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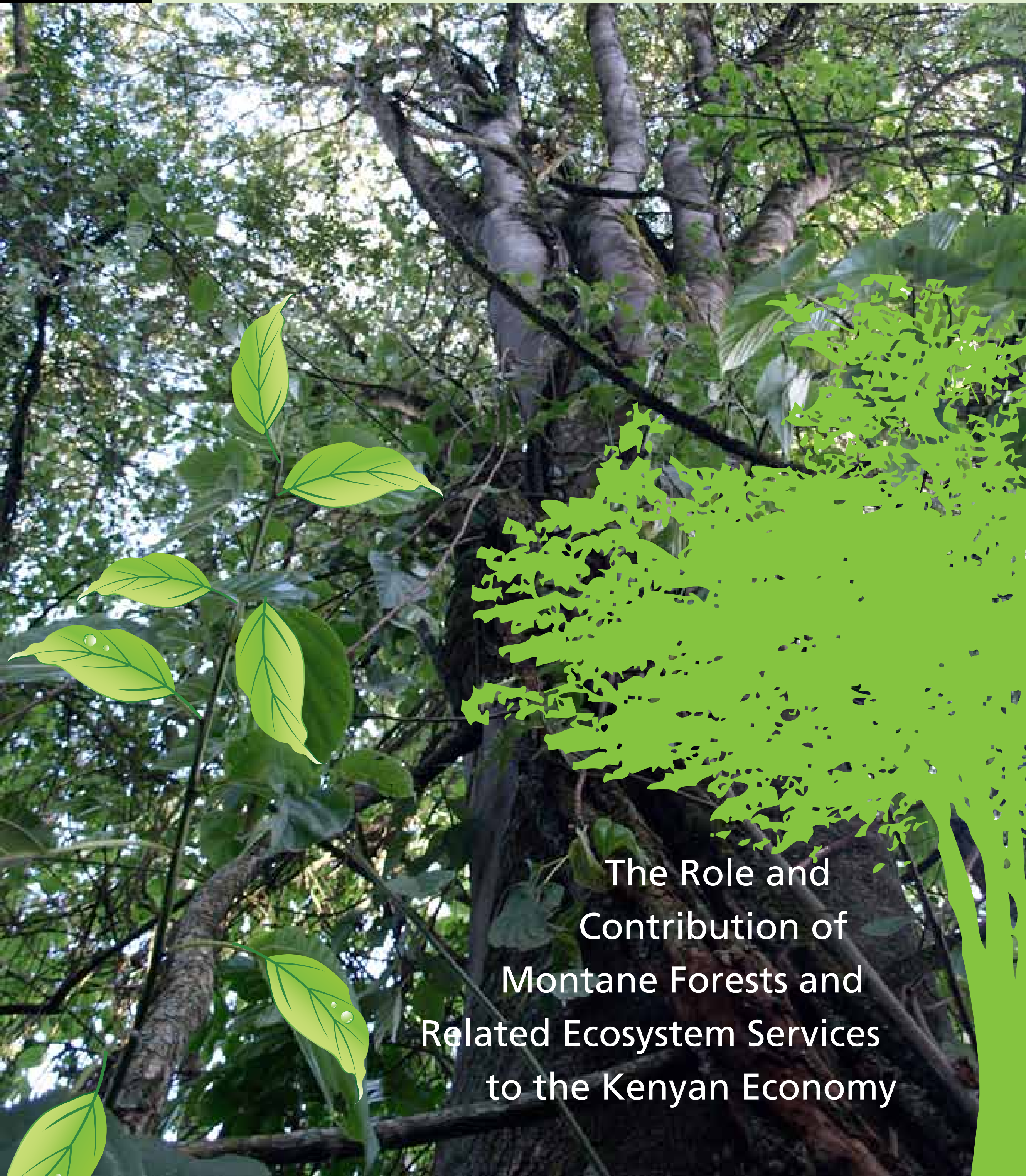

The Role and Contribution of Montane Forests and Related Ecosystem Services to the Kenyan Economy

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Contents

Foreword

Forests and their related ecosystem services play an important role in supporting economic activities and human well-being. This publication highlights the importance and contribution of Kenya's montane forests or "water towers" to its economy. The value-added by forest services to Kenya's economic sectors have either consistently been undervalued or ignored by headline economic indicators such as the Gross Domestic Product (GDP). Measuring and understanding the economic value of forests is important for decision-making processes including planning and budgetary allocations. The recently concluded UN Conference on Sustainable Development (Rio+20) has re-affirmed and underlined the need to better account for natural capital and critical ecosystems such as forests and urged member states to use a "new system of environmental and economic accounts" towards a transition to a Green Economy.

This publication represents some of the on-going efforts by the Government of Kenya in this direction, including its recently launched Green Economy initiative and the country's overarching development aspirations embedded in the strategic document entitled 'Vision 2030'. Among the six sectors identified as priorities within the Medium Term Plan 2008-2012 of Vision 2030, at least four (agriculture, tourism, wholesale and retail trade), which make up the largest part of Kenya's GDP, have linkages either directly or indirectly to montane forests and the crucial services they provide. Other sectors supported by forests include energy, inland fisheries and manufacturing.

Using best international analytical practices and environmental and economic evidence, this publication underlines the need for better management and increased investments in montane forests as well as innovative policy instruments such as REDD+. The extraordinary value of the ecosystem services of the Mau forest complex to the Kenyan economy calculated by the UNEP, the government and partners is already catalyzing a response and support from a range of donors and the private sector.

This publication, if acted upon, may provide similar pathways to improve the prospects and sustainable management of forests elsewhere in the country and provide inspiration for other economies in East Africa and beyond.

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Abstract

The montane forests of Kenya, better known as Kenya's "Water Towers", produce direct economic value for its citizens. This value accrues not only from the production of various timber- and non-timber forest products, but also from a range of regulating ecosystem services that provide an insurance value to several key economic sectors. There is also a secondary or indirect multiplier effect associated with the direct economic value of the Water Towers.

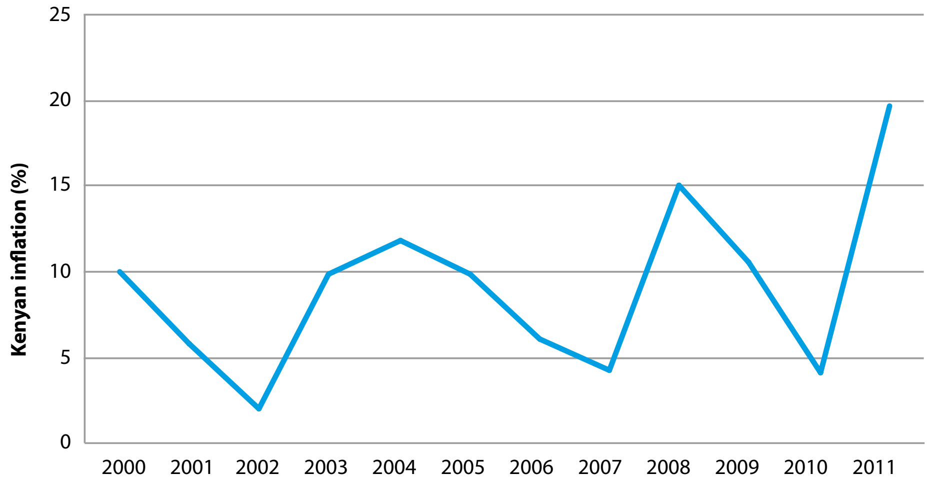
This report estimates these economic values, by means of best international analytical practices and environmental and economic evidence from Kenya, and shows that montane forests have consistently been undervalued in conventional national accounting.

The findings underline the need for better management, increased investment in montane forests and innovative policy instruments (such as Reducing Emissions from Deforestation and forest Degradation (REDD+)).

1. Summary

Kenya's economy grew at an average rate of 5% of Gross Domestic Product (GDP) per year over the period 2000-2010. However, this growth was highly variable and interspersed with periods of extreme rates of inflation (Figure 1.1). Country inflation rate is a measure of economic resilience. It measures the ability of an economy to maintain its function and growth under the influence of external factors.

Figure 1.1: Inflation is an indicator of economic resilience



Note: Inflation in Kenya has exceeded 10% on four occasions since 2000. In all these instances, inflationary pressure resulted from droughts, combined with increasing crude oil prices and weaker exchange rates. The Kenyan economy is highly vulnerable to water availability.
Source: UNEP 2012a

Kenya's vulnerability to high inflation results from three key factors. Firstly, Kenya has a fledgling energy sector, and thus the economy is sensitive to increases in international crude oil prices. Secondly, the economy is vulnerable to inflationary pressures when the Kenya Shilling (KSh) weakens against the currencies of its major trading partners. Thirdly, inflationary pressure arises during periods of drought when the water-dependent economic sectors come under pressure.

The Water Towers of Kenya have a positive impact on the economic resilience of the country. This positive impact stems from the significant economic benefits provided to the economy of Kenya. The forest sector as a whole comprises montane forests (the Water Towers), other indigenous forests, plantation forests, dryland forests and farm forests. The forest sector has strong linkages to the rest of the economy, both in providing intermediate products and services for the industries downstream and providing goods for consumption by households. The montane forests in particular do not only provide such goods but, in addition, provide a range of services that supply an insurance value to the economy. This insurance value is important, not only to maintain economic resilience to seasonal environmental and economic changes but also to long-term economic hazards, such as climate change.

The Millennium Ecosystem Assessment (MA 2005) defines these services as regulating services. Not only do these services regulate Kenya's water yield (the total water yield from the Water Towers is possibly more than 15,800 million cubic meters per year (m^3/year), which is more than 75% of the renewable surface water resources of Kenya) and thus water-dependent sectors, but it also benefits a range of other economic sectors. These include the agriculture, forestry, fishing, electricity, water, hotels and accommodation, public administration and defence sectors.

UNEP's technical report *Kenya Integrated Forest Services* (UNEP 2012a) shows evidence of the value of these forests and the effects of deforestation. In the 10-year period, 2000-2010, deforestation in Kenya's Water Towers amounted to an estimated 50,000 hectares (ha). By 2010 such deforestation of montane forests yielded a timber and fuelwood volume of 250 m^3/ha, with a cash value of 272,000 KSh/ha. At an estimated deforestation rate of 5,000 ha/yr by 2010, this was equivalent to a cash revenue of approximately KSh 1,362 million in 2010. It is these types of revenue streams that provide an incentive for illegal deforestation activities. However, this cash revenue comes at a large cost to the national economy, through losses in regulating services. Whereas the cash value of forest products has a once-off value, the benefits of regulating services in preceding years continue to be felt in the economy in every subsequent year that the national asset, the Water Towers, is degraded. By 2010, the cumulative negative effect of deforestation on the economy through reduction in regulating services was an estimated KSh 3,652 million/yr, more than 2.8 times the cash revenue of deforestation.

The largest component of this was attributable to changes in river flows resulting from a reduction in dry-season river flows, which reduced the assurance of water supply to irrigation agriculture. This reduced agricultural output by KSh 2,626 million in 2010 (UNEP 2012a). Reduced river flows also lowered hydropower generation by KSh 12 million. Although not a very high value in relative terms, the multiplier effect of hydropower on the rest of the economy is considerable. In 2010, reduction in water quality due to siltation and elevated nutrient levels running off degraded land into fresh water systems reduced inland fish catches by KSh 86 million and increased the cost of water treatment for potable use by KSh 192 million. Well-managed montane forest cover reduces malarial disease prevalence. Incidence of malaria as a result of deforestation is estimated to have cost KSh 395 million by 2010. This resulted in additional health costs to the Government of Kenya and through losses in labour productivity. Forest loss is also detrimental to the global carbon cycle. The above-ground carbon storage value forgone through deforestation was estimated at KSh 341 million in 2010 (UNEP 2012a).

