned tea	Contour strips are possible just above the tea field but not within the crop itself The contour strip along the upper border may need to be combined with physical measures such as *fanya juu* due to steep slopes in many tea fields Prunings are currently being used as mulch within tea fields
II+III coffee	Contour strips Mulch	Perennial vegetation is currently being used to stabilize terrace risers Mulch and contour strips are commonly used in annual crop fields in the coffee zone
II, III and IV maize III + IV cotton	Contour strips Tied ridges	Contour strips and ridges but rarely tied ridges are currently practised, especially in zones III and IV *Fanya juu* stabilised by perennial grasses is a common practice in zones III and IV

6.1.2 Attributes and levels: what factors may influence farmers' participation?

Once the alternative situation is selected, it is important to break it down into its most important parts, or attributes. For design of a Green Water Credits scheme, attributes can explore issues such as institutions involved, costs and benefits for the farmer, and potential externalities.

Attributes have different levels. These levels could be quantitative, for example KES500, KES 1000, KES 2000 for cost, the proportion of cropland that the farmer needs to allocate to the SWC package (5, 10, 50, 100 per cent), and the labour time involved (5 days, 10 days, 15 days). Attributes could also be qualitative, conveying descriptive information, for example the type of institution involved in managing the project at local level (public-private partnership, Ministry of Agriculture, private institution).

Selection of the attributes and their levels should be relevant to the problem in hand, credible and realistic, and easy to understand. It is important to include potential benefits as well as costs (implicit and explicit), to encourage the farmer to explore the trade-offs embedded in their decision-making process. In the case of Green Water Credits, selection of the attributes is a combined result from the focus groups in the area (conducted by ETC) which provided first-hand information from farmers, literature review, and meetings with key stakeholders, such as local offices of the Ministry of Agriculture and Ministry of Social Services.

According to the focus groups, attractive packages for farmers offer short-term and on-site benefits in large increments, require affordable inputs (especially labour), do not use up productive land, have little risk and are consistent with existing socio-economic environment of the farmers (ETC 2007). Structures that take up a lot of time to construct, or require too much area in their plots (already quite small) are not attractive. Inputs that could only be purchased were very unattractive, more than inputs that could be supplied with family labour or exchanges with neighbours (such as mulch, manure or canes).

Based on these discussions, the theoretical model designed for the likelihood of farmers' adoption in the Upper Tana is:

Equation 1

$$\text{Rating} = a\,\text{SWC}_0 + b\,\text{I} + c\,\text{EB} - d\,\text{CL} - e\,\text{CI} + f\,\text{Contract} + g\,\text{Inst} + e\,\text{GTh}$$

Where,

Rating 5 highest, 1 lowest

SWC_0	Level of SWC practices in plot (current level)
I	Incentive type
EB	Timing of expected benefits at farm level
CL	Additional costs in labour
Contract	Length of contract
Inst	Institutional setting at local level
GTh	Group adoption threshold level

Other household variables determining the probability of engagement include: farmers' income, availability of household labour, location, access to markets for sale of produce. In the case of the Upper Tana, where there are many smallholders, the system needs to keep transaction costs low by achieving high levels of local cooperation. Table 14 describes these variables and their expected effects on adoption of SWC.

Table 14: Variables likely to affect adoption of SWC

Variable		*Levels*	*Description*
EB (+)	Short-term benefits at farm level	0,1	Binary variable, expected benefits will be perceived in: EB_1 short term EB_0 medium- long term
CL (-)	Labour days (acre/season)	10 15 20	Continuous variable
I (+)	Incentive type		Several types of incentives. Each option will have only one type of incentive.
I_1	In-kind compensation	No (0) Yes (1)	Access to in-kind incentives such as seed bank, or implements
I_2	Access to revolving funds (soft credit)	No (0) Yes (1)	One-off payment to community group (in the form of trust-fund) as the basis for revolving credit for members
I_3	Annual cash payments	KES 0 KES 1000 KES 1500 KES 2000	Continuous variable: cash payment related to the cost of labour/inputs
Contract (+/-)	Contract length	1,3,5 years	Continuous variable
Inst (+/-)	Institution administering scheme		Qualitative variable: Public-private partnership, Ministry of Agriculture Independent private group
GTh (+/-)	Group threshold level	50% 80% 100%	Continuous variable: minimum group adoption levels - if adoption is lower than the threshold then incentives are lost
Additional variables that may affect adoption			
SWC_0 (+)	Level of present SWC practise in the plot	0,1,2,3	Continuous variable: 0 No SWC 1 Less than half of the plot 2 About half of the plot 3 More than half of the plot 4 All of the plot
Market (+)	Access to markets for produce	0,1	Binary: 0 Poor access to markets Good access to markets
HL (+)	Availability of household labour	0,1	Binary: 0 No household labour available 1 Household labour available

6.1.3 Expected benefits at farm level

Farmers' investment in SWC depends on their perception of the on-farm benefits, and when they accrue. Focus groups report the following benefits:

- Improved crop yields
- Improved soil conservation
- Improved water retention
- Conservation of soil organic matter and applied nutrients/improved fertility
- Increased fodder availability from fodder crops planted on terrace risers, saving
- costs of buying in fodder
- Improved crop health

Benefits from communal work include cleaner water with reduced sediments, and reduced gullying of public areas (roads). An important consideration for the farmers is the possibility of benefits accruing in the short-term, for example, the use of grass strips along the contours generates fodder for livestock which, in turn, generate capital and manure; whereas fruit trees generate additional income only after several years.

