Baseline Review of the Upper Tana, Kenya

ISRIC World Soil Information

Green Water Credits Report 8

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Green Water Credits

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Green Water Credits Report 8

Foreword

ISRIC – World Soil Information has the mandate to create and increase the awareness and understanding of the role of soils in major global issues. As an international institution, ISRIC informs a wide audience about the multiple roles of soils in our daily lives; this requires scientific analysis of sound soil information.
The source of all fresh water is rainfall received and delivered by the soil. Soil properties and soil management, in combination with vegetation type, determine how rain will be divided into surface runoff, infiltration, storage in the soil and deep percolation to the groundwater. Improper soil management can result in high losses of rainwater by surface runoff or evaporation and may in turn lead to water scarcity, land degradation, and food insecurity. Nonetheless, markets pay farmers for their crops and livestock but not for their water management. The latter would entail the development of a reward for providing a good and a service. The Green Water Credits (GWC) programme, coordinated by ISRIC – World Soil information and supported by the International Fund for Agricultural Development (IFAD) and the Swiss Agency for Development and Cooperation (SDC), addresses this opportunity by bridging the incentive gap.

Much work has been carried out in the Upper Tana catchment, Kenya, where target areas for GWC intervention have been assessed using a range of biophysical databases, analysed using crop growth and hydrological modelling.

This review sets out the background situation upon which legal and institutional arrangements as well as financial mechanisms and project implementation modalities with be built. There is no single effective *green water* management technique that will satisfy both upstream farmers and downstream water user needs. To arrive at a set of practically feasible *green water* management techniques, all options, both existing and alternatives, need to be biophysically possible, economically feasible and socially acceptable. This review offers sources of potential methods and actions.

Dr ir Prem Bindraban
Director, ISRIC – World Soil Information

Key Points

- The 1st phase of the Green Water Credits (GWC) programme in Kenya, the Proof-of Concept, confirmed the need to address water shortages for the main user groups and demonstrated the feasibility of GWC to offer a long-term solution. The parameters analysed in the Upper Tana catchment included natural resources, livelihoods, implementing institutions, and legal and financial frameworks.

- The goals of the second project phase, the Pilot Operation in the Upper Tana are (i) designing the GWC scheme for the Upper Tana and (ii) capacity building of national institutions to implement GWC.

- The design of the second phase requires detailed baseline data in the fields of human and natural resources, which are not accessible at the moment. This review identified some of the data gaps. The planned Management Information System at KARI-KSS has the potential to complete this database.

- The Upper Tana catchment includes several associated projects, which are important for GWC; therefore operational linkages should be established in an early stage. A key initiative is the *Natural Resource Management* project, which covers activities directly linked to Green Water Credits, including the Management Information System.

- There is no single effective *green water* management technique that will satisfy both upstream farmers and downstream water user needs. To arrive at a set of practically feasible *green water* management techniques, all options, both existing and alternatives, need to be biophysically possible, economically feasible and socially acceptable. This review offers sources of potential methods and actions.

- In the Upper Tana, both on-farm and road erosion seem to be significant. For effective sediment reduction to take place in the reservoirs, sediment sources need to be tackled by (i) a GWC focus on-farm, and (ii) public works to carry out erosion control measures along roads.

- To be cost-effective, GWC must rely on remote sensing data. A clear example is the innovative measurement of evaporation and transpiration based on satellite earth observations. However, for the sake of validation and calibration of models, field surveyed data remain essential.

- For Green Water Credits to work, it should be embedded in relevant ministries. Currently, the Ministry of Water and Irrigation has adopted GWC as a National Programme. Other ministries linked to water resources management include the Ministry of Agriculture, the Ministry of Environment and Natural Resources, the Ministry of Energy and the Ministry of Finance.

- To arrive at an effective institutional framework for farmers, an unambiguous institutional link will be required between the Stakeholder Forums and the Water Resources Users' Associations. Such an operational link needs to be identified during the GWC Pilot Operation and developed by the Ministry of Agriculture (through NALEP) and the Ministry of Water and Irrigation (WRMA).

- This review sets out the background situation upon which legal and institutional arrangements as well as financial mechanisms and project implementation modalities with be built.

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Acronyms and Abbreviations

AAK	Agrochemicals Association of Kenya
ACDI/VOCA	Agricultural Cooperative Development International and Volunteers in Overseas Cooperative Assistance
AEZ	Agro-Ecological Zone
AFC	Agricultural Finance Corporation
AI	Artificial Insemination
ASAL	Arid and Semi-Arid Lands
ASARECA	Association for Strengthening Agricultural Research in East and Central Africa
ASCA	Accumulating Savings and Credit Association
ASCU	Agricultural Sector Coordination Unit
CAAC	Catchment Area Advisory Committee
CAFI	Conservation and Farming Initiative
CBA	Cost-Benefit Analysis
CBK	Cooperative Bank of Kenya
CBS	Central Bureau of Statistics
CDD	Community Driven Development
CDF	Constituency Development Fund
CGA	Cereal Growers Association
CMS	Catchment Management Strategy
COSOP	Country Strategic Opportunity Programme
CRI	Cooperative Resources International
CRU	Climatic Research Unit, University of East Anglia
CSS	Culture and Social Services
DEM	Digital Elevation Model
DivSHF	Divisional Stakeholder Forum
DSC	District Stakeholder Committee
DSHF	District stakeholders' Forum
DSMS	District Subject Matter Specialist
ENSO	El Niño-Southern Oscillation
ES	Environmental Service
ESMF	Environmental and Social Management Framework
ERS	Economic Recovery Strategy
ETC	Educational Training Consultants
FEW	Frontline Extension Worker
FSA	Financial Service Institute
FVC	Fraction Vegetation Cover
GBM	Green Belt Movement
GEO	The Group on Earth Observation
GIS	Geographic Information System
GMR	Guaranteed Minimum Returns
GoK	Government of Kenya
GWC	Green Water Credits
HAC	Harmonization, Alignment and Coordination
HCDA	Horticultural Crops Development Authority

ICIW	International Course on Institutions for Water-management
ICRAF	World Agroforestry Centre
IFAD	International Fund for Agricultural Development
IIED	International Institute of Environmental Development
IMAWESA	Improved Management of Agricultural Water in East and Southern Africa
ISRIC	World Soil Information
IWMI	International Water Management Institute
KACE	Kenya Agricultural Commodity Exchange
KAPP	Kenya Agricultural Productivity Programme
KAPSLM	Kenya Agricultural Productivity and Sustainable Land management
KARI	Kenya Agricultural Research Institute
KCC	Kenya Cooperative Creameries
KENFAP	Kenya National Federation of Agricultural Producers
KenGen	Kenya Electricity Generation Company Ltd.
KFS	Kenya Forest Service
KJAS	Kenya Joint Assistance Strategy
KMDP	Kenya Maize Development Programme
KPCU	Kenya Planters Cooperative Union
KSS	Kenya Soil Survey
KTDA	Kenya Tea Development Agency
KWFT	Kenya Women Financial Trust
KWSP	Kenya Water and Sanitation Programme
MARD	Ministry of Agriculture and Rural Development
MCA	Multi Criteria Analysis
MDGs	Millennium Development Goals
M&E	Monitoring & Evaluation
MFI	Microfinance Institutions
MIS	Management Information System
MKEPP	Mount Kenya East Pilot Project
MoA	Ministry of Agriculture
MRGM	Mwea Rice Growers Multipurpose
MWI	Ministry of Water and Irrigation
NALEP	National Agriculture and Livestock Extension Programme
NASEP	National Agriculture Sector Extension Policy
NDVI	Normalised Difference Vegetation Index
NEMA	National Environmental Management Authority
NGO	Non-Governmental Organisation
NIB	National Irrigation Board
NRM	Natural Resource Management
NWMP	National Water Master Plan
NWRMS	National Water Resource Management Strategy
PES	Payment for Environmental Services
PRESA	Pro-poor Rewards for Environmental Services in Africa
PSC	Provincial Stakeholder Committee
PSMS	Provincial Subject Matter Specialist
PWS	Payments for Watershed Services
RBO	River Basin Organisation
RELMA	The Regional Land Management Unit
RGS	Regular Gauging Stations
RO	Regional Office

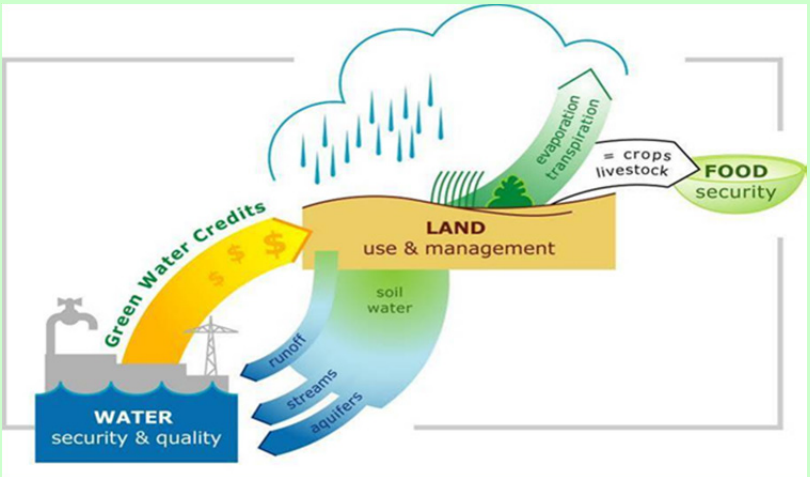
ROSCA	Rotating Savings and Credit Association
SACCOs	Savings and Credit Cooperatives
SCMP	Sub-Catchment Management Plan
SCWD	Soil Conservation and Water Development
SDC	Swiss Agency for Development Cooperation
SEBAL	Surface Energy Balance Algorithm for Land
Sida	Swedish International Development Cooperation Agency
SMART	Specific, Measurable, Achievable, Relevant, Time-bound
SRA	Strategy for Revitalizing Agriculture
SRO	Sub-Regional Office
SWAT	Soil and Water Assessment Tool
SWC	Soil and water conservation
SWMnet	Soil and Water Management network
TARDA	Tana and Athi River Development Authority
UN	United Nations
UNEP	United Nations Environment Programme
VASClimO	Variability Analysis of Surface Climate Observations
WDC	Water Resources Users Association Development Cycle
WEAP	Water Evaluation And Planning tool
WKCCD/FM	Western Kenya Community Driven Development and Flood Management
WKIEMP	Western Kenya Integrated Ecosystem Management Project
WOCAT	World Overview of Conservation Approaches and Technologies
WOFOST	World Food Studies
WRMA	Water Resources Management Authority
WRUA	Water Resources Users Association
WSP	Water Services Providers
WSRP	Water Sector Reform Programme
WSTF	Water Service Trust Fund

Green Water Credits: the concepts

Green water, Blue water, and the GWC mechanism

Green water is moisture held in the soil. Green water flow refers to its return as vapour to the atmosphere through transpiration by plants or from the soil surface through evaporation. *Green water* normally represents the largest component of precipitation, and can only be used *in situ*. It is managed by farmers, foresters, and pasture or rangeland users.

Blue water includes surface runoff, groundwater, stream flow and ponded water that is used elsewhere - for domestic and stock supplies, irrigation, industrial and urban consumption. It also supports aquatic and wetland ecosystems. *Blue water* flow and resources, in quantity and quality, are closely determined by the management practices of upstream land users.



Green water management comprises effective soil and water conservation practices put in place by land users. These practices address sustainable water resource utilisation in a catchment, or a river basin. *Green water* management increases productive transpiration, reduces soil surface evaporation, controls runoff, encourages groundwater recharge and decreases flooding. It links water that falls on rainfed land, and is used there, to the water resources of rivers, lakes and groundwater: *green water* management aims to optimise the partitioning between *green* and *blue water* to generate benefits both for upstream land users and downstream consumers.

Green Water Credits (GWC) is a financial mechanism that supports upstream farmers to invest in improved green water management practices. To achieve this, a GWC fund needs to be created by downstream private and public water-use beneficiaries. Initially, public funds may be required to bridge the gap between investments upstream and the realisation of the benefits downstream.

The concept of green water and blue water was originally proposed by Malin Falkenmark as a tool to help in the understanding of different water flows and resources - and the partitioning between the two (see Falkenmark M 1995 Land-water linkages. FAO Land and Water Bulletin 15-16, FAO, Rome).

1 Introduction

1.1 Need for a review

Phase I of the 'Green Water Credits' (GWC) programme, the *Proof-of-Concept*, finished in December 2007 and work for phase II, the Pilot Operation, was then initiated. The Proof-of-Concept identified the benefits of Green Water Credits and explored the feasibility of the programme in the Middle and Upper Tana catchment.

The two main objectives of the Green Water Credits Pilot Operation are to design the GWC operational plan for the Upper Tana catchment and make a start with the capacity building of the Kenyan implementing institutions. These objectives are to be realised in the period 2008 to 2010. By June 2009, the operational design, information system and communication strategy need to be ready. IFAD is the main financer of Green Water Credits; co-funding is provided by the Swiss Agency for Development and Cooperation (SDC).

For the pilot operation, detailed information about the Upper Tana is required. Accurate biophysical data, such as data on geology, climate, soils, hydrology, erosion and land use and management, is vital to make a well-grounded operational plan. A socio-economic analysis is needed to investigate the costs and benefits of *green water* management. Agricultural and livelihood statistics are therefore essential. Furthermore, information needs to be gathered on farmers' potential and willingness to adopt *green water* management technologies. Finally, the legal, institutional and financial framework needs to be explored.

This review gives an overview of the baseline data that is available for the Upper Tana. It also gives an outline of the associated projects in the project area and suggests areas of cooperation. Information sources are publications of operational projects in the Upper Tana catchment, documents from governmental institutions and studies on PES-systems.

This review is structured as follows. General information on the concept of Green Water Credits and is given in paragraph 1.2 and 1.3. Chapter 2 covers the biophysical data, whereas Chapter 3 focuses on the social setting in the Upper Tana. Chapter 4 is about the legal and institutional framework; the financial framework is described in Chapter 5. Lastly, Chapter 6 deals with implementation of the Green Water Credits programme.

1.2 GWC Proof-of-Concept reports

The Proof-of-Concept phase resulted in seven reports, which are summarised below.

Report 1: Basin Identification
In the first GWC report, four potential basins were identified in Africa, of which the Upper Tana catchment in Kenya ranked number one (Droogers *et al.* 2006). The Tana river, with five large dams is crucial for the main water users which are: (i) the Kenyan hydropower company (KenGen), (ii) urban water supply (80% of Nairobi's water) and (iii) irrigated agriculture (66% of Kenya's irrigated agriculture). The chapter on the Tana catchment provides baseline data at an exploratory level of meteorological and hydrological conditions, and data regarding soil, land and socio-economics.

Report 2: Payment for Environmental Services
The second report reviews the GWC concept and summarises lessons learned from Payment for Environmental Services (PES) world-wide (Grieg-Gran *et al.* 2006). These lessons are taken into account within the GWC programme. GWC is a variant of PES, focussing on human land-use; in particular on rainfed agriculture and rangeland.

Report 3: Green and blue water assessment
GWC report 3 provides baseline information at exploratory to reconnaissance levels on terrain, climate, hydrology, land-use, soil, erosion and population (Kauffman *et al.* 2007). It analyses the *green water* management scenarios for the Upper Tana. For the pilot operation, it identified a need for information on agricultural management of crops (e.g. planting dates, fertilizer application and irrigation), detailed baseline biophysical data that should include groundwater hydrology, and specific erosion and soil information to make solid analyses for GWC intervention areas and relevant *green water* management techniques. As well, an analysis of the potential benefits of evaporation reduction measures is required.

Report 4: Water use and Demand
GWC report 4 starts with an outline of the political setting in Kenya in relation to the water sector. An analysis of supply-demand scenarios of the main water users is carried out, using the Water Evaluation and Planning tool (WEAP) (Hoff and Noel 2007). A cost-benefit analysis of three different *green water* management technologies was performed. Both the use of tied-ridges and mulching were identified as having potentially positive impacts by reducing siltation and evaporation.
For the Pilot Operation it is necessary to:
- establish accurate values for the WEAP parameters, together with Kenya institutions and relevant IFAD projects;
- use detailed information of costs and benefits of feasible *green water* management technologies under local conditions. The availability and alternative uses of mulch must be taken into account.

Report 5: Farmers adoption of GWC
GWC report 5 evaluates farmers' interest and willingness to adopt *green water* management techniques. It also researches the role of GWC payments (Porras *et al.* 2007). Socio-economic data collected through a household survey in the Upper Tana are analysed. The main conclusions are:
- Soil and water conservation (SWC) is mainly seen as means to an end, namely for crop production and income generation;
- There is a need for tangible, sustained benefits and GWC can fulfil this role;
- Success of the implementation of GWC will depend very closely on the cooperation of farmers.

For the pilot operation, issues regarding gender-bias in relation to different kinds of incentives must be taken into account.

Report 6: Political, Institutional and Financial framework
GWC report 6 analyses the political, institutional and financial framework required for the implementation of Green Water Credits (Meijerink *et al.* 2007). The main conclusions are:
- The programme is in line with current policy reforms in Kenya's water sector, because it uses a market-based mechanism;
- Funding of *green water* management is a key constraint in the adoption process at farm level;
- Past experiences indicate the importance of farmer involvement from the early design of the programme;
- Existing farmers' groups have systems in place for collecting and administrating payments, monitoring and enforcing compliance with contracts at field level;
- Transaction costs need to be kept to a minimum.

For the Pilot Operation, at institutional level, more information is needed on informal arrangements.

Report 7: Synthesis Report
The final Proof-of-Concept paper, GWC report 7, synthesises the major findings of the previous six reports (Dent and Kauffman 2007). The main points include:

- *Green water* potential can be much better exploited, and downstream delivery of fresh water better regulated by two fundamental improvements in rainfed farming: increasing the infiltration of rainwater (thereby cutting runoff) and reducing unproductive evaporation;
- Green Water Credits are payments for water management services by farmers, which are currently unrecognised and unrewarded;
- Green Water Credits supports the current water reform in Kenya by providing a market-based mechanism by which many of the goals of reform may be achieved;
- Capacity building is needed at all levels.

Further information on the main points is given in Annex 1.

Now that the concept of Green Water Credits has been proven, the GWC operational programme needs to be designed in detail.

1.3 Principles of Green Water Credits

Green and blue water[1]
Green water is that fraction of rainfall that infiltrates into the soil and is available to plants (Figure 1). Contrastingly, evaporation is the non-productive return flow to the atmosphere. *Green water* is the largest fresh water resource and the basis of rainfed agriculture and all life on land. Yet it has received remarkably little attention in contrast to *blue water* – the fraction of water that reaches rivers directly as runoff, indirectly, through deep drainage to groundwater and stream baseflow. *Blue water* flow can be tapped for use elsewhere for domestic use, stock water, irrigation, industrial and urban (Droogers *et al.* 2006; Ringersma *et al.* 2003).

[1] See "GWC: the concepts" page 10 (page number to be added – and this refers to the GWC concept note that needs to be added also)

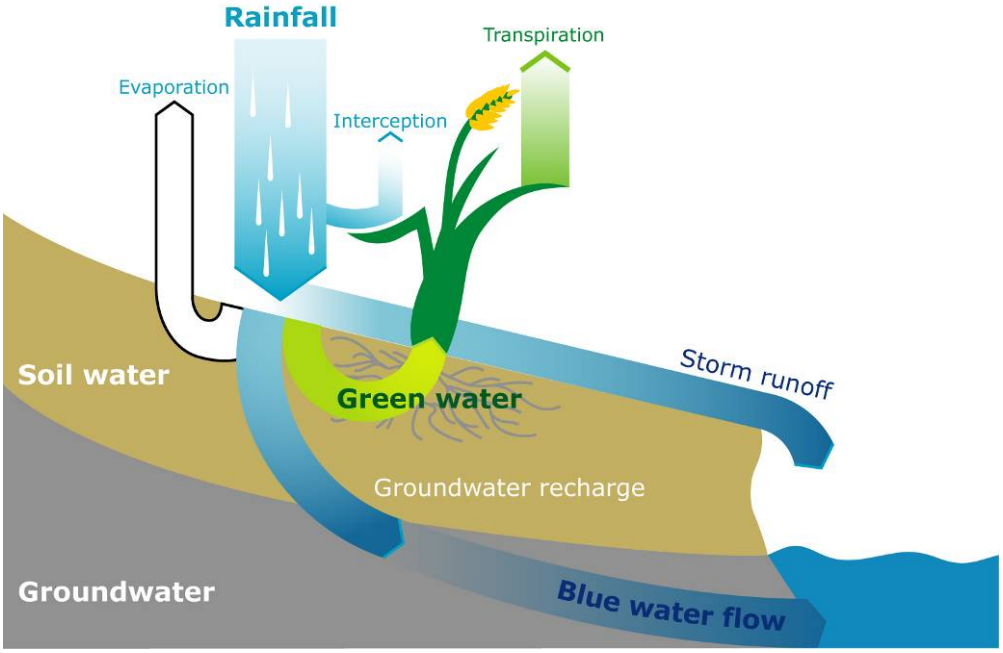


Figure 1

Partitioning of rainwater into green and blue water flows

Green water management

Soil and crop management determine water infiltration, runoff and erosion, and evaporation in farmland. Runoff and evaporation constitute significant losses of water on-farm and also influence the water supply downstream. Practices that enhance infiltration, and reduce both runoff and unproductive evaporation fall under *green water* management*;* this includes mulching, minimum tillage, vegetation strips along the contour, tied ridging, and terracing (Kauffman *et al.* 2007). The 21st century has shown an increasing acknowledgement by scientists of the potential of *green water* management (Falkenmark and Rockström 2005). Especially in semi-arid countries like Kenya, where more than 75% of the production comes from rainfed agricultural areas, recognition of the importance of *green water* management is rapidly increasing (IWMI 2007). Poor rural communities depend on food from rainfed agricultural land. Most countries depend primarily on rainfed agriculture for their grain supply. Women are especially dependent on rainfed agriculture, since they make up approximately 70% of the world's poor (IWMI 2007).

There is a call for large investments in water management and specifically in rainfed agriculture. However, by doing so, local *blue water* resources will be influenced through the increase in *green water* consumption that will take place. Thus trade-offs with downstream users need to be addressed.

Pioneers in the *green* and *blue water* concept are Malin Falkenmark and Johan Rockström. In their 2004 publication "Balancing Water for Humans and Nature", they lay the foundation for this debate by clarifying the links between humans, water and ecosystems. Particular focus is put on the highly vulnerable semi-arid tropics, where excessive, non-productive evaporation takes place. Water management can play a significant role in protecting the large amounts of water available in these areas. Finally, crucial water functions are integrated into a catchment perspective by an analysis of various hydro-solidarity aspects involved (Falkenmark and Rockström 2004).

2 Biophysical Conditions

2.1 Water resources

Globally, water use has been growing at more than twice the rate of population increase in the last century. Although there is no global water scarcity as such, an increasing number of regions are chronically short of water. By 2025, 1.8 billion people will be living in countries or regions with absolute water scarcity (UN-Water 2006). Irrigated agriculture will be the first sector affected by water shortage, resulting in a decreased capacity to maintain sufficient food production, while meeting water needs for domestic, industrial and environmental purposes (UN-Water 2006).

Kenya is classified by the UN as a chronically water-scarce country[2] with an annual freshwater supply of about 647 m^3 per capita, which is significantly below the 1000 m^3 per capita set as the marker for water scarcity (Mogako *et al.* 2006). The current level of development of water resources in Kenya is very low. Only 15% of the safe yield – the proportion of renewable water that can be used - has been developed currently (Mogako *et al.* 2006). Moreover, only 57% of Kenya's population has access to an improved water source (World Bank 2008).

However, the country possesses sufficient water resources to meet demand (Mogako *et al.* 2006). One major constraint concerns funding. Insufficient funds have been allocated to police illegal water extraction, control discharge of wastes into lakes and rivers, protect catchments and help prevent excessive erosion in headwaters (Mogako *et al.* 2006). In Kenya, the major factor that controls agricultural productivity is rainfall (Biamah 2005). Until present, rainwater has however rarely been integrated into water management strategies, which usually focus exclusively on surface- and groundwater (UN-Water 2006). Variations in precipitation due to climate change cannot be controlled, but if by means of *green water* management water quantity can be increased, this will have a positive influence on agricultural productivity.

Upper Tana catchment

The Upper Tana catchment is situated north-west of Nairobi (Figure 2) and covers Mount Kenya and the Aberdares highlands. Its surface area is approximately 12,500 km^2 (World Resources Institute *et al.* 2007). Elevation ranges from 5199 m on Mount Kenya to 400 m in the east of the catchment (Figure 3). Themain rivers of the catchment are the Sagana and Thiba. Important tributaries include the Chania, Mathioya, Maragua, Nyamidi, Rupingazi, Ena, Tunga and the Gura (IFAD 2002b; IFAD/UNEP/GEF 2004; World Bank 2007b).

[2] Water scarcity is defined by UN-water as: "the point at which the aggregate impact of all users impinges on the supply or quality of water under prevailing institutional arrangements to the extent that the demand by all sectors, including the environment, cannot be satisfied fully". UN-Water 2006. *Coping with water scarcity. A strategic issue and priority for system-wide action*, UN.

Figure 2

The Tana basin

The upper Tana catchment covers the following administrative districts: Nyeri, Meru, Kirinyaga, Muranga, Maragua, Embu, Tharaka, Mbeere and part of Thika. There are several protected areas in the Upper Tana (Figure 4), such as the Mount Kenya National Park and the Aberdares. The protected areas consist of several rare forest ecosystems, where biodiversity is high. Six large mammal species of international significance can be found in the forests surrounding Mount Kenya including the African elephant (IFAD 2002b).