The benefits of the forests have an economy-wide effect with a considerable multiplier effect. An industry that directly depends on regulating services generates demand upstream (for intermediates from other industries) and also supplies inputs to other industries downstream. Taking into account these interdependencies between sectors, the decrease of regulating services due to deforestation caused a total impact of KSh 5.8 billion in 2010. This means that the cost of limiting regulating ecosystem services as a production factor for the economy was all in all 4.2 times higher than the actual cash revenue of KSh 1.3 billion (UNEP 2012b).

The challenge for Kenya (and other countries facing natural-resource degradation) is to institutionalise incentives for internalising the benefits of sustainable management of forests. For instance, in the case of the UN's Reducing Emissions from Deforestation and forest Degradation (REDD+) initiative, a carbon value of US$ 6/ton provides insufficient economic incentive (KSh 68,200/ha) to compensate for deforestation (KSh 272,000/ha). However, this analysis shows that the total ecosystem service value of the montane forests far exceeds the carbon-storage value. Carbon, as a proxy for regulating ecosystem services, has a regulating-service multiplier effect of more than 7 (UNEP 2012a).

It is clear from the analysis given above that appropriate and well-funded policies, policy instruments and response strategies are required to protect the natural assets that Kenya's Water Towers represent.

2. Introduction

The MA highlighted the importance of the invaluable services provided by montane forests and their associated ecosystem services – especially measured in terms of human well-being outcomes such as livelihoods, health, and protection against natural hazards. It also warned that 60% of world ecosystems are now under threat.

One of the main recommendations from the MA was to use tools and instruments (both market and non-market) backed by data and science to further understand and better manage these assets. As pointed out by famed economist Partha Dasgupta: "At the end, everything including the supply of all commodities can be traced back to the natural environment"(2001).

Kenya's long-term strategic development is outlined in a document entitled *Vision 2030* (Republic of Kenya 2007). *Vision 2030* is based on three main pillars: economic, social, and political. The economic pillar in particular seeks to "improve the prosperity of all regions of the country and all Kenyans by achieving and maintaining a sustained 10% GDP growth rate from 2012 and beyond". Although Kenya has registered an annual real GDP growth of around 4.2% for the year 2011, the prospects and forecast for Kenya's growth potential are upbeat. A great part of achieving this growth and ultimately human well-being will be subject to the sustainable use of natural capital - especially forests. Among the six sectors identified as priorities within the Medium Term Plan 2008-2012 of *Vision 2030* at least four, which make up the largest part of Kenya's GDP, have linkages (either directly or indirectly) with montane forests and the various crucial services they provide. These sectors are: agriculture, tourism, wholesale and retail trade.

As highlighted in UNEP's *The Economics of Ecosystems and Biodiversity* (TEEB 2008) report, few ecosystem services have explicit prices or are traded in an open market. Those ecosystem services most likely to be priced in markets are the consumptive, direct-use values of 'provisioning services', such as crops or livestock and fish or water, which are directly consumed by people. Non-consumptive use values, such as recreation or non-use values, which may include the spiritual or cultural importance of a landscape or species, have often been influential in decision making but these benefits are rarely valued in monetary terms. Some other ecosystem benefits, especially regulating services such as water purification and climate regulation (e.g. carbon sequestration), have only recently begun to be assigned an economic value, referred to as "indirect use values".

All these above-mentioned values, when calculated, should form the majority of the total economic value of an ecosystem, but remain largely invisible in the day-to-day accounts of society.

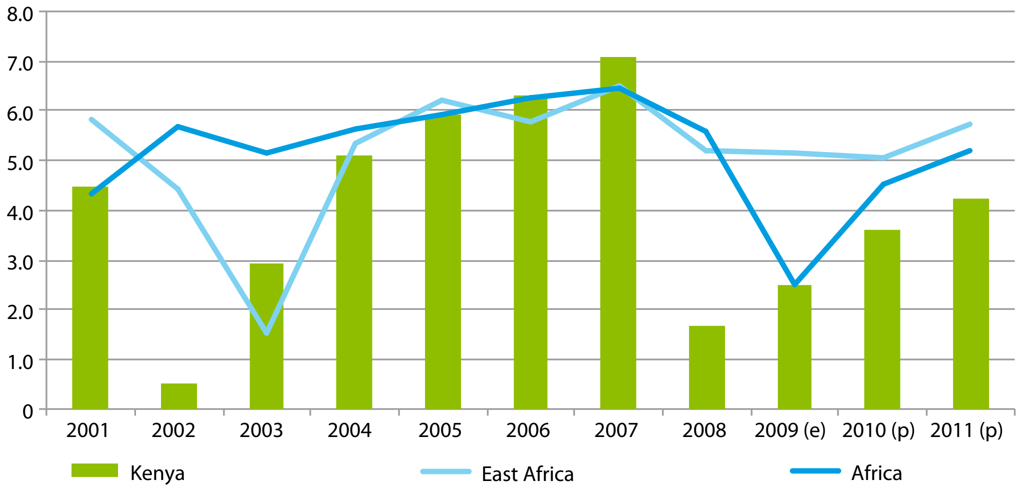
Montane forests play an important role in Kenya's economy and the shortcomings pointed out by both the MA (2005) and the TEEB (2008) reports also apply to the country as a whole. Despite increasing recognition of the multiple services provided by montane forests to human well-being, policies tend to fall short because most of these services take place outside of the market sphere and are not measured in national wealth statistics. Therefore, there are no direct incentives nor an accountability framework for preserving forests. For the most part, economic policies are ruled largely by the market and in the case of the multiple services provided by forest ecosystems this amounts to an important market failure.

3. The Kenyan economy and the contribution of forest products

GDP growth and sector contribution to value-added

In the last decade, Kenya has become Eastern Africa's hub of financial and communication services. Its economy is market-based and provides a good physical and legal infrastructure for foreign investors. Nevertheless, the agricultural sector, which plays a crucial role in terms of food security, is still by far the most dominant industry. Further challenges are persistent poverty, the high unemployment rate especially among youth, and highly volatile inflation rates. The following section briefly sketches the basic indicators for the Kenyan economy.

Figure 3.1: Real GDP growth rates of the Kenyan economy between 2001-2011



e: estimated, p: provisional
Source: AfDB *et al.* 2011

Between 2004 and 2007 Kenya's economy registered higher growth rates than Eastern Africa (represented by the members of the Eastern African Countries (EAC) Tanzania, Uganda, Rwanda, Burundi, Kenya and Djibouti, Ethiopia and Eritrea) growing at a rate of 6.1% on average (Figure 3.1). However, the 2007 post-election violence, drought and the global financial crisis triggered a slowdown of the economy, and even though the growth is forecast to continuously increase, the absolute rate lags behind the average growth rate in Africa. Reasons for the turnover were favorable climate conditions and higher prices for export goods, especially for agricultural products (AfDB 2011), demonstrating the strong reliance of the economy on this sector.

Table 3.1 presents a list of industries[1] and their corresponding shares in total value-added for the years 2000, 2005 and 2009. In 2000, the primary sector contributed more than one third of total value-added, with the agricultural industry being the main driver.

[1] Industries are classified according to the International Standard Industry Classification (ISIC)

During the last decade this position has deteriorated slowly. The production of Kenya's main crops – i.e. maize, beans, potatoes and tea – rose significantly in 2010, while horticultural products still recorded slow output growth compared to 2009.
The production of coffee and sugar cane decreased. The second important industry has been tourism, which has noticeably suffered from the 2007 post-election violence. Wholesale and retail trade and financial services also make a significant contribution to Kenya's economy, highlighting the position of the country as a regional hub. Despite its market-based orientation, the public sector, mainly represented by education, health and public administration also provides a major share in the domestic product. It is also worth mentioning that in the last years, the manufacturing and the construction sectors have become stable pillars of the economy, in which an expanding informal sector has been engaged.

Table 3.1: Sector share in value-added between 2000 and 2010, %

	2000	2005	2010
Agriculture	31.1	25.3	25.7
Forestry and logging	1.2	1.2	1.0
Fishing	0.8	0.5	0.5
Mining and quarrying	0.5	0.5	0.6
Food manufacturing	3.3	3.4	3.5
Textile and clothing and Leather and footwear	1.1	0.6	0.5
Wood and cork and furniture	0.8	0.2	0.2
Paper and Printing and publishing	1.2	0.8	0.5
Petroleum and chemicals	1.2	2.0	0.7
Other manufacturing	2.9	4.7	5.1
Electricity and water supply	2.2	2.3	2.6
Construction	3.2	4.4	4.8
Wholesale and retail trade	10.2	10.2	11.0
Hotels, restuarant and transport and communication	10.8	13.0	12.7
Financial services and real estate	10.3	10.1	11.9
Public administration	5.2	5.0	5.0
Education and health	9.1	11.1	9.5
Other community services	4.9	4.6	4.4
	100	100	100

Source: KNBS 2010

The forestry sector in the Kenyan economy: an intersectoral linkage analysis

Despite the relatively low value-added of the forestry sector[2] in the Kenyan economy (about 1% - see Table 3.1), it is important to highlight that this sector plays a key role in the Kenyan economy in terms of energy, since wood fuel and charcoal represent more than 75% of domestic energy. Between 1997 and 2009 the value-added generated in the forestry sector increased (see Figure 3.2), except for the periods of financial crisis and drought during 2001 and 2008-2009. In relation to the value-added of all other industries, it remains stable at around 1% of overall GDP. However, in assessing the importance of an industry, the share of value-added is not a sufficient indicator; it is essential to investigate its relation to other sectors as well. This section will highlight the linkages of the forestry sector to the rest of the economy over time.

Table 3.2 gives the percentage share of inputs of the forestry sector in the total intermediate inputs demanded by different industries between 2001 and 2009 (the imports of forest products have not been deducted). Wood plays a major role in the wood product industry (for the production of saw timber, veneer and construction poles) as well as in the paper industry (for the production of pulp, paper and paperboard), and the chemical industry (mainly for producing wattle bark extract and charcoal). It is also an important input for construction (timber) and the food-manufacturing sectors (predominantly industrial firewood for the tea industry).

Table 3.2: Percentage share of forest products in intermediate and final demand, 2001-2009

	2000	2004	2008
Food, beverages and tobacco	0.5%	0.6%	0.3%
Wood and cork products	13.5%	2.6%	1.5%
Paper and paper products	10.7%	19.7%	10.4%
Chemical industry	24.1%	24.6%	15.4%
Construction	2.1%	0.9%	1.3%
Households	0.9%	1.4%	1.7%

Source: UNEP 2012b

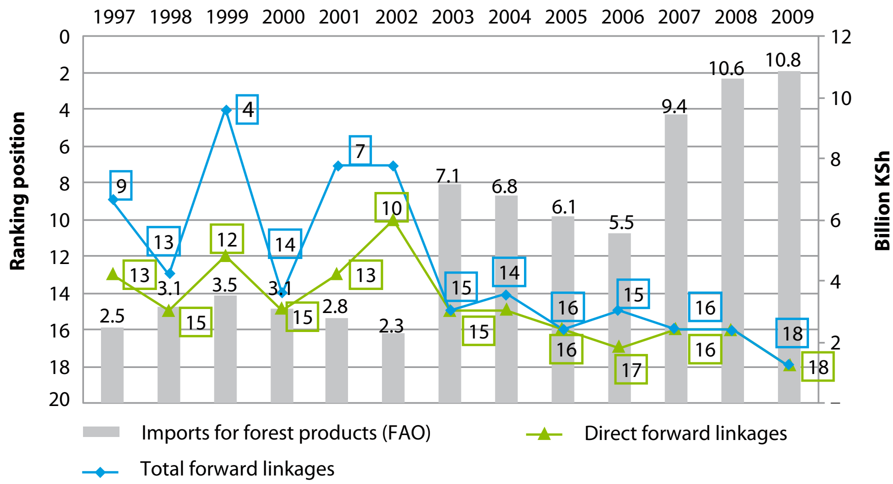
With regard to private consumption, the share of firewood and charcoal in the expenditure of private households almost doubled between 1997 and 2009.