In order to measure this effect, the choice experiment includes a binary attribute on the timing of expected benefits at the farm level (short versus medium/long term). Farmer's possibilities to bring the extra produce to the market are also likely to affect adoption. Poor access to markets makes investment in the farm less desirable; this is an issue in the Upper Tana (with the exception of tea) where marketing is hampered by bad roads and inadequate information on produce prices, quality and demand.

6.1.4 The potential additional labour cost

The impact on labour is analysed by including different levels of labour required by the SWC package. This is an important variable, as it will explore the trade-offs for the farmer. The household may be able to assume the extra cost if there is enough family labour; it becomes limiting when the farmer needs to hire labour or when the farmer needs to work somewhere else to earn cash. The values presented (Table 15) are very rough, and only indicative.

Table 15: Availability of household labour

	Household members	*Labour- productive members*	*Working on farm*
AEZ I	3.6	2.4	1.8
AEZ II	4.6	2.6	1.8
AEZ III	4.1	3.1	2.3
AEZ IV	6.3	3.7	2.3
mean	4.6	2.9	2.0

6.1.5 Cooperation between farmers and threshold levels

Most farmers belong to some kind of organisation. The importance of farmer's cooperation is important on two counts - transaction costs and threshold levels.

Advantages of group organisation, especially for smallholders, lie in maketing and buying, where better prices may be got, and to access training and support from Government agencies. Farmers groups may be key players in Green water Credits, holding down transaction costs, in monitoring and policing of contracts, raising standards of practice, and in cooperation to achieve large projects like gully and landslide control. Threshold level refers both to the farm area that will need to be under SWC, and the cooperation among farmers to ensure achievement of minimum threshold levels in the area.

6.1.6 Institutional setting

Intangible issues are often at the heart of SWC adoption. Experience from application of choice modelling in Monteverde, Costa Rica (Porras and Hope, 2005) shows that the institution managing the scheme was one of the most important attributes determining participation. In Monteverde, farmers were reluctant to enter contracts with the Government.

In the Upper Tana, operational success of Green Water Credits will depend on the way farmer groups fit into a larger management structure at the Basin level.

In the focus groups, farmers were asked what institutions they have more experience with. The Ministry of Agriculture and the Ministry of Social Services were well rated; at the same time, many groups were linked to private institutions, mostly for commercial reasons. The new institutional units WRUAS established under the new water legislation are still only nascent and oriented mostly to management of irrigation water; some farmer groups also have dealings with banks, such as K-Rep.

6.1.7 Incentives

It is argued that SWC is in the farmers' best interest and there have been many attempts to promote SWC through information, training and short-term incentives. However, the reality is that adoption and maintenance is poor; land degradation continues apace and this is affecting water supplies and siltation downstream. This attribute, therefore, explore different incentives to improve adoption and maintenance of SWC. Two kinds of incentives are explored:

- *Monetary:* Three monetary incentives are suggested: a) access to soft credit through revolving funds, b) direct cash payments to the farmer, c) tied-cash rewards, like school vouchers
- *Non-monetary:* Seeds, seedlings, implements and equipment
- *No incentive:* Training and capacity building offered to all

6.1.8 Current soil and water conservation practices

The model predicts that uptake of SWC practices will be higher for farmers that have already invested in SWC. The level of practice varies considerably across AEZs (Figure 11).

