Direct use values of climate-dependent ecosystem services in Isiolo County, Kenya

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Abbreviations and acronyms

Ada	Adaptation (Consortium)
CIDP	County Integrated Development Plan
IIED	International Institute for Environment and Development
ILRI	International Livestock Research Institute
IUCN	International Union for Conservation of Nature
LARMAT	Land Resource Management and Agricultural Technology
MID-P	Merti Integrated Development Programme
NDMA	National Drought Management Authority
NDVI	normalized difference vegetation index
NRT	Northern Rangeland Trust
RAP	Resources Advocacy Programme
RUA	Rangeland Users Association
TEV	total economic valuation
WRMA	Water Resources Management Authority

Note regarding currency conversions: We used the official exchange rate of Ksh 87.92 to US$1, calculated as an annual average for 2014 based on monthly averages. See: http://data.worldbank.org/indicator/PA.NUS.FCRF

Executive summary

The county government of Isiolo, Kenya, faces a significant challenge – to maximise the value of local services, including those already provided by the ecosystem under conditions of increasing climate variability and change. This report describes a research approach to support this endeavour, exploring the development of a generic profile of the current ecosystem service values in the county economy through a framework for total economic valuation (TEV). Our approach differs from previous TEV studies conducted in the region because we give greater consideration to service values achieved per cubic metre of water. The availability of water is sensitive to climatic variations, which affect its spatial and temporal distribution. Many other essential services in Arid and Semi Arid (ASAL) environments are also dependent on climate and water availability.

Our research focuses on compiling and synthesing 'direct use values' associated with the main climate-dependent provisioning services – water, energy, fibres and foods – for the year 2013–14. Based on consultation with partners in Isiolo County and a series of research activities that took place over 2012–2015, we explore the flows of these services and a range of market and non-market values that can be associated with them. In this assessment, we estimate the direct use value of a cubic metre of water for domestic uses at US$0-17 (market value) or around US$90 (non-market value), whereas the same volume used for livestock water provisioning would generate a direct use value of US$13–22 (market value of meat offtake and milk production). But in case of direct use for irrigated agriculture and tourism, the values that we could identify per cubic metre of water were US$0-4 (market value). Those for water used in tourism enterprises were even less.

Overall, in this study we identify climate-dependent ecosystem service values produced during 2013-14 that were worth almost a quarter of a billion US$ per year to the county. However, this total includes values that some may consider controversial or overlapping, and we acknowledge that our assessment of the services and their values was still very far from exhaustive. To improve the assessment and management of ecosystem service flow volumes and values, we recommend that the county government enhance its systems for mapping and monitoring them. Since many of these flows and values are sensitive to seasonal and inter-annual variations in climate, it would also be desirable to quantify the extent of this sensitivity.

Through the TEV framework, we can further supplement the assessment of direct use values by considering other indirect use, option and non-use values. A discussion of the possible effects of these value types highlights that, where services such as water, firewood and grazing resources are over-extracted, we must weigh the positive direct use value against the negative (indirect) loss of ecosystem value to society. The spatial and temporal context in which the direct uses occur determines the extent to which they will be affected by these indirect values. Option values are related to direct use values, and also heavily depend on spatial and temporal context.

Although areas for further research and data collection remain, we conclude that the assessment framework is ready enough to explore a practical test-case application in Isiolo County. Under the current County Integrated Development Plan (CIDP) 2013-7, a series of investments have been made and could be evaluated. However, it is also worth noting that the effects of any given investment decision might be anticipated to accrue over a timeframe e.g. of at least 10 years. The profile of direct use values over a single year that we have developed so far could be extended to explore longer-term decision scenarios that could take into account the likely effects of climate change and variability. An iterative process involving stakeholders and allowing space for debate would enable public review and progressive refinement of the framework and assessment of direct use patterns and values identified through this research.

Kulamawe before the rains, Isiolo County. Photo credit: Caroline King-Okumu

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1 Introduction

Arid and semi-arid lands (ASALs) may have higher potential for economic growth and development than more humid areas (GoK 2012, based on evidence presented by Fan and Hazell 2001). This is because ASALs start from a lower base in terms of pre-existing economic activities and therefore have more room for growth. ASAL county governments, including Isiolo's, have the challenge of leading and prioritising public and private sector investments to maximise returns in terms of improving living standards for their resident populations.