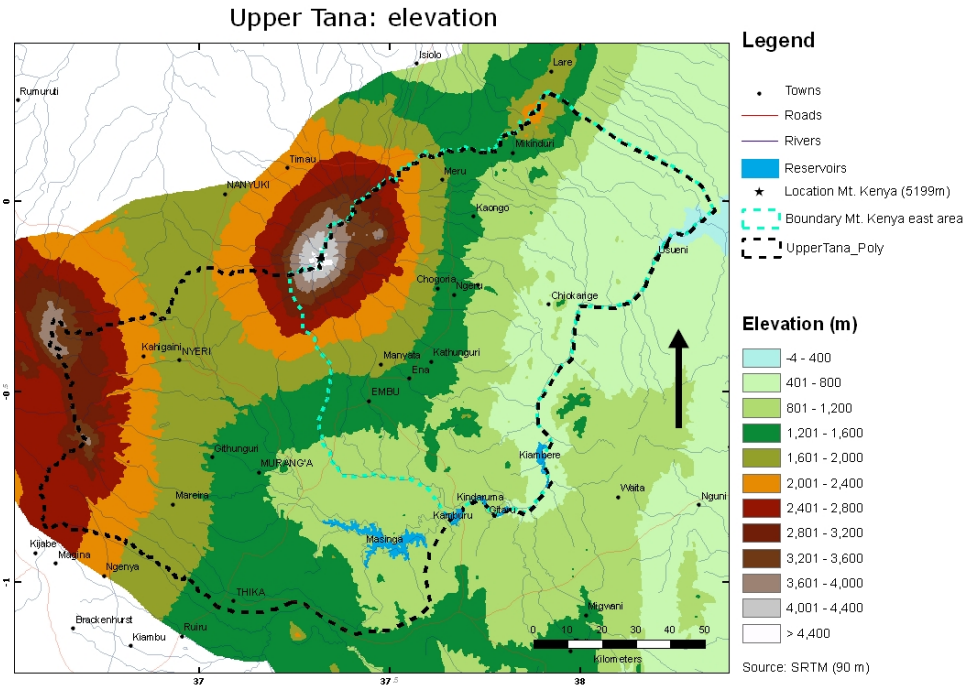


Figure 3

Elevation in the Upper Tana catchment

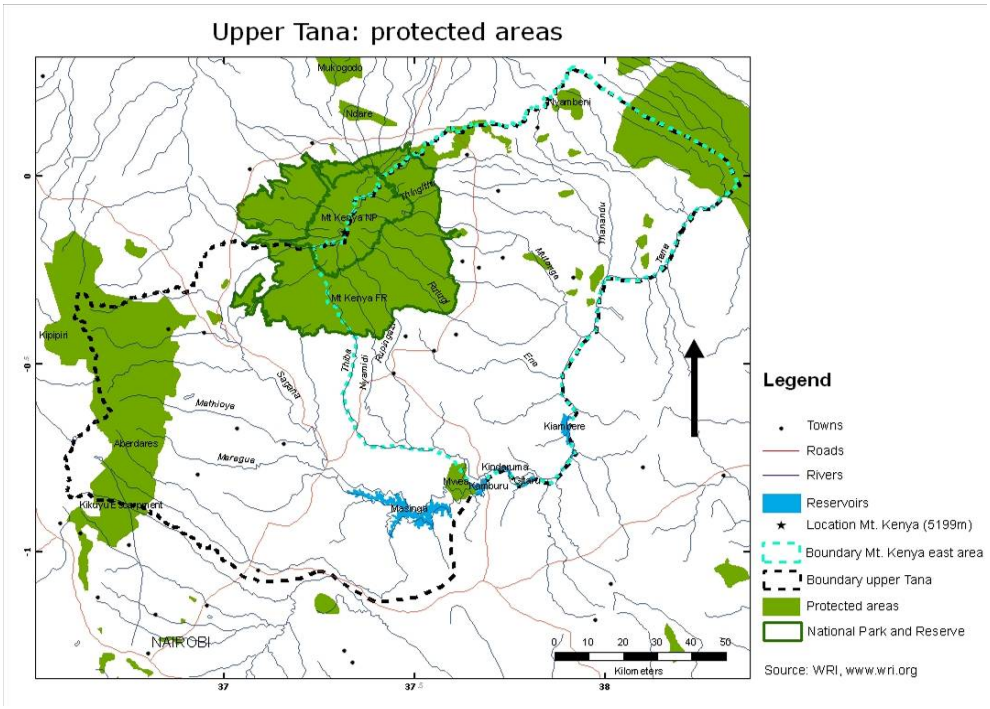


Figure 4

Protected areas in the Upper Tana

The Tana river is utilised for hydropower by KenGen, Kenya's main energy company (KenGen 2005a, 2008). Five major reservoirs have been built on the upper reaches: Kindaruma in 1968, Kamburu in 1975, Gitaru in 1978, Massing in 1981, and Kiambere in 1988 (Figure 5). Together, these provide three quarters of Kenya's electricity and regulate the riverflow.

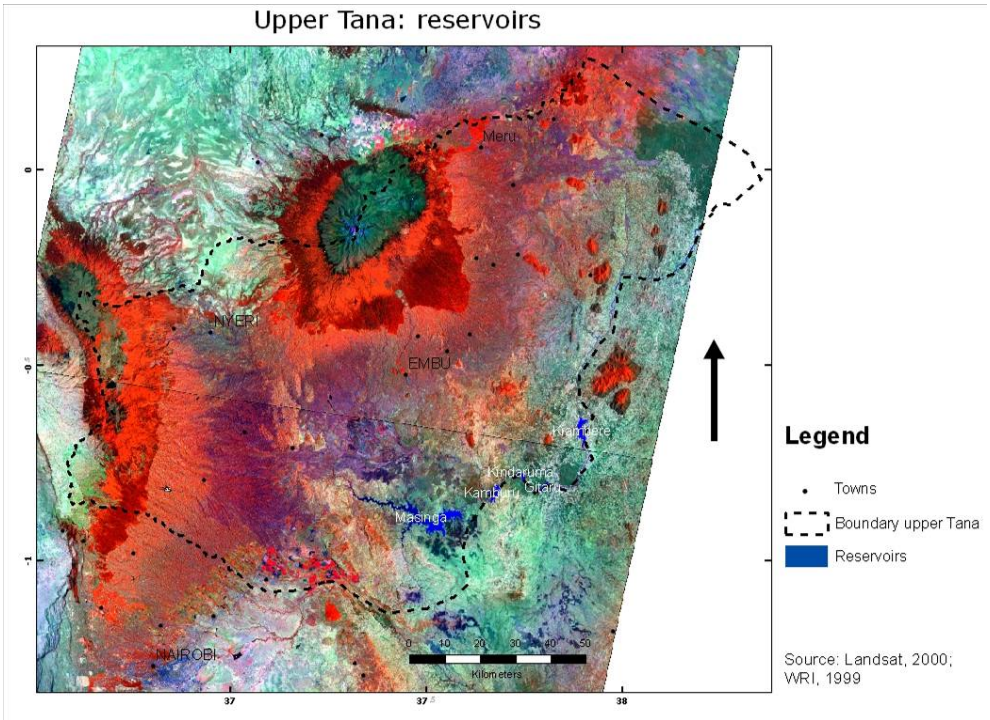


Figure 5

Reservoirs in the Upper Tana catchment

The Upper Tana catchment copes with severe water shortages. In dry periods many rivers cannot provide enough water for the various users. Potential evapotranspiration ranges from 500 mm per year in the forest to 1700 mm in the lowlands, so that practically all areas below the forest zone experience a rainfall evaporation deficit (Notter *et al.* 2007).

2.2 Climate

Climate in Kenya

Kenya is highly vulnerable to climate variability. The El Niño/La Niña system (see Box 1) caused severe flood events in 1997/98 and a prolonged drought, resulting in costs estimated at 64 billion Kenyan Shilling (KSh) and 220 billion KSh respectively (Mogako *et al.* 2006). Due to poor water resource management in recent years, Kenya is not prepared for such events. Clearly, long-term benefits from prudent protection, development and management of water resource, far outweigh the costs of cleaning up (Mogako *et al.* 2006).

Action is needed, as climate change scenarios predict an increase in flood flow and decreasing low flows (Notter *et al.* 2007). Adapting to these changes will require an adequate water storage - and delivery infrastructure (IWMI 2006). *Green water* management provides answers to these requirements through improving rainwater storage in the soil and as groundwater, instead of needing to construct further open water reservoirs with their inherent high evaporation losses and construction costs.

Box 1

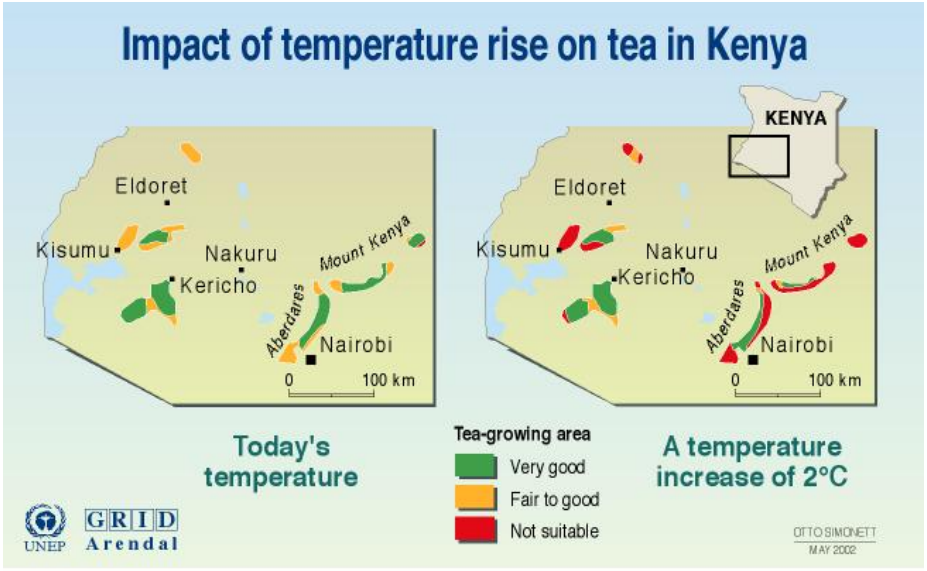
The El Niño-Southern Oscillation

The El Niño-Southern Oscillation

The El Niño-Southern Oscillation (ENSO or simply El Niño) is a global coupled ocean-atmosphere phenomenon, which has important consequences for the weather around the globe. It is associated with floods, droughts and other disturbances in a range of locations around the world.
El Niño and La Niña are temperature fluctuations in surface waters of the tropical Eastern Pacific Ocean. During an El Niño event, temperatures in the waters in the central and eastern tropical Pacific Ocean rise, and easterly trade winds weaken. As a consequence, rainfall follows the warm water eastward, which causes floods in western South-America (Peru) and drought in Indonesia and Australia
The name El Niño, from the Spanish for "the little boy", refers to the Christ child, because the phenomenon is usually noticed around Christmas time in the Pacific Ocean off the west coast of South America.
ENSO is the most prominent known source of inter-annual variability in weather and climate around the world (occurring every 3 to 8 years approximately).
The mechanisms that cause an El Niño event are still being investigated due to the difficulties in establishing clear patterns that allow reliable forecasts. As the phenomenon is located near the equator, events in both hemispheres may have an effect.

Data sources:
http://www.pmel.noaa.gov/tao/elnino/el-nino-story.html
http://en.wikipedia.org/wiki/El_Ni%C3%B1oSouthern_Oscillation#Causes_of_El_Ni.C3.B1o

In the Third Assessment Report of the United Nations Environmental Programme (UNEP 2005) a number of important graphs that present climatic trends for Africa are summarised. One of the important conclusions drawn in the report is that Africa will experience increasing water stress, due to climate change and increased population pressure. Figure 6 shows one of the possible effects of climate change on the agricultural suitability of tea in the Upper Tana. The figure indicates that if temperatures rises by 2°C, large areas of the Aberdares and Mount Kenya region will become unsuitable for tea growing.



Source: Otto Simonett, *Potential impacts of global warming*, GRID-Geneva, case studies on climate change. Geneva, 1989.

Figure 6

Impact of temperature rise on tea in Kenya

Climate of the Upper Tana

The study area experiences two rainy seasons a year as a result of the Intertropical Convergence Zone; the *Long Rains* last from around March to June and the *Short Rains* from September to December. However, the rainy seasons vary from year to year in their duration and rainfall totals. Rainfall patterns in the mountainous catchments are very heterogeneous and difficult to capture with the monitoring network, as there are few meteorological stations. Average annual precipitation increases from 400 mm in the savannah to 2300 mm on the windward south-eastern side of Mount Kenya, and drops to 800 mm in the summit region (IFAD/UNEP/GEF 2004; Notter *et al.* 2007). Figure 7 shows the variability of precipitation over the years, as measured in Embu (located at 1493 m) and Meru (1554 m) for 1996-2008[3].

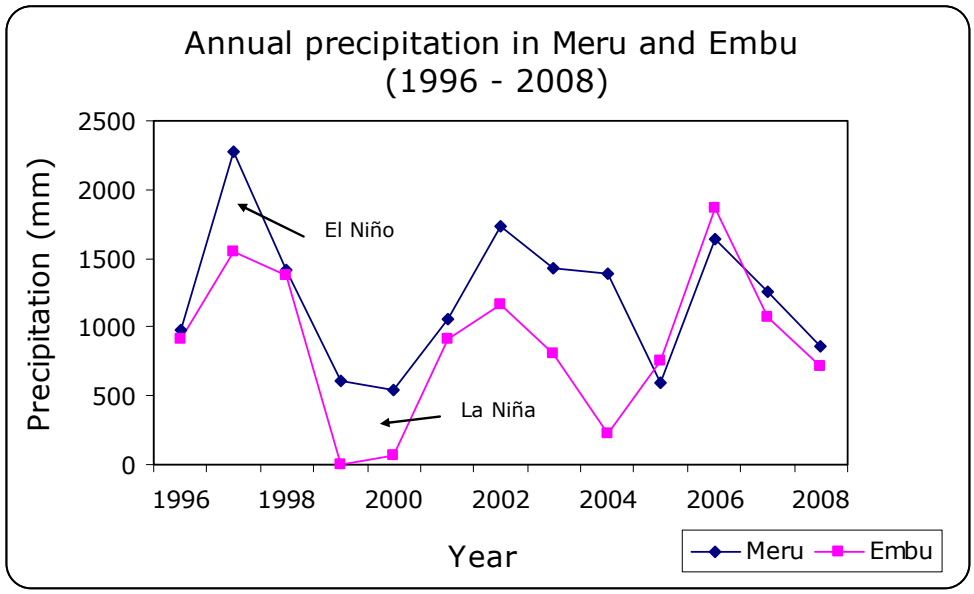


Figure 7

Precipitation in Meru (weather station 636950) and Embu (637200)

Potential evapotranspiration drops from around 1700 mm in the savannah zone to less than 500 mm in the summit region, meaning that all areas below the forest zone experience a rainfall evaporation deficit. As a consequence, the forest and moorland zones provide most of the discharge of the rivers during the dry periods (Notter *et al.* 2007). The combination of elevation and climatic characteristics makes it possible to divide the catchment into agro-ecological zones (see Figure 12). Every agro-ecological zone is associated with a certain type of land use.

Issues for Green Water Credits

For the Proof-of-Concept, water-balance calculations were based on climate data of 8 meteorological stations in the Upper Tana catchment. Hydrological basin calculations were based on the CRU[4] dataset, which is also derived from these same meteorological stations. For the Pilot Operation, a more detailed assessment will be made using more detailed baseline data:

[3] Source: www.tutiempo.net

[4] CRU: Climatic Research Unit, University of East Anglia.

1. Data from the Variability Analysis of Surface Climate Observations (VASClimO) dataset[5].
2. Expansion of the current dataset with precipitation records of 2nd class stations.
3. Development of an elevation-rainfall function to interpolate rainfall between the meteorological stations. This function is probably available at the Kenya Meteorological Institute. The area interpolation can be implemented with the use of a DEM.
4. Rainfall data from the Tropical Rainfall Measuring Mission at a spatial resolution of 25 km and a temporal resolution of one hour. Long-term trends are not available.

2.3 Hydrology

2.3.1 Surface and groundwater

Mount Kenya National Park and National Forest Reserve (and the Aberdares) together with the surrounding agricultural land, respectively form the watershed and the water catchment areas for two major rivers: the Tana and the Ewaso Nyiro. They serve about three quarters of the surface area of the country, with the Tana river providing water to about 50% of the country's population (IFAD/UNEP/GEF 2004). The water resources provided by Mount Kenya are used for irrigation (which accounts for over 75% of total water demand) of cash and export crops. There is increasing demand for irrigation water on the slopes of Mount Kenya, particularly to support horticulture production. But water usage in the area affects water availability in lower lying, drier areas. Water is also important for electricity generation, industry, commercial and tourism operations, and livestock (IFAD/UNEP/GEF 2004).

In the Upper Tana, the most important problems concerning surface and groundwater are (WRMA 2007a):
– Poor water quality (concentration of fluoride is too high), which leads to health issues; and
– (Local) over-abstraction of water.

The WRMA has developed a Catchment Management Strategy (WRMA 2007a) for the Tana basin to address these problems. The Upper Tana catchment has been divided into sub-basins, for each of which a River Basin Management Plan has been proposed (MKEP 2005, 2006 and 2007).

Tana river

A study on river discharge, sediment transport and exchange in the Tana estuary was conducted between February 2001 and November 2003 (Kitheka *et al.* 2005). Discharge of the Tana river has a marked seasonal signal, which is inconsistent with patterns observed in other dammed river systems such as the Zambezi. The discharge of the Tana ranges between 60 and 750 $m^3 s^{-1}$. The maximum measured river discharges during the southeast and northeast monsoons were 750 and 350 $m^3 s^{-1}$, respectively. The peak river discharges occurred in May and November. The total daily sediment load of the Tana river varied from 2796 tonnes day^{-1} during the dry season, to 24,322 tonnes day^{-1} during the rainy season. Per year this can be translated into a minimum of 1 million tonnes of sediment to a maximum of 8 million tonnes of sediment being transported into the ocean. It is estimated that in 1965 the Tana river carried 250,000 tonnes of sediment into the Indian Ocean (IFAD/UNEP/GEF 2004). By 1986, it carried approximately 2.5 million tonnes, a tenfold increase. Extrapolation of these figures give an estimated 4 million tonnes of sediment being carried by the Tana river in 2001 (IFAD/UNEP/GEF 2004), which according the research of Kitheka *et al.* (2005), might well be correct.

The regulation of the flow of the Tana river by the Upper Tana reservoirs is limited, probably because of the small size of the reservoirs, and also because of the fact that downstream of the Upper Tana reservoirs the

[5] For information, data and downloads, see: http://www.juergen-grieser.de/downloads/VASClimO/vasclimo.htm

river receives considerable flow (Kitheka *et al.* 2005). According to the study of Kitheka *et al.* (2005) most of the sediments transported by the river are associated with soil erosion due to poor land use activities in the Tana basin. The total annual sediment load is 6.8 million tonnes tonnes yr^{-1}, which is less than the sediment load prior to the damming of the river in the Upper Tana basin. Reduced sediment load is attributed to the trapping of sediments in the reservoirs in the Upper Tana basin.

Surface- and groundwater withdrawal

Kenya uses both surface and groundwater resources to meet the current water demand (Mogako *et al.* 2006). It is estimated that for the Tana river basin approximately 6,800,000 m^3 can safely be abstracted from surface water and 685,000 m^3 from groundwater (Mogako *et al.* 2006). According to the aftercare study on the National Water Master Plan (RoKenya *et al.* 1998) 15.9% of Tana river basin's water volume is abstracted. For Kenya as a whole, actual withdrawal from both surface and groundwater resources is much smaller than the potential safe yield; six times more water can still be safely abstracted from surface water resources, and approximately five times more water from groundwater resources (Mogako *et al.* 2006). The main principal causes of water resource degradation in Kenya are (Mogako *et al.* 2006):

- Excess local abstraction of surface and groundwater;
- Soil erosion causing turbidity and siltation;
- High nutrient levels causing eutrophication of lakes and pans; and
- Toxic chemicals, including agricultural pesticides, and heavy metals, which are toxic to water-dependent biota.

The availability and quality of river water is declining because of the breakdown in the control and regulation of water abstraction from rivers (IFAD/UNEP/GEF 2004). Only about 10-20% of water abstractions are legal; existing water permits stipulate a maximum offtake rate, which is neither enforced nor enforceable because all the water guards have been retrenched. The current situation is that the greater the offtake the cheaper the water, so inevitably water abstraction is being maximised. District Water Offices do not have up-to-date information on water projects under their jurisdiction. The absence of data is clearly not a sound basis for planning of water resource development (IFAD/UNEP/GEF 2004).

As rivers are no longer closely monitored, a "free for all" situation is developing under which no-one is concerned about downstream users. The main constraints to proper water management that were identified in the area are: (a) uncontrolled water abstractions that make planning of water resource management difficult; (b) inadequate capacity of the Water Department to regulate and control water use in rivers; (c) lack of district and local water management plans; (d) weak collection and analysis of water data; (d) the need to transfer water over long distances due to the steep terrain; and (e) pollution of rivers from urban centres, leading to poor quality water downstream. The rules relating to land and water management, such as those restricting cultivation near watercourses or on slopes, are not adhered to, owing to an increase in the demand for land for cultivation, a situation that is not likely to cease in the near future. While changing land-use need not necessarily lead to environmental degradation, the current situation is that those living in the tea and coffee zones are engaging in activities that are detrimental to the quality and quantity of river water (IFAD/UNEP/GEF 2004).

Problems of agriculture and water are inextricably linked: as farmers abandon traditional non-irrigated crop production in favour of cash crops such as horticulture, demand for irrigation increases. Farmers do not yet view or value river water as a finite resource and downstream users suffer the consequences of over-abstraction upstream because dry season riverflow is falling. The end result is that the availability of water for the ASAL (arid and semi-arid lands) areas, where the end-users (the poorest and most vulnerable target groups) live, is insufficient to meet demand. Given this scenario, agricultural intensification in these areas becomes almost impossible (IFAD/UNEP/GEF 2004).

Gauge stations

Streamflow monitoring, both quality and quantity, is vital for sustainable and equitable water resources management. In 1960, multiple Regular Gauge Stations (RGS) were established in the Tana basin. However, over the years, the equipment has become defective, as no new investments had been made. As a result, by 1992, many stations were not operational anymore and records were missing. Since then, the situation has deteriorated.

Accurate data are necessary for sound governance of water resources. Currently, the Water Resources Management Authority (WRMA) is reactivating the stations (World Bank 2007b). By the end of 2008, data will be available for all stations. MKEPP has established new - and has rehabilitated existing - gauging stations for purposes of monitoring hydrological data in the project area. Daily flow measurement are presently being carried out at seven stations (UNOPS Africa Regional Office 2007). For both MKEPP and NRM, WRMA is the principal agent responsible for the reactivation of the hydrological stations. Box 2 gives an overview of the information on monitoring stations in the Upper Tana; in *Issues for Green Water Credits*, an overview is given of the hydrological data that are still lacking.

Box 2

Monitoring stations

The WRMA distinguishes four types of stations:

1: National importance	The Garissa station (4G01) in the Tana basin
2: Regional importance	Six stations in the Tana (4 F19, 4EA, 4DD2 (Thiba), 4CB4, 4BE10, 4AC4)
3: Management unit stations	16 stations in the Tana basin
4: "Special stations"	2 stations in the Tana basin

Station type 4 is a temporal station which is set up at outlets where data is needed for the management of a specific project (e.g. outlet of a smallholder farm-field using overland flow irrigation). A location map of the gauge stations is not yet available.

Effect of forest clearance on hydrology

Deforestation affects the hydrology of an area. Generally, it can be said that it increases the runoff (Zhang *et al.* 2001), because vegetation cover is removed. However, in areas where cloud forests occur, like in the Aberdares and Mau Ranges of Kenya, forest clearance will actually reduce the runoff and riverflows from these areas (Mogako *et al.* 2006). Approximately 5% of the precipitation is a result of the direct "cloud" harvesting effect of the trees. Therefore, clearance of these areas may lead to a reduction in effective precipitation of about 5% and consequently lead to a reduction in the amount of runoff and riverflow. Decreases in river discharges after forest clearance may also be the result of dense settlement patterns, since an increase in population will lead to higher water abstraction amounts.

Forest clearance also affects the hydrological cycle by the change in evapo transpiration. According to a simple two-parameter model that relates mean annual evapotranspiration to rainfall, potential evapotranspiration, and plant available water capacity, forested catchments have a higher evapotranspiration than grassed catchments (Zhang *et al.* 2001). However, a change from forest into agricultural fields, or bare land, may in fact increase the amount of evaporation. The model from Zhang *et al.* provides a tool to assess these changes in hydrology on a catchment scale.

Issues for Green Water Credits

For the hydrological assessment performed for the Proof-of-Concept, only 12 gauging stations were used (Kauffman *et al.* 2007). For the pilot operation, more detailed hydrological data are vital. Below a summary is given of options for data collection.

1. Establishment of a gauging network is one of the goals of the WRMA, falling under the Natural Resource Management project, as well as under the MKEPP. For pilot operation, the data from these stations should be included in the hydrological assessment.
2. A report from Texas A&M University mentions seven supplementary monitoring stations (Jacobs *et al.* 2003). These seven stations should be included in the new hydrological assessment.
3. The Water Department of the Ministry of Environment and Natural Resources has a surface water database containing the following datasets (ETC 2002):
   – Basic information on Regular Gauging Stations (RGS) of the riverflows
   – Daily water levels
   – Rating curve equations for the various rivers

   It needs to be verified whether this data is available for GWC, up-to-date and adequately covers the Upper Tana Catchment. If so, it should be obtained and used for hydrological modelling.
4. The Water Department of the Ministry of Water and Irrigation has conducted a number of projects in line with water conservation, flood control and surface - and groundwater investigations (MWI 2008). Projects include:
   – Water conservation structures in 44 districts in ASAL Areas;
   – Riverflow measurements (countrywide);
   – Updating hydrological data into computers (countrywide);
   – Monitoring of water levels and weather stations (countrywide);
   – Rehabilitation of hydro-meteorological stations (countrywide);
   – Regional hydro-geological survey (Upper Tana); and
   – Groundwater monitoring and data analysis (countrywide)

   These projects will enhance the availability of hydrological data and therefore will make an accurate assessment with the SWAT model possible.

Other hydrological data that are needed include:
– Infiltration capacities and rates;
– Groundwater systems: depth to bedrock;
– Groundwater flows: velocity and directions; and
– Detailed surface water data: flow velocities, sediment loads, total volume, and dams.

2.4 Geology and structure

Kenya is underlain by Neoarchean rocks in the west of the country; metamorphic rocks of the Neoproterozoic Mozambique Belt mainly in the northern central part of the country, sediments ranging from Late Paleozoic to recent times along the coast and predominantly younger volcanic soils associated with the rift formation in the central part of the country (Schluter 2006). The Upper Tana can be divided in two main geological structures: in the west volcanic rocks of the Cenozoic are found and in the east the bedrock consists of metamorphic rocks of the Mozambique belt (Figure 8). Mount Kenya, an extinct volcano formed between 100-4000 million years ago (IFAD/UNEP/GEF 2004), is located in the west of the catchment. The volcano erupted for the last time between 1.6 and 3.1 million years ago (Baker 1967). Around the major lakes in the Upper Tana, patches of Precambrian intrusive rocks can be found.

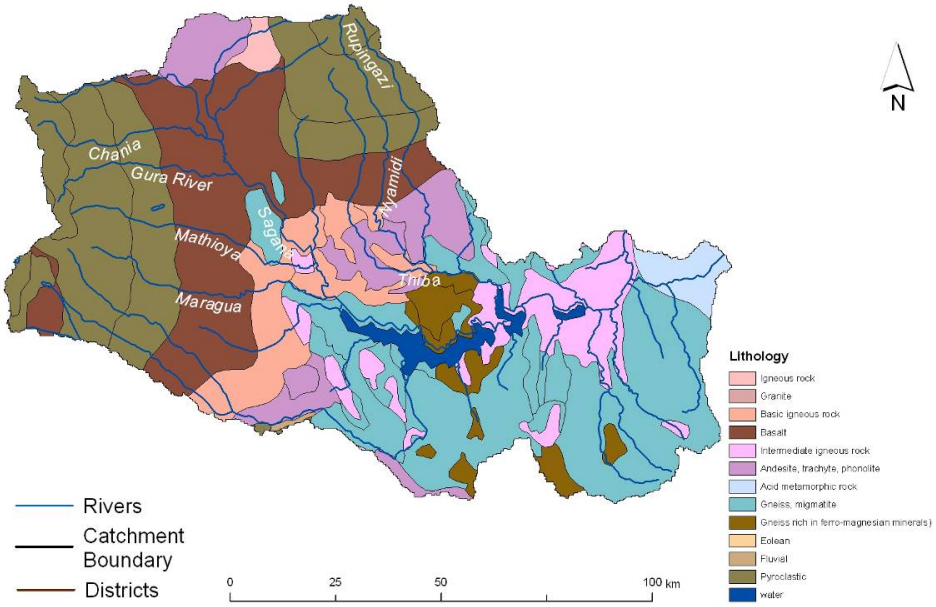


Figure 8
Lithology of the Upper Tana, Kenya

Issues for Green Water Credits
More detailed baseline information on geology is needed, preferably on a scale of 1:250.000.