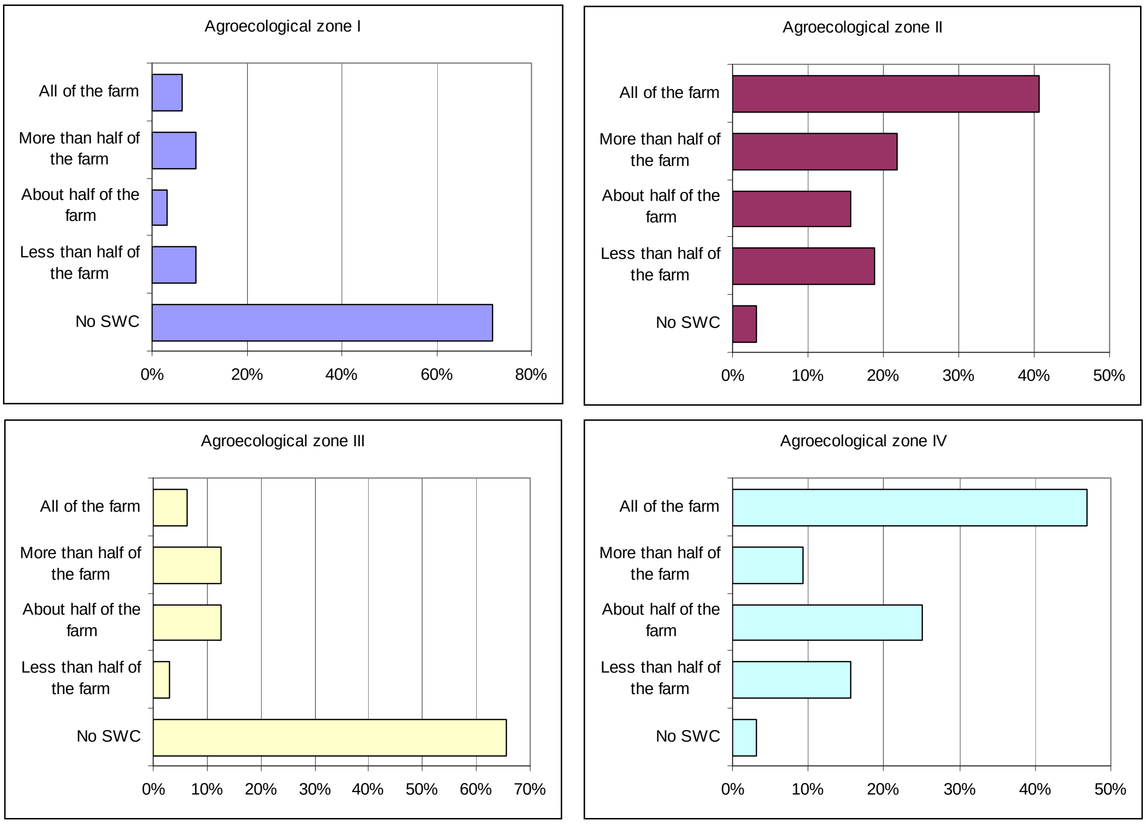


Figure 11: Current level of SWC, by AEZ

6.1.9 Access to markets

This variable measure farmers' perceptions of how easy or difficult it would be for them to sell any additional produce obtained through improved farming practices. techniques. Results (Figure 12) show that the perceived access to markets varies significantly with farmers in AEZ I reporting easier access to markets than farmers in AEZ IV. There is also a counter-intuitive, negative correlation between the perceived access to markets and the level of SWC.

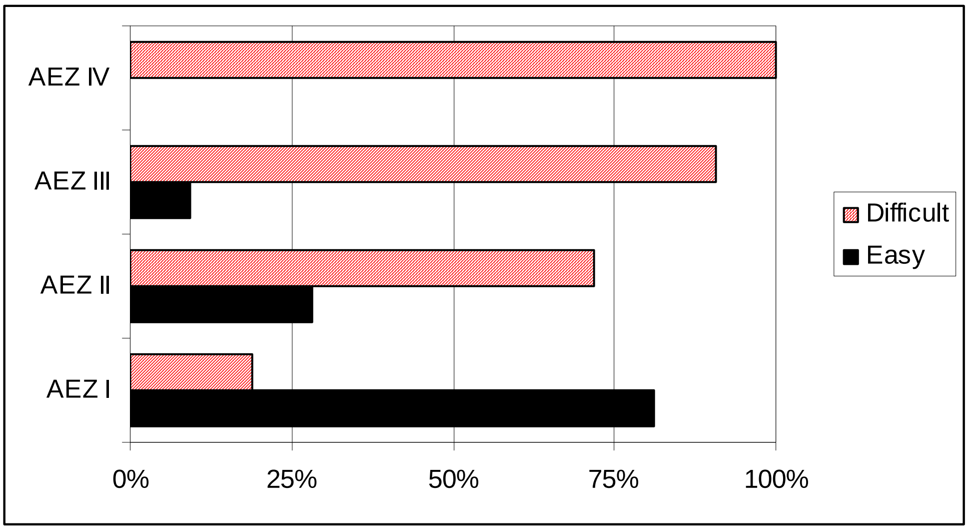


Figure 12: Perceived access to markets

6.1.10 Experimental design and choice sets

The next step is the design of random combination of attribute levels to generate the alternative scenarios presented to respondents. Ideally, respondents should be asked to rate each one of the scenarios involved (*complete factorial design*). This is difficult to implement; in practice respondents are asked to rate a fraction of randomly assigned scenarios (*fractional factorial design*), chosen using a special software package.

Respondents are presented with different profile packages, and are asked to rate them according to their likelihood of engaging in each one of them. It is important to ask respondents to rate their own *status quo*, in order to have a comparison point for the other scenarios.

Choice sets may be presented in different ways:

- Respondents are presented with separate scenarios one at the time, and are asked to rate them individually. The rating could be in the form: 'How likely are you to engage in this policy package?' Levels are from 1 to 5, with 1 indicating not likely to 5 indicating very likely.
- Paired comparison. Respondents are presented with two cards side-by-side and asked to choose one of the options. The decision could be binomial (A, B or none), or a continuous from 'more likely A', 'indifferent', to 'more likely B', or ,'none'.
- Group comparison. Respondents are presented with more than two options and asked to rate them. The rating could be individual, or could be in order of preference. This method has the advantage of showing fewer scenarios, but it could overload the respondent.

6.1.11 Estimation procedure

Roe and others (1996) suggest that estimates of compensating variation can be derived by looking at the respondent's rating of the *status quo* (no project) and the alternative condition being proposed. The choice model can also be tested for consistency by stating it in different forms. Porras (1999) suggests 3 forms:

1. A model based on a linear combination of the attributes. Its orthogonal design means that the variation of each attribute is independent of the variation of all other attributes, so it is possible to obtain marginal rates of substitution for the different attributes;
2. Ratings Difference: This uses the rating of the *status quo* as a reference point to analyse the increase/decrease in utility from alternative scenarios;
3. Binary Response: This converts the continuous scale 0 to 10 into binary responses (YES or NO) and estimates the corresponding probability of accepting certain rating. This may be achieved either by estimating the probability of the alternative scenario being preferred to the *status quo,* or by assuming a threshold above which reponses are considered 'yes' and below which 'no'.