Understanding the material differences that development projects could make – to various sections of the population and over the longer term – is complex and can be contentious. Despite growing interest in the use of decision support tools (Shepherd *et al.* 2015), there is no definitive framework for assessing anticipated returns to current patterns of (predominantly communal pastoralist) land use in northern Kenya under anticipated climate changes (King-Okumu 2015a). Although Kenya is drafting its national Green Economy Strategy and Implementation Plan (GoK 2015), this intended green agenda does not yet take into account the significance of increasing water scarcity and variability for the ASALs' natural resource-based economies (King-Okumu 2015b).

Without systematically considering the interdependence between the climate, environment and economy in the ASAL context, it is impossible to assess the merits of various investment options. There is therefore a risk that some proposed changes that appear progressive could reduce, rather than increase, benefits to the economy and society from the existing ecosystem. This loss of benefits is likely to occur over the long term, but could also be in the shorter term. There is also a chance of overlooking investments that could generate a higher return over either or both timeframes.

To enable understanding of the effects of particular investments to achieve changes in the system —for example, from one land use management regime to another – we need to create a general profile of the current system, including its various functions, services and values. We can then use this to measure the positive or negative effects of any proposed changes. We could also use such an approach to assess the effects of investments intended to enhance water service infrastructure or improve processing facilities, such as the creation of an abattoir or a milk packaging plant.

This report describes the findings of research the International Institute for Environment and Development (IIED) and partners carried out between 2013 and 2015 to establish a generalised profile of the value of Isiolo County's climate-dependent ecosystem services. Our overarching objective was to contribute to creating a profile of the total economic value (TEV) assessment of ecosystem services under a variable and changing climate in Isiolo County.

The main research questions we address are:

- What are the main climate-dependent ecosystem services in the Isiolo economy?
- What are their current direct use values?
- How could these values inform a general profile of the economy of Isiolo?

Resource extraction at a riverbed, Isiolo County. Photo credit: Caroline King-Okumu

2

Assessing the economic value of ecosystem services

From an economic point of view, we can understand ecosystems as 'natural capital' and the flow of ecosystem services as the 'interest' on that capital that society receives (Unai Pascual and Muradian 2010, Costanza *et al*. 1997). A range of previous studies have explored ecosystem services associated with pastures or grasslands (Costanza *et al*. 1997, White *et al*. 2000, Havstad *et al*. 2007, Knight *et al*. 2011, McGahey *et al*. 2014, Favretto *et al*. 2014, 2016, Petz *et al*. 2014, Reed *et al*. 2015).

The main ecosystem services influenced by climate in dryland pastoral systems include the provisioning services that humans need – water, plant products, wildlife and livestock.[1] The dryland ecosystems also carry out regulating and cultural services that are essential for resilience to climate change through their hydrological, geochemical and biotic processes. These services are not usually quantified or priced because they do not require extraction or other intervention by humans. Renewable energy supplies provided by ecosystems can also be harnessed.

Rain-fed vegetation often responds directly to rainfall and temperature, whereas land-use decisions and technologies mediate the effects of climate on livestock and human wellbeing. Watershed models can integrate land-use conditions to simulate effects on these aspects of pastoralist systems and human settlements under different climate

1 Other important natural resources provided by the environment such as minerals are affected by the climate over long-term timescales. We do not explore these in this report.

scenarios (Droogers and Bouma 2014, Droogers *et al*. 2012). These models need information on hydro-climatic conditions, land characteristics and management regimes. Where these are not available, decision makers must rely on resource users' observations of the effect of climate on productivity.

2.1 Value to whom?

Individual stakeholders and stakeholder groups can attach a range of different values to ecosystem services (Hein *et al.* 2006). For example, the survival of an elephant may be important to international conservationists, but if the elephant is likely to interfere with crop production, farmers may consider it a source of expense rather than of value. A farmer may value water supplies that (s)he can use for irrigation as an essential input to her/his livelihood, but a pastoralist may question why (s)he should support the provision of this service – particularly if (s)he does not anticipate any direct share in the benefits from crop production and has observed frequent crop failures.