Table 3.2 shows only the direct contribution of the forestry sector to other industries. However, its output subsequently enters the production in other industries, so that the forestry sector also has an indirect effect on the annual output produced in these sectors.

Figure 3.2 displays the ranking position of the domestic forestry sector among the other industries in the economy with regard to so-called "forward linkages". Direct forward linkages measure the role of a sector as a supplier of intermediate products to the rest of

[2] The forestry sector thereby comprises the following main activities: growing and logging of timber and pulpwood; production of wood in the rough; forestry and logging service activities, as well as the production of charcoal. Conversely, production of charcoal through distillation is included in the chemical sector.

Figure 3.2: Forward linkages: Ranking position of the forestry sector among all other industries (34 sectors in total)



Source: UNEP 2012b

the industries. By delivering to sectors such as the chemical industry and the construction sector etc., the forestry sector represents an important industry in the economy: the industry ranks on average at position 14 among all 34 sectors and is at the top of the other primary industries (agriculture, fishing, and mining and quarrying). When the indirect effects are taken into account, the significance of the domestic forestry sector rises remarkably (e.g. from position 13 to rank 9 in 1997). However, its ranking position has almost continuously deteriorated since 2003, while forest-related product imports have more than quadrupled over the whole period under study.

Value-added induced by the forestry sector

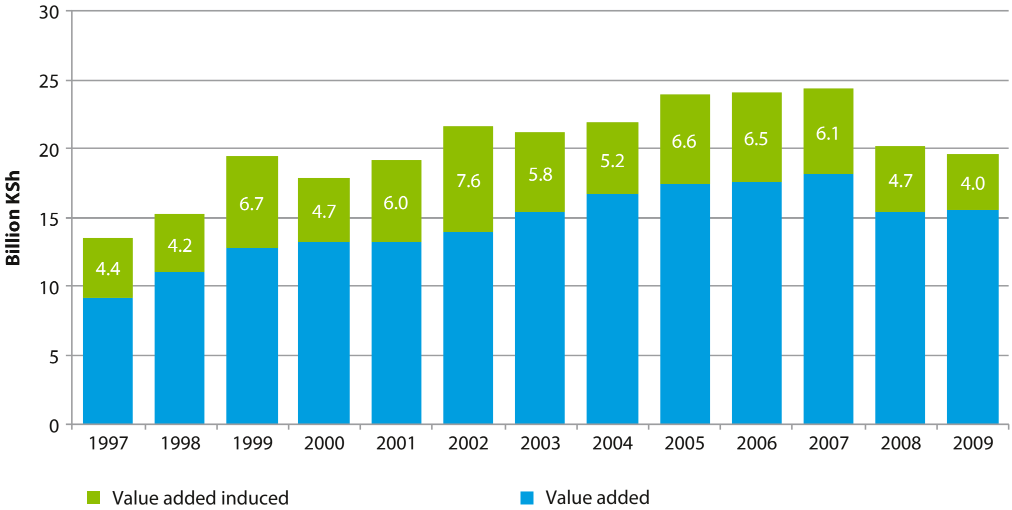
As a further indicator for estimating the economic significance of the forestry sector, the authors analysed the extent to which the forestry sector contributed to the value-addition in other sectors from 1997 to 2009. The central question behind this approach is: Given one more unit of primary input (e.g. additional labour cost) in the forestry sector, how much is the direct and indirect effect on the value-added created in any other industry?

Figure 3.3 shows the value-added created in the forestry sector as well as the added value that is induced by this sector in production downstream. While in 1997 the domestic forestry industry generated KSh 4 billion, which is 47% above its own value-added, in the rest of the industries this percentage share declined significantly to 26% (or KSh 4 billion) in 2009, implying that imports fill in the gap between current demand and actual domestic supply of forest products.

At a sector level, Table 3.3 and Figure 3.4 show the percentage contribution of the total value-added induced by the forestry sector to the added value of the other industries. The chemical sector has recorded the strongest backward linkages to the forestry sector in the period under study: on annual average, the forestry sector generated 30.7% of its total value-added induced in the chemical industry. The forestry sector also has a big impact on agriculture (15.5%), the wood and paper industry (13.3%), and the construction sector

(12.3%). The comparison over time reveals that the latter two industries have become more dependent on the forestry sector in recent years, while the linkages to agriculture have significantly decreased since 1997.

Figure 3.3: Value-added induced by the forestry sector, 1997-2009



Source: UNEP 2012b

The previous discussion clearly shows that forest and forest related products are crucial both for the industry structure (in terms of intermediate products) and the population (in terms of firewood and charcoal). However, the domestic forestry sector has become less able to meet the growing intermediate and final demand. The first of these becomes evident in an increasing trade of forest products from abroad; the second in an expanding shadow-market for fuel wood and charcoal. Regarding international trade, Kenya is a net importer of forest products: in 2009 imports of wood and wood-related articles amounted to 15.2 billion KSh, the major share of which constitutes paper board, but also wood-based panels and pulp. In comparison the value of exports was about KSh 2.7 billion. Kenya's major trading partners have been Tanzania (16% of forest imports), South Africa (12%), Sweden (10%), India (8%), China and Egypt (6%). The Kenyan Forest Service (KFS) recently reported an increasing importation of timber from the Democratic Republic of Congo and Angola's Cabinda area due to the construction boom in Nairobi. Moreover, there is a growing demand for firewood from tea factories and for electricity transmission poles. Regarding this timber shortage, the business of growing Eucalyptus trees in Kenya has been proposed as the best option for enhancing domestic supply, since investment costs are low compared to those of other cash crops. Recent studies (Senelwa *et al*. 2009; Ndegwa, 2010) show that growing Eucalyptus is a profitable business in Kenya and that farmers would be willing to plant trees on their fallow land.

A further argument for fostering sustainable biomass production in Kenya is the impact on local employment and income generation. The forest industry is still based on traditional, labour-intensive production techniques, especially in firewood and charcoal production. This is due to the particular value chain in the wood fuel market, spanning from tree growing and wood harvesting to the transport of wood fuel and retailer services. Each of these steps involves a significant amount of labour. Studies show that wood and other biomass resources generate at least 20 times more local employment within the national economy than other forms of energy, per unit (Trossero 2002). However, reliable estimates on total employment involved in biomass production and trade are difficult to obtain. This is because of the absence of associations between the market agents (FAO 2008) who work in an isolated and uncoordinated manner and due to the weak boundaries between farm and non-farm activities in an ever-increasing informal sector. It is estimated that the charcoal industry employs about 700,000 people in production, transport and trade who support more than 2 million family members (Mutimba 2005). The industry has an especially high labour stimulus in rural and poorer areas, and expanding the number of wood fuel plantations would provide even more local employment (Kammen and Lew 2005). Furthermore, it is important to consider the local disparity in fuel use: over 90% of rural households use firewood for cooking and heating while 80% of urban households depend on charcoal as a primary fuel source (EPZA 2005). The high rate of urbanization thus puts further pressure on the charcoal industry.

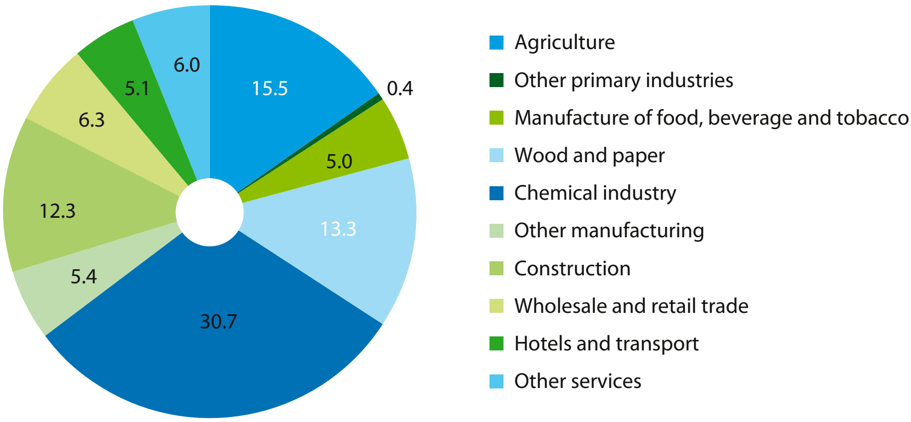
Table 3.3: Contribution of the forestry sector to value-added in the different industries (as a share of total value added induced), 1997-2009

	Agriculture	Other primary industries	Manufacture of food, beverage and tobacco	Wood and paper	Chemical industry	Other manufacturing	Construction	Wholesale and Retail Trade	Hotels and transport	Other services
1997	20.8	0.2	6.0	14.0	29.2	5.6	9.3	5.2	3.6	6.1
1998	19.8	0.2	5.5	17.2	25.5	5.5	8.9	6.6	4.3	6.6
1999	19.8	0.6	5.6	6.3	32.5	5.8	9.7	7.0	5.2	7.6
2000	14.2	0.5	3.8	10.3	27.2	5.8	18.0	7.4	6.2	6.6
2001	21.0	0.5	4.8	7.9	34.8	4.4	8.9	5.8	5.2	6.8
2002	19.4	1.0	4.8	8.2	26.7	6.3	10.9	7.3	7.1	8.4
2003	17.9	0.8	5.5	14.3	27.7	6.0	9.9	6.2	5.4	6.3
2004	15.1	0.6	5.7	17.3	26.1	6.5	8.4	7.3	6.4	6.7
2005	12.8	0.3	4.5	14.5	39.8	4.9	8.6	5.9	4.4	4.4
2006	11.7	0.3	5.1	14.4	39.5	5.5	8.3	5.9	5.0	4.2
2007	9.9	0.3	4.4	15.2	32.3	4.6	16.0	6.9	5.5	4.9
2008	10.7	0.2	4.5	15.9	33.8	4.1	17.2	5.8	3.9	3.9
2009	8.4	0.4	5.3	16.6	24.4	4.7	25.6	5.0	4.0	5.6

Source: UNEP 2012b

All these facts give rise to a discussion of future forestry policy design. One-sided, restrictive measures such as logging bans have negative side effects – e.g. increasing illegal extraction and job destruction. Policy design needs a more articulated concept of sustainable forest management that includes research on and development in improved species and more efficient production techniques, as well as incentives to invest in tree farming.