Estimation is done using *Ordinary Least Squares* estimation (OLS) or maximum-likelihood estimation procedures; these includes binary options like *logit* and *probit*, and continuous forms like *ordered logit*, *nested logit*, and *panel data* models.

The decision-making can be correlated with personal information, such as income, education, gender, farm information, and location.

6.2 Results from pilot implementation

6.2.1 Sample selection

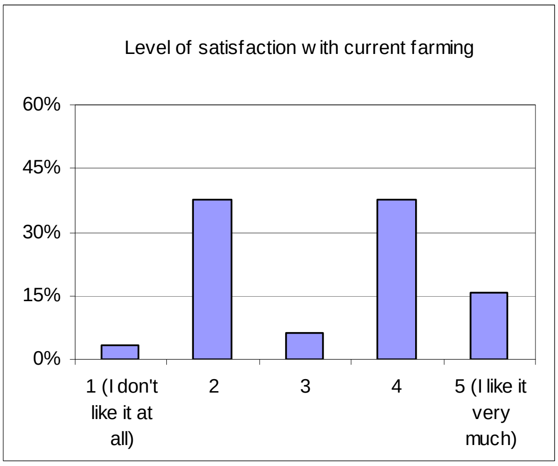
A farmers survey was implemented in the Tana Basin in March 2007 for this study. This exploratory survey covered four agro-ecological zones, and interviewed a total of 128 farmers (see methodology in Section 1.2.2)

Table 16: Choice experiment interviews

AEZ	*District*	*Division*	*Location*	*Cluster*	*No. households*
I	Nyeri	Tetu	Thegenge	Kariguini	16
		Mathira	Maguta	Kiamucheru	16
II	Muranga	Kahuro	Weithaga	Rukui-Wangu	16
		Mathioya	Kamacharia	Ihiga ria Iguru	16
III	Kirinyaga	Mwea	Murinduku	Mugamba Ciura	16
		Mwea	Kangai	Kombuini	16
IV	Mbeere	Gachoka	Mutuobare	Kathari	16
			Mbita	Kambita	16

6.2.2 Farmers assessment of current situation

Assessment of the current situation helps to understand the likelihood of farmers wanting to engage in alternatives; the likelihood of participation in alternative scenarios will increase if the farmer is dissatisfied with the present situation. Figure 13 shows the initial distribution of the farmer's rating of current and alternative scenarios. Ratings are well distributed across the categories (1 to 5), which minimizes the statistical errors of co-linearity.



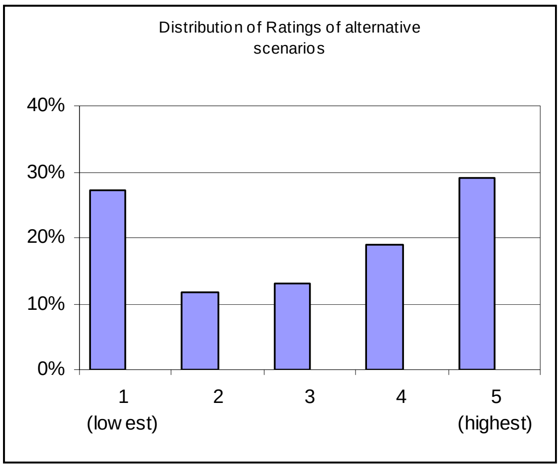


Figure 13: Farmers' assessment of the current and alternative situations

6.2.3 Model application

The theoretical model estimate the likelihood of farmers' adoption in the Upper Tana is:

Equation 1

Rating = a SWC_0 + b I + c EB – d CL – e CI + f Contract+ g Inst + e GTh

Where:

SWC_0	Level of SWC practices in plot (current level)
I	Incentive type
EB	Timing of expected benefits at farm level
CL	Additional costs in labour
Contract	Length of contract
Inst	Institutional setting at local level
GTh	Group adoption threshold level

Other household variables that could affect the probability of engaging include: farmers' income, availability of household labour, location, and access to markets to sale produce. Table 17 presents a reduced model form, where the estimation is based only on the existence of an incentive (any) as opposed to no incentive at all. The most statistically significant variables of the regression are incentive, term of expected benefits, and managing institution. At lower confidence levels we find the contract length and the number of labour days required.