2.5 Soils

The dominant soil type of the Upper Tana catchment is the *Humic* Nitisol (Figures 9 and 10). Humic Nitisols (see Box 3) in the Tana basin have formed on the volcanic deposits and thus are found within high altitude zones. Most Nitisols in the catchment are cultivated for tea or coffee. In general these soils are highly resistant to erosion.

Figure 9
Example of a Nitisol, Kenya (Source: ISRIC – world Soil Information)

However, poor land management can degrade these soils leading to soil erosion (ISRIC 2008).
Other soil types in the Tana catchment include Vertisols, Cambisols, Ferralsols, Andosols and Leptisols (Box 3).

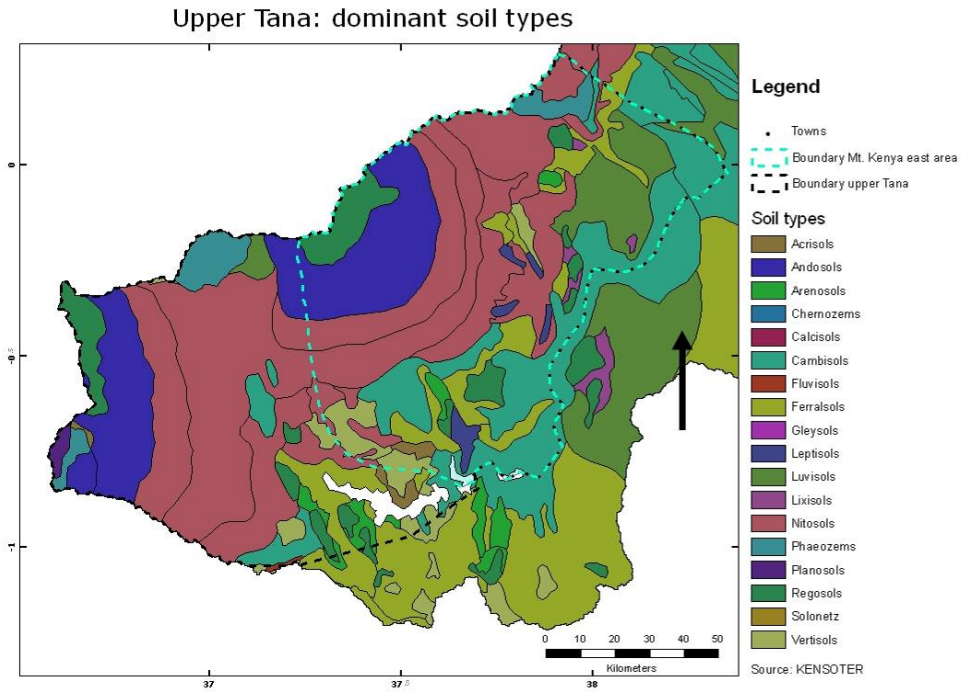


Figure 10

Dominant soils in the Upper Tana catchment

Issues for Green Water Credits

Soil data are required for the catchment hydrological model assessment and for identification of appropriate *green water* management techniques.

The following soil baseline data are required for the Pilot Operation:

- Data of the unpublished Muranga sheet/district will be made available by KARI-Kenya Soil Survey;
- More-detailed soil attribute data are required for the basin hydrological model, especially soil physical data for WOFOST and SWAT[6]:
  a) Soil erodibility, preferably some field measurements to calibrate derivation from soil texture, organic matter content, mineralogy;
  b) Soil water retention curves;
  c) Infiltration rate;
  d) Saturated hydraulic conductivity (or, for all hydrological attributes, classification by hydrological group);
  e) Rootable depth; and
  f) Depth to bedrock.
- Additional field observations are needed on infiltration and soil water retention.

[6] Soil and Water Assessment Tool (SWAT) and World Food Studies model (WOFOST).

2.6 Land use and management

2.6.1 Land use in Upper Tana

Land use in the Upper Tana consists of three main classes: natural vegetation (forest, grassland and wetlands), rainfed and irrigated agriculture (tea, coffee, maize and cereals) and rangeland (Figure 11). The catchment can be divided into different agro-ecological zones (Jaetzold and Schmidt 1983), corresponding to different land-use types (Figure 12). The upper zone, 4000-5200 m is the afro-alpine zone. Between 3300 and 4000 m there is moorland. The forest zone is located between 2200 and 3000 m and comprises highly diverse indigenous forest. Below 2200 m the natural vegetation has been largely removed and the land has been converted to agriculture (Panafcon 2007). The tea zone is located between 1800 and 2200 m. Below the tea zone, the coffee zone can be found (1300-1800 m), although presently, many farmers are turning their coffee fields into subsistence cropping. Between 1100 and 1300 m subsistence cropping (maize, sunflower etc) is taking place. Below about 1100 m are the arid and semi-arid lands (ASAL) (Panafcon 2007). (IFAD/UNEP/GEF 2004; MKEPP 2006)

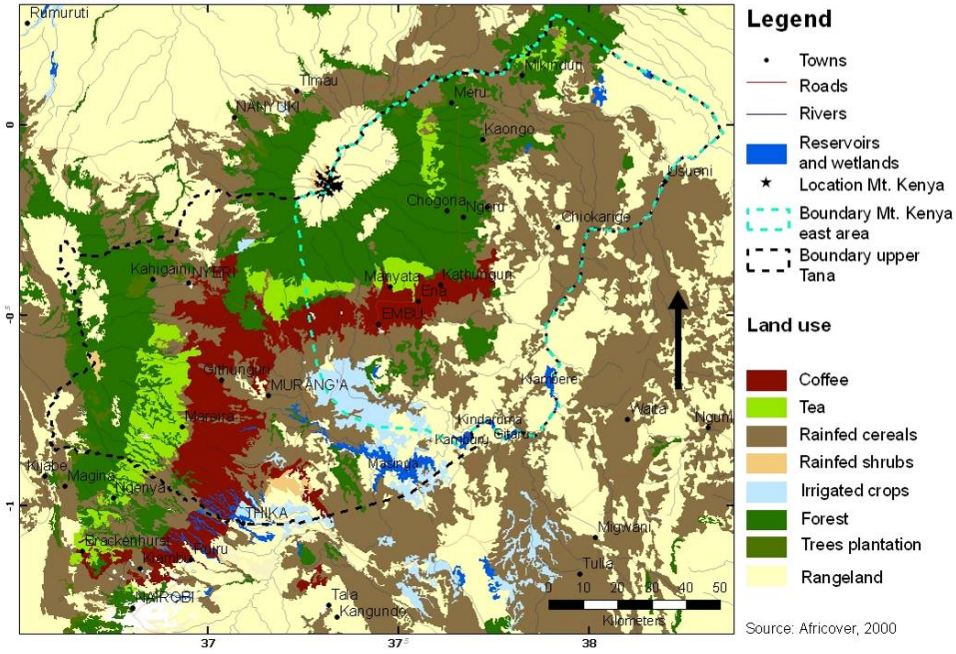


Figure 11
Land use map of the Upper Tana

Population density is highest in the southern and eastern parts due to high rainfall and relatively fertile soils. The farmlands are privately owned. Small-scale cash crop and subsistence farming dominate. The cropping intensity increases with elevation, because of the better soils and higher water availability. Farm size varies from 0.2 ha to 1.6 ha. Small plots near the homestead are used for subsistence crops such as maize and beans, and trees are planted along the boundaries of the plots. A variety of crops are produced, including maize, beans, arrowroot, yams, bananas, macadamia nuts, passion fruit, coffee and tea as well as some livestock kept (IFAD/UNEP/GEF 2004).

Agroforestry and farm forestry are both found in the area, including in the tea zone. Trees are planted around the homestead and along farm boundaries. In agroforestry and farm forestry systems, the tree mix consists of both indigenous and exotic tree species, but faster growing exotics dominate. Such species include silky oak, blue gum, river red gum and the cypress. Farm forestry and agroforestry are an increasingly important livelihood activity as a result of the ban on logging in the Mount Kenya Reserve since 2000 (IFAD/UNEP/GEF 2004).

Kenya's economy relies heavily on the agriculture and associated industries. It accounts for 60% of total employment and contributes 25% to Gross Domestic Product. The most important export products are tea and coffee. Agriculture is the main economic activity in the Tana basin. The type of agriculture practiced and potential productivity depends mainly on altitude which in turn determines temperature and rainfall. On the eastern and southern slopes of Mount Kenya intensive arable farming is practiced. In the upper reaches of the catchment, potatoes, pyrethrum and tea are grown. In the mid-altitude zones, coffee, maize, beans, rice and bananas and mixed livestock are produced, while in the lower zone, tobacco, cotton, sorghum, millet, and pigeon peas and cowpeas are most common. Income varies between agricultural zones: farmers in the tea zone have the highest gross income and those in the cotton/tobacco zone the least (IFAD/UNEP/GEF 2004).

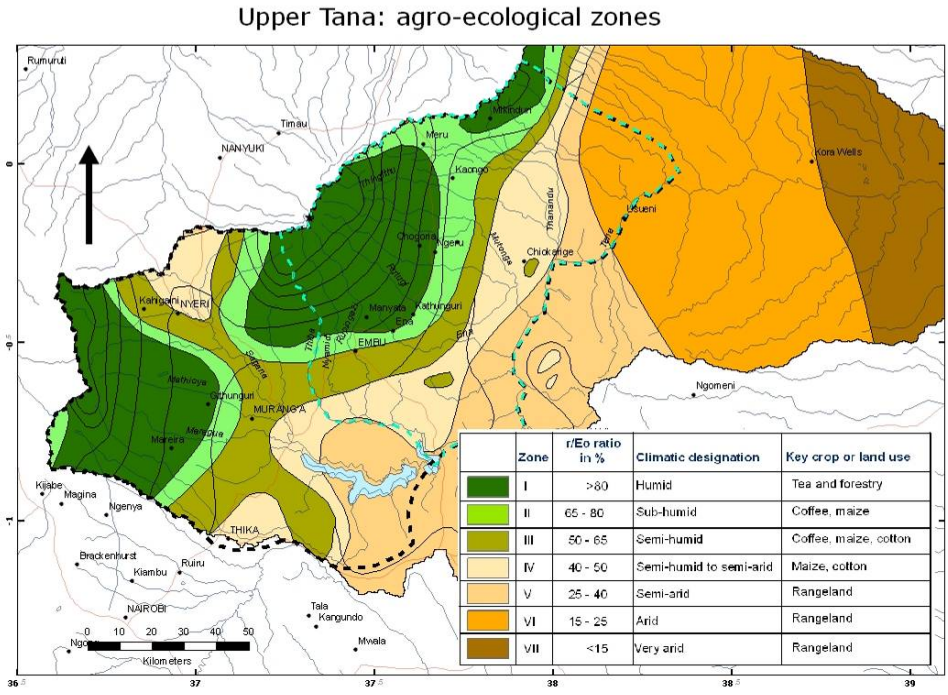


Figure 12
Agro-ecological zones in the Upper Tana

2.6.2 Land use management and hydrology

The Proof-of-Concept showed the linkage between upstream land use management and the effects on basin water balance and downstream hydrology.

The fact that the majority of the farmers view soil and water conservation (SWC) as a means towards increasing crop production and income and not an end in itself suggests that there is a strong focus on short-

term benefits. Therefore it is important to look at biophysical aspects in relation to crop output generated income. In the central Kenyan highlands soil conservation technologies like terraces and green manure contribute to an increase in yield (Ekbom 2007). Interestingly, agroforestry often negatively influences crop yield. Considering intercropping activities as conservation activity, the use of large water- and nutrient consuming tree species may not be the best option. On the other hand, contour hedges of leguminous trees and napier grass are capable of controlling soil and nutrient losses while simultaneously enhancing soil fertility in the arable sloping lands of central highlands of Kenya (Morita-Lou and Galioto 2007).

GWC firstly focuses on conservation activities in existing land use management. However, it may also be necessary to change the crop type or land use, to avoid a vicious cycle in which land keeps degrading and farmers get poorer and poorer (Ekbom *et al.* 2001; ICRAF 2005).

Important problems concerning land management in the Tana catchment are (KenGen 2005a, 2008; MKEPP 2005, 2006, 2007; Panafcon 2007):
- Wetland and riverbank farming;
- Poor soil conservation measures on coffee fields;
- Few conservation measures on subsistence cropping fields;
- Poor crop yields; and
- Small size of land.

In the catchment, terraces are soil conservation practices often used (KenGen 2005a; MKEPP 2006). Green Water Credits could promote these and other SWC-measures such as mulching, grass strips and contour cropping.

Forest conversion to agricultural land use
Since the 1970s, large areas of forests were replaced by agricultural fields (Malesu *et al.* 2006a). Conversion of forest to agricultural land, leads, as mentioned in paragraph 2.5.1, to changes in hydrology.
Maingi and Marsh (2001) performed a study to quantitatively document the extent and continuity of the riverine forests and associated land covers along the Tana river floodplain. Results concluded a significant decline in riverine forest between 1989 and 1996 due to cutting of the trees for charcoal and creating farmland for irrigated agriculture (Maingi and Marsh 2001).

Issues for Green Water Credits
There is need for a detailed, up-to-date land use map. The most suitable satellite images for land use classification are probably ASTER images, which have a resolution of 15m. Multi-temporal classification may provide sufficient spectral information, to be able to distinguish between the most important crops, such as coffee, tea, maize and rice. To be able to perform this classification, accurate ground truth data are vital. Therefore, a fieldwork should be out carried, preferably in cooperation with other running projects, such as MKEPP, NRM and PRESA. Green Water Credits can lead this operation.

2.7 Erosion

A review of the status of erosion in Kenya and the Upper Tana is given in GWC Report 3 (Kauffman *et al.* 2007). The SWAT model was used to calculate the amount of erosion under different land management scenarios in the Upper Tana (Figure 13). The main conclusions are that, depending on management, crop, rainfall and local soil and terrain, *green water* management can:
- Decrease sediment input to the Masinga reservoir by 22-72 % (0.3-2.5 million tonnes/year);
- Increase groundwater recharge from cropland by 4-57 % (16-160 mm per year), which is a potential annual gain of 160-1600 m^3/ha of accessible water;

– Cut damaging runoff by 22-66 %;
– Reduce unproductive evaporation of water from the soil surface by up to 15% (50 mm/year), which is a water gain of 500 m/ha/year.

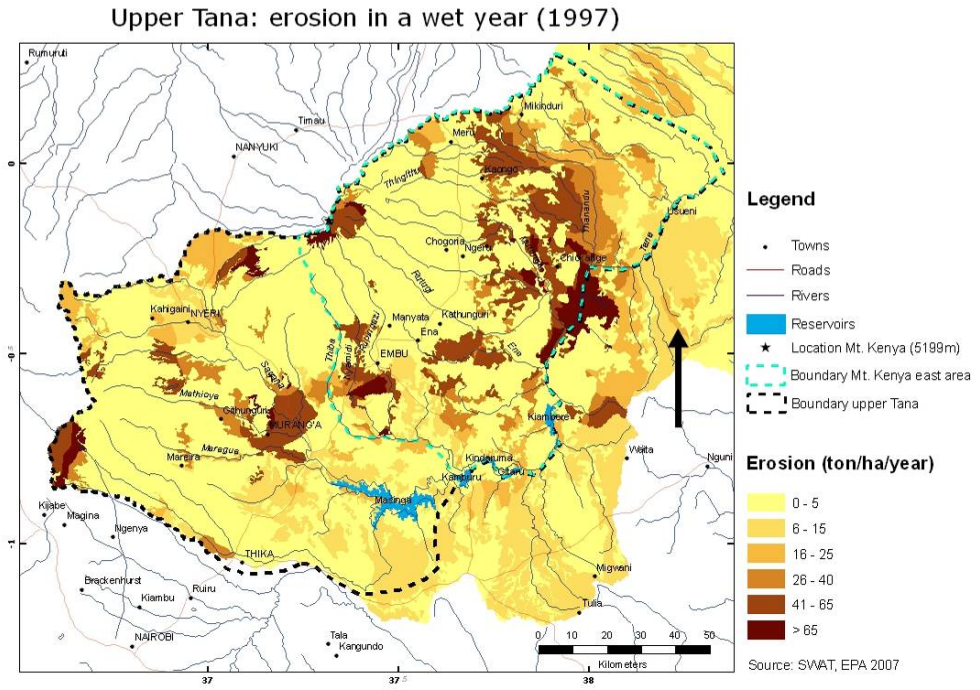


Figure 13
Erosion map of the Upper Tana, as modelled with SWAT

For identification of the GWC target areas in the Pilot Operation, a more detailed and with field information calibrated erosion map with actual erosion rates is required. However, based on the available data, a map of target areas in the Upper Tana is presented in section 2.7.1.

In a WRMA Erosion study (Panafcon 2007), the main causes of sedimentation of the Tana river are discussed. On agricultural lands, rangeland and roads, erosion takes place, it is however unclear which source provides most sedimentation into rivers and reservoirs. This information is essential for GWC when it comes to payments for environmental services. GWC does not include public-infrastructural measures to reduce sediment resulting from runoff/erosion, as this is the task of public works.

If road erosion is substantial, the ministry responsible for public-infrastructure maintenance must also play a role within GWC to ensure successful implementation and sustainability of the programme.

There is strong evidence from controlled experiments throughout the world that deforestation leads to increased erosion and sedimentation. However, forest clearance does not necessarily lead to soil loss. If good ground cover is maintained on the cleared land, by mulching for example, then the ability of the raindrops and runoff to detach soil particles is greatly reduced (Mogako *et al.* 2006).

Downstream effects of erosion

One of the downstream effects of erosion is sediment deposition in reservoirs. The silting up of reservoirs reduces the hydraulic capacity of the conveyance facilities, disrupts water supply operations and reduces the economic life of the reservoirs. The suspended sediment load also causes mechanical damage to the power production infrastructure. The main dam of the Tana basin is the Masinga Dam, which was constructed in 1980. The dam was designed on the basis of a siltation rate of 3 million tonnes per year. However, by 1988, the siltation rate had increased 3.5 times to 10 million tonnes per year, because of upstream catchment degradation, and Masinga reservoir has lost 87 Mm^3 of storage volume by then (KenGen 2005a; Mogako *et al.* 2006). The loss of 200 m^3 of live storage, which has almost certainly already occurred in the Masinga reservoir, may be associated with a loss of revenue for Kenya's electrical company KenGen, in the order of US$ 2.0 million/year in drought years compared to the original yield. In addition, there is the prospect of further reductions in eight hydropower stations if proposals for water supply transfers from Mathioya and Maragua rivers to Nairobi are implemented (KenGen 2005a).

2.7.1 Target areas in the Upper Tana based on land use and erosion

Figure 14 shows a map where erosion as modelled by SWAT is combined with the land use map. Green Water Credits focuses on rainfed agriculture and its goal is to improve the quality and quantity of water up- and downstream by introducing soil and water conservation or "*green water* management" measures. Therefore, the most suitable areas for the pilot operation are those where there is severe erosion on rainfed agricultural land. The map shows that areas surrounding Muranga, south-east of Ena and areas around Thanandu are very suitable for Green Water Credits. According to an erosion report made for WRMA, erosion from catchments draining from the Aberdares is most severe (Panafcon 2007). KenGen is planning a pilot project to reduce erosion in a sub-catchment of the Maragua river, because erosion is severe and coffee and annual cropping is present there (KenGen 2008).

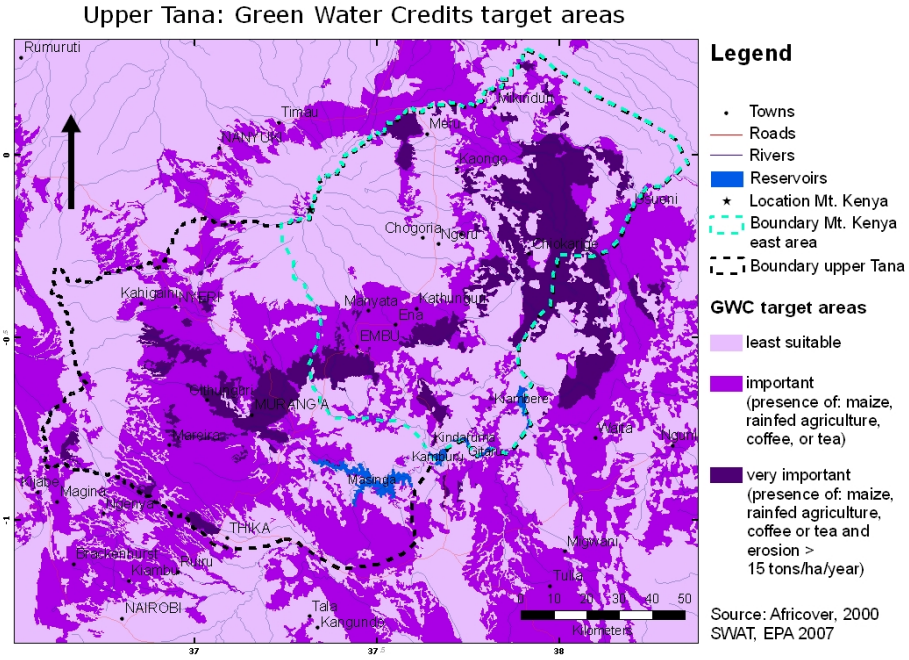


Figure 14

Target areas for Green Water Credits in the Upper Tana

Issues for Green Water Credits
Awaiting the results of better erosion models, the SWAT approach will be continued to calculate the local, spatial and basin wide erosion and sediment rates.
However, the calculation of sediment rate by erosion with models remains uncertain unless they are calibrated with river sediment load measurements. The reactivation of the network of hydrological gauging stations measuring water quantity and quality will offer scope for calibration. Possibilities for cooperation with KenGen in the sub-catchment of the Maragua river need to be examined.

2.8 *Green water* management

Historically, soil conservation has been practiced by Kenyans even before colonisation. It was during the colonial period that this practice was tainted due to the enforcement procedures that accompanied it. The concept of soil conservation was so tainted that no politician or administrator could mention it (Njuki 2000). Njuki summarises general trends in conservation of soil and water in Central Province of Kenya over the last 30 years.

2.8.1 *Green water* management packages

A review of soil and water conservation techniques and its effects on sediment and evaporation reduction is given in GWC Report 3 (Kauffman *et al.* 2007). In terms of sediment reduction, Wanyonyi (2002) cites a reduction of 80% in siltation following the introduction of *green water* management in the catchment of the Tungabhada reservoir in India (Wanyonyi 2002). In addition to conservation measures on farmland, reforestation of land above 1850 m may result in a 7% decrease of sedimentation in the Masinga reservoir (Jacobs *et al.* 2003).
Mulching reduces evaporation and enhances infiltration, prevents erosion, and it may enrich the soil with organic matter. Organic mulches include crop residues and cut weeds, and composted wastes. As there is shortage of bio-mulch due to competitive use, alternatives are (i) composted municipal wastes (Agassi *et al.* 1998), (ii) stone mulch only for soils with high stoniness, and (iii) artificial mulches, for example with plastic foil as discussed by Kauffman (2007).

The *green water* management packages considered in the GWC Proof-of-Concept were limited to three low-cost measures: contour ridges, mulch and tied ridges. For the pilot operation, more *green water* management techniques will be introduced. Final *green water* management measures that will be used in the Upper Tana depend on their success in the area.

Currently, there are many and various SWC technologies used in Kenya. Thomas (1997) in his "Soil and Water Conservation Manual for Kenya" gives an overview and technical description of the main options. The WOCAT database[7], which includes around 450 SWC technologies and over 250 approaches gives many more examples world-wide. Printed information of 42 WOCAT Soil and Water Conservation cases are given in "Where the land is greener" (WOCAT 2007), which include among others cases of Conservation Agriculture (see Box 5), manuring, vegetative strips/cover, agroforestry, water harvesting, gully rehabilitation, terraces and grazing land management.

[7] WOCAT 2007. World Overview of Conservation Approaches and Technologies, Centre for Development and Environment: http://www/wocat.net/databs.asp

Information can also be found in the FAO Land and Water Digital Media Series that include nine CDs of conservation approaches and technologies, training and extension, dry land management and soil erosion processes (FAO 2001a, b, c, d, 2002, 2004a, c, 2005a, 2006). A comprehensive overview of no-till farming systems world-wide is given in a publication of the World Association of Soil and Water Conservation (Goddart *et al.* 2008). Examples of easy to read SWC information sources are the booklets from the Agrodok-series that present hands-on information of water harvesting and soil moisture retention, erosion control in the tropics, soil fertility management and uses of compost (Anschutz *et al.* 2003; Inckel *et al.* 2002; Kuypers *et al.* 2005; Scholl and Nieuwenhuis 2005).

Table 1 presents nine *green water* management practices in the Upper Tana. All these techniques will be evaluated in the Pilot Operation project on their merits to cut runoff, improve infiltration and reduce evaporation, and the feasibility and adaptability for farmers.

Table 1

Cases of green water management in the Upper Tana (WOCAT database[7])

Case ID	Name	Soil loss reduction (t/ha) [(a)]	Soil loss reduction (%)	Runoff reduction (% of rainfall)[(a)]	Runoff reduction (%)
KEN10	Road runoff management - Nyeri	10	40	30	60
KEN11	Road runoff system - Mwingi	10	83	70	88
KEN16	*Grevillea* tree planting	2	30	5	13
KEN22	Water harvesting and enlarged structures	7	90	38	84
KEN23	Riverbed reclamation & silt trapping	7	58	40	67
KEN24	Gully reclamation	609	100	50	83
KEN25	Pasture management	2	67	12	60
KEN26	Water table management	1	67	4	50
KEN27	Gully blocking by stone checks	5	91	40	80

(a) Soil loss and runoff reduction are expressed as the difference of with and without the practice under consideration.

Another commonly mentioned SWC measure is conservation agriculture. More information is given about that in Box 5.

Box 3

Conservation Agriculture

Conservation Agriculture (CA) aims to achieve sustainable and profitable agriculture and subsequently aims at improved livelihoods of farmers through the application of the three CA principles: (i) minimal soil disturbance, (ii) permanent soil cover and (iii) crop rotations (FAO 2008). There are both positive and negative effects of CA as demonstrated in the case study of Laikipa District, Kenya (Kaumbutho *et al.* 2007). In terms of soil quality, there is improvement both in fertility as in moisture content, which is attributed to increased soil organic matter and decreased evapotranspiration. The negative effect is the growth in the number of insects and diseases attacking the crops. Increased use of pesticides led to 50% increase in spraying costs. Other negative effects of zero-tillage are the emergence of weeds competing with the crop for moisture and nutrients. The costs of these side-effects need to be included in cost-benefit analysis. Other costs related to the adoption of CA practices like buying new equipment and extra labour costs also need to be taken into account when calculating the costs and benefits of CA. Easy to use tables to calculate the costs and benefits of CA for a farm are given in a manual for extension workers in Africa adopting CA (IIRR and ACT 2005).

Source FAO 2008: http://www.fao.org/ag/ca

2.8.2 Rainwater harvesting

Green water management is a type of in-situ water conservation, as it aims at increasing the amount of rainwater infiltration in the soil. More water will become available to crops and for recharge of the groundwater. Storage of infiltrated water in the soil will increase transpiration, depending on the crop type. By reducing evaporation, more rainwater can be held in the soil as *green water and as blue water in groundwater* (Kauffman *et al.* 2007).

Rainwater harvesting includes the harvesting of rainwater from roofs, or from other catchments that collect runoff (Oduor and Malesu 2006). This type of rainwater harvesting focuses therefore on *blue water*. The water harvested can be used for domestic purposes, but if it is used for industrial or large-scale purposes, it should be noted that it has an impact on water availability downstream. Rainwater harvesting is extensively practiced in Africa. Kenya is one of nine African countries for which a map showing the potential of rainwater harvesting was constructed (Malesu *et al.* 2006b).