Figure 3.4: Contribution of the forestry sector to value-added in the different industries, annual average (as a share of total value induced)



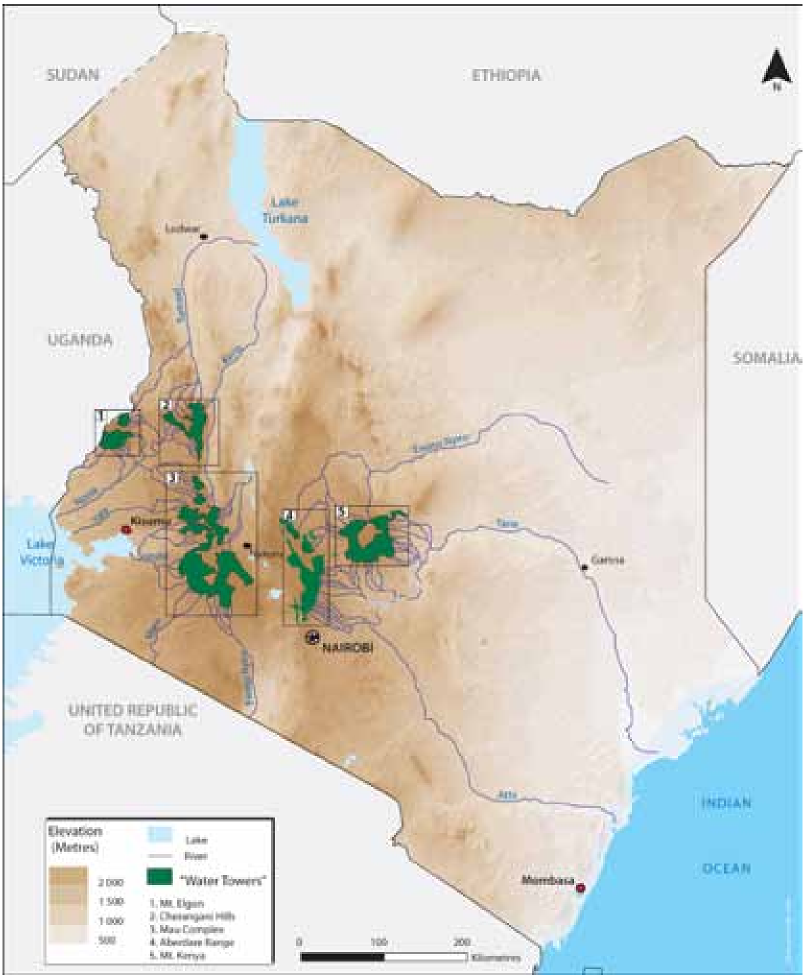
Source: UNEP 2012b

4. Kenya's Water Towers and their ecosystem services in the context of the national economy

Kenya's five Water Towers provide various benefits to the economy of Kenya

The headwaters of Kenya's five primary catchment areas all arise in five indigenous montane (mountain) forest areas. These five forest areas are commonly referred to as Kenya's "Water Towers". The five Water Towers comprise the Mau Forest Complex, Mount Kenya, the Aberdares, Mount Elgon and Cherangani (Figure 4.1).

Figure 4.1: The montane forests of Kenya - the "Water Towers". These forests lie at the source of the five major drainage basins of the country.



Source: Mogaka *et al*. 2006

The economic incentives from forest products harvested from the Water Towers lie principally in the immediate availability of woody biomass in the form of timber, fuelwood and polewood; and the opportunity to acquire land. The Kenya Forest Master Plan (1994) reports volumes for timber, fuelwood and polewood of 61,149 and 45 m^3/ha respectively in indigenous forests. Cash values for the timber and fuelwood are determined by market prices, which were KSh 3,000/m^3 for roundwood in 2010. Assuming polewood is used primarily for own use, the revenue generated by deforestation was approximately KSh 272,000/ha in 2010.

The Water Towers protect the headwaters of these river systems, and they provide a range of other benefits to the economy. These benefits are defined by the MA (2005) as ecosystem services.

The MA defines three key categories of ecosystem services: provisioning services, cultural services and regulating services. Provisioning services cover the renewable resources that are mostly directly consumed. The cultural services capture many of the non-use (or passive use) values of ecological resources – such as spiritual, religious, aesthetic and inspirational well-being. Regulating services are indirect services that determine the capacity of ecosystems both to regulate the impact of external shocks and to respond to changes in environmental conditions without losing functionality (see Table 4.1). Much of the value of biodiversity is embedded within the regulating services. These services ensure the delivery of final consumption services over a range of environmental conditions (Perrings 2006). Thus regulating services reduce risk to the economy and can be considered as providing an insurance value to the economy.

Table 4.1: Regulating services produced by Kenya's five indigenous montane forest areas

Regulating services defined in the MA	Description
Local climate regulation	Ecosystems may influence climate both locally and globally (e.g. locally, land cover changes can affect temperature and precipitation; globally, ecosystems play an important role in the carbon cycle).
Water regulation	The timing and magnitude of runoff and flooding can be strongly influenced by changes in land cover, including, in particular, changes in the water-storage potential of the system such as the conversion of wetlands or the replacement of forests with croplands or croplands with urban areas.
Erosion regulation	Vegetative cover plays an important role in soil retention and the prevention of landslides.
Water purification and waste treatment / Water pollution sink	Ecosystems can help to filter out and decompose wastes introduced into inland waters and coastal and marine ecosystems. In many cases the waste-removal capacity of the ecosystem may be exceeded. In such cases the ecosystem serves as a water-pollution sink
Disease regulation	Changes in ecosystems can directly change the abundance of human pathogens such as cholera and can alter the abundance of disease vectors such as mosquitoes.

Source: UNEP 2012a

Table 4.2: The regulating services provided by Kenya's five Water Towers and their indirect benefits

Regulating services of Kenya's five Water Towers	Economic sectors that benefit indirectly
Local climate regulation Water regulation Erosion regulation Water purification and waste treatment / Water pollution sink Natural hazard regulation Disease regulation	Agriculture Forestry Fishing Electricity (hydropower) Water services Public administration and defense Tourism (Hotels and accommodation) Households that benefit indirectly

Source: UNEP 2012a

This insurance value is important, not only to maintain economic resilience to seasonal environmental and economic changes but also to long-term economic hazards, such as, climate change.

The regulating services of Kenya's natural ecosystems are important production factors to the agriculture, forest and fishing sectors, the electricity and water sectors, tourism (hotels and accommodation sector), the public administration and defence sectors, and households (Table 4.2). These sectors, together, contributed between 33%-39% to GDP between 2000 and 2010. In addition, these sectors have a significant multiplier effect on the rest of the economy's GDP.

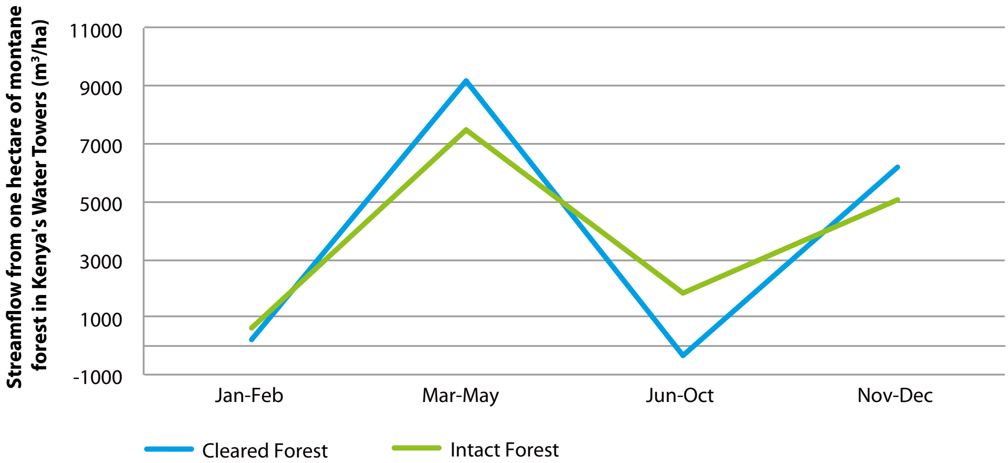
Local climate regulation and water yield regulation – the effects of forests on water availability

High-elevation, high-rainfall areas display high water yield. At an average annual rainfall of 2,300 millimeters (mm) and a potential rainfall-runoff ration of 65%, total water yield from the Water Towers could be more than 15,800 million m^3/yr, which is more than 75% of the renewable surface water resources of Kenya.

The evidence from experimental results (Bosch and Hewlett, 1982) is that deforestation and conversion to shorter vegetation types will generally increase water yield. However, in the case of Kenya's montane forests it is most likely that the gains in water yield as a result of deforestation will be offset by the loss in cloud water interception in these forests occurring at such high elevations. The Water Towers also regulate the seasonal flow of water in rivers, and deforestation can severely reduce dry-season river flows. Forests create soil-protective- and infiltrative conditions conducive to the water-holding capacity and slow release of water from a catchment, which will result in a more even distribution of flow throughout the year. Generally the higher the overall water yield from a catchment the higher the flow in all seasons and the more sustainable the flow during prolonged periods of drought.

What, therefore, is the effect of deforestation on seasonal flow in Kenya? During the rainy seasons (March to May, and November) (Figure 4.2), increased runoff from deforested areas results in elevated sediment loads and reduced water quality in fresh water systems. During the low-flow seasons, especially the five-month period from June to October, reduced water availability becomes a limiting factor to economic activities. Total annual renewable surface water in Kenya that is available for use is estimated at about 19,700 million m³/yr (Mogaka *et al*. 2006).

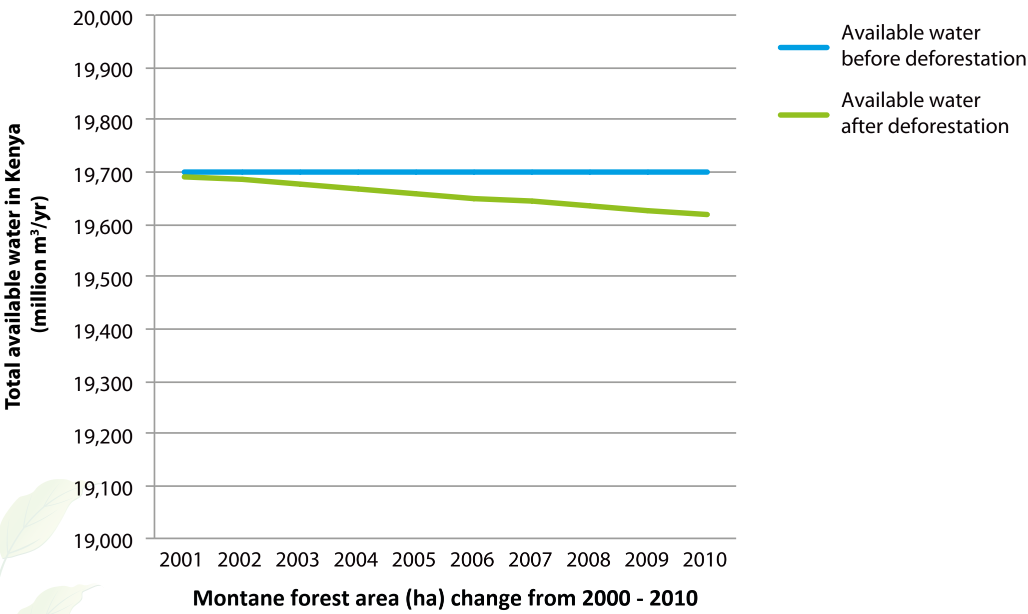
Figure 4.2: Changes in long-term seasonal flow distribution of one hectare of intact and cleared montane forest areas in Kenya's Water Towers



Note: During the rainy seasons (March to May and November), increased runoff from deforested areas results in elevated sediment loads and reduced water quality in fresh water systems. During the low-flow seasons, especially the five-month period from June to October, reduced water availability becomes a limiting factor to economic activities.