Table 17: Results of ratings regression, model 1

Attributes	*Unstandardized coefficients*		*Standardized Beta*
	B	*Std. Error*	
(Constant)	2.098**	0.619	
Current level of SWC	0.044	0.054	0.046
Term of expected benefits	0.348**	0.181	0.109
Number of labour days required	-0.038	0.025	-0.096
Contract length (years)	-0.084	0.055	-0.086
Managing institution - Min of Ag	0.407*	0.219	0.122
Managing institution - Private	0.264	0.225	0.078
Threshold level	0.003	0.005	0.039
No of household members working regularly on farm	0.093	0.098	0.054
Incentive	0.801**	0.215	0.21
Access to external markets	0.162	0.201	0.046

Dependent Variable: Rating ** significant at 0.05 confidence level; * significant at 0.1 confidence level

We can predict the weight of each variable with the standardized beta[1]. According to the regression analysis, the variables that have a stronger effect on participation are:

- *Increase the rating by more than 10 per cent*
    - Incentive (21 per cent)
    - Managing institution – Ministry ofAgriculture
    - Term of expected benefits

- *Decrease the rating by more than 10 per cent*
    - Number of labour days required
    - Contract length (years)

- *Very low effect (less than 10 per cent)*
    - Managing Institution - Private
    - No of household members working regularly in the farm
    - Current level of SWC
    - Access to external markets
    - Threshold level

Because, in all cases, farmers were offered capacity building, this model shows that using an incentive, of any kind, will increase participation rates by more than 20 per cent.

A more in-depth analysis of the types of incentives suggested is shown in Table 18. This regression model breaks-down the different types of incentives offered: tools, cash (Ksh 1000, 1500 and 2000), tied cash (i.e. school vouchers) and access to a revolving fund.

[1] The standardized beta is used to compare the strength of different independent variables measured in different ways. They vary from -1 to 0 to +1 and are similar to correlation coefficients. The unstandardized beta is used to make actual predictions in the regression model.

Table 18: Results from ratings estimation, model 2

Attributes	*Unstandardized Coefficients*		*Standardized Beta*	*Significance*
	B	*Std. Error*		
(Constant)	2.527**	0.544		0.000
Current level of SWC	0.035	0.054	0.037	0.513
Term of expected benefits	0.369**	0.183	0.116	0.045
Number of labour days required	-0.039*	0.025	-0.100	0.120
Contract length (years)	-0.088*	0.055	-0.091	0.113
Managing institution – Min of Ag	0.407*	0.222	0.122	0.067
Managing Institution - Private	0.291	0.226	0.085	0.199
Threshold level	0.002	0.005	0.023	0.716
Incentive: FUND	0.652**	0.284	0.153	0.023
Incentive cash (Thousand KSh)	0.355**	0.163	0.152	0.031
Incentive in-kind (implements etc.)	1.195**	0.305	0.255	0.000
Incentive tied cash	0.809**	0.293	0.186	0.006
No. of household members working regularly in the farm	0.113	0.098	0.066	0.249

Dependent Variable: Rating ** significant at 0.05 confidence level; * significant at 0.1 confidence level

Additional information from this model is that:

- In-kind incentives are is most preferred, increasing the rating of the package by 25 per cent;
- Tied-cash is the next most preferred incentive, increasing the rating by 20 per cent;
- Access to a revolving fund or cash payments increase the rating of the package by 15 per cent.

Table 19 shows the breakdown of the model when applied to the different ecological zones. As expected, reducing the sample size decreases the model's prediction power. However, the same relationships held almost across AEZs.

Table 19: Model differences across agro-ecological zones

AEZ	*Comments*
I	Only incentive variables Fund and Tied-cash are statistically significant ; rating increases 38% with access to Fund, and 35% with Tied-cash Management by Min of Ag increases rating by 17% (not statistically significant) Ratings decrease when the community threshold adoption level increases, and with days of labour for work (part-explained by poor track record of SWC in zone) All other variables have little effect on the rating (3-8%)
II	Only Contract Length statistically significant, longer contract lengths will decrease the rating of the package by 38% In-kind incentives, cash, threshold level and Ministry of Agriculture as managing organisation each increase rating by 15% The difference in sign for threshold level with respect to AEZ I may be explained by stronger presence of SWC, giving farmers confidence that neighbours are likely to meet the target
III	Only Ministry of Agriculture managing the program is statistically significant, increasing ratings by 30% Private institution as program manager next most-preferred, increasing rating by 15%
IV	In-kind benefits are most preferred and increased ratings by 47% All other incentives increase ratings (cash 24%, revolving fund 21%, and tied cash 21%) Contract length (-20%) and number of days required for SWC package (-14%) decrease the rating

Example:
This section presents a simple exercise applying the results of the model. Except for incentives, attributes are kept constant at the following levels:

Attributes	*Levels*
Labour requirements	*10 days*
Program management	*Ministry of Agriculture*
Time horizon of expected benefits	*Medium to Long-term*
Number of household members working on-farm	*3*
Existing SWC measures in farm	*About half the plot*
Threshold level	*About 50% of association members*
Contract length	*3 years*

Using "no incentive" to estimate a baseline, the estimated ratings level is 3.2 out of 5 (5 being definitively engage, and 1 being definitely not engage). This result shows that there is some degree of interest, partly because farmers are offered capacity building, but the existence of the incentive increases the potential engagement. If farmers were offered cash, rather than tools, the ratings increase as the amount of cash increases. Figure 14 shows the effect on adoption rates if all is kept constant except the type and level of incentive. An incentive of 1000 KSh increases the ratings by 10 per cent, followed by access to revolving funds. The higher ratings are obtained with in-kind incentives (nearly 40% increase).