A study in Tanzania on the economics of rainwater harvesting indicates that rainwater harvesting systems designed to collect water from macrocatchments linked to road drainage have the most positive effect (Hatibu *et al.* 2006). Contrary to expectations, improving rainwater harvesting systems by adding a storage pond may not lead to increased productivity. The study shows that investments in rainwater harvesting combined with investments in improved road drainage structures, give the best results. Ngigi *et al.* (2007) developed a tool to assess the impacts of land use change on the hydrological regime in a river basin (Ngigi *et al.* 2007). The model can be used to calculate the downstream effects of upstream water management.

2.8.3 Location of *green water* management

As mentioned already, the WRMA has developed a catchment management strategy to protect and conserve the Tana catchment. For the choice of the focus areas of the Green Water Credits programme the following points need to be considered:

– The focus areas should be in line with the Catchment Management Strategy of the WRMA (WRMA 2007a); and
– The areas have need to have good potential for reducing evaporation and erosion.

Furthermore, in certain areas, an important goal of *green water* management will be reducing the sediment load in rivers and reservoirs. When this is the case, special attention will be given to land use close to the river, as sediment reduction measures in this area will have more effect than random adoption within the study area (Kauffman *et al.* 2007). Land adjacent to the river is defined by the WRMA as riparian land and thus protected by law. This implies that the government can evict farmers from land close to the river. GWC might be of help in these cases, by paying farmers to leave.

An important target of GWC is enlarging the quantity of *blue water* downstream. It is necessary that *green water* management measures are applied to a large area, because there is a linear relationship between the surface area on which *green water* management is taking place and the increase of *blue water* quantity downstream (Kauffman *et al.* 2007). The objective will be to address both targets simultaneously: implying that the focus will be on large areas, including riparian zones.

Issues for Green Water Credits

– The Hydrological tool of Ngigi *et al.* should be considered as a method to assess the impacts of *green water* management in the Upper Tana (Ngigi *et al.* 2007).

2.9 Remote sensing

Remote Sensing techniques can be used to acquire the following data:

– Evaporation
– Evapotranspiration
– Rainfall
– Land use
– NDVI (Immerzeel 2008)
– Percentage of vegetation cover
– Qualitative erosion assessment

These are all important for either the hydrological or erosion modelling, or both.
Evapotranspiration data can be calculated with the SEBAL (Bastiaanssen *et al.* 2005) approach (see Box 6).

Box 4

Concept of SEBAL

Surface Energy Balance Algorithm for Land (SEBAL)

The major bottlenecks in estimating the spatially distributed surface energy balance in composite terrain by means of remote sensing are summarised in a study by Bastiaanssen *et al.* (1998a). The principles of the Surface Energy Balance Algorithm for Land (SEBAL) and a summary of its accuracy under several climatic conditions at both field and catchment scales is given by Bastiaanssen *et al.* (2005).
The new SEBAL model estimates (i) the spatial variation of most essential hydro-meteorological parameters empirically, including rainfall, evaporation and transpiration, (ii) requires only field information on short wave atmospheric transmittance, surface temperature and vegetation height, (iii) does not involve numerical simulation models, (iv) calculates the fluxes independently from land cover and (v) can handle thermal infrared images at resolutions between a few meters to a few kilometres. For validation, available data from the large-scale field experiments in Spain, Niger and China were used (Bastiaanssen *et al.* 1998b). SEBAL was also used for detecting spatial variation of water productivity and scope for improvement in eight irrigated wheat systems (Zwart and Bastiaanssen 2007).

Monitoring

Green Water Credits aims at using remote sensing (RS) for the monitoring of the programme's progress. Monitoring with RS has several advantages because it can offer adequate and frequent data at low cost, as well for remote areas. Research at various sites in the world reveals options for mapping erosion with the use of remote sensing images (Vrieling 2007). For example, in the West Usambara Mountains of Tanzania, accurate evaluation of erosion risk was performed by the use of vegetation and slope data derived with remote sensing. It was concluded that flexible, qualitative, region-dependent approaches that effectively use data from space borne sensors can provide good means for quick and accurate regional mapping of erosion risk. Information on monitoring and evaluation of soil conservation and watershed development projects is given by De Graaff *et al.* (2007), focusing both on physical and socio-economic factors and indicators. It gives an overview of monitoring and evaluation systems in various types of soil conservation and watershed development projects world-wide.

The Group on Earth Observations has presented a list of current satellite systems used for agricultural monitoring (GEO 2007). This paper provides an extensive overview of monitoring and evaluation concepts, needs, models and systems. In Annex 3 an overview of a number of satellite systems used in agricultural monitoring can be found.

Issues for Green Water Credits

The following are relevant for the Pilot Operation in the Upper Tana catchment:

- *Verify the potential of the SEBAL approach;*
- *Verify the options for erosion mapping with remote sensing.*

3 Socio-economic and livelihood conditions

3.1 Introduction

Kenya has a population of 34,708,000 (CIA 2006). Its Human Development Index is 0.52, which ranks the country 148th out of 177 countries with data (UNDP 2008). The population of the Upper Tana is approximately 3.1 million people (World Resources Institute *et al.* 2007). The catchment covers 11 districts (Figure 15): Thika, Maragua, Murang'a, Nyeri, Kirinyaga, Embu, Mbeere, Meru South, Meru Central, Meru North and Tharaka (World Bank 2007b; World Resources Institute *et al.* 2007). The average population density is 250 people per square kilometer (World Resources Institute *et al.* 2007). The largest towns are Thika and Nyeri (45 km and 165 km from Nairobi, respectively), followed by Embu (135 km from Nairobi) and Meru (275 km from Nairobi). These towns host various agriculture-based industries (e.g. coffee and tea factories, flower farms, milk and cotton processing) and some small-scale timber based industries (e.g. saw mills and furniture manufacturing). The secondary road network is denser and better developed in Thika, Maragua, Murang'a, Nyeri, and Kirinyaga Districts. It is less dense in the remaining foothill Districts of Mount Kenya farther east, and is least developed in the plains (World Resources Institute *et al.* 2007). Agriculture is the main economic activity in the region (IFAD/UNEP/GEF 2004).

The Upper Tana contains a broad cross-section of very poor and less poor communities. The most poor communities can be found in the drier plains below the foothills downstream of the Aberdare Range and Kenya (World Resources Institute *et al.* 2007). The main causes of poverty in the Upper Tana area can be summarised as follows (IFAD 2003b, c):

– degradation and overexploitation of natural resources;
– small land size and low productivity; and
– population pressure.

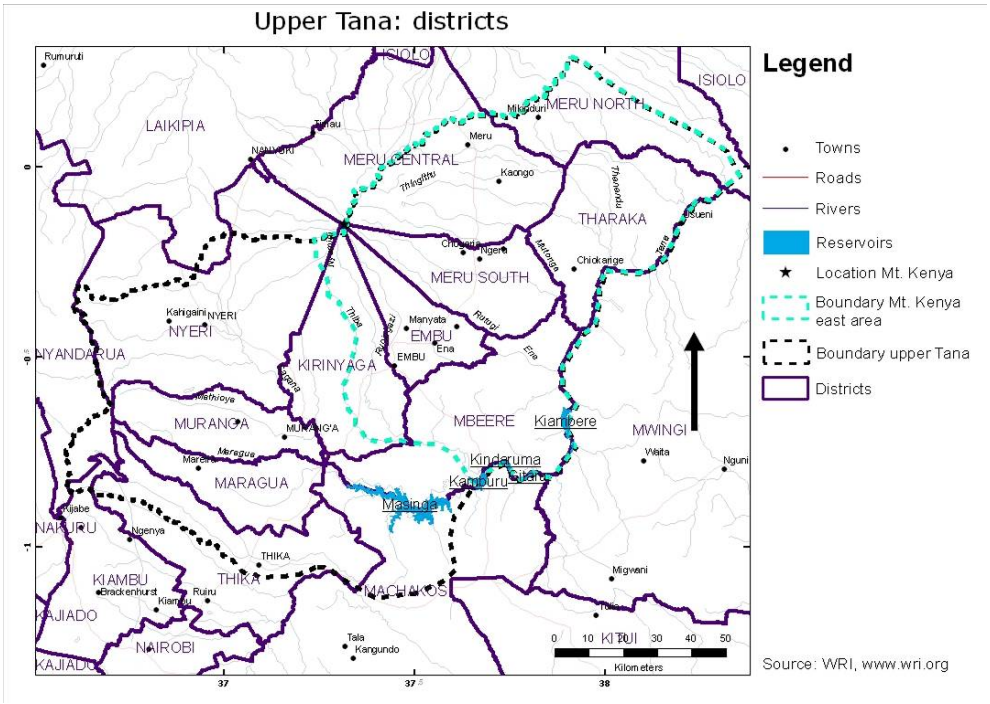


Figure 15

Districts and Towns in the Upper Tana

3.2 Livelihood and agricultural statistics

3.2.1 General

Figure 16 shows the population density of the Upper Tana. It can be noted that population density declines with elevation (except for the National Parks of the Aberdares and Mount Kenya, where very few people live). This is because the higher altitude areas correspond with better soil fertility and rainfall. Figure 17 shows the percentage of people living below the poverty line (World Resources Institute *et al.* 2007).

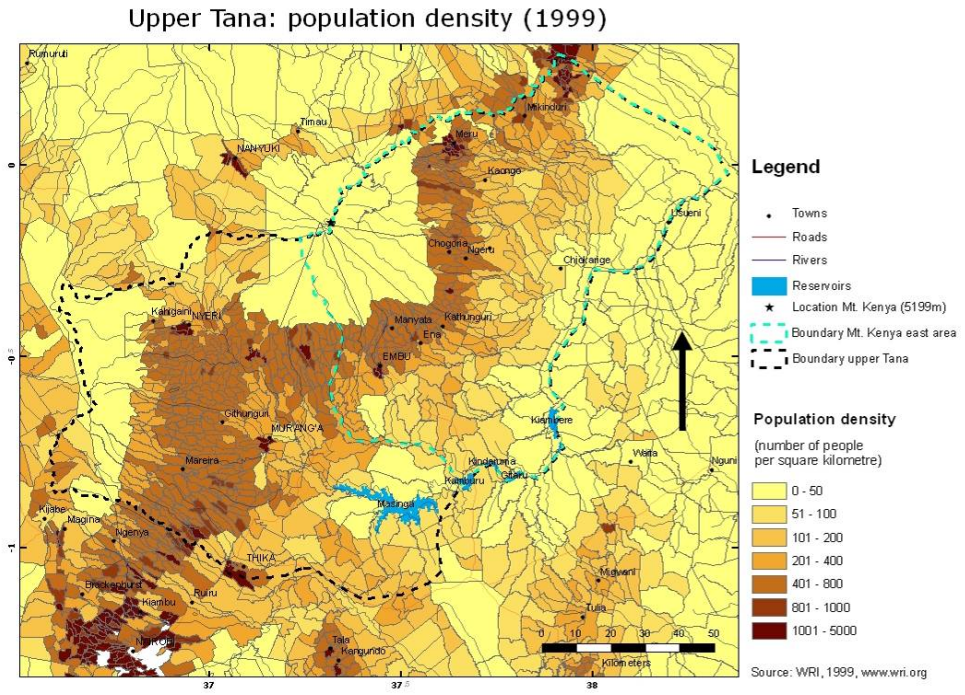


Figure 16

Population density in the Upper Tana (1999)

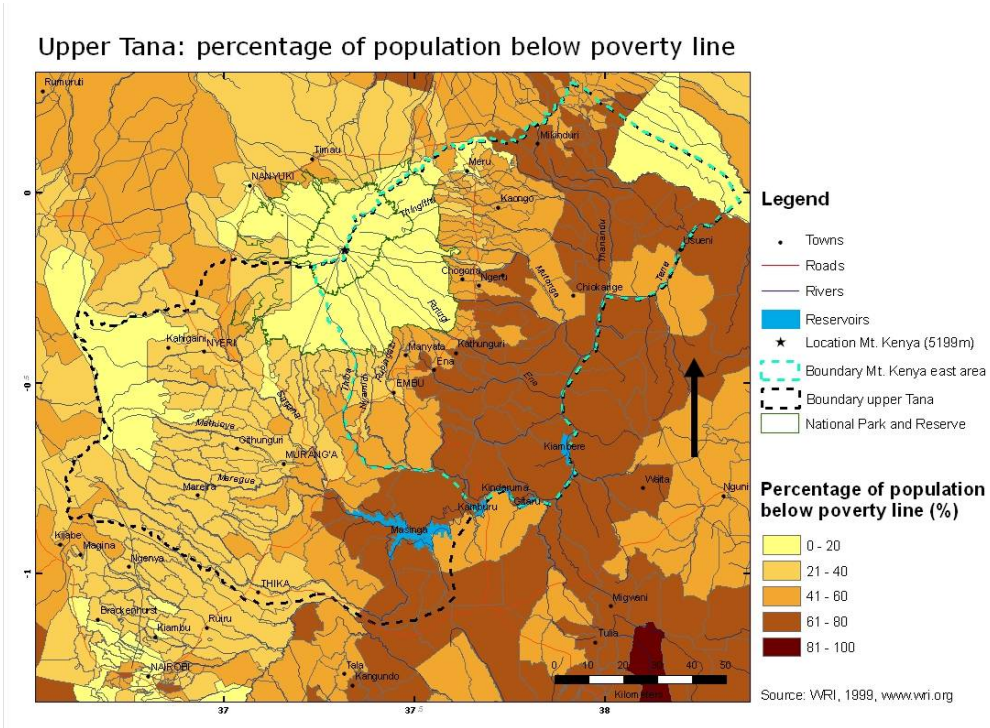


Figure 17

Percentage of population living below poverty line in the Upper Tana

Most of the area is covered by smallholder agriculture. Farm size varies from 0.2 ha to 1.6 ha. Small plots near the homestead are used for subsistence crops such as maize and beans, and farm forest trees are planted along the boundaries of the plots. A variety of crops are produced including maize, beans, arrowroot, yams, bananas, macadamia nuts, passion fruit, coffee and tea as well as some livestock (IFAD/UNEP/GEF 2004). The government has set aside a significant portion of the land for biodiversity and watershed protection, including Mount Kenya National Reserve, Aberdare National Park, Aberdare Forest Reserve, Meru National Park, and Mwea Reserve (World Resources Institute *et al.* 2007).

A seven year Kenya nation-wide study that used longitudinal data collected from 1,324 households, in 1997, 2000, and 2004, showed that access to land continues to be a major determinant of rural household welfare (Burke *et al.* 2007). Households that had moved positively out of poverty had significantly increased the amount of land they controlled, from an average of 1.2 ha in 1997 to 2.0 ha in 2004.

This is also acknowledged by the studies of IFAD and Government of Kenya (IFAD/UNEP/GEF 2004). They name the following problems that cause the widespread poverty in the Upper Tana:

a) Shortage of land for agriculture linked to high population and plot fragmentation, which has led to the cultivation of steep slopes, riverbanks, and wetlands – with environmental consequences in terms of soil erosion (loss of top soil, declining soil fertility, and loss of water catchment capacity leading to lower dry season flows and flooding during wet seasons);
b) Loss of coffee and dairy farming incomes linked to the loss of services provided by parastatals in these industries, with the result that the farmers have opted for other activities such as illegal harvesting of trees in the forest for sale and growing marijuana in the forests;
c) Unregulated water use for irrigation in the middle catchment areas has deprived the communities in the ASAL areas of water which they need for their livestock, and which could be used for intensifying agricultural production. In response the farmers resort to opportunistic activities such as charcoal burning which destroys the vegetative cover and causes accelerated soil erosion which further reduces land productivity;
d) Sale of subsistence crops at harvest time leaves many families vulnerable for several months before the next harvest; and
e) Lack of markets for farm produce in general, so that farmers are not earning income which could be invested in their farms, and they use inappropriate technologies resulting in further soil degradation (IFAD/UNEP/GEF 2004).

3.2.2 District data

In this section, agricultural statistics and general information is presented for four districts in the Upper Tana: Nyeri, Maragua, Thika and Kirinyaga. Table 2 presents indicative data for these districts.

Table 2

Main characteristics of four districts in the Upper Tana

District	Nyeri	Maragua	Thika	Kirinyaga	Total
Land area (km2)	3,284	1,065	1,960	1,478	7,787
District headquarters	Nyeri	Maragua	Thika	Kenol	-
Administrative divisions (nr.)	7	4	6	4	21
Population (persons)	650,000	409,000	702,000	457,000	2,218,000
Smallholder farmers (households)	93,000	91,000	117,000	114,000	415,000
Smallholders involved in commercial production (households)	88,000	82,000	82,000	50,000	302,000

Nyeri District (Community-Organisation-Consultants 2003)
Nyeri District has a total area of 3,284 km^2. Based on the 1999 census, the district has a population of about 650,000 people living in seven divisions. Nyeri District's main economic activity is agriculture, but there are also trade activities, coffee estates, tourism and several manufacturing industries, such as flour milling and water bottling companies. Dairy and tea dominate the farming systems in high-potential areas. In the medium-potential areas coffee and dairy are predominant. In low-potential areas, ranching and maize farming are common, but irrigated horticulture is a fast growing type of farming in this area. Table 1 in Annex 2 presents the main smallholder commercial crop and livestock production activities in Nyeri District. There are 24 cooperative dairy societies with a membership of about 40,000 farmers (10,000 active members). These cooperative societies assist members with inputs, AI and marketing.

Maragua District (Community-Organisation-Consultants 2003)
Established in 1997, Maragua is one of the new districts in Central Province. It is a relatively small district with four administrative divisions and a total area of 1,065 km^2. The population is about 409,000 people in 91,000 households of which 40,000 are female headed. Besides smallholder farming, economic activities in the district include plantation farming (mainly coffee, passion fruit and pineapples) and agroforestry.

The western part of the district consists of the high-potential areas on fertile volcanic soils. Tea, coffee, dairy production and food crops such as maize, beans and potatoes are grown in this area. The coffee zone is located in the middle part. The low potential areas towards the east are generally flat and semi-arid. The soils are shallow and poorly drained, only suitable for drought tolerant crops such as cotton and sorghum. Horticultural crops are possible if irrigation water is available. Table 2 in Annex 2 presents the main smallholder commercial crop and livestock production activities in Maragua District.

A number of institutions provide technical advice to farmers. The Ministry of Agriculture and Rural Development (MARD) has been the main provider but because of the new demand-driven approach, a number of NGOs and private companies have stepped in to fill the gap.

Credit services are available but are mainly concentrated in Kangari town, which is close to the richer tea zone. Banks and non-bank financial institutions include three commercial banks, two building societies, at least four Cooperatives, two Microfinance Institutions (MFIs) and the Agriculture Finance Corporation (AFC). These institutions provide credit but their loan conditions and interest rates are rather prohibitive, and to most farmers they are beyond reach.

Thika District (Community-Organisation-Consultants 2003)
Thika District is relatively new - established in 1995 - with six administrative divisions,. It was carved out of Kiambu and Murang'a Districts, has a total area of 1,960 km^2 and borders Nairobi. The district is relatively small but heavily populated with some 360 people per km^2. The upper parts of the district are generally medium to high potential agricultural areas, while the lower parts are low potential. The district has an estimated population of 702,000, with about two-thirds being rural.

In terms of agricultural productivity, the district is divided into three zones: the high-potential western and northern parts of the district, which are dominated by coffee, tea and dairy farming; the middle part being of medium potential; and the semi-arid eastern parts where cattle rearing and irrigated horticulture are the main forms of commercial farming. Table 3 in Annex 2 presents the main smallholder commercial crop and livestock production activities in Thika District. Generally, maize and beans are normally intercropped and grown by farmers throughout the district.

There are over 80 institutions, ranging from NGOs, Government of Kenya (GoK) departments, parastatals, to private sector companies and farmers groups, providing inputs and services to smallholders in Thika District. There are good quality extension services, but these do not adequately reach smallholders. More than 14 institutions offer technical advice and training. Government policy has changed from going to farmers, to waiting for farmer groups to seek services, sometimes at a cost to the farmers who have to provide transport for the officers. The majority of financial institutions are not interested in credit delivery to smallholder farmers. They consider farming, especially rainfed farming, a risky business.

Kirinyaga District (Community-Organisation-Consultants 2003)
Kirinyaga District lies on the southern slopes of Mt Kenya and occupies an area of 1,478 km^2. The district is relatively small, but densely populated and of moderate- to high-potential. Kirinyaga district has an estimated population of 457,000 people (1999) with a rural population of 402,000 people. There are a total of 114,000 households out of which 15,000 are female headed.

There are about 35 small community irrigation schemes where tomatoes are grown, in total involving some 11,000 farmers. Table 4 in Annex 2 presents the main smallholder commercial crop and livestock production activities in Kirinyaga District. For example, to grow tomatoes, a farmer needs a starting capital of at least KSh 40,000 per hectare. Rice is a major crop in Kirinyaga District, mainly grown in Mwea Division. About 78,000 farmers grow rice under the Mwea Irrigation Scheme while another 21,750 farmers grow what is referred to as *jua kali* rice, i.e. outside the irrigation scheme. Farmers stopped selling their rice to the National Irrigation Board (NIB) and are selling it on their own under the Mwea Rice Growers Multipurpose (MRGM) cooperative society. In livestock production, dairy farming is the most common activity. This is done individually but there are ten groups each of about 200 farmers who have come together to jointly market milk and procure AI services. Dairy farming is mainly concentrated in the coffee zones. Kirinyaga District has one large cooperative union and ten different types of cooperatives.

Issues for Green Water Credits
- More statistical data should be obtained from the Central Bureau of Statistics (CBS) in Kenya.
- The following information on household level should be gathered:
  - Family income
  - Market share of specific crops
  - Gross-margin / crop
  - Gross-margin / livestock

3.3 Costs and benefits

The selection of relevant soil and water conservation techniques need to be followed by a cost-benefit analysis (CBA). A useful guide for this is given in *Guidelines for economic appraisal of watershed management projects* (Gregersen *et al.* 1987)[8]. De Graaff also presents an economic evaluation of soil conservation and watershed development. Extensive information is given on Cost-Benefit Analysis (CBA) and Multi Criteria Analysis (MCA) including the pros and cons. Also, onsite and downstream impact assessment of Soil Conservation and Water Development (SCWD) are included (de Graaff 1996).

Costs from water resource degradation
A World Bank working paper gives costs of a number of water resource degradation cases (Mogako *et al.* 2006). For example, siltation of water reservoirs will cost around KSh 3 million annually due to reduced life of pumps, and lowering water tables will cost KSh 870 million due to increased pumping costs for Nairobi's water supply.

3.4 Farmers' adoption of *Green Water* Management

GWC report 5 evaluates farmer's interest and willingness to adopt *green water* management techniques and the role of GWC payments (Porras *et al.* 2007). Socio-economic data collected in a household survey in the Upper Tana are analysed. The main conclusions are:
- Soil and water conservation is mainly seen as means to an end, that is just for crop production and income generation;
- There is a need for tangible permanent benefits; GWC can fulfil this role; and
- Success of the implementation of GWC will depend closely on the cooperation of farmers.

For the Pilot Operation, issues regarding gender-bias in relation to different kinds of incentives must be taken into account such as up-front in-kind (in otherwords, non-tangible services) or rewards in the form of securing access to markets, revolving funds or favourable terms of credit, or community benefits such as roads, schools and clinics, or capacity building.

Soil conservation will only be adopted if it makes economic sense to the farmers. Farmers will only accept policies that promote agriculturally-based sustainable development, if the policies are biophysically possible, socio-politically acceptable and economically feasible (Ekbom *et al.* 2001).

Sustainable adoption
For successful adoption of soil and water conservation, farmers must be motivated with positive stimuli to start experimenting. Such early actions are essential in motivating stakeholders in environmental-related programmes (Kessler 2006a). Kessler gives four recommendations:
1. Focus on most progressive farmers;
2. Achieve short-term impact and success in SWC;
3. Enhance the profitability of agriculture; and
4. Invest in satisfying households' basic needs.

[8] *Gregersen et al.* 1987: http://www.fao.org/DOCREP/006/T0038E/T0038E00.HTM

Kessler (2006b) explains the principle behind the logical strategy. Sustainable development is possible whenever the community is motivated to make progress. Such a progress driven attitude can be generated by a process of awareness raising, motivation and genuine participation in collective actions (Kessler 2006b).

De Graaff presents models and graphs on how farmers make decisions concerning the adoption of soil and water conservation) measures(de Graaff 1996). He recognises eight steps in the process of farmer adoption of SWC measures. These eight steps can be divided in two phases, namely the problem recognition and the adoption phase. The first phase concerns farmers' recognition of erosion symptoms and effects and whether farmers take erosion seriously. The second phase concerns farmers' awareness of adequate measures, their ability, willingness and finally readiness to undertake measures.

Okoba (2005) developed a tool for participatory soil erosion mapping at field and catchment scales. The aim of this tool is to involve farmers in the fight against erosion. The tool is based on farmers' knowledge and perceptions of soil degradation and uses farmers' indicators for soil erosion and sedimentation (Okoba 2005). The conclusion of this study was that actively involving farmers increases their motivation to participate in soil and water conservation activities. Above that, using farmers' knowledge of topsoil profile characteristics led to simple approaches of quantifying soil productivity. Okoba also presents a tool that could be applied to engage farmers to map extent of soil erosion and through which participatory soil and water conservation planning could be realised within the framework of a Catchment Approach (see Box 7)

Box 5

A tool for participatory erosion mapping

"The participatory erosion mapping tool" (Okoba 2005):

1. Identification of local key informants across the catchment area
2. Reaching consensus on soil erosion indicator list valid for the catchment area
3. Key informants and other farmers draw catchment field map
4. Key informants conduct field survey of erosion indicators and produce catchment soil erosion status map
5. Key informants predict crop yield losses on field-by-field basis using the soil erosion status map
6. Experts quantify the predicted yield losses experimentally using the soil erosion status map

Issues for Green Water Credits

From past experience it appears that most SWC approaches are operational only during the period of the project. After this intervention maintenance of established measures is generally neglected. GWC aim is a long-lasting permanent stimulus for farmers to continue *green water* management and to further develop where required. To establish the level of incentives that will be required for farmers to adopt *green water* management, a baseline survey is needed to establish the present land use systems and related farm incomes, and research the additional capital, labour and management costs of *green water* management and the additional farm income to be expected from *green water* management.

3.5 Water users

GWC report 4 gives an outline of the political setting in Kenya in relation to the water sector and an analysis of supply-demand scenarios of the main water users using the Water Evaluation and Planning tool (WEAP) (Hoff and Noel 2007). Cost-benefit analysis of three different *green water* management technologies were analysed. Both the use of tied-ridges and mulching are identified as having potential positive impacts on siltation- and evaporation reduction.
For the Pilot Operation it is necessary to:

- establish accurate values for the WEAP parameters together with Kenya institutions and relevant IFAD projects;
- use detailed information of costs and benefits of feasible *green water* management technologies under local conditions. The availability and alternative uses of mulch must be taken into account.

The 1992 National Water Master Plan (NWMP) estimates the future demand for water in the year 2000 and 2010 (Mogako *et al.* 2006). Irrigated agriculture is the largest water-using sector. Its demand is estimated to double between 1990 and 2010 from 3965 million m^3/day (1990) to 8138 million m^3/day (2010). Second largest is domestic water use. Urban water demand is predicted to increase by 309% and rural demand by 203%. Industrial water is thought to increase by 223% to 491 million m^3/day by 2020 (Mogako *et al.* 2006). Concerning hydropower, the NWMP estimated that its growth will be 86%: a growth from 4230 GWh (2006) to 7900 GWh by 2010/11. This will require a doubled peak capacity of 1400 MW by 2010. Table 3 gives an overview of estimated water demand from the multiple water users.