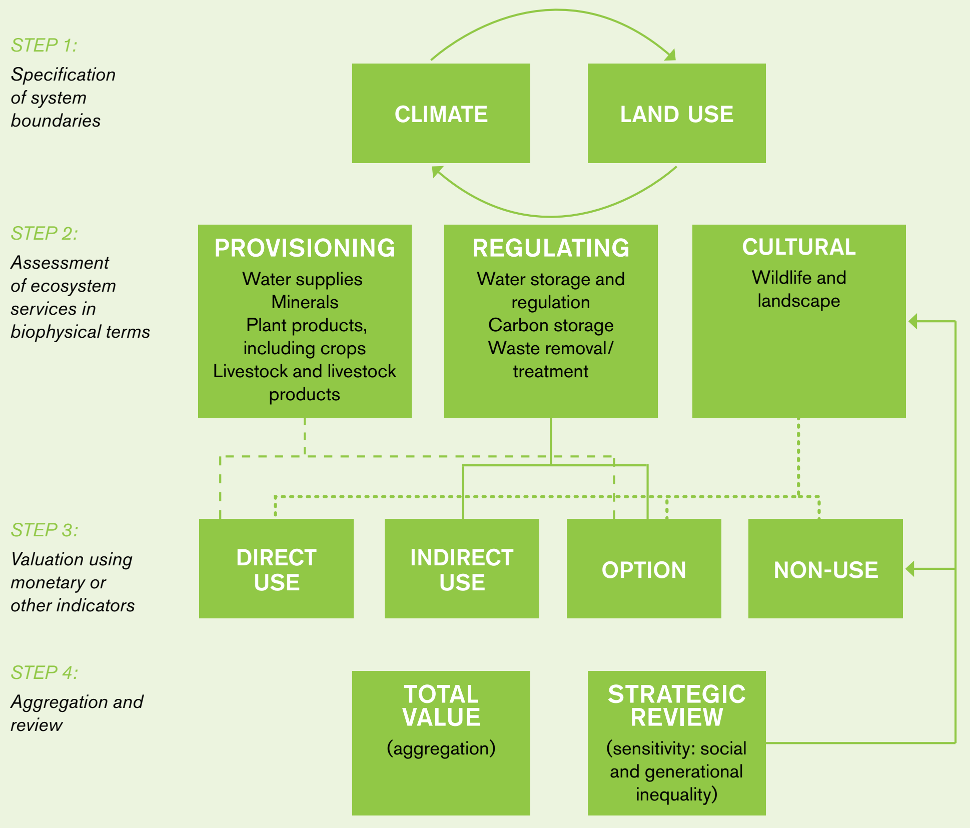
We can understand these individual value calculations as financial valuations. Economic value concerns value to society as a whole rather than to individuals. This raises questions about who is and is not a member of the society in question, and whether society should value benefits to some of its members more highly than others (see a recent discussion of this in Kenter *et al.* 2015). In this study, we explore the value of services to the communities that live in Isiolo, particularly those who depend on natural resources.

2.2 What is total economic value?

Every ecosystem service contributes to the economy and society in a range of different ways (Unai Pascual and Muradian 2010, TEEB 2011, Bateman *et al*. 2011, Wainger and Mazzotta 2011). The value of their contributions may exceed the market price that users pay for them, if any. An approach to the valuation of ecosystem services – known as TEV – seeks the full value of natural resources to the economy, including direct use, indirect use and option values (after Krutilla 1967, Pearce 1991, Pearce and Turner 1990, Pearce 1989). TEV also encompasses non-use values associated with the existence, bequest and stewardship of resources (Figure 1).

Since the 1990s, environmental economists and others have used this approach to incorporate a range of different valuation methods – including market and non-market values – to place a value on wetlands, pastoral production systems and other ecosystems. The TEV can incorporate the various value types into the calculation of an overall value of an ecosystem service or services. But it is not always logical to add up all the possible values to arrive at a total.