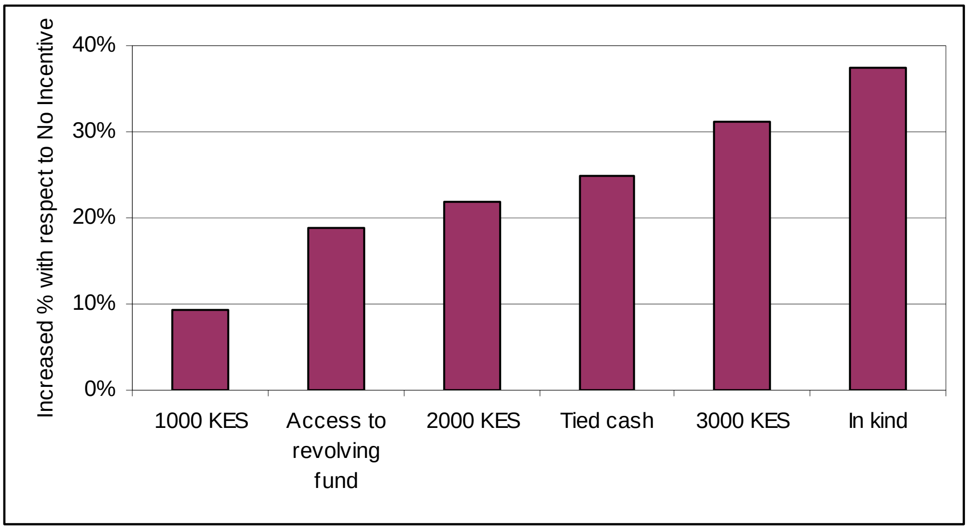


Figure 14: Impact on adoption ratings by type and level of incentive
Note: the baseline is drawn by estimating the rating using No Incentive

6.3 Main outcomes from choice experiment

For the proof-of-concept, only an exploratory exercise has been undertaken; its results should be considered only indicative rather than definite. The main issues highlighted by this exercise are:

Variables that tend to increase the rating by more than 10 per cent
- Incentives, in order of preference:
  - In-kind incentives
  - Tied-cash
  - Cash and access to revolving funds
- Management by the Ministry of Agriculture
- Benefits expected at medium to long term (not necessarily on the short term)

Variables that tend to decrease the rating by more than 10 per cent
- Number of labour- days required, more labour = less attractive
- Contract length – shorter contract = less attractive

Variables with low to negligible effect
- Management by a private institution
- Number of household members working regularly in the farm
- Current level of SWC
- Access to external markets
- Threshold level

An uncomplicated program based on simple, easy-to-understand and easy-to-adopt practices, and providing a suitable incentive, could have a significant uptake in the Upper Tana. Concentrating time and effort on those variables that may not have a large effect on uptake, like access to markets, or enforcement of threshold levels may divert scarce funds from where they are most needed. Some issues need clarification for the design of a Green Water Credits mechanism:

1. Cash is an important asset in the household but farmers apparently perceive some in-kind incentives, like implements and equipment, as a more permanent benefit; cash incentives can be withdrawn but the farmer gets to keep the implements;
2. The marked preference for the Ministry of Agriculture as the project manager could be due to the way in which the question was framed; the alternatives offered were vague (private institution, or public-private partnership) and farmers may have been preferred a known institution to an unknown.

7 Implications for Green Water Credits

7.1 Potential providers and livelihoods

Potential service providers in the Upper Tana Basin are many and varied. Farmers are mostly smallholders depending on maize, usually intercropped with beans, as the main subsistence crop. The main cash crops are tea, coffee and cotton and irrigated rice, depending on rainfall, terrain and soils. However, on the farm the crops are much more diverse; households can own as many as 20 plots on which different crops are grown, often intercropped. Most households also own livestock. Average earnings per farm type range from almost no income, due to crop losses, to over 7000 US$ per year (MONQI data for Nyeri, Embu and Mbeere).

The need for incentives to secure SWC in the long term is indicated by analyses of opportunity costs. Information on the kind incentives that farmers would be willing to accept under Green Water Credits is based on results from the Focus Groups, the Choice Experiment (Table 19).

Table 20: Summary of results from upstream studies

Sources of information	*Main Results*
Modelling and livelihoods study *Theoretical models to understand linkages between private land use and externalities in the Upper Tana*	Labour costs are the main part of farmer's costs The costs of constructing and maintaining SWC structures can be substantial, these costs often outweigh the benefits, requiring Green Water Credits to overcome these costs A supply-response curve for water management services can be built, linking to SWAT model results, to support the design studies for Green Water Credits
Focus groups *Elicit farmers' views on SWC, markets, organisational capacity and institutional settings in the Upper Tana* *Sample: Eight focus groups with irrigation and non-irrigation farmers in 4 agro-ecological zones*	Wealth of knowledge and capacity in SWC has been won through decades of implementation, but there is much scope for improvement; maintenance of structures is poor Farmers are aware of their private benefits from SWC, but demand tangible, short-term benefits Existing farmers' associations (marketing, benevolence, cultural) may serve as a foundation for collaboration in Green Water Credits To ensure ownership by the farmers, the project design process should take into account farmers' views on incentives and modes of payments The contract should preferably be signed at the group level which, in turn, enforces the contract obligations upon members. Most farmers preferred contracts between 3 to 5 years with higher preference to 5 years. There is need for a clear channel for periodic monitoring and feedback on progress of activities