Table 4
Estimated water demand, 1990-2010 (millions of m^3/day)

Demand by Category	1990	2000	2010
Domestic water			
Urban	573	1169	1906
Rural	532	749	1162
Industrial	219	378	494
Irrigation	3965	7810	11655
livestock	326	427	621
Inland fisheries	44	61	78
wildlife	21	21	21
Total/Day	5680	10615	15937
Total m^3/Year (Millions)	2073	3874	5817

Source: Mogako *et al.* 2006

Hydropower
Although not mentioned in Table 4, the hydropower company KenGen is one of the most important water users in the region, producing approximately 80% of the energy consumed in Kenya[9]. In an annual report, KenGen

[9] KenGen: http://www.kengen.co.ke

mentions that one of their main challenges is the adverse hydrological conditions owing to poor inflows into a number of critical dams. Hydropower unit sales as a result of this, declined more than 10% (KenGen 2005b).

Ecosystems

The environment including its multiple ecosystems is an important water user. The National Water Resources Management Strategy (NWRMS) takes the precautionary approach of ring-fencing a *Reserve*, defined as water for basic human needs and for protection of aquatic ecosystems, which "*has priority over all water uses and the requirements of the Reserve must be met before water can be allocated for other uses*". The strategy acknowledges that, in some cases, water *is* already allocated to other uses - in which case the Reserve will then have to be recouped progressively over time (Hoff and Noel 2007).

4 Legal and institutional setting

4.1 Introduction

GWC report 6 analyses the political, institutional and financial framework required for the implementation of Green Water Credits (Meijerink *et al.* 2007). The main conclusions are:
- The programme is in line with current policy reforms in Kenya water sector using a market-based mechanism;
- Funding of *green water* management is a key constraint in the adoption process at farm level;
- Past experiences indicate the importance of farmer involvement from the early design of the programme;
- Existing farmers' groups have systems in place for collecting and administrating payments, monitoring and enforcing compliance with contracts at field level; and
- Transaction costs need to be kept to a minimum.

With the promulgation of the Water Act 2002, the Government of Kenya provided an enabling legal and institutional framework for the implementation of a fundamental reform in the water sector. To support this reform, a Water Sector Reform Programme (WSRP) was established which will continue until 2013 (GTZ 2007). Lessons learned include:
- Activities and outputs generated by the programme are likely to allow the programme team to reach the outcome and indicators by the end of the last phase;
- The water sector institutions have been successfully established and first steps have been undertaken to reach financial self-sustainability;
- The Catchment Management Strategy (CMS) development process was very successful and led to the wish of the Water Resource Management Authority (WRMA) and Kenya Water and Sanitation Programme (KWSP) to have the programme develop CMS's for all the remaining catchments;
- The formation of the Water Resource Users Associations (WRUA) has been successful; they are a useful instrument to deal with conflict about water resources and need to be expanded more;
- The ambitions of the Water Services Trust Fund (WSTF) are high, but their institutional capacity urgently needs to be developed to be able to cope with the funds planned to be provided by various development partners. Project appraisal systems for the settlements of the urban poor need to be established;
- The aim of integrating the local private sector to invest in, or run, Water Services Providers (WSP) has not been reached. So far, the local private sector has shown little willingness to invest in this business area;
- The timeframe for the sector reform and thus some of the programme outcomes and indicators was ambitious, in some cases too ambitious; and
- Communication among sector institutions, among donors and between the various parties needs to be improved.

4.2 Country background

The rapid socio-economic changes and agricultural reforms has created a pressing need to develop new government policies. The government had the obligation of providing guidance and creating a favourable environment for other service providers, in line with the strategies of liberalising, privatising and commercialising many public services. In the agricultural sector the new policies and acts that have been developed during the 1990s include the following (Community-Organisation-Consultants 2003):
- Sessional Paper No. 2 of 1994 on National Food Policy;
- National Agricultural Extension Policy, 2001;

– The Cooperative Societies Act, 1997;
– Irrigation and Drainage Development Policy (2001 draft);
– The Coffee Act, 2001;
– The Tea (Amendment) Act, 1999;
– The Sugar Act, 2001;
– The Cotton Bill, 2001 (draft);
– Policy Paper on Liberalization of the Pyrethrum Industry (2002 draft);
– Horticulture Policy in Kenya, 2001;
– Kenya Plant Health Inspectorate Service (KEPHIS) Order, 1996;
– The Seed and Plant Variety Act (revised in 1991);
– Kenya Dairy Development Policy (2000 draft); and
– The Animal Feedstuffs Bill, 1998 (draft).

In 2004, the Government of Kenya launched the Strategy for Revitalizing Agriculture (SRA) 2004-2014. Contributing ministries included the Agricultural Sector Ministries representing the Ministry of Agriculture, the Ministry of Livestock and Fisheries Development and the Ministry of Cooperative Development and Marketing. The strategy proposes far-reaching policies and institutional changes that are necessary for reversing the decline of the sector and placing it competitively on the global arena[10]. The SRA is a strategy based on a paradigm shift whereby:
– The Government and local communities plan and implement priority projects and programmes in a participatory manner;
– Local communities are empowered to manage the available resources;
– The Government supports initiatives of local communities;
– Farmers, pastoralists and fisherfolk view agriculture and fishing as a business;
– Private–public partnerships are created to facilitate competitiveness, enhance market access and improve farm incomes; and
– Diversification and optimum capacity utilisation are encouraged to ensure increased incomes.

4.3 Rules

4.3.1 Formal: legal setting

The Water Resources Management Authority (WRMA) has established a set of draft rules (WRMA 2006b) covering the following subjects:
– Approval, authorisation and permits;
– Surface water;
– Groundwater;
– Water quality monitoring and effluent discharge;
– General works;
– Conditions of authorisation, permits and approved water uses;
– Water use charges;
– Conservation of riparian and catchment areas;
– Catchment management strategies;
– Protected areas and groundwater conservation areas; and
– Resource classifications, the reserve and resource quality objectives.

[10] Republic of Kenya 2008: Strategy for Revitalizing Agriculture (SRA): http://www.kilimo.go.ke

The WRMA has delineated the Tana catchment Area into 17 management units (WRMA 2006a).

4.3.2 Informal: local norms and values

No publications so far have been obtained on relevant local norms and values relevant for sustainable land management.

4.4 Contractual arrangements

4.4.1 Water resource management rules

The draft rules for water resource management address environmental protection and conservation by defining the reserve, protected areas, swamps, wetlands, and riparian areas, as well as incorporating the means through which these fragile water resource related environments are protected(WRMA 2006b). Water is both seen as:

– a social good, with threshold levels for water allocation accommodating the needs of small water users and ensuring an adequate minimum quality and quantity of water for all uses; and
– an economic good, by harmonising water permitting fees and introducing water use charges for certain categories of permits for which water is used for commercial and economic purposes.

Preservation, conservation and protection of available water resources are addressed through the establishment of a system to declare groundwater conservation and protected areas and the development of management measures. To ensure sustainable, rational and economic allocation of water, the Catchment Management Strategy (CMS) includes zoning of catchments, their classification, assessment of status and systems for the determination of permit classes. The rules promote decentralised decision making within the WRMA. With regard to decisions pertaining to the local allocation of water, Water Resources Users Associations (WRUAs) will be fully engaged. The regional Catchment Areas Advisory Committees (CAAC) will support the WRMA regarding the management of catchments. The draft rules also promote stakeholder participation and offers channels through which civil rights can be addressed.

4.5 Monitoring and evaluation

Effective monitoring systems are needed to make proper decisions on water allocation, enforce pollution controls, plan and design water resource infrastructure and target investments in better catchment management (Mogako *et al.* 2006).

It is also important to monitor the crop status when zero-till and mulch is adopted, because of potential increase in diseases (Kaumbutho *et al.* 2007). Three years ago a large research project took place involving the Tegemeo Institute. The project, including household surveys, was focused on agricultural monitoring and policy analysis (KARI/TAMPA 2005).

Centralised Management and Information System (MIS) for Monitoring & Evaluation (M&E)
Currently a number of GWC relevant projects are under implementation:

– Natural Resource Management (NRM) Project;
– Western Kenya Community Driven Development and Flood Management (WKCDD/FM) Project;
– Western Kenya Integrated Ecosystem Management Project (WKIEMP);
– Kenya Agricultural Productivity Programme (KAPP); and

– Kenya Agricultural Productivity and Sustainable Land Management (KAPSLM).

These projects have synergies regarding the focus on sustainable Natural Resource Management, Community Driven Development (CDD), community empowerment and poverty reduction through improvement in agricultural production in smallholder systems (World Bank 2007b). In order to harness the synergies in these projects and avoid duplication of activities, a central Management Information system (MIS) will be established that will have technical oversight responsibility for Monitoring and Evaluation (M&E) for these projects. The central MIS will be based at the Kenya Soil Survey (KSS) Geographic Information System (GIS) laboratory at the Kenya Agricultural Research Institute (KARI) in Nairobi (World Bank 2007b). The Management Information System (MIS) is also pivotal for data handling for the GWC Pilot Operation and the envisaged National GWC Programme. In the Mount Kenya East Pilot Project mention is also made of the MIS (IFAD 2003b, c).

On the 10th of March 2008, a delegation consisting of members from different Project Implementing Agencies under the WB programme held a WB-meeting at KARI in Nairobi concerning the MIS and M&E. the result of this meeting include…….

Issues for Green Water Credits
Adequate definition and frequency is required at low cost. The MIS, complemented by remote sensing with limited field checks, is probably the only way. Possibilities should be investigated of acquiring air photos or high-resolution satellite imagery to delineate spatial details, followed by repeat, low-cost but lower-resolution satellite imagery to detect changes during the operation of the programme. Options for the high-resolution imagery include: QuickBird (0.61m resolution). IKONOS (0.82m), SPOT-5 2.5m/5m/10m. For a lower resolution, time series imagery from the following might be used: Landsat 7 +ETM 14.25m/28.5m, ASTER 15m/30m, MODIS 250m/500m

4.5.1 Self-regulation: farmers' groups

The Water Act 2002 recognises the need to promote integrated resource management through the involvement of stakeholders and pursuant to Section 15(5) of the Act, the Catchment Management Strategy is to encourage and facilitate the establishment and operation of Water Resources Users Associations (WRUA) as a forum for conflict resolution and co-operative management of water resources. Thus the involvement of these stakeholders in water resources management is a central principle in the access, development and use of the water resources. At present WRMA has initiated this process with 42 WRUAs already fomed and about half of the number of these WRUAs have started their preparatory activities with initial assistance of WRMA (WRMA 2007a). WRUAs are mainly involved in activities such as environmental education, awareness creation, improved irrigation practices, reforestation and regulating water (Kiteme and Gikonyo 2002). They may also function as mitigating agencies during water conflicts related to over-abstraction (Liniger *et al.* 2005).

4.5.2 Independent agencies

Mweiga Research Station
In annex 7 of the formulation report of the Mount Kenya Ecosystem Conservation Initiative (IFAD 2004c), the Mweiga Research Station is mentioned as contributor to the monitoring and evaluation component. An integrated geographical information system (GIS) should have been developed to store layered ecosystem data on water resources, soils, climate, habitats, wildlife, physical infrastructure and socio-economic characteristics.

4.6 Institutions, responsibilities and influence

4.6.1 National level

Two ministries linked by green and *blue water* are important partners for Green Water Credits: the Ministry of Agriculture (MoA) and the Ministry of Water and Irrigation (MWI). Figure 18 illustrates the integrated character of these two ministries.

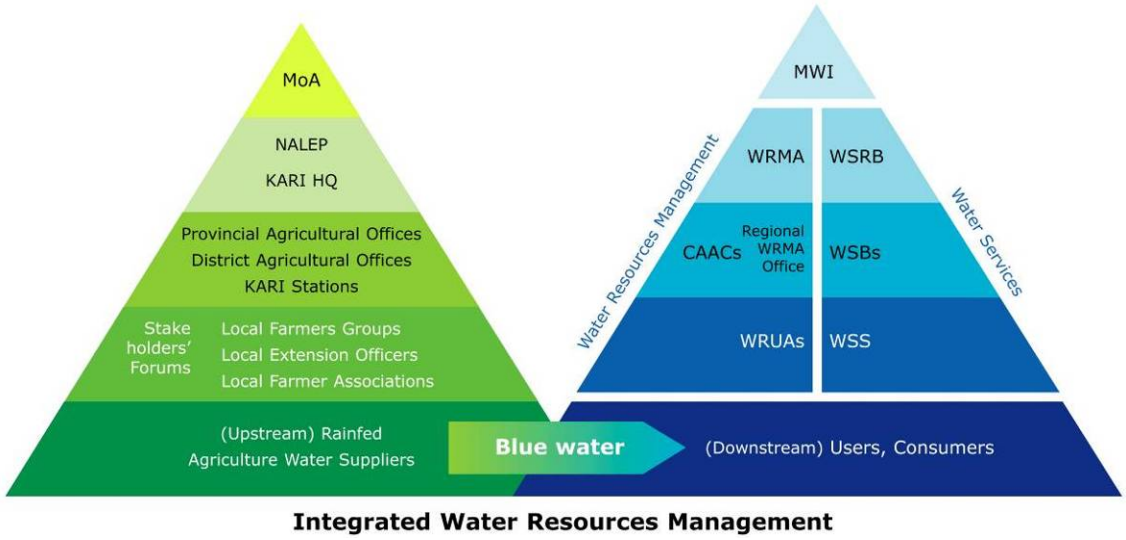


Figure 18
Green Water Credits institutional framework

Ministry of Water and Irrigation
The Ministry of Water and Irrigation (MWI) was created in 2002 to consolidate the responsibility for the management and development of water resources. Its mandate is to protect, harness and develop the country's water resources to ensure the availability of high-quality water to all. Its main roles include the development of legislation, policy formulation, sector coordination and guidance, and monitoring and evaluation of the water resources in Kenya (MWI 2007).

Ministry of Agriculture
A review of the Ministry of Agriculture (MoA) on agricultural marketing gives an extensive outline of the MoA (IFAD 2004d). Table 5 gives its core functions. The outline also includes an evaluation of strengths and weaknesses of the MoA.

Table 5
Core functions of the MoA

1	Formulate, implement and monitor the legal framework and agriculture-related policies
2	Development and coordination of programmes in agriculture
3	Information management for agriculture
4	Regulatory management and quality control of inputs and agricultural products
5	Management and control of pests and diseases in crops
6	Provision and facilitation of extension services
7	Setting the research agenda and coordination of agricultural research
8	Management and conservation of the resource base for agriculture
9	Management and monitoring of food security
10	Promotion of private sector and agribusiness development in agriculture

Water Resource Management Authority (WRMA)
Following the enactment of the Water Act 2002 in November 2002 the primary task is to establish and operationalise the Water Resources Management Authority (WRMA). This called for opening up of the Regional Office (RO) at Embu to manage Tana basin and the subsequent opening up of sub-regional offices (SRO) as administrative units for the catchment management (WRMA 2007a).

The responsibilities and objectives, targets and strategic actions of the WRMA within the Tana catchment are outlined in the draft summary booklet *Catchment Management Strategy* (WRMA 2007b). The *Catchment Management Strategy* proposes strategies to conserve farmlands (WRMA 2006c). Relevant strategies include:
- Identify the farmlands and classify them;
- Check the status conservation of farmlands;
- Form a WRUA if there is none;
- Create awareness among the stakeholders on the need to conserve farmlands;
- Capacity build the communities on conservation of farmlands;
- Support resource mobilisation for WRUA activities;
- Promote the adoption of best soil and water conservation practices at farm level. The WRMA can leverage the adoption of these practices by placing the requirement for a Soil and Water Conservation Plan as part of the water permit in accordance with the WRM Regulations.

Further information and strategies are given in WRMA (2006c).

The WRMA is developing a Catchment Management Strategy (CMS) for each of the six catchment areas (regions) in Kenya; the Tana catchment is one of them (Figure 19). To implement the CMS at the grass roots level, 25 sub-catchments were identified during the CMS drafting stage. Five sub-catchments are identified in the Tana which include: Murang'a, Kerongoya, Kitui, Meru and Garissa. A sixth sub-catchment is planned, that will be the Lamu/Garsen sub-catchment. At each sub-catchment level, tailormade sub-catchment management plans (SCMP) will be developed together with the WRUA. WRUA receives funding from WRMA and/or the Water Service Trust Fund (WSTF) to implement the sub-catchment management plans.

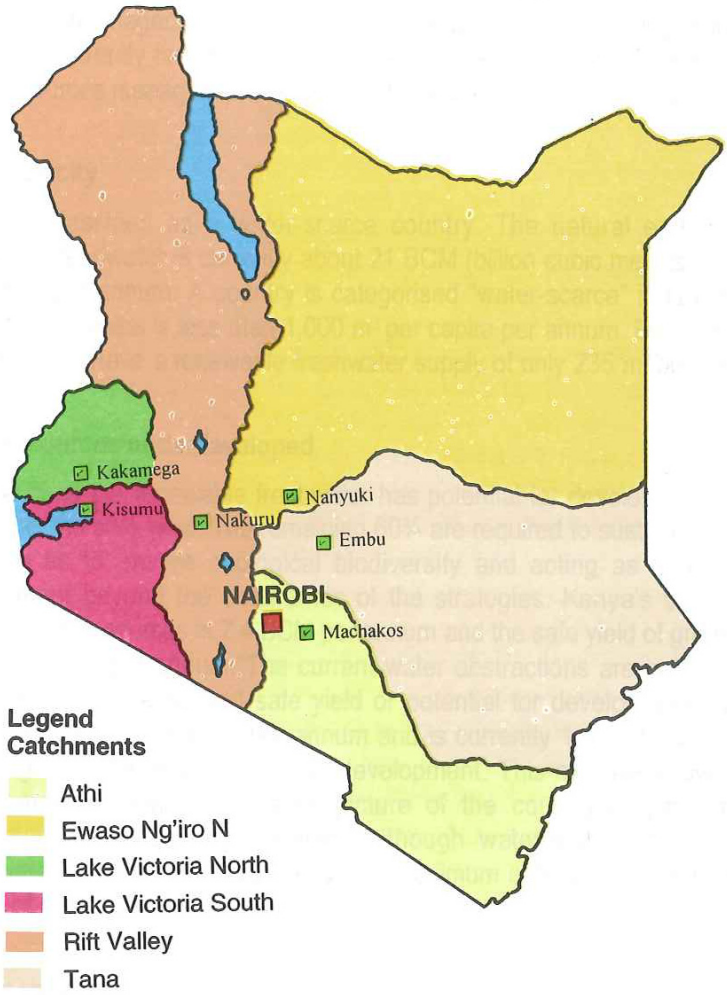


Figure 19

Six catchment areas/regions in Kenya (MWI 2007)

Kenya Agricultural Research Institute (KARI)

The Kenya Agricultural Research Institute (KARI) is the premier national institution bringing together research programmes in food crops, horticultural and industrial crops, livestock and range management, land and water management, and socio-economics. KARI promotes sound agricultural research, technology generation and dissemination for food security through improved productivity and environmental conservation. Additional information about KARI, including the work with farmer groups and organizations, is given by Kamau (Kamau 2007).

Water Services Regulatory Board (WSRB)

The WSRB's mandate is to licence water providers. Considering the WSRB and also the Water Services Board, the poor have a right to be represented on these boards. The boards present the poor with a forum through which they can lobby and push for their right to access water supply. For both rural and urban poor to have a voice, it is important that representatives from urban poor organisations or their advocates sit on this board (K'Akumu 2004).

4.6.2 District level

Kenya Maize Development Programme (KMDP)
The KMDP is a consortium of partners that supports maize farmers to carry out various functions along the value chain (Muyanga and Jayne 2006). Table 6 gives the four main partners including their roles.

Table 6
KMDP partners and their roles

Partners	Role
Fips Africa [1]	Production and promotion
Kenya Agricultural Commodity Exchange (KACE)	Market intelligence to the farm
Cereal growers association (CGA)[2]	Capacity building and group formation to encourage collective marketing of maize
ACDI/VOCA [3]	Offer useful training to farmer groups, e.g. farming as business, power of attitude change

Source: [1] www.fipsafrica.com; [2] Kaumbutho *et al.* 2007; [3] http://www.acdivoca.org

Tana and Athi Rivers Development Authority (TARDA)
Information regarding this River Basin Organisation (RBO) is given by TARDA (TARDA 2006), including contact names, basin details, authorities, structures, responsibilities and associated ministries. The main objectives of RBO include: flood control, water scarcity regulation, water conflict regulation, river regulation and water resource planning and development.

Catchment Area Advisory Committee (CAAC)
A Catchment Area Advisory Committee is set up in relation to a specific catchment area (Rural-Focus 2005). For the Upper Tana, there have been CAAC members appointed. CAAC members are mostly farmers and other inhabitants. They are appointed by the Ministry of Water Irrigation in consultation with the WRMA. CAAC members are generally advisors to the Regional Government. These people have in-depth knowledge about the catchment. CAAC members may include representatives of government institutions like the National Environment Management Authority (NEMA). Some of the issues dealt with include catchment protection, water allocation and water conservation. The roles of CAAC members consist of:
- To advise WRMA officers at the appropriate regional office concerning water resources conservation, use and apportionment;
- To develop guidelines for issuance of permits by the regional WRMA;
- To advise the WRMA concerning the grant, adjustment, cancellation of variation of any permit;
- To advise the WRMA on any other matters pertinent to the proper management of water resources; and
- To work closely with Water Resource User Associations (WRUAs).

4.6.3 Local level

Water Resource Users Association (WRUA)
Frequent conflicts between up- and downstream users and between human and wildlife have been reported over the last years. The Water Resources Users Associations (WRUA) are recognised as one of the most effective initiatives to prevent and resolve water use conflicts (Kiteme and Gikonyo 2002).

The Water Resources Users approach is a relatively new strategy in the management of water resources. WRUAs started up in the late 1990s as a strategy employed by the larger Water Awareness Creation Campaign initiative. WRUAs are formed through the efforts of the major water users within a river sub-catchment, who, aside from mobilising the local community, also provide the necessary financial and logistical support. A WRUA consists of an executive committee, a special task committee, and a water situation monitor. WRUAs are registered with the Ministry of Culture and Social Services (CSS) as self-help group. Apart from their role in mitigating conflicts related to over-abstraction, WRUAs are also involved in activities such as environmental education, awareness creation, improved irrigation practices, reforestation and regulating water (Liniger *et al.* 2005).

One of the activities of the World Bank supported Natural Resource Management project, is to strengthen the capacity of WRUAs (World Bank 2007b). WRMA will play a key role as facilitators in the establishment of WRUAs and assisting them in their development and operations. In the 2005/06 annual report, a table is presented with 9 recognised WRUAs that were to be registered with WRMA on gazetting the rules (WRMA 2006a). It also includes a list of 28 WRUAs that are planned, registered or not yet registered with the CSS. Figure 20 presents the key linkages between the relevant Water Resource Management institutions at different levels.

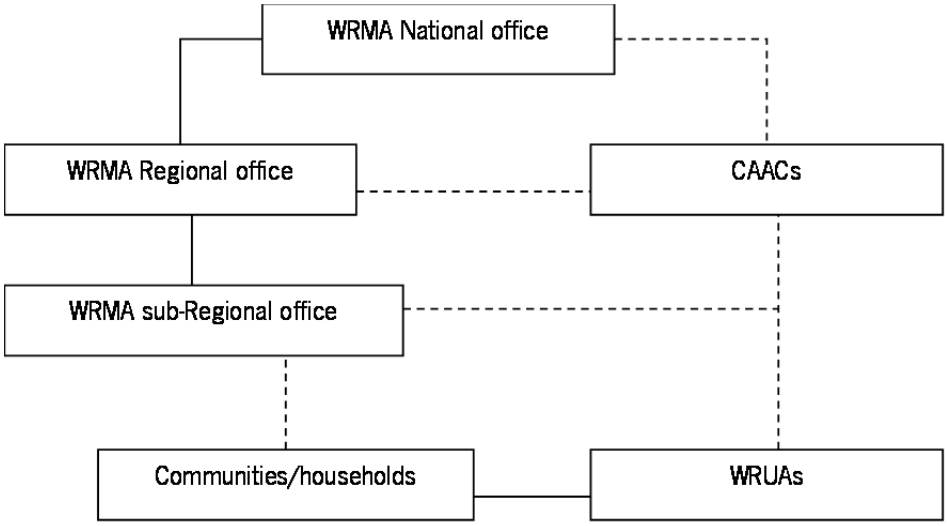


Figure 20
Key linkages for WRUAs

The dotted lines mean that the relationship is one of collaboration while the full lines indicate a stronger reporting and accountability relationship. The relationship between WRUAs and community members is shown with an unbroken line because WRUAs are accountable to their members (Rural-Focus 2005). A general list of roles and responsibilities of the institutions under the Ministry of Water and Irrigation, including the WRUAs and CAACs, is given in by the MWI (MWI 2007).

WRUA Development Cycle (WDC) in the framework of GWC
One of the tasks of the Water Resource Management Authority is to get the Water Resources Users Associations) up and running. To assist this process, the WRMA has developed a WRUA Development Cycle (WDC) including training modules and operational guidelines (WRMA 2008). A number of links can be developed

with GWC Pilot Operation. Firstly, according to the operational guidelines, the categorisation of the water bodies has been undertaken in a fairly subjective manner so far. It is indicated is that a more rigorous categorisation methodology will be undertaken in the future to establish the status of water bodies with respect to the resource quality objective. This is one of the tasks of GWC Pilot Operation. Secondly, it appears that the role of the large number of rainfed farmers determining the fate of the source of freshwater (rainwater) is not adequately recognised. GWC Pilot Operation will explicitly focus on this huge group of farmers. Thirdly, the document mentions a number of mainly engineering works that contribute to soil conservation. Management measures to be performed by farmers are not explicitly mentioned nor are details given (WRMA 2008). This is the core of GWC Pilot Operation. Lastly, WDC adopts a project approach with a one-time investment. The GWC goal is to establish an on-going, institutional programme that is embedded in farmer's livelihoods.

4.7 Farmer organisations

A working paper from the Regional Land Management Unit (RELMA) provides some experiences with farmer organisations from East Africa in the face of liberalisation and institutional reform. A general conclusion of this paper is that cooperatives thrived before the shift in policy, but they failed to adjust and compete in the liberalised economies and many collapsed after the reforms (Abaru *et al.* 2006).

In the Tana catchment, IFAD projects have worked with civil society groups such as health groups, water users associations, farmer groups, and other target groups. Kenya's national farmers' organisation (KENFAP) has recently set up regional offices in Embu and Meru (Agriterra 2006).

4.7.1 Transaction costs

The inclusion of many farmers, each of whom controls only a small plot of land, imposes high transaction costs. Transaction costs erode the net benefits of Payment for Environmental Services (PES), especially for smallholders, so application procedures need to be as simple as possible. To enable the poorer farmers to take part in GWC, rules will be needed that allow for informal tenure and small land holdings, and which hold down transaction costs. A way to do this is by establishing a group application and monitoring procedure (although contracts should be individual). Civil society organisations have also performed channelling and implementing functions to overcome transaction cost barriers to participation; government entities may also fill this gap (Grieg-Gran *et al.* 2006).

4.7.2 Threshold level

The 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. According to an experiment within the Upper Tana conducted to determine the policy components or attributes that would make Green Water Credits more attractive to farmers, threshold levels were predicted as having low effect (Porras *et al.* 2007).

5 Financial Mechanism

5.1 General background

Report 6: Political, Institutional and Financial framework
GWC report 6 analyses the political, institutional and financial framework required for the implementation of Green Water Credits (Meijerink *et al.* 2007). The main conclusions have already been given (see Section 4.1) For the Pilot Operations, at institutional level, more information is needed on informal arrangements.