Figure 1: The ecosystem valuation framework



Source: modified from Hein *et al.* (2006)

Figure 1 shows a brief overview of the steps towards a TEV assessment of ecosystem service values. This framework includes consideration of different value types, including direct use and others. In the remainder of this section, we summarise these value types and the relationships between them. Although this report focuses on the direct use values of ecosystem services, it is important to understand that these direct use values often interact with other indirect and option use values.

2.3 Value types

2.3.1 Direct use values

A service – such as the supply of fresh milk – may have one market price for some users and a lower price for others. Subsistence producers, for example, may not need to pay the same price as middle class consumers to get the same direct use value of the service. In some cases, valuable products used by the population may have no market price at all – illustrations might include hunting wild animals or collecting plants that are not available on the market to use for food. Clean water provided by ecosystems often has no price either, or is priced according to subsidised pump operating costs. Assessing such direct use values can be challenging. This study aims to respond to this challenge and help stakeholders to identify the extent and magnitude of these values.

Traders at Isiolo market. Photo credit: Peter Cacah

2.3.2 Indirect use values

There are two main types of indirect values for ecosystem services – ecosystem resilience and induced economic values. Both affect direct use values, by supplementing or multiplying them, or by revealing tradeoffs between direct use values across different spatial and temporal scales.

Ecosystem resilience value refers to the benefit that humans derive indirectly from ecosystem regulation services, which create and sustain conditions that we value – such as the quality of the climate, hydrological cycle and land productivity. Options for valuing these indirect services include establishing a market to assign value through a system of payments for environmental services, or assessing the costs of replacement after depletion or degradation.

It is possible to find the value of the regulating service by working out the value of the direct uses that depend on it – based on an anticipated future cost of their loss – and the comparative value of avoiding these costs. In such cases, we would not need to aggregate the value of the ecosystem and the direct use values it was derived from, because we would effectively be counting the same value twice. For example, if we have already fully valued and counted the present and future human water use values, we may not need to also count the value of storing this water before its use. But if depleting water storage causes negative effects other than reducing the volume to be used, we should also deduct these negative values from the TEV of the resource use. Such negative effects are sometimes called externalities. Examples might include reduced water quality due to extraction and use patterns.

Induced economic value refers to additional benefits that accrue from directly using natural resources. This creates a value chain involving a series of additional (dis)benefits that depend on the initial availability of the produced good or service. Previous studies identified value chains for livestock products in Isiolo – such as milk and meat – that involve middlemen or women, traders and transporters (Hesse and Macgregor 2006), which the government has consequently targeted in their agricultural sector development strategy (GoK 2011). Further studies explored the market price and distribution of benefits of Isiolo's pastoral livestock value chains (Gituku *et al.* 2015, Iruata *et al.* 2015, Mwaura *et al.* 2015) and the value chains of a range of other products from Isiolo's ecosystems, such as gums and resins (Mwongela 2012, CARE 2010). But none of these studies consider the additional and altered demands for ecosystem services that the value chains create through their demand for water and energy.

2.3.3 Option values

Even when people are unsure about their future demand for a service, they might assign it a value to keep open the option of using it in the future (Pearce 1989, Hein *et al.* 2006, Jantzen 2006, Unai and Muradian 2010, ELD 2013). In finance, 'option' refers to access to buy an asset in the future. Numerous studies discuss various forms and applications of these option and 'quasi option' values (Mäler and Vincent 2005, Hanley and Spash 1993, Arrow and Fisher 1974, Conrad 1980, Freeman 1984, Hanemann 1989, Pindyck 2007, Dixit and Pindyck 1994, Tietenberg 2006, Traeger 2014, Unai and Muradian 2010). Option values usually refer to a direct use value that will be accessed at some point in time. But the timing and flexibility of the option may increase the overall value obtained either from the option alone or option plus direct use.

Mineral options – in the form of rights to exploration and extraction – will often have a present market value that will not detract from the eventual market value for the direct use of the minerals. Other ecosystem services – for example, a plant species – may not have a current market value, but society may decide to conserve the diversity of this plant species to benefit from potential future medicinal or other uses that have yet be fully recognised and commercialised. In pastoral societies, livestock traditionally provides a value similar to that of an insurance policy that can be considered as additional to the value their owners will derive from selling them (Behnke and Muthami 2011).