Source: adapted from Brakel (1984) and Decurtins (1985)

Figure 4.3: Based on the reduction in dry-season flow resulting from deforestation of montane forests in the Water Towers, the long-term water yield in Kenya had decreased by 62 million m³ per year by 2010



Source: UNEP 2012a

Table 4.3: Estimated water demand in Kenya for 2010

Demand by Category	Water demand projected by the Kenya Water Master Plan (million m^3/year)			Estimate of actual water demand based on actual irrigation area in 2010 (million m^3/year)
Year	1990	2000	2010	2010
Domestic water				
Urban	209	427	696	696
Rural	194	273	424	424
Industrial	80	138	180	180
Hydro-electricity				109*
Irrigation	1,447	2,851	2,957	1,434*
Livestock	119	156	227	227
Inland fisheries	16	22	28	28
Wildlife	8	8	8	8
Total	**2,073**	**3,874**	**4,519**	**3,107**

*Estimate of hydro-electricity consumptive use
Source: Kenya Water Master Plan (1992) as reported in World Bank (2006)

The reduction of dry-season flows reduces the long-term total availability of water. By 2010, the deforestation of the Water Towers between 2000 and 2010 of 50,000 ha had thus resulted in a reduced water availability of approximately 62 million m^3 per year (Figure 4.3). This reduction in water availability will affect the irrigation sector most severely, as it is the sector that has the lowest assurance of water supply. Hydropower generation will also be negatively affected as stream flow reduces.

Experiments in many parts of the world suggest that any undisturbed natural- or well-managed vegetation cover will control overland flow or surface runoff and thus peak flows. (See for example Hewlett and Helvey 1970; Hewlett and Bosch 1984; Kirby *et al.* 1991; Taylor and Pearce 1982.) Conversely, vast areas of poorly managed vegetation cover can be conducive to surface runoff and some degree of flooding. The section above has shown that wet-season flows are likely to be increased by forest conversion of significant magnitude in Kenya.

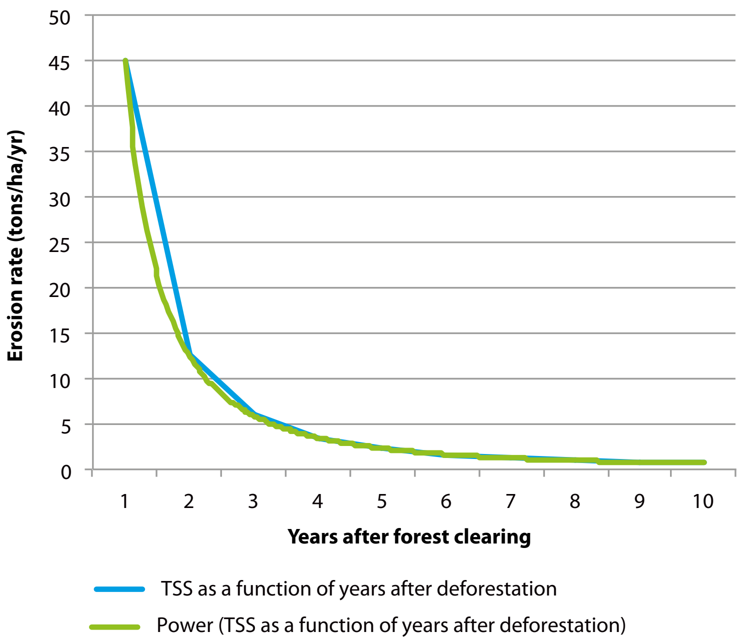
These increased wet-season flows, accompanied by cleared land areas, lead to large-scale erosion and sedimentation. Erosion results in loss of productive soil resources. This in turn increases nutrient content in fresh water systems, causes siltation of channels, reservoirs and dams, and increases turbidity of water supplies. Evidence from Kenya is that the activities that replace previous forest areas in the Water Towers are degrading to the environment (Akotsi *et al.* 2006).

Based on the evidence reviewed, erosion and sedimentation from cleared forest may thus initially proceed at a rate of 45t/ha/yr and, thereafter, reduce at a declining rate (Figure 4.4). At this rate of erosion, the cumulative effect of deforestation in the Water Towers for the period 2000-2010 was 1,990,000 tons of sediment. The rate of sediment production is displayed in Figure 4.5 below. Assuming that all the additional sediment would have been deposited in reservoirs and dams at a sediment density of 1.95 tons/m^3, the cumulative loss in water-storage capacity due to deforestation exceeds 1 million m^3 (Figure 4.5).

Google Earth image of the outflow of the Masinga Dam and the Masinga Power Station, on the Tana River, in November 2003, during the short rainy season

Note: The Masinga Dam has been well documented as suffering from severe siltation resulting from deforestation activities upstream

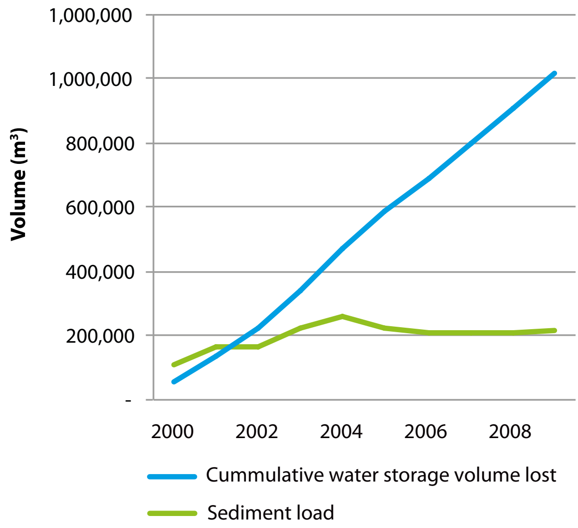
Figure 4.4: Effects of deforestation on erosion and siltation in Nigeria



Note: Total suspended solids in water as a result of erosion was high immediately after forest cleaning

Source: Lal 1985

Figure 4.5. Deforestation in the Water Towers for the period 2000-2010 produced a cumulative sediment load of 1,990,000 tons



Note: Assuming that all the additional sediment would be deposited in reservoirs and dams at a sediment density of 1.95 tons/m^3, the cumulative loss in water-storage capacity due to deforestation exceeded 1 million m^3
Source: UNEP 2012a

Water purification and waste treatment

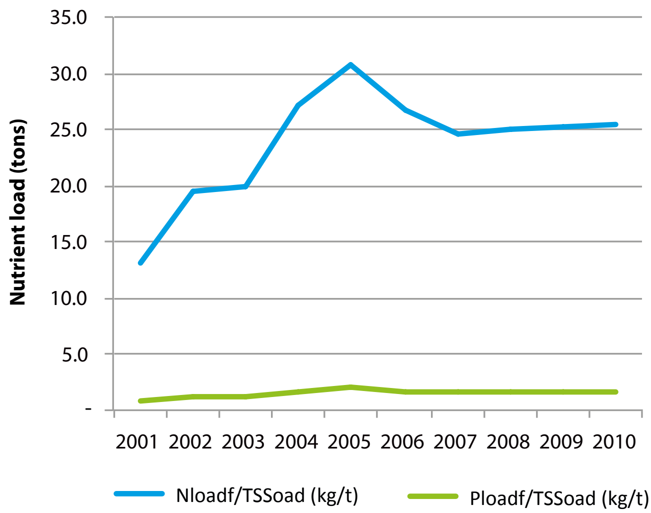
Under natural conditions, fresh-water ecosystems have the ability to self-regulate water quality. Deforestation-induced erosion and sedimentation result in water-quality degradation in the downstream catchment area to levels that exceed the ability of the natural systems to purify and treat water. This is the result of both increased sediment and nutrient loads. Elevated sediment loads and nutrient levels reduce water-storage capacity – and thus reduce water yield – reduce fish production, and increase the cost of water treatment.

Sedimentation affects fisheries in a number of ways. It results in elevated levels of suspended solids in water and this causes increased water turbidity. Increased turbidity results in decreased light penetrability in the water, which in turn inhibits phytoplankton growth. Phytoplankton is an important element in the food chain for fisheries. Increased turbidity results in increased water temperatures due to the heat-adsorbing characteristics of sediment particles, and this adversely affects aquatic biota by decreasing the amount of dissolved oxygen available and also by increasing the rate of biochemical reactions, which require more oxygen by fish. Fish therefore become oxygen deprived. Turbid water also results in the abrasion of gill membranes and interferes with the feeding of visual feeders.

Deposited sediments can also be harmful to fish habitats. Some of the impacts of increased sediment deposits on lake floors include the destruction of habitats of bottom-dwelling organisms on which fish rely for food; the elimination of sheltered areas between boulders and gravel particles that young fish need for survival; and the clogging of spaces between gravel particles that prevent the free flowing of oxygenated water and the removal of waste products from developing egg deposits in the gravel.

Increased nutrient loading in water systems increases the risk of eutrophication (Figure 4.6). Eutrophication is a result of algal blooms (biomass increase) from the plant-growth-limiting nutrients (NO_3-N and especially PO_4-P) now present in excess within the water system. Eutrophication results in decreased dissolved oxygen concentrations because of the greater oxygen demand of the primary producers (algae), which result in fish kills. The formation of the algal mats on the water surface results in decreased light penetrability. Increased primary production will also result in increased hyacinth growth. Increased hyacinth growth will further decrease the water quality by the increase in organic material content of plant material degradation and the resulting toxic conditions. Hyacinth also influences the accessibility of water as a resource and negatively impacts on the fishing communities due to increased hiding places for fish and decreased sites of extraction. Cyanobacteria flourish in the presence of increased accessible nutrients and produce toxic substances, resulting in secondary water-quality degradation.

Figure 4.6: Increased nutrient loads (nitrogen and phosphorus) resulting from deforestation in Kenya between 2000 and 2010



Source: UNEP 2012a

Disease regulation

Deforestation can change the microclimate of an area, resulting in an increase in vector-borne disease (Zhou *et al*. 2004; Afrane *et al*. 2006; Zhou *et al*. 2007; Afrane *et al*. 2008). Through the process of clearing forests and subsequent agricultural development, deforestation alters every element of local ecosystems – including the microclimate, soil, and aquatic conditions and, most significantly, the ecology of local flora and fauna, including human disease vectors (Yasuoka and Levins 2007). Deforestation exposes areas to greater sunlight, increasing the ambient temperature in the area and increasing the temperature of stagnant pools of water, which may act as breeding sites for vector insects. The malaria-carrying mosquito is the vector insect that has been shown to be most sensitive to change in forest cover (Yasuoka and Levins 2007). There is significant clinical evidence from Kenya that a deforestation-induced change in microclimate has a significant impact on the mosquito vectoral capacity and can increase the number of new mosquito infections from one infected individual by 77.7% (Afrane *et al.* 2008).

Deforestation of these areas has resulted in small increases in ambient temperature and changed the vectoral capacity of mosquitoes, increasing the risk of humans contracting malaria in an area that was previously malaria free or a low-risk area. Of particular interest to deforestation and the disease-regulations services of the forest are the highland epidemic-prone areas. Malaria in these areas is seasonal, with considerable year-to-year variation. Climate conditions need to be favourable for malaria transmission, with a minimum temperature of around 18ºC required (Malakooti *et al.* 1998), which usually occurs during the long rains of March to May every year.

5. The potential benefits of REDD+

Despite their economic and environmental importance, montane forests in Kenya continue to be under threat of conversion to other land-use types (Table 5.1). The main hazards are: charcoal production, logging of indigenous trees, marijuana cultivation, cultivated fields in the indigenous forest, shamba-system practices, livestock grazing, quarry landslides, and human settlements. Various reports point to the extent and devastating effects of such practices on erosion, sedimentation, water quality, etc. (Brakel 1984; Mogaka 2006). Illegal montane forest clearing is reaching dramatic proportions in some areas.