Sources of information	*Main Results*
Choice experiment *Objective: pre-feasibility study to determine the policy components (or attributes) that would make GWC more attractive (higher ratings) to farmers* *Sample size: 128 farmers in 4 agro-ecological areas*	Variables that tend to *increase* the rating by >10%: - Incentives, in order of preference: in-kind incentives, tied-cash, cash and access to revolving funds - Management by Ministry of Agriculture - Benefits expected at medium to long term Variables that tend to *decrease* the rating by >10%: - Higher labour requirement - Length of contract (e.g. 3, 5 10 years) Variables with low predicted effect: - Managing institution - private - Number of household members working on-farm - Current level of SWC - Access to markets - Threshold level

7.2 Constraints

7.2.1 Poverty

Farmland in the Upper Tana is occupied by very many smallholders, holdings are not only small but sub-divided. Farmers are usually poor, with limited access to markets and low prices for their produce. Linked to poverty are the need for diversification of livelihoods and preference for short-term benefits.

The cost of SWC measures is likely to outweigh the benefits received at the high discount rates driven by poverty so innovative solutions are needed to balance poverty alleviation and investment in sustainable land and water management. Green Water Credits appears to offer just such a solution. However, poverty must also be taken into account if payments from downstream users result in higher water rates. Farmers in the Upper Tana are poor but so are very many city dwellers, and many of these already pay high rates for water (mostly purchased through vendors). Increased water fees could have negative effects on these already vulnerable groups.

7.2.2 Measurement

Willingness of downstream water users to pay for water management services in the medium to long term hinges on the clear link between efforts made by farmers upstream and water delivery downstream. Given the high variability of rainfall in the catchment, it will be difficult to disentangle the risk of no delivery due to variable rainfall from the risk from farmers' failure to comply? Who assumes this risk?

7.3 Conclusions

- While there is wealth of information and capacity in SWC, won through decades of implementation, maintenance of SWC structures is often poor. Soil erosion, destructive runoff and downstream floods and siltation of reservoirs are increasing; river base flows are decreasing.

- Farmers are aware of their private benefits from SWC but demand tangible rewards for them to keep up with the labour involved; they see SWC as means to an end (i.e. production and income generation), rather than a goal in itself. There are existing initiatives rewarding farmers for SWC investments - for example, a reduction of 5% from water charges is proposed for farmers doing good SWC. The effects on small farmers will be small or negligible for rain-fed agriculture, but it shows willingness to try financial mechanisms for rewarding SWC.

  Potential rewards include cash payments and revolving funds or soft credit, and in-kind benefits such as implements. Other suggestions include community benefits such as better roads, schools or clinics. There are advantages and disadvantages to all of these methods, especially linked to the creation of negative expectations, a climate of dependence (in the case of cash payments), and difficulties of enforcing project requirements in the case of up-front in-kind benefits. These issues are taken up in Report 6.

- Cooperation among farmers and local organisations will be key in developing an efficient reward mechanism for the Tana Basin. There will be many cases where local erosion falls beyond the private plot of a particular individual (i.e. gully erosion, road sedimentation), or the level of the task is too demanding for one person (i.e. landslides). In these cases, group cooperation, together with local Government units, will be key in ensuring a low sediment delivery downstream.

  There are farmer groups and associations in place, usually linked through a business-objective such as market production. These groups have to enforce regulations related to quality control, including fertilizers, promotion of group cooperation and implementation of sanctions, as non-compliance affects the quality of the final produce and the competitiveness of the group in the markets (for example, if produce is for export). These groups could be a framework for SWC, as part of a 'quality control' package for their associates.

- There is capacity in existing Government institutions carrying out training on SWC. At first sight, however, their efforts seem uncoordinated and not necessarily reaching the most vulnerable farmers.

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APPENDIX – Choice experiment questionnaire

Farmers' Preference Survey
Tana Basin, February 2007

The Green Water Project is a combined effort of local and national institutions aiming at improving management of soil at farm level as ways to improve water availability downstream. By introducing and sustaining simple and inexpensive soil and water conservation measures, farmers are able to maintain farm fertility by avoiding soil losses and maximising the use of rainfall. At the same time, appropriate measures can help important downstream impacts, such as reduction of sediments. With this study we aim at understanding farmers' preferences towards technological packages for soil and water conservation, and what are the best forms of organisation at the Tana level that will ensure appropriate feedback. The results from this survey will feed directly into the national debate on soil and water policies.
THANK YOU VERY MUCH FOR YOUR COOPERATION.