For success of water resources management reforms, it is essential that water is treated as a social and economic good, and financial practices are realigned accordingly. The new Water Act includes provisions for water user charges, catchment levies, and licenses to pollute (Republic of Kenya 2002). The Water Act also provides for establishing a fair mechanism for financing water resource management (Mogako *et al.* 2006).

It is generally recognised that there are multiple farmers groups and committees that recognise the land degradation problems and who are willing to undertake action to mitigate its effects. However, lack of resources to do so is the main constraint. This is the main reason for creating a robust financial mechanism that is integrated in the government financial system.

Literature from the 1980s and 1990s gives numerous examples of conservation activities conducted on farm fields in Kenya (Lundgren 1993). Training of farmers is essential for their participation in the planning and design-making phase. The role of women is also important as they will be dominantly the actual implementers of Green Water Management. The challenge will be to give them an equal voice in the negotiation platform. The role of women is also emphasised in a background paper of the International Course on Institutions for Water management (ICIW) on integrated water resource management (ICIW 2000).

Lack of flexibility and creativity toward soil and water conservation activities is noticed from the ministerial to the grassroots level (Wenner 1992). Projects failed where extension agents followed rules rigidly even when farmers already had conservation practices in place. These farmers were obliged to change these practices. Back in the 1980s the importance of local inputs was already recognised. Local knowledge is an important factor to be considered in GWC Pilot Operation. Wenner also recognises the importance of choosing the right ministries through which donor countries contribute to soil conservation. In GWC, it is assumed that the Ministry of Agriculture is a key ministry as most soil and water conservation activities are realised on farm- or on rangeland. Other important ministries are the Ministry of Water and Irrigation and the Ministry of Education and Finance.

Literature from more than 15 years ago shows that farmers are well aware of the problems of land degradation and are enthusiastic to conserve their land. The main constraint recognised in the past is a lack of financial resource capacity at farm level and a lack of skills and knowledge at the level of extension services (Lundgren and Taylor 1993). These are also the constraints of today.
Valuing water and ecosystems
One of the four Dublin principles states that water has an economic value in all its competing uses and should be recognised as an economic good (ICIW 2000). Water value and cost concepts are given in this paper.

The total economic value of ecosystems has four components: direct values (e.g. raw material), indirect values (e.g. flood control), option values (the premium placed to maintain future development options and uses), and

existence values (e.g. spiritual values). All these values are important in decision making (Emerton and Bos 2004). The simplest and most commonly used method for valuing any good or service is to take its market price. Thus the price of products directly harvested from ecosystems determines their value. When these products and services are not directly traded in markets, their value can be derived from their contribution to other production processes or their impact on the prices of other commodities. Ecosystem values can also be determined through assessing the cost of man-made products, infrastructure or technologies that could replace ecosystem goods and services. Finally the damage that is avoided to downstream infrastructure, productivity or populations by the presence of ecosystem services can be ascertained (Emerton and Bos 2004).

Need for a robust stimulus
Many African farmers are disadvantaged by the global agricultural trading system and the increasing privatisation of agricultural research. Abundant evidence of the transformation process elsewhere indicates that growth in non-farm sectors typically starts from a robust stimulus to agriculture, which generates rural purchasing power for goods and services (Jayne *et al.* 2006).

5.2 PES experiences

A number of lessons learned from PES experiences are given in GWC report no. 2 (Grieg-Gran *et al.* 2006). The report covers PES issues related to; (i) security of expectations, (ii) policy, legal, and institutional framework, (iii) design of payment mechanisms, (iv) costs and benefits for upstream land managers, (v) costs and benefits for downstream water users, and (vi) applying Green Water Credits in Africa.

In recent years, innovative financing mechanisms, and specifically payment for ecosystem services (PES), have been recognised as crucial for addressing some of the identified failures in environmental management. PES makes it possible to take into account environmental externalities (UN 2005). This paper presents a number of innovative financial mechanisms for environmental services from around the world.

A robust and restrictive definition has been proposed in which PES is considered to be (IIED 2005):
- A voluntary transaction;
- A well-defined environmental service (ES) (or a land use likely to secure that service);
- Is being purchased by at least one buyer;
- From at least one ES provider, and;
- If, and only if, the ES provider ensures the supply of the ES

Marketing mechanisms
Broadly speaking four different marketing strategies or mechanisms can be distinguished, of which only two strictly qualify as PES (Halsema 2005):
1. Local private/public arrangements around specific services;
2. Trade in green/pollution credits, such as nitrate, salt or carbon sequestration, at local, national or global level;
3. National public arrangements with (cross) sectoral subsidies; and
4. Emerging market opportunities and trends for green products such as biofuels and green energy.

The first is the most PES-like mechanism closely followed by the second. The third and fourth strategy have no direct link to PES, but can however be brought into such mechanisms.

Payment for Watershed Services (PWS) is a PES variant that recently has attracted significant attention (IIED 2005). The traditional means of securing the quantity and quality of water has been to declare key areas in watersheds as protected areas. Outside these protected areas governments have tried to use regulatory

approaches to influence land use and land management. PWS have the potential to create incentives for land managers and also address livelihood issues.

Three broad sets of constraints to watershed market development can be identified: constraints related to high transaction costs, demand-side constraints and supply-side constraints (Landell-Mills and Porras 2002). High transaction costs are especially apparent within watershed protection due to the many players involved, but also due to underdeveloped market infrastructures. Factors leading to high transaction costs include: multiple-stakeholder transactions, lack of cost-effective intermediaries, poorly defined property rights and lack of a clear comprehensive regulatory framework. Factors that undermine demand include a lack of scientific information establishing the benefits of natural resources, lack of participation of key stakeholders and lack of willingness to pay. Factors that undermine demand include: low awareness of market opportunities and capacity to exploit these, lack of credibility in service delivery and cultural resistance (Landell-Mills and Porras 2002).

Leimona and Lee define three prerequisites for a PES to be effective:

1. Effective supply and demand for PES mechanism;
    a) availability of market opportunity
    b) adequate spatial and temporal scales for delivering environmental services
2. Supportive national and international conditions; and
3. Support by credible intermediary organisations (Leimona and Lee 2008).

Porras *et al.* stress that the "sellers" of environmental services often do not receive significant financial payments. In these cases, non-financial benefits such as strengthening of property rights and capacity building are part of the reason why farmers participate and continue to participate in PES or PWS schemes (Porras *et al.* 2008).

For "buyers" the problem that arises is that there is (often) little evidence to support the ecosystem service that is being "sold" as truly providing the services for which buyers are paying (The Katoomba Group 2008). The reasons for this are linked to both ecological challenges associated with monitoring, as well as the reality that there is very little robust monitoring and evaluation underway with existing PES projects.

A description of a contract mechanism developed for the Regional Integrated Silvo-pastoral Ecosystem Management Project is given in (Pagiola *et al.* 2004) with PES experiences from southern America. Issues are presented such as 1) measuring the actual amount of environmental services being provided, so that appropriate payments can be made; 2) providing payments in a way that resulted in the desired change in land-use; and 3) avoiding the creation of perverse incentives are addressed; for example for land users to cut down existing trees so as to qualify for additional payments for tree planting. Other relevant PES experiences and lessons learned are given in (FAO 2003, 2005b; Pagiola *et al.* 2007; WWF 2003).

On the western border of the Upper Tana catchment, the lake Naivasha-Malewa is located. An ongoing PES project in this area may provide valuable field-experience data for GWC (CARE-WWF-WSUP 2006). A cost-benefit analysis was established of options for both buyers and sellers of watershed services. This paper also mentions the CARE-WWF-IIED global PWS programme. During the Pilot Operation phase it may be interesting to investigate possibilities for co-funding of GWC through this programme. GWC has much common ground with PWS. The GWC programme however envisions a payment mechanism where there is a much stronger link, based on market principle, between upstream service providers and downstream water users.

5.3 Role of Banks

Access to rural financial services has the potential to make a difference in agricultural productivity, food security and poverty reduction. However, an efficient, sustainable and widely accessible rural financial system remains a major development challenge in most Sub-Sahara African countries. The Economic Recovery Strategy (ERS) for Wealth and Employment Creation has identified poor access to farm credit and financial services as a contributing factor to the decline in agricultural productivity (Kibaara 2006). The Strategy for Revitalizing Agriculture (SRA) proposes to improve access to rural financial services in Kenya. As a follow up on SRA, the Agricultural Sector Coordination Unit (ASCU) has fast tracked access to rural financial services by establishing a thematic group on inputs and rural financial services with the overall objective of developing an Integrated Farm Input Strategy. In the late 1990s, most mainstream commercial banks closed down the rural branches in order to cut costs and improve profits. Since then, a number of non-traditional financial institutions have emerged to fill the gap created by the mainstream banks which locked out low income and irregular earners (Kibaara 2006).

A number of key rural financial models have evolved to address the demand for rural financial services in Kenya. These include: Community Owned Rural Financing Models, Private Commercial Bank-Led Model, Government-Led Rural Finance Model, Donor Guarantees-Input Supply Model, Managed SACCO-Beach Banking Model and the Informal Group Based Rural Financing Model. The Government on its part has restructured the operations of Agricultural Finance Corporation (AFC) in line with the Strategy for Revitalization of Agriculture (SRA). The emerging leading indigenous banks have also set up fixed and mobile branches in the rural areas (Kibaara 2006). Interestingly, the K-Rep Bank is not mentioned in this paper.

The community owned model has a wide outreach and it is a low cost model. Policy intervention whose objective is to increase financial service should strengthen the community owned model. The rural communities could consider setting up a similar facility using the Constituency Development Fund (CDF) money (Kibaara 2006).

In 2003, IFAD conducted a review on the rural finance sub-sector in Kenya to assist in the planning phase for IFAD's potential future interventions in Kenya's rural finance (IFAD 2003a). Four layers are recognised within the rural financial sector in Kenya: the formal banking sector; savings and credit cooperatives (SACCOs); micro-finance institutions and community-based financial arrangements. The report follows with an elaboration on these layers; which banks are dominant, who are the main players and who are the new players, strengths and weaknesses of the rural SACCOs, rapid growth of microfinance institutions, financial service institutes (FSAs), village banks and accumulating savings and credit associations (ASCAs) as credible community-based arrangements, financing by marketing companies and projects and finally donor support to rural finance.

The Cooperative Bank of Kenya (CBK), with its 94% share of formal small-scale rural lending, is the dominant formal banking institution in the sector. However, past experiences have indicated that the CBK is not as stable; in 2000, the bank produced a huge KSh 1.8 billion (US$ 25 million) loss, mainly due to writing off bad loans. Although losses reduced in the years thereafter, CBK's portfolio remains vulnerable (IFAD 2003a).

5.3.1 Microcredit

There are three microfinance banks in Kenya getting increasing attention over the past decade: the K-Rep Bank, the Equity Building Society and the Family Finance Building Society (IFAD 2003a). A location map with addresses is provided by the K-Rep Bank (K-Rep 2007).

Of interest is also the Kenya Women Financial Trust (KWFT), a microfinance institution that provides microcredits for women who want to start a business (IFAD 2004b). IFAD initiated the KWFT Development Programme 2002/03 – 2006/07 with the overall goal of advancing and promoting the access of economically active low-income women to sustainable financial and non-financial services to enable them to improve the economic and social status of their households.

Critique comes from a study done by through Egerton University (Argwings-Kodhek 2004), stating that the agricultural sector stakeholders have not been part of the emerging debate about how to avail financial services to rural Kenyans. Farmers are particularly disadvantaged because advances have been made in developing products for rural businesses, but not for agriculture. The new government pledged to make credit available to farmers and moved to examine the possibilities for reintroducing Guaranteed Minimum Returns (GMR) and funding Agricultural Finance Corporations (AFC) as a means of implementing this pledge. Players in the rural finance sector can see the need, and business potential, of lending to the largest sector of the economy. But despite the many different institutions, institutional forms and products, difficulties in the product markets, and problems with the regulatory framework have slowed product development. Government can play a more proactive role in advancing dialogue and underwriting product development in the agricultural credit sector. The focus should go far beyond a single government owned institution that provides subsidised credit to a few large farmers.

One of the strategic objectives of Country Strategic Opportunity Programme (COSOP) 2007-2012, is to increase investment opportunities for the rural poor through improved access to rural financial services (IFAD 2007b).

CARITAS
Caritas International is a confederation of 162 Catholic relief, development and social service organisations working to build a better world - especially for the poor and oppressed - in over 200 countries and territories. Caritas counts five development partners in Kenya that provide support to projects including community savings and credit schemes, environmental programmes which include rehabilitation of the land, reforestation and education. Additional information can be obtained from the CARITAS-website[11]. Possibilities for cooperation during GWC Pilot Operation need to be analysed.

5.4 Informal credit systems

Farmers' groups rely on informal finance, in-kind credit arrangements for seeds, and community access to microcredit. The main source of microcredit is the informal "merry-go-round" to which members contribute money regularly and vote on whom is to receive the lump sum contributed each meeting day; no interest is charged (Meijerink *et al.* 2007).

Under informal credit systems fall amongst others "community-based arrangements". Most have been developed from the principles of Rotating Savings and Credit Associations (ROSCAs) based on predominantly short-term arrangements involving small groups. This has roots in the traditional mutual guarantee system. The short-term loans issued to members are charged interest of up to 10 % with a 2-weeks repayment period. A second type is the Accumulating Savings and Credit Association (ASCAs) whereby the cash collected is allowed to accumulate to form a bigger basis for lending activities (IFAD 2003a). This association is very popular, especially among women.

[11] www.caritas.org

One example of a "merry-go-round" initiative in Kenya is given by the Conservation and Farming Initiative (CAFI)[12]. CAFI is an NGO with a vision of enhancing sustainable solutions for achieving the millennium development goals so as to bring satisfaction and happiness to the lives of rural people. Its mission is to initiate sustainable and environment friendly community development projects among small-scale farmers to improve food security, human health and the environment.

In-kind microcredit arrangements involving export companies were also reported. Farmers receive seeds of horticultural crops at planting time; the cost is recovered upon sale of produce to the same company. Similar procedures have also been used in promoting farmers' access to fertilizers for tea (by Kenya Tea Development Agency) and coffee (coffee SACCOs). However, arrangements for coffee production have slumped along with coffee prices.

5.5 Environmental services

Environmental services include amongst others; biodiversity conservation, carbon sequestration, watershed protection and maintenance of landscape beauty (Grieg-Gran 2004). In this presentation-paper, a general outline is presented on market mechanisms for environmental services and how they can work for the poor. An overview of definitions, key concepts, obstacles, policy options and research needs for environmental services is provided in a briefing note from the FAO (Sakuyama 2005). To create an understanding of the different roles of agriculture in developing countries, a FAO research programme summary report (FAO 2004b) provides the necessary background information. One of the recommendations of the GWC Proof-of-Concept report is to create a financial system based on the quality of soil conservation and not on a decrease in quantity of sediment trapped in reservoirs. This because in years with less rain, there will automatically be less erosion whereas in years of high intensity rain events, more erosion will potentially take place. It is thus important to develop an effective monitoring system whereby quality control is central.

5.6 Platform for negotiation

Experiences from Payment for Environmental Services (PES) schemes have produced much literature. A paper from the International Institute of Environmental Development (IIED) provides a number of lessons listed below (Hope *et al.* 2007):

1. Introduce incentive mechanisms that respond to shared interests;
2. Find incentives that work for both people and the environment;
3. Institutions matter as they can reduce transaction costs, build local capacity, and empower vulnerable and excluded groups;
4. Negotiation needs active engagement: understanding the community characteristics of service providers and users and involving them from a pre-negotiation stage is critical;
5. Start at the local level with a generally perceived and recognisable problem;
6. Use multi-prolonged (broad) approaches; and
7. Have realistic and measurable goals which are: Specific, Measurable, Achievable, Relevant, Time-bound (SMART).

[12] http://www.cafikenya.org/about_cafi.php

5.6.1 Water users and water managers

There is no direct link yet between the Stakeholder Forums, as recognised by NALEP, and the WRUAs (SIDA 2007). Stakeholder Forums fall under the Ministry of Agriculture and WRUAs fall under the Ministry of Water and Irrigation. This link needs to be identified during the GWC Pilot Operation and developed by NALEP and WRMA.

5.7 Collection, management and payment of credits

The goal of the GWC programme is to develop a robust system that is integrated into existing financial mechanisms.

Collection and management
It is 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. 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 (Porras *et al.* 2007).

Payment mechanism
In Kenya, where bank branches are few and far between, M-PESA, a mobile-payment scheme run by Vodafone, a telecoms firm, and Safaricom, a Kenyan operator, with the backing of the British government's Department for International Development, has created an alternative to banks. Most M-PESA customers have no bank account, but they withdraw cash and make payments or send money using their mobile phones. Their cash points are a network of airtime sellers dotted around the country—Safaricom shops, petrol stations, or any other shop used to handling cash. Once they have verified a customer's identity via their telephone number, the agents will facilitate a transaction. M-PESA keeps tabs on all the money and the float is held in a single account at the Commercial Bank of Africa in Nairobi (Economist 2007).

Microfinance organisations can handle the issuance and monitoring of payments. The public-civil society partners can be responsible for steering, advice, and feedbacks on implementation of *green water* management and the resulting wider water benefits. K-rep Bank has devised and trialled a low transaction-costs mechanism for numerous small payments, such as will be necessary for Green Water Credits (Meijerink *et al.* 2007). The system uses the widely available GSM infrastructure and technologies, which include:

1. *SokoTele* disbursement terminals at the water services buyers or at a central Fund;
2. A *smart card* enables the farmer or farmers' group to withdraw money at local outlets that have a mobile phone connection;
3. The system incorporates procedures for registration, agreement on disbursement between water buyer and services provided by the farmer, and can generate a legally valid record of all transactions, electronically and also as a paper trail.

6 Project implementation

6.1 General background

Top-down, technology centred, one-size-fits-all projects are of the past. Today, increasingly bottom-up, pro-poor approaches are being adopted, and with success. In an article *Enabling pro-poor growth through agriculture*, IFAD compiled a series of trends, opportunities and constraints for "farmer first" approaches (IFAD 2005). For GWC it is relevant to consider options for empowering communities and farmer groups. By doing so, they may potentially obtain a stronger collective voice and when the time comes to negotiate with other stakeholders, the downstream water users, they have a stronger position. The role of women must also be considered as they often form a neglected group when actually, considering their important role within agriculture and soil conservation, they are of critical importance in the GWC implementation (phase 3).

Vision 2030
One of the goals for *Visions 2030* is increasing value in agriculture (Republic of Kenya 2007). Kenya will raise incomes in agriculture, livestock and fisheries by processing and thereby adding value to her products before they reach the market.

Kenya Joint Assistance Strategy (KJAS)
The first *Kenya Joint Assistance Strategy* was established in the previous years for 2007 to 2012. It represents the mutual commitment of government and donors to develop a new, more effective way of working together (KJAS 2007). To assist in the establishment and actions of KJAS, the Harmonization, Alignment and Coordination (HAC) work programme was initiated (HAC 2007).

The operational follow-up for KJAS has not yet moved forward. Nevertheless, the World Bank is keen to work with the WRMA because the WRMA is dealing with WRUAs. Any information on water issues and KJAS will go through the WRMA and relevant information will reach the GWC team through J. Kinyua of the WRMA.

Swedish International Development Authority (Sida)
Early experiences from the Swedish International Development Authority (Sida) – based on the work of the Regional Soil Conservation Unit (RSCU) which was the direct predecessor of RELMA (see below) illustrate the need for more bottom-up, flexible, tailor made approaches toward land management (Lundgren 1993; Lundgren and Taylor 1993; Wenner 1992).

Regional Land Management Unit (RELMA)
After years of activity in eastern and southern Africa, having gained a lot of experience within land management and development, the Regional Land Management Unit (RELMA) left Kenya in 2006. Lessons learned have been documented in a working paper on participatory watershed management (Azene and Kimaru 2006). Issues such as building trust among farmers and extension providers, participation within projects, farming system analysis, deployment of multidisciplinary teams, and use of information and incentives are dealt with. Key recommendations include:
- Emphasise market-focused development innovations;
- Necessity of formulating broad land use and agricultural policies to guide researchers, extension workers and farmers;
- Give attention to land and resource tenure;
- Respect indigenous knowledge and combine it with the formal modern science and technology;

– Incorporate local traditional institutional within the whole process;
– Dissemination in a "language" that farmers and members of traditional institutions can understand; and
– Identify and incorporate strong and effective farmers' organisations.

DAAD Participatory Watershed Development Plan (DAAD 2006)
In 2006, a participatory watershed development plan was developed for the Bwathonaro watershed in Meru North District in the Upper Tana. In this report, the Bwathonaro WRUA (BWARUA) is mentioned as being one of the first WRUAs in the Tana basin. According to Mr. B. Mwaniki, the BWARUA is still operational (pers. comm. 2008). Last year the BWARUA undertook and supported various activities, like the demarcation of the Mporoko wetland as one of the main sources of the Bwatonaro river. Furthermore, BWARUA received funds from the Constituency Development Fund (CDF) to implement a Water Kiosk Project.

At present different stakeholders recognised that the WRUA is strongly dominated by a few management members and the objective to manage the water resources in a participatory way is not their first priority. Information is not being smoothly communicated from the Committee to the WRUA Members. Empowering and capacity building of the members in line with the constitution, which was not really considered during the formation process, could be the first step to overcome this problem.

Although there are rainfed farmers included in the BWARUA, they play only a minor role. The WRUA is dominated by Members of Water Projects. Limiting the WRUA only to the WRUA Management one can consider the BWARUA as an active WRUA. Looking at the WRUA as a whole one must conclude however that this is not an active WRUA and that they are not aware of their mandate. In conclusion of the above mentioned facts, as the way things are at the moment, it is recommended not to use BWARUA as an example of "good practice" for GWC. There are certain WRUAs elsewhere in the catchment which are more suitable as an example of "good practice".

After the preparation of the Sub-Catchment Management Plan (SCMP) during the DAAD Summer School in 2006, a one-week workshop to monitor the implementation of the developed SCMP, took place in August 2007. The next follow-up, in connection with the DAAD Summer School, is planned for July/August 2008.

A recent World Bank publication gives an extensive overview of watershed management approaches, policies and operations and lessons learned for scaling-up based on experiences from around the world (World Bank 2007a). A basic ten-step watershed management plan is presented, intended to illustrate possibilities for designing and implementing watershed management programmes (Box 8).

Box 6

Ten step watershed management plan

At the national level, establish a supportive policy and institutional framework

1. Mainstream watershed management concerns and practices within relevant institutions, especially those concerned by or affecting watershed hydrology (e.g. power and transport sectors, agriculture, forestry, agribusiness, local governments)
2. Set up or strengthen institutions specifically in charge of watershed management and provide capacity building (for example, to a river basin agency, or forestry department)

At the watershed level, develop and implement watershed management plans in partnership with government agencies and local stakeholders

3. Identify linkages between upstream land uses and practices and downstream environmental conditions, and identify key socio-economic and environmental characteristics of upland areas
4. Define broad criteria to target critical watersheds and sub-watersheds, and interventions within these areas
5. Adopt a sequencing and up-scaling strategy, whereby a few sub-watersheds would be targeted for interventions first, and others in following years, to test and refine the approach
6. Engage communities in targeted sub-watersheds and develop community watershed management plans, that would include both livelihood development and conservation measures
7. Carry out a detailed financial and economic analysis to assess the financial feasibility of the plan and the economic interest to society
8. Implement the management plans
9. Monitor that the project is on track to achieve desired livelihood and environmental objectives, adapt plans as needed
10. Quantify downstream positive externalities and, if necessary and feasible, value costs that upland stakeholders should be compensated for, and develop an incentive structure for sustainable land and water management.

6.2 Associated projects

Within the Upper Tana, there are a number of ongoing projects that deal with overlapping development aspects as GWC. The many and various associated projects require a detailed review and coordination of activities and information flows. A Management Information System (MIS) has been established to harness the synergies in these projects (World Bank 2007b). Alongside an MIS, an Environmental and Social Management Framework (ESMF) has also been established to provide a strategic guide for the integration of environmental and social considerations in the planning and implementation of both the Natural Resource Management (NRM) project and the Western Kenya Community Driven Development and Flood Management (WKCDD/FM) project. Collected data within the ESMF may be useful for GWC.

Natural Resource Management (NRM) Project

The objectives of the Natural Resource Management project are to enhance the institutional capacity to manage water and forest resources, reduce the incidence and severity of water shocks in river catchments and improve the livelihoods of communities participating in the co-management of water and forests. The project area is the Upper Tana. Activities include strengthening of the information base, improving decision-making to include water users, training and sensitization of farmers and WRUAs to improve land use and water conservation methods. The WRMA will target microcatchment "hotspots" through the above mentioned process, and invest one million US dollars per year in catchment protection activities such as erosion control, terracing, small to medium water storage infrastructure and the rehabilitation of existing structures as well as improvement of on-farm agronomic practices. The regional WRMA will work closely with the Kenya Forest Service (KFS) to ensure synergies with their work in the gazetted forest and with neighbouring communities.

Achievements under the project will be measured by indicators tracking changes in organisations and their performance, in the health of the natural resource base, and in welfare of participating communities.

The proposed NRM project has four focus points:
– water resource management and irrigation;
– management of forest resources;
– livelihood investment in management, and
– monitoring & evaluation.

The first two points support the legal and institutional reforms contained in recent legislation, as well as investments in catchment areas. The third provides assistance to communities participating in management of the resources. The fourth provides managerial oversight and monitoring and evaluation for the project. A summary of activities and responsibilities of the WRMA and WRUAs within the NRM Project is outlined in Annex 4 of the project appraisal document (World Bank 2007b).

The NRM project will initially focus on two sub-catchments in the Upper Tana, the Sagana and the Thiba river (pers. comm. Eng. J. Kinyua). The NRM project has two main components:
– Component on WRUA activities: e.g. riverbank protection, water conservation and catchment protection;
– Livelihood component: rewarding alternative land management; Microcredit projects; Alternative activities to substitute unsustainable activities → these alternative activities should be income generating.

Specifically in the NRM project, identified WRUAs within the Upper Tana will develop their Sub-Catchment Management Plans (SCMPs) and get funding from the World Bank to implement specific activities in line with the these plans.

Rainfed farmers will only be included in the NRM project if their role is important in catchment protection. Some additional information on conservation and catchment protection can be found in the 2007 draft Catchment Management Strategy for the Tana water catchment area (WRMA 2007a). However, it appears that detailed information explicitly dealing with farmer's land management in the framework of soil and water conservation is limited.
Also, micro-projects have been developed. The operational goals of these micro-projects include:
– To improve the incomes of farmers in the sub-catchments so that they can continue good land management practises and subsequently contribute to catchment protection and rehabilitation;
– To finance WRUA activities in WRM activities as planned in the SCMPs.

Improving Management of Agricultural Water in Eastern and Southern Africa
Under the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA), the Soil Water Management Network (SWMnet) could potentially provide dissemination of Green Water Credits results at regional level. First contacts are established to elaborate joint activities. The international institution "Improved Management of Agricultural Water in East and Southern Africa" (IMAWESA) may also assist in dissemination of knowledge at regional level. For contact details see (IMAWESA-SWMnet-ASARECA 2008).

Mount Kenya East Pilot Project
The Mount Kenya East Pilot Project is an IFAD-supported project to arrest land degradation and enhance sustainable and equitable use of Natural Resources in part of the Upper Tana catchment (IFAD 2002b, 2003b, c; IFAD/GoK 2008a, b; IFAD/UNEP/GEF 2004; MKEPP 2005; UNOPS Africa Regional Office 2007). The project area covers the National Park and Reserve and river sub-catchments in five districts on the eastern side of Mount Kenya, three of which border the protected area. For the sub-catchments five River Basin Management Plans have been developed (IFAD and GoK 2006; IFAD 2007a, b; MKEPP 2005, 2006, 2007). The five districts are Meru Central, Meru South, Embu, Mbeere and Tharaka (IFAD/UNEP/GEF 2004). The

objective is to reduce degradation and enhance sustainable and equitable use of natural resources (IFAD 2002b, 2003b, c).