Table 5.1: Deforestation between 1990 and 2005

	2000	2003	2005	2010
Mau Complex	403,775	408,893	399,413	Not available
Mt Kenya	232,047	206,885	209,032	Not available
Mt Elgon	102,696	73,521	73,521	Not available
Cherangano Hills	97,397	120,995	120,995	Not available
Aberdares	253,375	244,896	244,896	Not available
Unspecified	150,710	119,810	117,143	
Total	1,240,000	1,175,000	1,165,000	1,140,000
Deforestation rate (ha/yr)	403,775	-5,000	-5,000	-5,000

Note: Deforestation rates for the periods 1990-1999, 2000-2003 and 2004-2005 were 2,681 ha/yr, 2,427 ha/yr and 3,666 ha/yr respectively. The estimated deforestation for the period 2006-2010 is based on the average rate of deforestation for the period 2000-2005.
Source: based on data sourced from Akotsi *et al.* 2004

Modelling and environmental economic evidence used

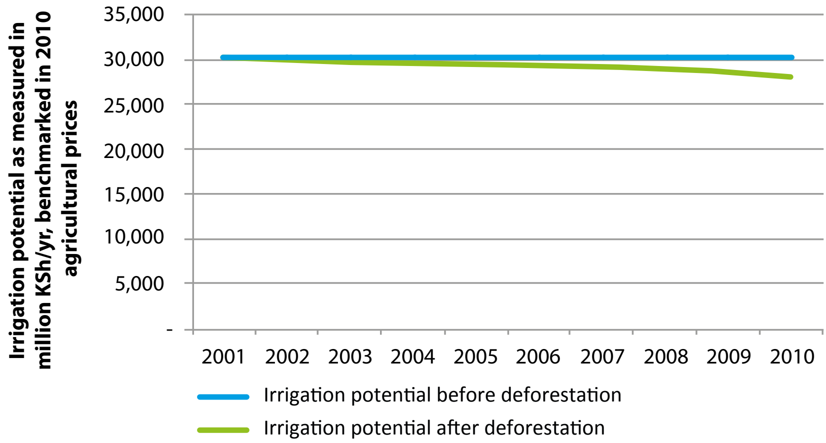
This section presents the modelling results of the effects of deforestation on the economy of Kenya in the agriculture, fishery, hydropower, water services, tourism and public administration sectors. It used best available environmental economic evidence and data.

The effects of deforestation on irrigation

The agriculture and forestry sector of Kenya is by far the largest economic sector and contributed between 25% and 30% to GDP in the period 2000-2010 (see Figure 5.1) (KNBS 2010). Although agricultural output in Kenya is dominated by rain-fed agriculture, the irrigation sector still plays an important role, and has the potential to grow significantly in future. Of the total land area under agriculture, irrigation accounts for only 1.7% but provides up to 18% of the value of all agricultural produce (Republic of Kenya 2010).

Deforestation at a rate of 5,000 ha per year between 2000 and 2010 would have reduced the available water (as a result of reduced low flows) by 62 million m^3 per year by 2010. Irrigation usually has the lowest assurance of supply of all water users and it can thus be assumed that this reduced available water will directly reduce irrigation agriculture. For this reason, because of the deforestation between 2000 and 2010, Kenya had forgone the opportunity to cultivate KSh 2,626 million of irrigation agriculture output.

Figure 5.1: Irrigation potential in Kenya reduces as a result of deforestation



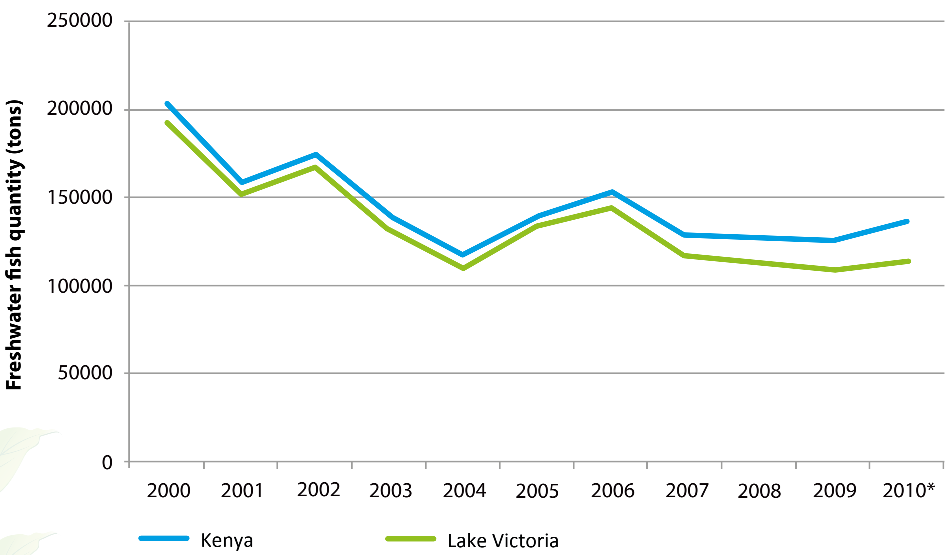
Note: This is because of lower assurance of water supply to irrigation, due to low-season reduced runoff from the Water Towers. The irrigation sector output lost in 2010 is estimated at KSh 2,626 million.
Source: UNEP 2012a

The effect of deforestation on inland fisheries

Inland fish production in Kenya has grown dramatically since the introduction of the Nile perch *(Lates niloticus)* in the early 1960s. The fishing sector contributes between 0.4%-0.6% to the Kenyan GDP annually (Simonit and Perrings 2011). The quantity of fresh-water fish landed constitute 94% of the total fisheries output in Kenya (Figure 5.2).

In Lake Victoria there is evidence that total phosphorus concentration seems to be the key element influencing phytoplankton growth in inshore waters (Simonit and Perrings, 2011).

Figure 5.2: Quantity of fish caught annually from Lake Victoria and in Kenya



Source: KNBS 2010, 2011; CBS 2005

An increase in chlorophyll-a concentration (a measure of water quality and eutrophication) is the result of nutrient loading from the catchment.

With increasing phosphate levels due to deforestation, a bio-economic fish production model developed by Simonit and Perrings (2011) can be adapted to estimate the effect of deforestation on inland fish catch.

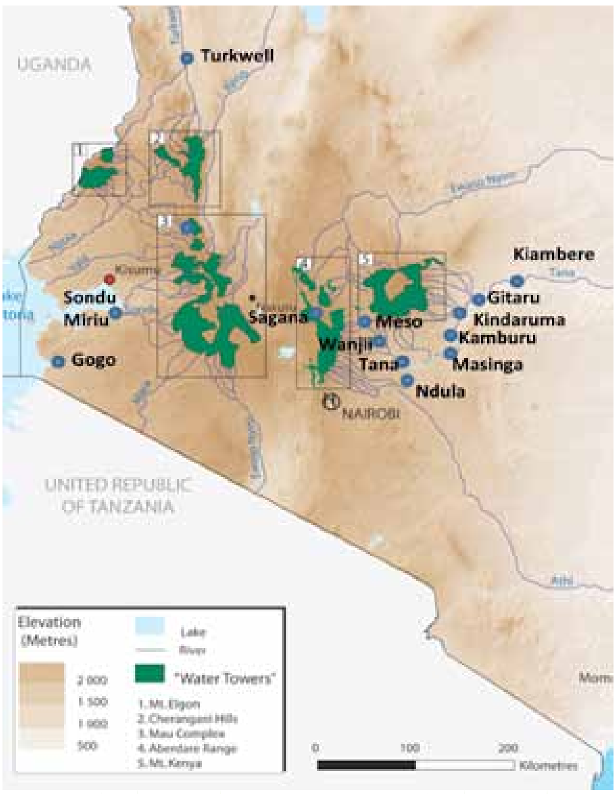
Total fresh-water catch in 2010 was 135,784 tons, with a total output of KSh 16,905 million in 2010. Bio-economic modelling estimates that the fresh-water fish catch was reduced by 690 tons or KSh 86 million in 2010, as a result of the elevated phosphate loads that resulted from deforestation between 2000 and 2010.

The effect of deforestation on hydropower generation

Kenya generated 6,976 million kWh of electricity from various sources in 2010. The majority of this power was generated from hydropower (46%) and thermal (37%) sources. Hydroelectricity production has historically been lower during periods of drought (Figure 5.3).

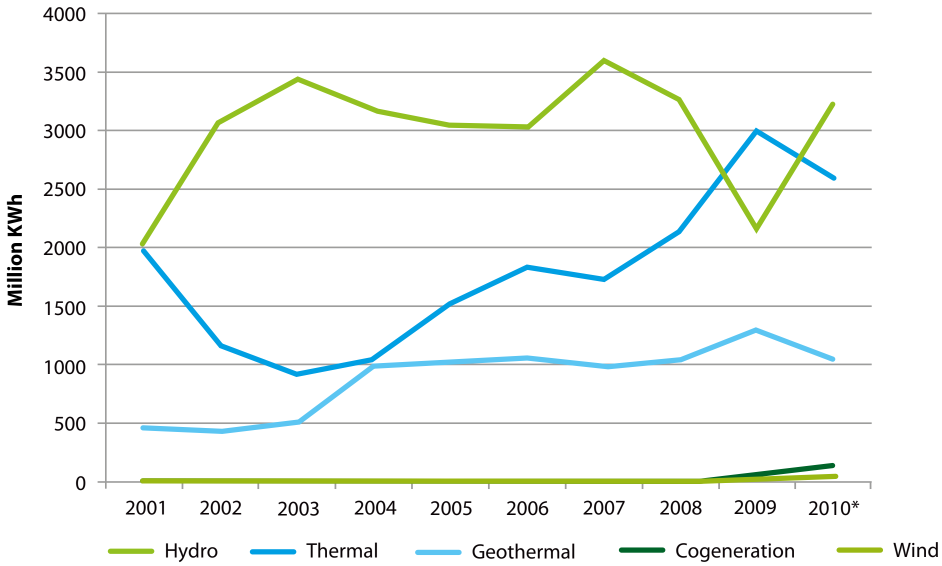
Most of Kenya's hydropower capacity (70%) is situated in 10 hydropower stations on the Tana River. The remainder is supplied from the Turkwell station (20%) and the rest from three smaller stations in the vicinity of Lake Victoria (Figure 5.4).