For some commodities, such as trees, both direct use and option values can continue to rise as time passes. For others, such as livestock, these values tend to peak and then decline. Option values for land can be sensitive to ecosystem conditions such as water availability and can be influenced by other factors, including accessibility of transportation networks and security.

2.3.4 Non-use values

Although these types of value do not depend on the use of ecosystem services, the values assigned to them can be influenced by the valuation of uses. There are three types of non-use value, and there is widespread recognition that they are inherently difficult to quantify (ELD 2015):

- **Existence value** is something that is beyond bequest value (Pearce 1989).
- **Bequest value** addresses inter-generational equity and is related to value for society and science gained from knowledge of the continued existence of species, habitats and ecosystems.
- **Altruist, or stewardship, value** accounts for intra-generational equity.

Travel cost methods are considered insufficient to fully capture existence value, but are often used as a means to partially capture some of its dimensions. The existence of dryland landscapes and wildlife can be of interest to people who have no intention of using them for recreation or even of travelling to the area they inhabit and do not expect their children to do so either (Stevens *et al.* 1991). Economic valuations tend to focus on the willingness to pay for environmental protection to maintain or preserve an asset or resource that has no current use, to ensure it is available for future generations (Perman *et al.* 2003). Some studies have explored willingness to pay for conservation of nature as an ecosystem service provided by pastoralists in other regions (Bulte *et al.* 2008, Osano *et al.* 2013). Others have focused on the value of specific wildlife species in the drylands (Barnes *et al.* 1992, Swanson and Kontoleon 2005).

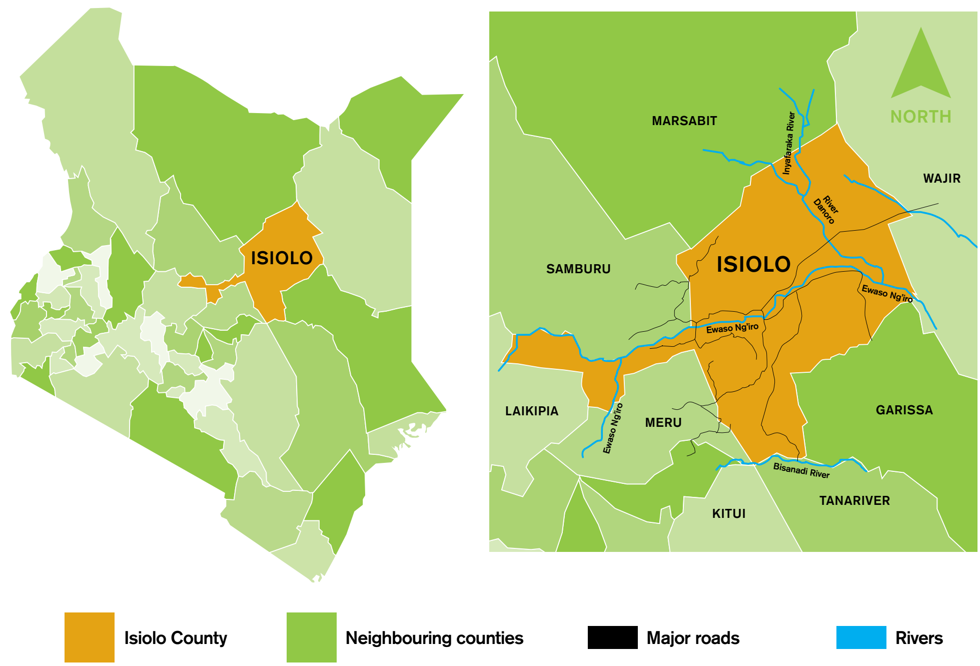
3

Isiolo's climate and ecosystems

Isiolo County is located in the heart of Kenya (Figure 2). The vision of the Isiolo County Integrated Development Plan (CIDP) is for a developed, just, cohesive county where everyone enjoys a good quality of life (GoK 2013a). The county government's overall mission is to improve people's livelihoods through participatory engagement and to create an environment that enables the sustainable use of available resources. They will do this by providing basic services, maximising production with appropriate technology and ensuring the sustainable exploitation of resources for a better quality of life.