Sub-components

Community natural resources management

– Protection of wetlands and riverbanks;
– Rehabilitation of hilltops;
– Stabilisation of road embankments;
– Efficient production and utilisation of charcoal; and
– Policy and legal rights advocacy.

Farm forestry

– Tree germplasm acquisition and supply;
– Marketing of farm forestry products; and
– Technology transfer (information, training and technical assistance).

Forest plantation development

– Preparation of management plans;
– Re-planting of about 2000 ha;
– Silvicultural operations; and
– Training about PFM and subsequent introduction.

Pro-poor Rewards for Environmental Services in Africa (PRESA)

PRESA is an ICRAF project supported by IFAD with which the joint activities are under discussion. PRESA is aimed at facilitating negotiated agreements designed to benefit hundreds of thousands of smallholder farmers and residents in East and West Africa through fair and effective agreements between the stewards and beneficiaries of ecosystem services. The expected outcomes of PRESA include, inter alia, setting up of workable environmental service agreements, private companies becoming increasingly involved in a range of initiatives for ecosystem management and increased number of environmental service reward mechanisms in place and operational. PRESA is active in three core and four associate landscapes in the highlands of East and West Africa, one of which is the Mount Kenya East area (World Agroforestry Centre 2008).

ICRAF has been asked to support Green Water Credits by identifying a sustainable tree-based management package for the Upper Tana[13].

Central Kenya Dryland Area Project

IFAD-supported project with district NALEP offices, covering 2500 poor farm households in focal areas in Nyeri South, Kirinyaga, Murang'a South and Thika Districts; addresses varied components but most relevant for Green Water Credits is the agriculture component focusing on water harvesting and *green water* management.

Kenya - Tana River Basin Development of a Model for Private-sector Payment for Environmental Services provided by Smallholder Farmers

This is an IFAD project.

[13] In close cooperation with KARI-KSS the lead agency for this activity.

Western Kenya Community-Driven Development
World Bank-supported project for catchment conservation/protection, poverty alleviation, flood and flood plain management, and early warning.

Rehabilitation of Aberdare Forest Ecosystem
This three year project (2006-2009) focuses on communities living adjacent to the Aberdare Forest and attempts to stimulate participation of these communities in planting trees to rehabilitate "the degraded areas" (AFD 2007). The goal is to restore the degraded areas of the Aberdare Forest ecosystem to improve its functions (e.g. water and biodiversity conservation) and improve the livelihoods of dependent communities. Objectives are: (i) Rehabilitation of 2000 ha of degraded areas and (ii) Public and institutional awareness and training. The three-year programme will support the communities adjacent to the Aberdare Forest ecosystem in planting trees to rehabilitate the degraded areas, and promote the conservation of endemic tree species and wildlife. The strategy involves seedling production, planting, maintenance and the protection of the forests. The communities are taught practical soil conservation, water harvesting and other good practices; and benefit from forest services and products. When all 2000 ha are planted, forest cover should better regulate water supply and quality and increase biodiversity. In the short term, communities that participate in tree planting and other income generating activities will earn cash.

Initially the core project area was 2000 hectares in Kinangop, Lari, Kigumo and Gatanga constituencies but this was expanded to areas in Kipipiri, Limuru, Gatundu North and South, Githunguri, Kiharu, Kangema and Mathioya that are adjacent to the forest or will give support to tree planting; the expanded areas will allow for the inclusion of some of the sites that are critical and that form part of Sasumua Dam catchment area.

Sasumua Reservoir Payment for Environmental Services
Sasumua Reservoir PES is a pilot project, supported by World Bank, which falls under the Kenya Agricultural Productivity and Sustainable Land Management Project. The project area is a sub-catchment that serves the Sasumua Water Treatment Plant operated by Nairobi Water Company. Project activities include tree planting to prevent sediment transport to the reservoir. Implementing agencies are Ministry of Agriculture and Ministry of Environment & Natural Resources; ICRAF will execute the payments for environmental services component. Exchange of information with Green Water Credits has been arranged with the ICRAF PRESA project manager.

6.3 Targeted areas

The Upper Tana includes 14 Districts: Maragua, Murang'a, Thika, Nyeri, Kirinyaga, Embu, Meru south and central, Mbeere, Tharaka, Machakos, Meru North, Nyandarua and Laikipia. Of the last 6 districts, only small parts are included. Together these districts contain 222 local administrative units (locations) and 823 sub-units (sub-locations) (World Resources Institute *et al.*). Furthermore, the Tana Catchment is subdivided into 5 sub-catchments, namely: Murang'a, Kerongoya, Kitui, Meru and Garissa. A sixth sub-catchment is planned; that will be the Lamu/Garsen sub-catchment.

6.3.1 Potential of RS / GIS tools

Remote sensing can contribute through the provision of biophysical data to assess the suitability of areas for Green Water Credits. However, a general lack of validation data to assess the accuracy of maps is a major concern (Vrieling 2006; Vrieling 2007). In the West Usambara Mountains in Tanzania, accurate maps of soil erosion risk could be calculated using NDVI and slope, both acquired through remote sensing. Proper timing of the Landsat image patterns of vegetation cover at the time of high erosion risk was considered important.

Additional information on Fraction Vegetation Cover (FVC), ASTER images and Quickbird images are given in (Vrieling 2007).

6.3.2 Erosion and AEZ

GWC Report 3 (Kauffman *et al.* 2007) estimates erosion risk within the Upper Tana using SWAT and presents the results in an exploratory map. However, calculations assume uniform land use of maize which is not the real situation over the whole Upper Tana. For the Pilot Operation, new erosion risk models are to be established using a more detailed and up-to-date land use map, in combination with more accurate precipitation data.

GWC Report 5 (Porras *et al.* 2007) elaborates on the current soil and water conservation practices according to the four agro-ecological zones (AEZs) (I-II-III-IV) (page 40). In AEZ I and AEZ III, farmers hardly adopt SWC practices on their land, whereas in AEZ II and AEZ IV, most farmers adopt SWC practices. From correspondence with. Davies Onduru it however became clear that - mainly in AEZs III and IV -, SWC practices are adopted. As for AEZ I (tea zone), a few structural measures are in place. Using tea prunings for mulching material is adopted common SWC practice in this area. However, farmers prefer to use the tea prunings for firewood.

6.4 Implementing agencies

A number of ministries are of importance for planning, design and implementation of GWC. A list of the relevant ministries with some background information and contact data is presented in (Republic of Kenya 2006). The following ministries are listed:
- Ministry of Finance;
- Ministry of Planning and National Development;
- Ministry of Agriculture;
- Ministry of Water and Irrigation;
- Ministry of Regional Development;
- Ministry of Energy;
- Ministry of Environment and Natural Resources; and
- Ministry of Lands.

One of the lessons from IFAD's COSOP-paper is the need for more simple and focused project designs, involving a minimum number of ministries (IFAD 2007b).

Extension services
Agricultural sector extension service plays a vital role in sharing knowledge, technology, agricultural information and also linking the farmer to other actors in the economy. The National Agricultural Sector Extension Policy (NASEP)-paper has presented an outline of its objectives and services (Republic of Kenya 2005).

6.5 Capacity building requirements

Knowledge and information alone is not enough to bring about change. Enabling and empowering individuals to use that knowledge will require training and capacity building. Institutions involved in water resource management will have to emphasise interdisciplinary approaches to water resource management, and generate and disseminate knowledge on good practices. Training in water law, conflict resolution and

mediation, water resources economics, environmental planning and management, and financial administration should be considered for WRMA-staff. The community and water users grouped under the Water Act will also need to be trained to make sure that they possess the skills and knowledge to be confident and effective in their roles (Mogako *et al.* 2006).

SWOT analysis tool
A useful tool in analysing the capacity building needs is the SWOT analysis tool. Internal strengths and weaknesses of the implementing agencies and external opportunities and threats to implement the Green Water Credits programme are set out to gain insight in these matters. In Kenya's 2002 Country Strategic Opportunity Paper (COSOP), Annex 3 provides an example of a SWOT analysis for four ministries (IFAD 2002a).

Once a SWOT analysis has been performed, a list of strategic action plans can be made whereby internal strengths and weaknesses are linked to external opportunities and threats. Four types of plans can be made: Strengths-Opportunities, Weaknesses-Opportunities, Strengths-Threats, Weaknesses-Threats. This activity must be performed together with the main implementing agency.

National Agricultural and Livestock Extension Programme (NALEP)
In their work plan for 2007-2008, the National Agricultural and Livestock Extension Programme present their goals, objectives, institutional setting, partners and actions (Sida 2007). Attention is given to training activities and extension approaches. Also, an outline is presented of the role of various players (pages 40 – 43) including:
- Divisional stakeholder Forum (DivSHF);
- Divisional stakeholder secretariat;
- District stakeholders' Forum (DSHF);
- District Stakeholder Committee (DSC);
- Provincial Stakeholder Committee (PSC);
- Frontline Extension Workers (FEWs);
- District Subject Matter Specialist (DSMS);
- Provincial Subject Matter Specialist (PSMS);
- Coordinators at all levels.

6.6 Dissemination

IFAD has five ongoing projects within IFAD's strategy in Kenya for 2007 – 2012, which focus is on improving the livelihoods of poor smallholder farmers, agro-pastoralists and pastoralists through projects that improve, diversify and market agricultural and livestock products (IFAD 2008a). These projects (located in Figure 21 below) are:
1. Central Kenya Dry Area Smallholder and Community Services Development Project (IFAD 2000a, b);
2. Mount Kenya East Pilot Project for Natural Resource Management (IFAD 2003b, c; IFAD/UNEP/GEF 2004);
3. Southern Nyanza Community Development Project (IFAD 2004a, e);
4. Smallholder Dairy Commercialisation Programme (IFAD 2006a, b);
5. Smallholder Horticulture Marketing Programme (IFAD 2007a, c).

Figure 21
Location map of IFAD's ongoing projects in Kenya

Of these five projects, the first and second are located within the Upper Tana and can be of importance for cooperation with GWC. The fourth borders the GWC project area. The third and fifth projects are located in western Kenya (Figure 21). For a more detailed overview of the locations, see (IFAD 2008b).

6.7 Alternative Innovative Ideas

Affordable Internet Map Servers (IMS)
An Internet Map Server is an Internet based GIS application designed to allow users to interact with geographic data using standard web browsers. With IMS, there is no need for more expensive GIS software. It is a low cost application ideal for volunteer organisations that lack significant funds or a full time technology information staff. However, the capabilities of an IMS application are much more limited than those capabilities provided within a fully functional desktop GIS (Lembo *et al.* 2007)[14].

Use of Coir (coconut) fibre mats to protect the soil from erosion
It is estimated that from one million coconut husks about 80 tonnes of coir fibre can be extracted (Banerjee 2003). Coir fibre is a biodegradable product which has a natural advantage over other products, which need to be incinerated or dumped in landfills at the end of their lifecycle. Two well-known manufacturing companies include:

- Hayleys Agriculture[15]
- Ficci, Federation of Indian Chambers of Commerce and Industry[16]: door for trade possibilities between Kenya and India (India who is main exporter (75%) of Coir fibre mats produced around the world).

[14] For downloads go to http://mapserver.gis.umn.edu/.
[15] Hayleys Agriculture: www.hayleysagriculture.com
[16] Ficci: www.ficci.com

Coir fibre can be manufactured into mats of different forms and sizes to cover sloping area. In the Philippines, coconut mats are used to protect sloping area along roads. Within a period of two years, the mats function as nets that captures airborne seeds and protect the soil from water and wind erosion, after which the map will have degraded and function as nutrient rich organic matter for the newly growing vegetation. Further investigation is needed on purchase and transport costs of coir fibre-mats. Secondly, research must be done on the possibilities to manufacture coir fire-mats in Kenya as alternative livelihood activity.

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Annex 1 Key Points from Report 7[17]

Water scarcity is undermining development, food security, human welfare, and ecosystems; shortage is increasingly felt in cities. Better soil and water management can greatly increase the resilience of farming systems and improve water availability downstream. By 2025, 2.8 billion people will be suffering absolute water shortage and two thirds of the world's people will be under water stress. Globally, two thirds of renewable fresh water is *green water,* held in the soil; only one tenth is accessible streamflow and groundwater, of which 70% is used for irrigation. But nearly all investment goes into abstraction from streams and groundwater; replenishment is neglected. Meeting the Millennium Goal on hunger means doubling water use by crops by 2050; irrigation cannot do it alone. A policy shift is required to improve water-use efficiency in rainfed farming and recharge streams and groundwater.

Green water **resources can be much increased and downstream delivery of fresh water better regulated by two fundamental improvements in rainfed farming: increasing the infiltration of rainwater, thereby cutting runoff; and reducing unproductive evaporation.** More infiltration means banking water in soils and aquifers, and better river base flow; less runoff means less erosion, less flooding and less siltation. Low-cost soil and water management packages can significantly increase available water resources.

Poverty is a severe constraint. **Farmers are aware of their private benefits from soil and water conservation but they need immediate as well as on-going returns for their labour and material inputs.** The Upper Tana is occupied by many smallholders, mostly poor, with limited access to markets, and low prices for their produce. Poverty drives a preference for short-term benefits, so that the cost of conservation measures outweighs their private benefits. Further incentives are needed to ensure wide adoption - and maintenance.

Green Water Credits are payments for water management services by farmers. These services are currently unrecognised and unrewarded. Quite small cash transfers from downstream water users will enable farmers to adopt sustainable management of land and water; at the same time they will combat rural poverty by diversifying income. The Proof-of-Concept demonstrates:

a) The link between upstream land use and management and downstream water supply, river regulation, and siltation of reservoirs;
b) Practical ways to assess the resource, optimise water allocation, and calculate the costs and benefits;
c) The cost of simple and effective soil management practices may be covered by the additional water revenues. For the Upper Tana, annual water benefits are US$ 12-95 million and costs 2-20 million; for a 20% adoption scenario, water benefits are US% 6-48 million (3-7 millions under the most pessimistic assumptions) and costs 0.5-4.3 million (2-8.5 million under the most pessimistic assumptions).

Green Water Credits supports the current water reform in Kenya by providing a market-based mechanism by which many of the goals of reform may be achieved. The National Water Resources Management Plan and the Water Act 2002 assign an economic value to water in all its competing uses; and Green Water Credits establish a market between water users and water services providers.

[17] Dent DL and Kauffman JH 2007. *The spark has jumped the gap.* GWC Report 7, ISRIC – World Soil Information, Wageningen

In the Tana basin, all water users (hydropower generation, municipal water utilities, irrigators) have substantial, and growing, un-met demands. Key issues for hydropower are low reservoir levels, and high silt loads that shorten the life of reservoirs and turbines. Most of Nairobi's water comes from the Upper Tana and demand is projected to increase steeply. Climate change will significantly increase un-met demands, especially for irrigation.

Immediate, nationally-significant gains in power generation and urban water supply may be realised by arresting siltation of reservoirs. For instance, the Masinga may have lost 30% of its capacity over 20 years up to 2002. Targeting siltation involves relatively small areas and few farmers; resources and managerial capacity are already available for a pilot application of Green Water Credits in the reservoir catchments.

Operation of Green Water Credits will depend on cooperation among farmers; good examples are already in place.

1. Soil and water conservation practices are more effective if neighbours work together as water services groups;
2. It will be easier to make and service contracts with groups rather than with individual smallholders; and
3. Farmers' groups can be self-policing in respect of compliance with contracts.

Technical procedures have been developed to assist water resources assessment, allocation, and financial transactions:

1. Well-tried basin hydrology models are already available; however, these require specialist professional staff;
2. The Water Evaluation and Planning (WEAP) model has been developed as a powerful yet easy-to-use tool for planning and water allocation; it integrates information on water supply, demand and cost and displays management scenarios. WEAP is free and can be operated with very little training; and
3. A low-cost, cash transaction system, making use of the mobile phone network, enables reliable, documented and low-cost cash transfer between individuals or groups anywhere in the country.

Capacity-building is needed: for local water services providers groups, for an intermediary organisation providing a platform for negotiations and management of contracts, and for water resources managers that must translate present and future water requirements into a rolling plan for implementation.

Annex 2 District information of the Upper Tana

Nyeri District (Community-Organisation-Consultants 2003)
Nyeri District has a total area of 3284 km^2. Based on the 1999 census, the district has a population of about 650,000 people living in seven divisions. Most of the district is high potential area, generally sloping with undulating lowlands in Kieni East and West Divisions, which are referred to as "settlement" divisions, as there were formerly large plantation and ranching areas that were settled by smallholders after independence. The district is endowed with a variety of natural resources such as Mt. Kenya and the Aberdare range, which make the district self-sufficient in water resources, the Aberdare and Mt Kenya national parks, and several major rivers. The main town centres are Nyeri, the district and Central Provincial headquarters, Karatina, the main market for farm produce, Naru Moru, Mweiga, Gichira, Othaya and Mukurweini, all of which are divisional headquarters. Karatina is known for having the largest fresh produce market in East Africa and also has Kenya Industrial Estate stalls, banks, a railway station and livestock feed millers. Other towns outside the districts have an impact in Nyeri's economic activities including Nairobi, Embu, Thika and Mombasa, all major markets for milk and horticulture crops.

The main roads in the district are tarmacked. The more interior parts of the district are served by murram roads, which are generally accessible year-round. However, most of the roads to the farms are inaccessible during heavy rains.

Dairy and tea dominate the farming systems in high potential areas. In the medium potential areas coffee and dairy are predominant. In low potential divisions, ranching and maize farming are common, but irrigated horticulture is a rapidly expanding type of farming in this area.

Out of the district's total population, it is estimated that 90% are smallholder farmers, 5% are in subsistence farming, 20% in semi-commercial farming, while 75% are in commercial farming. The average farm size is 1.8 hectares, but "settlement" divisions have bigger average farm sizes than the "traditional" divisions. The main crops grown by smallholder farmers are tea, coffee, potatoes, cabbages, snow peas, tomatoes and carrots. Livestock production is mainly in the form of dairy farming, poultry and rearing of dairy goats.

Table 1
Main smallholder commercial crop and livestock production activities in Nyeri District

Crop / livestock production	Estimated number of smallholders	Estimated area (ha)
Coffee	156,400	11,900
Dairy cows	80,000	x
Irish potatoes	80,000	16,000
Tea	28,200	5200
Cabbages	10,000	2000
Tomatoes	2500	500
Snow peas	2500	400
Carrots	2600	350

For many years, coffee was the leading cash crop but prices collapsed in the mid-1980s. Most smallholder coffee farmers are affiliated to coffee cooperatives, of which there are about 52 in the district running 100 coffee factories. Coffee is delivered directly to the factory in sisal bags, by bicycle, wheelbarrow or simply carrying the bags on the labourer's back. There is no storage at farm level unless the farmer wants to process dry cherry beans. The coffee factories are normally operated by cooperative societies, which are in charge of processing and marketing. Other institutions involved are the CRF, CBK and the Kenya Planters Cooperative Union (KPCU).

Smallholder dairy farming is very common in Nyeri district. There are about 24 dairy cooperative societies with a membership of about 40,000 farmers, but only 10,000 are active members. These cooperative societies assist members with inputs, artificial insemination (AI) and marketing. Milk is normally collected in cans and plastic containers and transported by bicycle or on foot to buying centres. Among the institutions involved are the Kenya Dairy Board, cooperative societies, private processors such as Brookside Dairies, SpinKnit Dairies, and input stockists.

Smallholder farmers grow potatoes both under sprinkler irrigation and rainfed farming. Potatoes are a high-value food crop. After harvesting, the potatoes are heaped in wooden or mud storage structures and later packed into sisal bags for sale. They are transported to selling points using family labour, are bought at the farm gate or transported by farmers or traders directly to major markets.

Tea is currently the main cash crop. Tea leaves are normally packed into special baskets that are used to deliver the leaf to buying centres. The tea is then collected by Kenya Tea Development Agency (KTDA) lorries and taken to any one of six factories in the district for processing.

Maragua District (Community-Organisation-Consultants 2003)
Having been created in 1997, Maragua is one of the new districts in Central Province. It is a relatively small district with four administrative divisions and a total area of 1,065 km^2. The population is about 409,000 people in 91,000 households of which 40,000 are female-headed. Maragua District is a medium potential district that is very hilly in the upper parts and generally flat in the lower areas. Besides smallholder farming, economic activities in the district include plantation farming, mainly coffee, passion fruit, pineapples, and agro-forestry. There is also quarrying which is spread throughout the district and sand harvesting. The district has 226 km^2 Gatare forest, several rivers that flow through the district, and the Ndakaini Dam, a main source of Nairobi City's water.

The Maragua District headquarters are at Kenol market centre, but most of the offices are at Makuyu town as there is no infrastructure at Kenol. Other market centres of importance in the district include Muthithi, where the largest produce market is situated, Kangari, which has about four banks, Saba Saba, with one bank, and Maragua, Makuyu, Kandara and Kigumo, which are all divisional headquarters. Nearby centres of importance but outside the district are Thika and Murang'a towns, where most farmers get their inputs and also sell their produce, and Nairobi, which provides a market for the produce especially vegetables and fruits.

The road network is generally good, with all-weather roads leading to the high potential areas, but they are not always well maintained. The new Maragua County Council, the various town councils and tea factories in charge of road maintenance need to have a coordinated plan so that feeder roads can be passable all year round.
The western parts of the district are the high potential areas with fertile volcanic soils. Tea, coffee, dairy production and food crops such as maize, beans and potatoes are grown in this area. The middle part is the coffee zone, gently sloping and of medium potential. The low potential areas towards the east are generally

flat and semi-arid. The soils are shallow and poorly drained, only suitable for drought tolerant crops such as cotton, sorghum. Horticultural crops are possible if irrigation water is available.

Out of the district's total population, 95% are smallholder farmers, of whom only about 5% are subsistence farmers. Most smallholders practice some form of commercial farming, while the purely subsistence farmers are typically plantation farm workers. The average farm size for the smallholder farmers is 0.93 ha. The main commercial crops in the district are tea, coffee, horticultural crops, including fruits, vegetables and flowers. Dairy farming and bee keeping are also major activities.

Tea is an important cash crop in the district, which is processed through four tea factories and over 200 tea buying centres. Tea-picking baskets are used to deliver tea to the buying centre on the same day it is picked. KTDA lorries collect the leaf for delivery to the factory. Farmers have very little to do with tea processing and marketing which are handled by the KTDA.

Table 2

Main smallholder commercial crop and livestock production activities in Maragua District

Crop / livestock production	Estimated number of smallholders	Estimated area (ha)
Coffee	64,000	8,000
Dairy cows	39,500	x
Bananas	14,500	2900
Tea	14,000	4000
French beans	7400	370
Tomatoes	6500	650
Avocadoes	3760	750
Bee keeping	2250	x
Mangoes	775	155

Though coffee is grown by a large number of farmers, it is not as important as tea in terms of income generated. Coffee farmers are organised around cooperatives. There are 60 coffee factories and 37 coffee cooperative societies in the district. Coffee cherry is harvested in plastic tins and then packed in gunny bags for transportation to the factory, typically using bicycles or wheelbarrows. The coffee factory handles the pulping and sells the clean coffee to millers who process and market. Institutions involved include the CBK, CRF, coffee factories, the KPCU and Thika Coffee Mills Ltd.

Bananas are grown by individual farmers, although one group of about 30 farmers came together to organise marketing. Bananas are harvested and sold in bunches, unless one wants to sell them ripe which requires a ripening store. Smallholders also grow avocadoes and approximately 12 groups with about 400 members have been organised to market avocadoes. Some of the farmers who grow mangoes have organised themselves into about seven marketing groups with some 200 farmers. Both bananas and avocadoes are packed in wooden crates, sold at farm gate or transported to the markets using bicycles or motor vehicles. Mangoes are sold at the farm gate or markets as they are harvested, and therefore no storage is necessary.

In some of the drier areas of the district, tomatoes and French beans are the main crops, mainly grown under bucket and furrow irrigation. Tomatoes are highly perishable and have to be sold as soon as they are harvested. They are picked, packed in crates and sold either at the farm gate or transported to the market

using pick-up trucks. French beans are a seasonal crop harvested at one and a half months. Just like tomatoes, French beans are harvested when a farmer is assured of a ready buyer. They are packed in cartons and sold to brokers or directly to exporters, who sometimes have an individual contract or a loose agreement with the farmer.

Farmers who practice dairy farming are not organised into groups, so the dairy milk is sold while fresh and mainly to hawkers. Bee keeping is practiced by about 2250 farmers, including some 300 farmers in about ten groups who buy hives, harvest and attempt to market the honey cooperatively. Veterinary and breeding services are available to farmers through NGOs, the MARD veterinary department and a whole range of private institutions. However, the services are expensive because the farmer has to meet the cost of transport for the veterinarian in addition to paying a fee. Maragua District has only 19 operational cattle dips out of a total of 103. There are also three operational private dips. There are an estimated 21 national companies mostly operating from nearby Nairobi that supply farmers in Maragua District. They supply to some 17 local distributors who in turn supply to over 107 stockists spread all over the district.

Farm inputs are generally available, but the main problem is high cost and at times shortage of specific brands. The local retailers approach is passive but the national companies often go directly to the farmers especially when they are promoting new products.

A number of institutions provide technical advice to farmers. The MARD has been the main provider but because of the new demand-driven approach, a number of NGOs and private companies have stepped in to fill the gap. Tea factories provide tea extension services; the Coffee Research Foundation offers training on coffee husbandry; NGOs organise training in topics such as water harvesting, bee keeping, dairy goats, poultry keeping, and organic farming; a private company trains farmers in bee keeping and honey extraction; other private companies train in production, spraying and grading of French beans; the Catholic Diocese conducts training on drought tolerant crops and small stock; agrochemical companies advise on the safe use of chemicals; etc.

Credit services are available but are mainly concentrated in Kangari town, which is close to the richer tea zone. Banks and non-bank financial institutions include three commercial banks, two building societies, at least four cooperatives, two MFIs and the AFC. These institutions provide credit but their loan conditions and interest rates are rather prohibitive and to most farmers, they are beyond reach.

In Maragua, there are 18 public markets distributed all over the district where farmers can take their produce for sale. Maragua Municipal Council and Maragua County Councils maintain market centres in the district. Farmers complain that the prices are so low that they do not make any profits. A number of private institutions are involved in buying, processing and marketing various crops and animal products. These include four tea factories, and various private companies that buy French beans, pigs, milk, honey, Macadamia nuts, or bananas. Most of the coffee cooperatives confine their activities to a location or sub-location level. Thika Coffee Mills dominates the marketing of coffee. Mwea ginnery buys and gins cotton.

The milk industry was seriously hit by the collapse of the KCC, which still owes farmers millions of shillings. With the exception of tea and coffee, cash crops are mainly sold to brokers and private export companies. Tea farmers have few complaints, but coffee societies face mismanagement and leadership wrangles forcing many farmers to neglect their coffee bushes.

If fair and efficient marketing systems are put in place, there is a lot of potential in smallholder commercial farming in Maragua. The district is capable of high production levels of both livestock products and farm produce if farmers are motivated with higher prices, assured markets and better infrastructure. Milk production in the district faces the particular problem of being relatively unorganised. Unlike other districts,

Maragua farmers are not organised into dairy cooperatives and as a result they depend on middlemen. The collapse of the KCC not only left behind a huge bill of unpaid farmers' dues; it also created an unprecedented gap in milk processing capacity. Farmers are reluctant to form new cooperatives because the old ones were badly managed and used only to enrich the officials.