Figure 5.3: Hydro-electricity power plants in relation to the five Water Towers of Kenya



Source: UNEP 2009

Figure 5.4: Trends in kilowatt hours of electricity generated in Kenya, by source, between 2000 and 2010



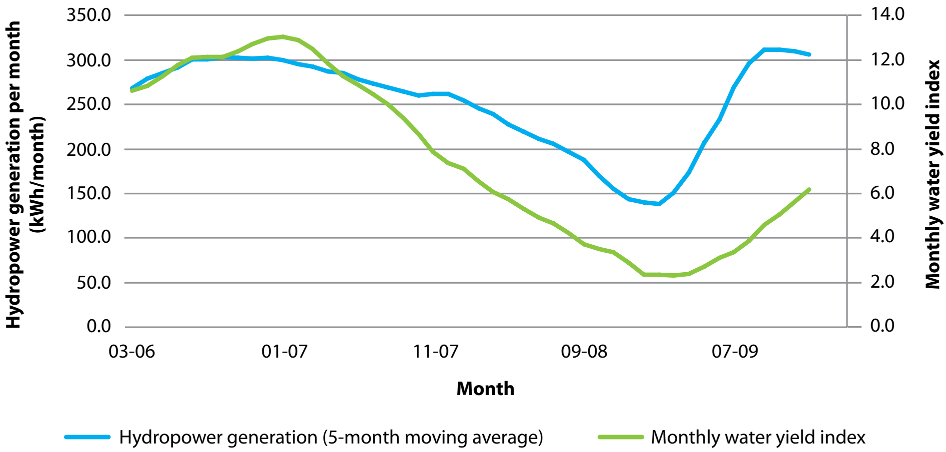
Note: Reductions in hydropower generation correspond to drought periods
Source: KNBS 2003; 2008 and 2011

Hydropower in Kenya is derived indirectly from the forested catchments of Kenya's Water Towers, and principally the Aberdares and Mount Kenya. Hydropower generation is dependent on river water flow. An index of lagged monthly rainfall data[3] for the Eldoret, Kakamega, Kisii, Kisumu, Kitale, Nakuru and Nyeri weather stations, in the catchments that serves the hydropower stations, correlates very closely with hydropower generation data (Figure 5.5). Thus, although hydropower generation is not a highly consumptive water use, it is highly sensitive to decreases in water availability and river flow. Dry-season flows especially severely limit hydropower generation.

At an average selling price of 20KSh/kWh, the reduced hydropower production as a result of reduction in water yield in 2010 was estimated at KSh 12 million. Although the quantum of this number is small, the economy-wide effect of this loss is significant. Owing to the importance of hydropower in the economy of Kenya, reduced dry-season flows make the economy of Kenya especially vulnerable to deforestation.

[3] http://www.tutiempo.net/en/Weather/Kenya/KE.html

Figure 5.5: The relationship between the lagged monthly water yield index and the five-month hydropower moving average indices.



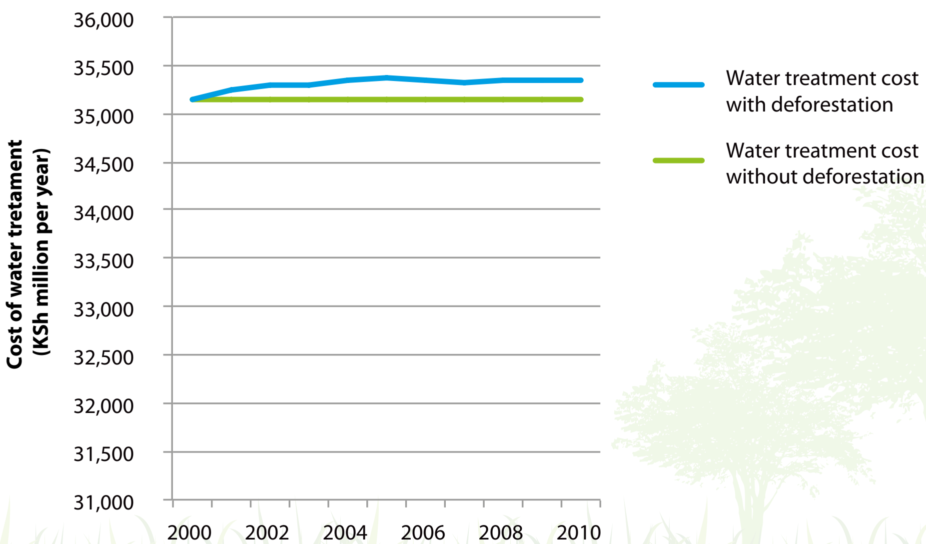
Note: An ordinary least squares regression analysis of these data sets indicates that monthly water yield explains 67% of the variation in hydropower generation.
Source: UNEP 2012a

The effect of deforestation on water services

Poor water quality resulting from increased nutrient content increases the cost of water treatment for urban and domestic use. These costs are borne by water treatment works operated by the Government of Kenya. Reduced water quality increases the costs of removing sediment and nutrient loads from treated water.

Nutrients in the form of nitrogen and phosphorous are removed from waters by employing treatment processes such as primary sedimentation, bio-filters and biological

Figure 5.6: The cost of water treatment by Government water schemes increases as a result of nutrient pollution due to deforestation



Source: UNEP 2012a

nutrient removal (BNR) processes, which remove suspended solids – nitrogen (as NO_3-N) and phosphorous (as PO_4-P).

Pollution load needs to be reduced for the total volume of water used by urban, rural and industrial water users. The resultant cost increase was KSh 192 million in 2010, which was a 0.55% cost increase compared to the pre-deforestation scenario (Figure 5.6).

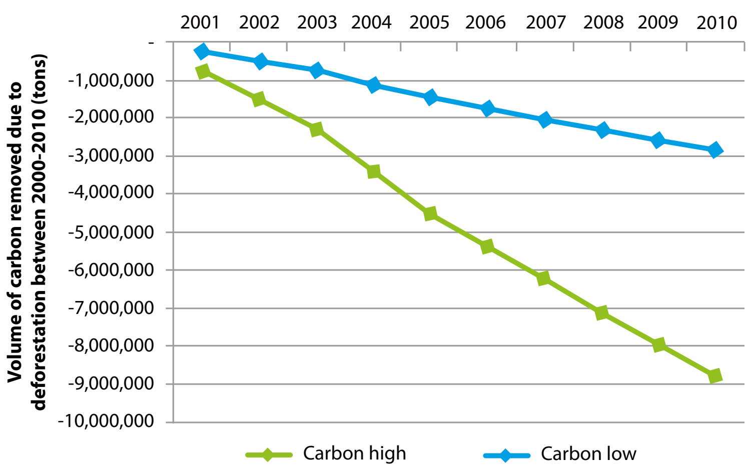
The effect of deforestation on public administration – carbon sequestration and REDD+

Carbon-trading mechanisms provide an opportunity for the Government of Kenya to earn foreign revenue. Once appropriate carbon trading mechanisms are available, unmitigated deforestation is thus a forgone revenue opportunity for the Government of Kenya, money that could otherwise have been spent on public administration.

As deforestation accounts for about 18% of global greenhouse gas (GHG) emissions, reducing emissions from deforestation and forest degradation (REDD+) has become a prominent potential mitigation strategy within the basket of major climate-change mitigation strategies. REDD+ is an initiative by the United Nations (UN), which intends to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. The REDD+ concept is predicated on the assumption that forests will contribute to climate-change mitigation only if their value increases to a level that makes protecting forests consistent with viable development strategies (Zarin *et al.* 2009).

REDD+ goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks. The UN estimates that financial flows for greenhouse gas emission reductions from REDD+ could reach up to US$30 billion a year. This flow of funds could reward a meaningful reduction of carbon emissions and could also support new, pro-poor

Figure 5.7: Reduction in above-ground carbon storage capacity in Kenya due to deforestation between 2000 and 2010.



Source: UNEP 2012a

development, help conserve biodiversity, and secure vital ecosystem services. Mitigation activities potentially included under REDD+ include reduced deforestation as well as reduced degradation (Zarin *et al.* 2009).

The above ground carbon storage potential of montane forests varies between 100 and 310 tons per ha (Wilson and Spracklen 2009; Zarin *et al*. 2009). At a carbon value of US$ 6/ton, and assuming an average carbon storage value of 190 tons per ha, this implies that the potential carbon value lost to deforestation in 2010 was KSh 341 million (Figure 5.7).

The effect of deforestation on public administration – public health

In Kenya an estimated 170 million working days are lost annually as a result of malaria (Maneno *et al*. 1998). Malaria treatment is the most common treatment provided by the health system, with 17 million doses of malaria medicines issued in 2009 in the public health care system alone (National Coordinating Agency for Population and Development *et al*. 2011). Malaria accounted for 25% of total health expenditure, amounting to a total of KSh 30.7 billion in 2009-2010 (Republic of Kenya 2010) or 1.4% of the GDP. Based on census population statistics this amounts to KSh 795 per person in Kenya.

In the Rift Valley and Nyanza provinces 31% of the population is treated for malaria every year. At this incidence rate, for people living in deforested areas (an estimated population of 150,000 or five people per ha), the health cost of malaria treatment due to deforestation was KSh 143 million in 2010. An additional productivity loss of KSh 252 million occurred.

The potential benefits associated with a successful REDD+ initiative

In the 10-year period, 2000-2010, deforestation in Kenya's Water Towers was approximately 50,000 ha. By 2010, such deforestation of montane forest yielded a timber and fuelwood volume of 210 m^3/ha, with a cash value of approximately KSh 272,000/ha. At an estimated deforestation rate of 5,000 ha in 2010, this is equivalent to a revenue of KSh 1,362 million 2010. This is a considerable economic incentive for illegal loggers.

However, the indirect costs of deforestation are borne by sectors and households elsewhere in the economy through the reduction in the value of regulating services. Regulating services ensure the delivery of final consumption services over a range of environmental conditions (Perrings 2006). Thus, regulating services reduce risk to the economy. Regulating services can also be considered as providing an insurance value to the economy. This insurance value is important, not only to maintain economic resilience to seasonal environmental and economic changes, but also to long-term economic hazards such as climate change.

Moreover, deforestation has a cumulative effect. Thus, whereas the cash value of timber and fuelwood has a once-off value, the consequences of deforestation in preceding years continues to be felt in the economy in every subsequent year.

The regulating services of Kenya's natural ecosystems are important production factors in the agriculture, forest, fishing, electricity, water, public administration and defence sectors. These sectors together contributed between 33-39% to GDP between 2000 and

2010. In addition, these sectors have a very significant multiplier effect on the rest of the economy's GDP.

By 2010, the cumulative negative effect of deforestation on the economy through reduction in regulating services was approximately KSh 3,652 million/yr (Table 5.2).

In 2010, the largest component of this was attributable to a reduction in dry-season river flows, which reduced the assurance of water supply to irrigation agriculture. This reduced irrigation agriculture output by KSh 2,626 million. Reduced river flows also reduced hydropower generation by KSh 12 million. Although this is relatively not a very large value, the multiplier effect of hydropower on the rest of the economy is considerable. Reduction in water quality due to siltation and elevated nutrient levels running off degraded land into fresh water systems reduced inland fish catch by KSh 86 million and increased the cost of water treatment for potable use by KSh 192 million (UNEP 2012a).

Deforestation increases malarial disease prevalence. Incidence of malaria under an exposed population of approximately 150,000 people was estimated to cost KSh 395 million by 2010. This is in the form of additional health costs to the Government of Kenya, and through losses in labour productivity (UNEP 2012a).

Forest loss is also detrimental to the global carbon cycle. REDD+, an initiative of the United Nations, is a prominent potential mitigation strategy within the basket of major climate-change mitigation strategies. REDD+ intends to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. REDD+ goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks. The above-ground carbon storage value forgone through deforestation was estimated at KSh 341 million in 2010 (UNEP 2012a).

In 2010, the total net cumulative effect of deforestation on the economy of Kenya was a loss of KSh 3.8 million. This loss in output has a considerable multiplier effect on the rest of the Kenyan economy (UNEP 2012a).

Whereas the immediate cash benefit of deforestation through timber and fuelwood sales is KSh 272,000/ha, the total effect of regulating services lost is estimated to be a loss of KSh 730,000/ha. Thus cost to the economy in 2010 outweighed the cash benefits by at least 2.8 times. This ratio will increase into the future as the cumulative effect of deforestation endures.