0.1	Name of interviewer	
0.2	Date (day/month/year)	

A. BASIC INFORMATION		
Geographical information		
A1	District	
A2	Agro-ecological zone	
A3	GIS information	

Household information		
A4	Name of interviewee	
A5	Gender	1 = Male 2 = Female
A6	# household members	
A7	# (labour) able members in household	
A8	# household members working in farm on a regular basis	
A9	Who manages the cash in the household?	1= husband 2=wife 3=both husband and wife
A10	What is the highest education level achieved in the household head?	1 = Non educated; 2= Primary or elementary school; 3 = post primary vocational; 4 = secondary school; 5 = post secondary vocational; 6 = formal education above secondary level; 7 = others

B. Group membership		
B1	Is the farmer member of a group?	1=YES 2 = NO
B2	Main activity of the group (cultural, marketing, etc)	1 = Benevolence/cultural; 2 = Merry-go-round/credit; 3 = Enterprise/marketing 4= Other (explain)
B3	Number of members in group	
B4	How long have you been a member? (years)	
B5	How satisfied are you with the group?	1 =Very 2= Not very 3 = Not at all
B6	What is your level of participation?	1 = Regular 2 = Occasional
B7	Does your group keep a bank account?	1= YES 2 =NO
B8	Is the group officially registered?	1 = YES 2 = NO
Please describe briefly:		
B9	Group composition	
B9.1	Total group membership	
B9.2	Number of women	
B10	Monitoring and/or control of infractions This question should address what happens (i.e. penalties) when members break the group by-laws	
B11	Does the group members to whom you belong to make financial contributions?	1 = Yes 2 = No
B12	If yes, how are the funds allocated?	

C. Production and access to markets			
C1	What is your farm size? (acres)		
C2	What are the three main enterprises/products from your farm? Write in order of importance		
C3	Please rate the importance of these activities in your production *1 is the most important activity, 3 is the less important activity*	C3.1 Production for export	
		C3.2 Production for local markets	
		C3.3. Production for self-subsistence	

C4	How easy is it for you to sell your produce? *This question is not about prices, it is about how difficult is it to reach the markets*	C4a. External markets	C4ai. Easy C4aii. Difficult
		C4b Local markets	C4bi. Easy C4bii. Difficult

D. Soil and Water Conservation experience		
D1	What is the current level of SWC practice in the farm/cultivated area?	0 No SWC 1 Less than half of the plot 2 About half of the plot 3 More than half of the plot 4 All of the plot
D2	Do you currently receive support for SWC?	YES NO
D3	Describe (see below)	

From whom	Provides support 1 = Yes; 2 = No	In what form			d. How often (the most dominant frequency)
		a. knowledge /training	b. In-kind (tools, seeds etc)	c. Cash	
D3.1 NGO					
D3.2 Govt					
D3.3 Church					
D3.4 Private companies					
D3.5 Financial institutions					
					Option (choose one) 1. Monthly 2. Quarterly 3. Half yearly 4. Annually 5. Ad hoc 6. Initially, and then stop

E. Choice Experiment question		
E1	**Current Situation** *What is the level of satisfaction with your current farming conditions in your farm? [Please rate from 1 to 5 where 1 = lowest; and 5 = highest]*	1. I don't like it at all 2. I don't like it 3. I am indifferent 4. I like it 5. I like it very much

Introducing the technology package

We would like to ask you to look at the technology package presented here. It represents relatively simple and effective measures for soil and water conservation. Some may be already in place in your farm.

Show photographs representing the technological package to the farmer

We would like to ask how likely is it for you to actively enter and keep the activities described.

Additionally, for this project to work, group cooperation will be essential in order to achieve minimum threshold levels at the community and at the Tana level.

The group will be divided in two and only one of the following question formats (E2 or E3) is presented to each farmer.

Individual contracts will be processed through local farmers groups, who will represent, monitor and distribute the benefits among its members.

You will be presented with five options representing different characteristics for the technological package.
Can you please let us know which are your preferred options by:

E2) ***Ranking the following options from 1 to 5***, *with 5 being the preferred option and 1 the least preferred one.* If the farmer does not like any option write ZERO, but try to avoid this situation by explaining as much as possible.

E2	**Alternative Scenario (*): RANKING**	Ranking (most preferred one on top)
1	Scenario #	
2	Scenario #	
3	Scenario #	
4	Scenario #	
5	Scenario #	

(*) *write here the scenario # from card options*

E3) **Rating the following options from 1 to 5**, with “1” indicating that you do not like the option at all and will not enter a contract for the technological package, "3" indicates that you are indifferent to the option, and “5” indicates that you will definitely take the option. *In this case present the farmer with each option at the time. Make sure that you do not introduce the card with cash incentive first to avoid biased responses.*

E3	**Alternative Scenario (*): RATING**	Rating (each scenario 1 to 5)	Ranking (1 to 5) *(ask the farmer to rank all the options at the end)*
1	Scenario #		
2	Scenario #		
3	Scenario #		
4	Scenario #		
5	Scenario #		

(*) *write here the scenario # from card options*

Green Water Credits reports

GWC 1	*Basin identification*	Droogers P and others 2006
GWC 2	*Lessons learned from payments for environmental services*	Grieg-Gran M and others 2006
GWC 3	*Green and blue water resources and assessment of improved soil and water management scenarios using an integrated modelling framework.*	Kauffman JH and others 2007
GWC 4	*Quantifying water usage and demand in the Tana River basin: an analysis using the Water and Evaluation and Planning Tool (WEAP)*	Hoff H and others 2007
GWC 5	*Farmers' adoption of soil and water conservation: the potential role of payments for watershed services*	Porras I and others 2007
GWC 6	*Political, institutional and financial framework for Green Water Credits in Kenya*	Meijerink G and others 2007
GWC 7	*The spark has jumped the gap. Green Water Credits proof of concept*	Dent DL and JH Kauffman 2007