Thika District (Community-Organisation-Consultants 2003)
Thika District is a relatively new district with six administrative divisions, established in 1995. It was carved out of Kiambu and Murang'a districts, has a total area of 1,960 km^2 and neighbours Nairobi. The district is relatively small but heavily populated with some 360 people per km^2. The upper parts of the district are generally medium to high potential agricultural areas, while the lower parts are low potential. The district is dominated by fairly flat plains, with red soils in the upper parts and black cotton soils and rock portions in the lower parts. The district has an estimated population of 702,000, with about two-thirds of the population being rural. There are a total of 172,000 households, out of which one quarter are female-headed households. Main town centres are Thika, which is the district headquarters and is home to many industries, Ruiru which is 15 km from Thika town and also fairly industrialised, Githurai which borders Nairobi and is a major retail market for farm produce and Gatundu which is a market for livestock and vegetables. Other towns outside the district but of major commercial importance include Nairobi, Matuu, Mwingi, Garissa, Maragua and Kandara, all of which provide markets for produce from Thika.

The district has a relatively good transport network especially in the upper part which has a good distribution of tarmac roads. The lower parts have black cotton soils (vertisols) and are sometimes inaccessible especially during the rains. There are also several seasonal rivers in these parts of the district with no bridges making the roads impassable during the rains.

In terms of agricultural productivity, the district can roughly be divided into three zones: the high-potential western and northern parts of the district, which are dominated by coffee, tea and dairy farming; the middle part being of medium potential; and the semi-arid eastern parts where cattle rearing and irrigated horticulture are the main forms of commercial farming. Areas fronting any of the five main rivers have high potential for irrigated farming. The district also has two main forests, Kimakia and Kamae forests.

Out of the total district population, it is estimated that 68% represent smallholder farm families. An estimated 30% of these are commercial farmers, 40% semi-commercial farmers, while 30% are purely subsistence farmers. The smallholder farmers have an average size of one hectare per farmer. The main commercial crops grown by smallholders are tea and coffee. Maize, beans, cabbage, kales, bananas, Irish potatoes and tomatoes are grown both for subsistence and commercial purposes. Livestock production is also practiced, mainly dairy farming, poultry and to a lesser extent rearing dairy goats. Tea growing is practiced in the upper parts of the district. There are five tea factories. Tea leaf is delivered to the buying centre on the day it is harvested, so the farmer is not responsible for storage, preservation, processing and packaging. The KTDA lorries collect the leaf. Tea marketing and sales are also handled by KTDA on behalf of the farmers.

Table 3

Main smallholder commercial crop and livestock production activities in Thika District

Crop / livestock production	Estimated number of smallholders	Estimated area (ha)
Coffee	unknown	11,800
Potatoes	23,400	7900
Maize	9000	13,600
Beans (intercropped with maize)	9000	9500
Dairy farming	9000	x
Bananas	8500	2300
Poultry (broilers)	4000	x
Cabbages and kale	2000	400
Tomatoes	500	360

Coffee is grown by smallholders who are members of about 35 cooperative societies, and is processed by 27 coffee factories in the district. The farmer needs to transport the coffee berries to the factory and this is usually done by family labour. Drying sheds and storage facilities for coffee berries are necessary. The cooperative society is in charge of pulping and then delivering the coffee beans to a miller who also does the sales and marketing. Some of the institutions involved in coffee production are the CRF, CBK, KPCU, and Thika Coffee Mills.

Maize and beans are normally intercropped and grown by farmers throughout the district. To store their maize, farmers need gunny bags and a clean, fumigated store. When ready, farmers transport the bags to the market, to millers and sometimes to the NCPB depot. Farmers also use gunny bags for storage of beans, which they transport to the market using hired pickup trucks or lorries, although these are often the responsibility of the buyers. About half of the smallholders who grow cabbage and kale use individual irrigation systems (sprinklers). Cabbages and kales have no storage, preservation, processing and packaging requirements at farm level. Farmers, however, need efficient transport services because these products are perishable.

Banana growers are distributed all over the district. After maturity, bananas are put in ripening stores, packed in crates and transported to the market. For potatoes farmers need a storage warehouse, potato gunny bags and a means of transport to the market. Tomatoes are the least common major crop, which is grown mainly in the lower parts of the district and along the main rivers. Tomatoes do not need on-farm storage facilities; farmers pack them into crates for transportation to market centres.

Dairy farming is practiced district-wide by smallholder farmers. A cooling facility, either a refrigerator or a cold-water bath, is needed for yogurt, mala, cheese, and butter. Farmers use a pick-up truck to deliver milk, or a bicycle if they live in proximity to a milk processing plant. Dairy goat farming is a new venture practiced by about 500 smallholder farmers, mainly for subsistence milk. This is done individually, but the farmers have formed 15 groups through which they upgrade their goat breeds. Poultry, both for meat and eggs, are also common. There are an estimated 4000 farmers involved in poultry for broiler production. Most of it is done on the understanding that KenChic Kenya Ltd. will buy the broilers, but firm contracts are rare. Poultry farming for eggs is practiced by individual smallholder farmers who sell to brokers and retailers in Thika, around Gatundu and Kiamwangi towns.

There are over eighty institutions, ranging from NGOs, GOK departments, parastatals, to private sector companies and farmers groups, providing inputs and services to smallholders in Thika District. The main agrochemical manufacturing companies operate from Nairobi through appointed local agents. There are several agrochemicals stockists (about five in each market centre) spread throughout the district. These are for-profit enterprises. The quality of services is generally good, but sometimes farmers get poor quality seeds as well as fake chemicals. Thika town has a number of animal feed manufacturers. The quality of the feeds also varies as some manufactures seem to take shortcuts and as a result, there is no guarantee of uniformity in feed quality.

In Thika District, inputs are available and provided by diverse groups. The major players are profit-oriented private sector companies. There are over 16 veterinary and artificial insemination service providers in Thika District. AI services are concentrated in the coffee and tea zones, but are poorly distributed in the semi-arid areas. These service providers are private companies and individuals technical officers. Semen from the CAIS Kabete is not always top quality. Cooperative Resources International (CRI) provides better semen but at higher cost. The quality of veterinary services is fair to very good. There are a total of 158 public dip tanks of which only 23 are operational. There are good quality extension services, but these do not adequately reach smallholders. More than 14 institutions offer technical advice and training.

Government policy has changed from going to farmers, to waiting for farmer groups to seek thelR services, sometimes at a cost to the farmers who have to provide transport for the officers. The MARD has staff available but they lack transport and cannot reach farmers regularly. The approach of demand-driven extension services has reduced the number of farmers who access these services. The private sector has ventured into extension work and appears to be taking over from the ministry. Agrochemical companies provide advice and technical services especially on how to use their products, an approach aimed at boosting sales. Most farmers now depend on agro-vets for their technical advice, which they solicit as they buy inputs.

There are over 17 banking institutions and MFIs in the district. Their loans are out of reach for smallholder farmers because of the loan conditions and fairly high interest rates. The majority of financial institutions are not interested in credit delivery to smallholder farmers. They consider farming, especially rainfed farming, a risky business. Farmers have very limited access to credit now that institutions like the AFC do not have money to lend out. There are a few NGOs attempting to fill this void, but they can hardly meet the demand and there are complaints that these organizations offer small amounts that farmers do not find useful.

There are about 12 public markets where smallholders sell their products and goods. Thika district has about 13 post-harvest service institutions. There are a few milk processing plants as well as fruit processing plants. With value-adding processors lacking in Thika District, most farmers sell their raw produce to brokers. This is especially true for horticultural crops and dairy products. Cooperatives, once a vibrant sector, are no longer operating effectively. Of about 226 registered cooperatives, 146 are operational.

The low prices of coffee coupled with high production, processing and marketing expenses have had a negative impact on the members' payments. All dairy cooperatives in the district are dormant as farmers fear that their money will be squandered by office bearers as has happened in the past. This has created marketing and general crop production challenges, and many smallholder farmers attempt to go it alone. Great opportunity awaits genuine marketing agencies, as farmers have the capacity for substantial production but do not have reliable markets.

Kirinyaga District (Community-Organisation-Consultants 2003)

Kirinyaga District lies on the southern slopes of Mt Kenya and occupies an area of 1,478 km^2. The district is relatively small but densely populated and of moderate to high potential. Kirinyaga is divided into three distinct relief zones: lowlands of gently rolling plains and isolated hills; the midlands; and the highlands bordering Mt

Kenya forest. The soils in the upper areas range from red to red-brown clays, which are deep and well drained. Volcanic ash soils are also found on the foothills of Mt Kenya. In the lower areas of Mwea Division, the soils are mainly black cotton of low fertility or poor workability. Several major tributaries of the River Tana traverse the district. There are three small salt lakes in Gichugu Division and natural caves in Central Division (Kutus). A significant area of the district is covered by part of the larger Mt Kenya forest. Administratively, the district is made up of four divisions. The district headquarters are in Kerugoya town.

The district road network is relatively good and can support the economic activities undertaken. However, in the hilly topography, gravel and earth roads transverse steep sections and are impassable during the rains, resulting in difficulties in transporting agricultural produce to the market.

Kirinyaga district has an estimated population of 457,000 people (1999) with a rural population of 402,000 people. There are a total of 114,000 households out of which 15,000 are female headed. Besides the district headquarters, other towns of importance are Kagio and Kutus, which are major markets and Sagana, Kagumo and Kimbimbi. Important towns outside the district are Karatina, Makutano, Murang'a, Nyeri and Embu, which are the major markets for farm produce from the district.

Out of the district's population of smallholder farmers, about 15% are commercial farmers, 35% semi-commercial, while the other 50% are subsistence farmers. The average smallholder farm size is 1.5 ha. The main commercial crops in the district are tea, coffee, rice, and horticulture crops, including tomatoes, French beans and vegetables. The main activities in livestock production are dairy farming and poultry keeping.

Table 4

Main smallholder commercial crop and livestock production activities in Kirinyaga District

Crop / livestock production	Estimated number of smallholders	Estimated area (ha)
Coffee	171,000	14,000
Rice	99,000	10,600
Dairy farming	63,000	x
Maize and beans (intercropped)	45,000	27,000
French beans	30,000	3000
Tea	27,000	5900
Tomatoes	20,000	2000
Bananas	12,000	2400

An estimated 27,000 farmers deliver their tea to five tea factories in the district. Tea is harvested and immediately taken to a buying centre, from where the KTDA takes over and does the processing, packaging and marketing on behalf of the farmers. Tomato is another crop of importance in Kirinyaga District. Farmers grow tomatoes mainly in Mwea Division, both rainfed and using irrigation systems. There are about 35 small community irrigation schemes where tomatoes are grown, in total involving some 11,000 farmers. To grow tomatoes, a typical farmer needs starting capital of at least KSh 40,000 per hectare. Tomatoes are also sold at farm gate and no on-farm storage is necessary, but farmers need plastic or wooden crates to pack the tomatoes for transport to urban markets. French beans are also mainly grown in Mwea Division. The Kibirigwi Irrigation Scheme has about 84 ha under French beans, mostly grown under loose contracts between exporters and farmer groups. Before deciding to grow French beans, a farmer needs to know the best variety

to plant as well as how to grade the beans. French beans are sold as they are harvested, are packaged in cartons and normally picked up from the farm gate or a known collection point by exporters and brokers.

Banana farmers are spread throughout the district, with high concentrations in Ndia Division. These are mainly individual farmers, but there are three groups of about 120 farmers who came together to attempt marketing bananas as a group. After harvesting, bananas require no storage if being sold green, but a ripening store is necessary if they are to be sold as fruits. Bananas are packed in crates or wrapped with dry banana leaves. They are either sold at the farm gate or taken to the market.

Rice is a major crop in Kirinyaga District, mainly grown in Mwea Division. About 78,000 farmers grow rice under the Mwea Irrigation Scheme while another 21,750 farmers grow what is referred to as *jua kali* rice, i.e., outside the irrigation scheme. To grow rice, a farmer needs to prepare the land, acquire certified seeds and establish a nursery. The farm needs to be flooded with water before transplanting, and weeding is very important thereafter. It costs about KSh 90,000 to plant a hectare. Rice is labour intensive during harvesting, winnowing and threshing. Farmers need a suitable place to dry the rice before it is packed in gunny bags and delivered to the rice mills, mostly concentrated near towns. The once vibrant rice market at Mwea Tabere has virtually collapsed due to management conflicts between the farmers and the NIB. Farmers stopped selling their rice to the NIB and are selling it on their own under the Mwea Rice Growers Multipurpose (MRGM) Cooperative Society. Although this is a promising development, the society needs institutional and capital support to be able to pay farmers fairly and on time. Maize and beans are commonly grown as intercrops. Maize farming is labour intensive especially during weeding. Maize is dusted with a pesticide to preserve it, and then stored in a well-ventilated, clean store that is fixed with rat guards. Depending on the quantity of maize, a vehicle for transport to the market may be necessary.
In spite of the large number of farmers who grow coffee, it is not as important as tea in terms of the revenue generated. Coffee growing is mainly concentrated in the midlands, where coffee farmers are organised around cooperatives. Coffee farming is labour intensive during pruning, and credit is required for coffee farm management. The coffee is packed in sisal bags to be taken to the cooperative-owned factory where processing and marketing is done. There are 77 coffee factories and about 16 coffee societies involved. The coffee industry has almost collapsed due to prolonged low prices and mismanagement of the coffee cooperative societies that has resulted into many splits. As a result, farmers have abandoned their coffee for other crops, especially horticulture.

In livestock production, dairy farming is the most common activity. This is done individually but there are ten groups of about 200 farmers who have come together to jointly market milk and procure AI services. Dairy farming is concentrated in the coffee zones. There are about ten poultry farmers groups of approximately 250 members who attempt to market and breed together. Ideally, a dairy farmer plants fodder crops beforehand and constructs a zero grazing unit. A cooling facility is needed for storing milk: it can be either a refrigerator or a coldwater bath. Milk is transported in aluminium cans to a collection point.

There are numerous input suppliers in Kirinyaga District. Many operate from Nairobi with only sales people visiting the district regularly. Stockists in the district are mostly based in Kerugoya town and in the smaller towns. There are a total of 94 stockists in Kirinyaga District. Cattle dips and AI services were privatised in the early 1990s and are now provided by the private sector, cooperatives, religious organisations and community groups, with the MARD veterinary department coordinating the activities. The farmers view the services as expensive as they have to pay for the semen and provide transport for the officers. There are about 114 cattle dips, 112 are public and two private. The private ones are operational, while only 68 of the public dips are operational. The growing number of non-operational dips is attributed to the KSh 25-30 charged for a service that farmers used to get for free. The communities have proved they cannot manage these dips even after being provided with the acaricides by the government.

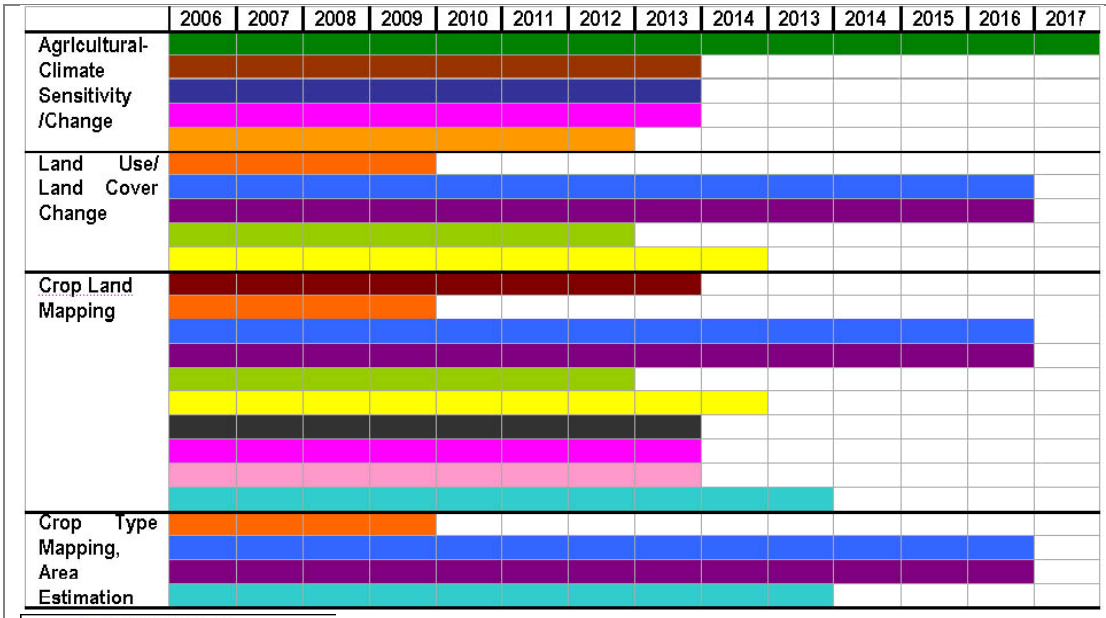
Technical advice is mainly offered by the private sector, including at least three agrochemical companies, the Agrochemicals Association of Kenya (AAK), five tea factories and the HCDA (Horticultural Crops Development Authority), as well as about four NGOs. The orientation of these institutions is mostly outreach: they organise field days to train farmers on various farming aspects. Some of the multinationals are also involved in this, both as a service to the farmers and to boost product sales.

The district has five banks and several non-bank financial institutions, but only one explicitly offers credit to farmers. All the banks are based at Kerugoya town, only KCB has another branch at Mwea town. The lending conditions of micro-finance institutions and banks are not favourable to smallholder farmers. There are eight open air markets in the district, two in each of the four divisions. Even the permanent ones have days that are referred to as the market days when there is usually more activity. There are many institutions involved in post-harvest activities, with a good number based outside the district. These institutions include five tea factories, six private sector companies and the HCDA that deal with French beans and other horticultural produce, two major coffee mills and one rice mill. Kirinyaga District has one large cooperative union and ten different types of cooperatives. There are a total of 73 registered cooperative societies, out of which 39 are active, five are semi-active and 29 are dormant.

Coffee societies are in the majority, 17 cooperatives that run 77 coffee factories, followed by 15 savings and credit cooperatives (SACCOs). The key crops that farmers rely on for income are tea, tomatoes and French beans. While the tea marketing is taken care of by the KTDA, marketing of tomatoes is mostly carried out at the farm gate. There is need for an improved system of marketing especially for the horticultural produce as the brokers currently dominate the market. The French bean market is controlled by a few exporters who provide farmers with seed and inputs on credit. There are no enforceable contracts and sometimes farmers or the exporters break the agreements unilaterally.

There are great opportunities for the dairy industry in Kirinyaga, as the district is served by only one dairy processor who cannot take all the milk. However, milk marketing needs to be streamlined so that both the producers' and investors' interest are balanced. Farmers are moving away from the technical advice and training provided by the MARD to private sector players who provide extension services when farmers buy their supplies and inputs. Some farmers are also benefiting from NGOs providing training and credit in the area and at the same time advising on sustainable agriculture.

Annex 3 Satellite systems



GEOSS/IGOL global agricultural monitoring requirements mapped against a number of the current satellite remote sensing systems for the next 10 years (The operational timelines of these systems are approximate) (GEO 2007).

The agricultural – climate sensitivity/change component can be addressed using coarse spatial resolution (500m – 8km) sensors such as the NOAA and MetOP AVHRR's, MODIS, SPOT VGT polar orbiting series. To monitor impacts of climate variability on agriculture, high temporal resolution data are needed and can be met by these sensors with a large spatial footprint and daily global coverage. The land use / land cover change, crop-land mapping, crop-type mapping and agricultural area estimation requirements can be met by moderate to fine spatial resolution sensors including the LANDSAT, SPOT, CBERS, IRS-AWiFs systems amongst others. The spatial resolution requirements will vary as a function of field size. In countries where large scale agriculture is common, e.g. USA, Argentina, Australia, Russia, Brazil most requirements can be met using sensors with a spatial resolution of 30 – 80m. In other countries for example in Africa and Europe where farm sizes are small and the agricultural landscape complex, mapping crop types and estimating agricultural area requires sensors with a spatial resolution less than 20m e.g. SPOT HRV (GEO 2007).

Annex 4 WRMA & WRUA responsibilities

19. **The focus will be on management of catchment area of Upper Tana River in the South-east Aberdares**[11]. Activities will include strengthening of the information base, improving decision making to include water users, training and sensitization of farmers to improve land-use and water conservation methods. The WRMA will target microcatchment 'hotspots' and through the above mentioned process, and invest one million dollars per year in catchment protection activities such as erosion control and terracing, small to medium water storage infrastructure and the rehabilitation of existing structures as well as improvement of on-farm agronomic practices. The regional WRMA will work closely with the KFS to ensure synergies with their work in the gazetted forest and with neighboring communities.

20. **There are two levels of activities which will be funded by the project related to catchment management activities**—these are:

(a) **Level 1: WRUA activities, supported by WRMA funding**, include the following (Note that the costs incurred by the WRMA in supporting these activities would be recouped by the WRMA retrospectively on the basis of 15 percent of the project costs):

i) riparian demarcation; what, when, who?

ii) catchment protection; " " "

iii) distribution of seedlings;

iv) establishment of WRUA; " " "

v) planning and training workshops; and

vi) preparation of bankable proposals.

(b) **Level 2: These will be WRUA activities, funded independently of the WRMA.** The activities would be included in project proposals (which are subject to the approval of the WRMA) and could include, but not necessary be limited to the following:

i) training and capacity building for WRUA stakeholders;

ii) mobilization of water resource users in WRM activities;

iii) activities associated with mitigation of water use conflicts;

iv) works for abstraction works, including the costs related to the modification of intakes, installation of master meters and water abstraction control devises;

[11] The Upper Tana catchment project area will include the area west of the major hydroelectric dams, including the districts of Kirinyaga, Muranga, Maragwa, Thika, and Nyeri,.

v) development and implementation of water allocation plans;

vi) development of gauging stations and stations to assist in monitoring the quantity and quality of the Reserve;

vii) water storage development, including pans, small dams, rain water harvesting;

viii) river bank protection and improved land use and delineation, conservation or protection of riparian land;

ix) catchment protection, including the costs of seedlings and other activities;

x) settling ponds, composting pits and other structures to reduce effluent discharge;

xi) work and or activities orientated towards assisting abstractors or dischargers to become compliant to the WRM Rules;

xii) works to control runoff and soil erosion such as check dams, terraces, storm water drains, etc.; and

xiii) works associated with the protection, conservation or enhancement of the water resource quality.

21. **The role of WRMA will be to prepare and enforce codes of practice and standards relating to the abstraction, use, allocation and management of the resource.** As the WRM regulator, the WRMA will avoid engaging in the direct implementation of WRM activities, and avoid the holding of monies for the execution of such is fundamental to its maintaining its independent role and is a key element of best practice and good governance. Whilst WRMA energetically supports the WRUAs in the preparation and development of the SCMP and its related projects, it is not involved in the design or implementation work.

22. **The above principles represent a significant achievement in terms of establishing the clear delineations of roles and functions of water sector institutions** as a pre-requisite framework to enhance good governance, and supporting check and balance mechanisms for quality control within the sector. The funds provided to WRUAs to support them in the implementation of their SCMPs, whether from donors or from revenue collected by WRMA, are to be entirely routed through the WSTF or other mechanisms such as District Steering Committees. 80 percent of the funds are henceforth under the direct management of the WRUA and the stakeholders who have the most to gain (and to loose) through their effective and transparent use. In this clear way the activities of the WRMA and the WRUAs further supports the development of democratic mechanisms to empower local organizations. WRMA will provide direct financing to WRUAs for WRM capacity building activities in the preparation of the SCMPs and the funding proposals to be submitted to the local financing mechanism, which may include

the establishment of WRUAs, planning workshops, riparian demarcation, abstraction monitoring, catchment protection and other similar activities:

(a) WRMA will support WRUAs in preparing SCMPs for submission to the local funding mechanisms. WRMA may assist the WRUA to engage consultants/NGOs with experience in this field to support the WRUA to prepare detailed proposals, which may include the preparation of detailed engineering designs and other activities which are better out-sourced.

(b) WRMA will support the WRUA in developing TORs and selecting consultants/NGOs for the preparation of detailed designs and/or implementation support required. In this way it will reduce the risk of there being a conflict of interest, where the role of facilitator, supervisor and regulator become merged.

(c) The role of the WRMA in the preparation of SCMPs and related proposal preparation phase will be supportive. The WRUA will own the resources and manages the process. In supporting WRUA project proposal preparation WRMA will not engage in the detailed technical design of infrastructure components, as it will later approve the designs in accordance with standards. WRMA will further regulate implementation activities through inspection of the WRUA's work.

GWC Reports Kenya

GWC K1	*Basin identification*	Droogers P and others 2006
GWC K2	*Lessons learned from payments for environmental services*	Grieg Gran M and others 2006
GWC K3	*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 K4	*Quantifying water usage and demand in the Tana River basin: an analysis using the Water and Evaluation and Planning Tool (WEAP)*	Hoff H and Noel S 2007
GWC K5	*Farmers' adoption of soil and water conservation: the potential role of payments for watershed services*	Porras IT and others 2007
GWC K6	*Political, institutional and financial framework for Green Water Credits in Kenya*	Meijerink GW and others 2007
GWC K7	*The spark has jumped the gap. Green Water Credits proof of concept*	Dent DDL and Kauffman JH 2007
GWC K8	*Baseline Review of the Upper Tana, Kenya*	Geertsma R, Wilschut LI and Kauffman JH 2009
GWC K9	*Land Use Map of the Upper Tana, Kenya: Based on Remote Sensing*	Wilschut LI 2010
GWC K10	*Impacts of Land Management Options in the Upper Tana, Kenya: Using the Soil and Water Assessment Tool - SWAT*	Hunink JE, Immerzeel WW, Droogers P, Kauffman JH and van Lynden GWJ 2011
GWC K11	*Soil and Terrain Database for the Upper Tana, Kenya*	Dijkshoorn JA, Macharia PN, Huting JRM, Maingi PM and Njoroge CRK 2010
GWC K12	*Inventory and Analysis of Existing Soil and Water Conservation Practices in the Upper Tana, Kenya*	Muriuki JP and Macharia PN 2011
GWC K13	*Estimating Changes in Soil Organic Carbon in the Upper Tana, Kenya*	Batjes NH 2011
GWC K14	*Costs and Benefits of Land Management Options in the Upper Tana, Kenya: Using the Water Evaluation And Planning system - WEAP*	Droogers P, Hunink JE, Kauffman JH and van Lynden GWJ 2011
GWC K15	*Cost-Benefit Analysis of Land Management Options in the Upper Tana, Kenya*	Onduru DD and Muchena FN 2011
GWC K16	*Institutes for Implementation of Green Water Credits in the Upper Tana, Kenya*	Muchena FN and Onduru DD 2011
GWC K17	*Analysis of Financial Mechanisms for Green Water Credits in the Upper Tana, Kenya*	Muchena FN, Onduru DD and Kauffman JH 2011

GWC Reports Morocco

GWC M1	*Impacts of Land Management Options in the Sebou Basin: Using the Soil and Water Assessment Tool - SWAT*	Terink W, Hunink JE, Droogers P, Reuter HI, van Lynden GWJ and Kauffman JH 2011
GWC M2a GWC M2b	*Options de gestion de l'eau verte dans le bassin du Sebou, Maroc – Analyse avantages-coûts utilisant le modèle WEAP* *Green Water Management Options in the Sebou Basin: Analysing the Costs and Benefits using WEAP*	Droogers P, W Terink, J Hunink, S Kauffman and G van Lynden 2011
GWC M3a GWC M3b	*Aspects institutionnels et financiers* *Institutional and Financial Aspects*	Benabderrazik H 2011

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