This loss in output has a considerable multiplier effect on the rest of the Kenyan economy: an industry that directly depends on the ecosystem generates demand upstream (for intermediates from other industries) in the domestic economy (backward linkages). It also supplies inputs to other industries downstream (forward linkages). A decrease of regulating ecosystem services due to deforestation thus has a direct effect (a decrease in production in the respective sector), as well as an indirect effect (decline in production in other industries) on the economy. The total impact – i.e. the direct and indirect changes in economic output of a decline in regulating ecosystem services due to deforestation – is determined by calculating the forward and backward multipliers, respectively.

Table 5.2: The total effect of deforestation of Kenya's montane forests for the period 2000-2010 on the economy of Kenya

	Cash value of deforestation		Losses to economic sectors resulting from deforestation	
Year	2009	2010	2009	2010
Total effect (million Ksh)	**1,308**	**1,362**	**-4,606**	**-3,652**
Growing of crops and horticulture			-3,595	-2,626
Forestry and logging	1,308	1,362		
Fishing			-67	-86
Electricity supply			-27	-12
Water supply			-191	-192
Hotels and restaurants				
Public administration and defence			-727	-736
Deforestation effects on conservation			*0*	0
Deforestation effects on carbon sequestration			*-341*	-341
Deforestation effects on health (malaria)			*-386*	-395

Note: At an average annual deforestation rate of 5,000 ha/yr, the deforestation in Kenya Water Towers in 2010 generated an estimated KSh 1,362 million in timber and fuelwood revenue. However, the negative effects of deforestation on the economy through reduction in regulating services was far higher than this, at KSh 3,652 million
Source: UNEP 2012a and UNEP 2012b

Table 5.2, 5.3 and Figure 5.8 display the impact of a decrease in regulating ecosystem services due to deforestation for the year 2009 and 2010. The total impact amounted to KSh 6.6 billion in 2009 and KSh 5.8 billion in 2010, which is more than one third of the value-added of the whole forestry sector in the respective years. This means that the cost of limiting the regulating ecosystem services as a production factor for the economy was between 4.2 (2010) to 5 times (2009) higher than the actual cash revenue of KSh 1.36 billion (see Table 5.2). Even when the inter-industrial linkages of the forestry sector were taken into account, the economic benefits of deforestation would not outweigh its total burden, as the resulting gain in land is most often not used economically. The variation in results between 2009 and 2010 demonstrates to some extent the insurance value that montane forests provide to the economy.

Of interest in the analysis is that a carbon value of US$ 6/ton provides insufficient economic incentive (KSh 68,000/ha) to compensate for deforestation (KSh 272,000/ha). However, this analysis shows that the total ecosystem service value of the montane forests far exceeds the carbon value. Carbon, as a proxy for regulating ecosystem services, has a regulating service multiplier effect of more than 7.

The key policy implication for the Government of Kenya lies in: (1) sustainable use of the forest resources (mainly timber and wood) through selective thinning regimes, instead of clear felling of large areas; (2) the protection of the forests against uncontrolled settlement; (3) adequate allocation and policing of water withdrawals; (4) and improved management of degraded land. This can be achieved through:

- Proper road and path planning, design, and maintenance;
- Establishment of crop systems that protect the soil and create microclimatic conditions resembling forest conditions as closely as possible (the shamba system, for example);
- Terracing on steep upstream cropped areas to reduce surface runoff and increase infiltration;
- Mulching bare areas to protect the soil and avoiding weed growth to reduce soil water loss through evaporation from the soil and through transpiration by weeds;
- Tied ridges that are very effective in controlling surface runoff and improving soil moisture conditions; and
- Payments for ecosystem services schemes related to the REDD+ initiative.

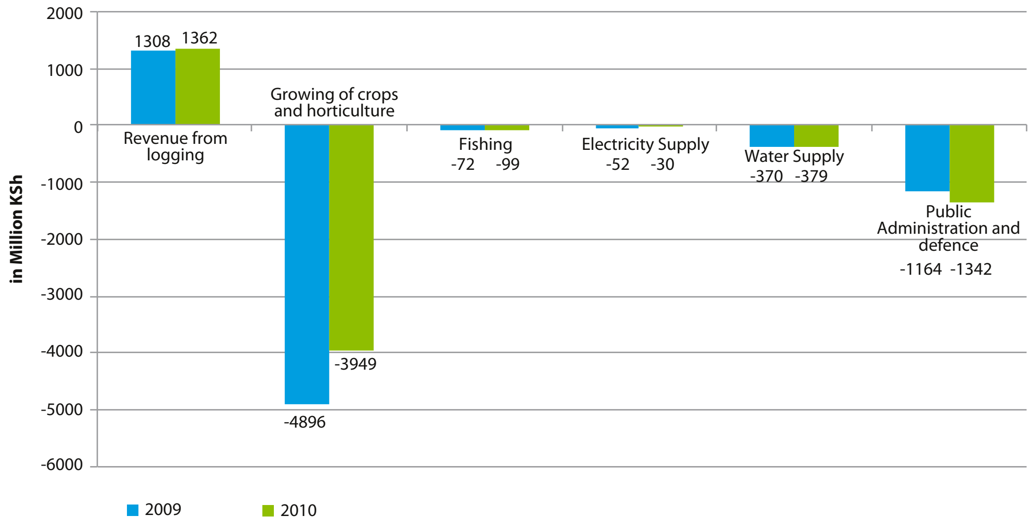
The cost of these mitigation measures is expected to be far less than the value of regulating services lost.

Table 5.3: The effects of deforestation on the economy in KSh/ha

	Cash value of deforestation		Losses to economic sectors resulting from deforestation	
Year	**2009**	**2010**	**2009**	**2010**
Total effect (Ksh/ha)	**261,698**	**272,393**	**-921,165**	**-730,338**
Growing of crops and horticulture			-718,991	-525,157
Forestry and logging	261,698	272,393		
Fishing			-13,387	17,184
Electricity supply			-5,308	-2,443
Water supply			-38,148	-38,412
Hotels and restaurants				
Public administration and defence			-145,332	-147,142
Deforestation effects on conservation			1	1
Deforestation effects on carbon sequestration			-68,184	-68,184
Deforestation effects on health (malaria)			-77,149	-78,959

Source: UNEP 2012a and UNEP 2012b

Figure 5.8: Total impact per sector due to the loss in regulating ecosystem services for 2009 and 2010



Source: UNEP 2012a and UNEP 2012b

Table 5.4: The impact of regulating ecosystem services on the economy for Kenya 2009

2009	Cash Value of Deforestation	Direct Effect	Indirect Effect	Total Impact
Total effect (million Ksh)	**1,308**	**-4,606**	**-1,951**	**-6,557**
Growing of crops and horticulture		-3,595	-1,301	-4,896
Forestry and logging	**1,308**			
Fishing		-67	-8	-75
Electricity and gas supply		-27	-25	-52
Water supply		-191	-179	-370
Public administration and defence		-727	-437	-1164
2010	**Cash Value of Deforestation**	**Direct Effect**	**Indirect Effect**	**Total Impact**
Total effect (million Ksh)	**1,362**	**-3,652**	**-2,147**	**-5,799**
Growing of crops and horticulture		-2,626	-1,323	-3,949
Forestry and logging	**1,362**			
Fishing		-86	-13	-99
Electricity and gas supply		-12	-18	-30
Water supply		-192	-187	-379
Public administration and defence		-736	-606	-1342

Source: UNEP 2012a and UNEP 2012b

6. Conclusions and recommendations

The forestry sector is indispensable for the Kenyan economy in many ways: Firstly, it directly and indirectly enters the production of all other industries. Secondly, fuelwood and charcoal represent the most important energy source for the population. And last, but not least, the forestry sector creates both formal and informal job opportunities, especially in rural areas.

Resource depletion sets a limit on domestic supply. Deforestation has largely been driven by private consumption, as the demand of households has doubled within the last 10 years according to official national account data. This number is under-estimated as it does not incorporate the informal sector. The shadow-market for fuelwood and charcoal has been expanding, particularly in rural areas where firewood is collected for free or exchanged for other goods.

The system of national accounts in Kenya puts the total annual contribution of forests at 1.1% of GDP, which is a gross underestimate. It has been demonstrated throughout this report that many key services, value-additions and the importance of the charcoal industry as a shadow economy, among other things, have not been incorporated within the said system of accounts. Thus, the current analysis is a relevant step towards a more accurate representation of the forestry sector in the Kenyan national accounts, despite the uncertainties inherent in these empirical calculations due to limited data availability.

The on-going work of the Kenya Forest Service together with the Kenya Bureau of Statistics and international partners on building a forest resource account has already revealed that the contribution of forest is undervalued by atleast 2.5%, which puts the estimate of its annual contribution to GDP at around 3.6%.

Forests not only contribute to growth, job creation and poverty reduction but also have an influence on well-being outcomes, such as the health impact of malaria. Forests in Kenya represent a great opportunity in terms of carbon storage and the use of carbon trading schemes.

In terms of recommendations, decision makers should place emphasis on:

- Incorporating the economics for sustainable forest management.
- Reducing the loss of regulating ecosystem services as the cost of not doing so is 4.2 times higher than the actual cash revenue of KShs 1.3 billion from defeorestation.
- Ensuring that Kenya has in place a fully functioning forest resource account in order to fully capture the various benefits provided by the forest.
- Stronger regulation of forest use. For instance the enacting of farm forestry, forest harvesting and charcoal regulations in 2009 represents an important step in the right direction and needs to be pursued.
- Encouraging investment in the forestry sector in order to increase efficiency in production, especially in sawn timber and charcoal production. The increased use of micro-credit schemes from the government, for instance, would decrease the size of the informal sector, slow down unsustainable resource depletion and would create job opportunities, particularly in rural areas.
- Addressing the growing trend of dependence on imports of forest products, which constituted more than 50% of domestic output for the year 2009.
- Adequate regeneration after harvest and an increased forest plantation growth in the long term, together with better coordination of regulating institutions, producers and consumers of forest products (Sedjo 2005).
- Mainstreaming the use of instruments and incentives such as payment for ecosystem services, trading and insurance schemes.

A Note on the methodology

The results in Section 3 are drawn from the compilation of annual non-survey-based input output tables for Kenya from 1997 to 2009. As a reference point a social accounting matrix established by the International Food Policy Research Institute in Kenya in 2003 was used and for- and backdated by official data from various sources (KNBS, UN national account data, UN-Comtrade, etc.). Owing to a lack of availability of forest data and in order to shed further light on the development of the forestry sector, the physical flows of the different types of forest in Kenya (indigenous, dryland, plantation and farm forests) to the industries and final demand together with price ranges of forest products were used to assess the linkages between the forestry sector and the rest of the economy.

The physical table was compiled from different data sources FAO, KFS, and KNBS, among others) that partly contain estimates about hitherto unrecorded activities. The results are therefore very much shaped by the extent and quality of the data available. Approaching the role of the forest from a physical perspective allows re-evaluating the forestry industry, given its weak representation in national accounts data. Owing to the high inflation rates Kenya reported for the period under study and in order to allow for a comparison over time, figures are shown in constant prices of the year 2005.

Abbreviations and acronyms

BNR	Biological nutrient removal
DRSRS	Kenya's Department of Resource Surveys and Remote Sensing
FAO	Food and Agriculture Organisation
FRA	Forestry Resources Account
GDP	Gross Domestic Product
GHG	Greenhouse gases
KFS	Kenya Forest Services
KNBS	Kenya National Bureau of Statistics
KSh	Kenya Shilling
KWh	Kilo Watts per hour
MA	Millennium Ecosystems Assessment
mm	Millimeters
REDD	Reducing emissions from deforestation and forest degradation
TEEB	The Economics of Ecosystems and Biodiversity
UN	United Nations
UNEP	United Nations Environmental Programme
USD	United States Dollar

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