The 2009 census confirmed that Isiolo County's population already had a longer life expectancy than the national average, despite having relatively few public healthcare institutions. Pastoral production systems provide protein intake, income, employment, mobility and outdoor life skill training for youths, retirement income for the elderly and marketable assets for 80 per cent of the population (GoK 2013a). Rural households combine livestock raising, herding and marketing with other small trading, hospitality, family duties and local environmental protection. The quality of the county's air, water and locally produced foods is high, and pollution, noise, stress, crime and insecurity levels are relatively low compared to other parts of the country.

Figure 2: Location of Isiolo County



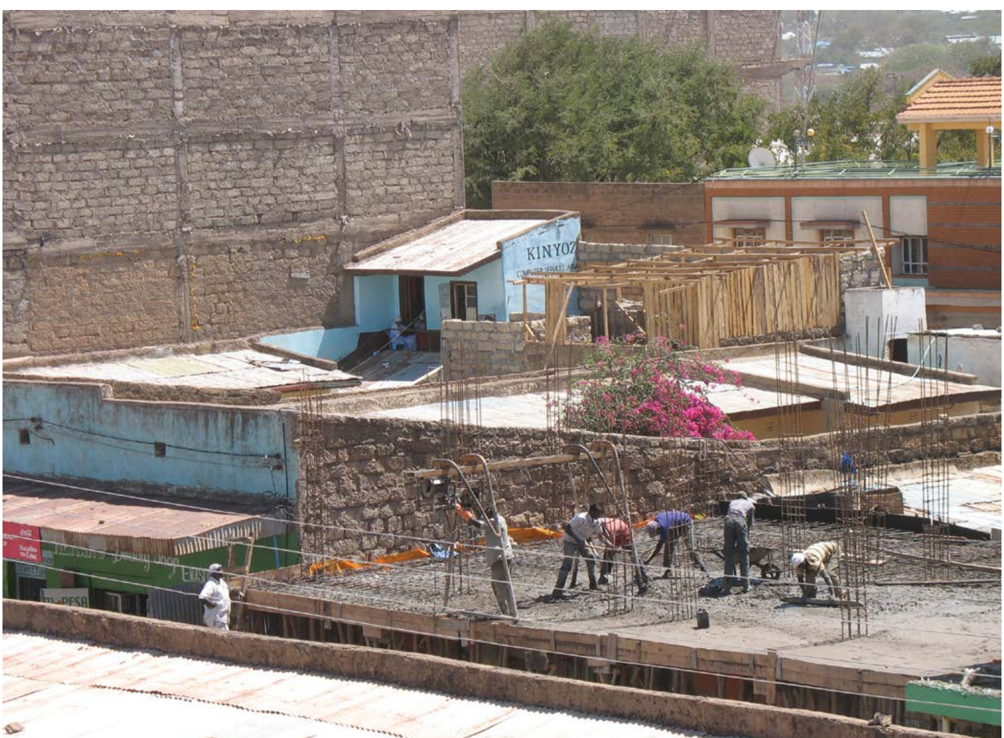
Source: DURP (2015)

The county covers an area of about 25,700 square kilometers. Average rainfall may be close to 580 milimetres a year (GoK 2013a), but distribution and storage is uneven and often difficult to predict. Current projections for future water availability foresee an increasing imbalance between water supply and demand during both drought and normal conditions (GoK 2013c, WRMA 2013). The county will depend on boreholes to be sunk into the Merti and Garbatulla-Modogashe aquifer system to meet identified and unidentified water supply needs over coming decades. We can expect a rise in water demand for economic uses; this will compete with domestic and livestock needs (GoK 2013b).

The CIDP (GoK 2013a) reflects on the likely exacerbation of climatic variability the country has already experienced – drought, unpredictable rainfall patterns and floods – as a cross-cutting challenge affecting all sectors of the economy. Increasing temperatures, evapotranspiration, water scarcity and ongoing climatic variability limit human consumption, health and productive activities that require water, deplete groundwater reserves to buffer future droughts, reduce vegetative cover and threaten biodiversity. All of this constrains prospects for development.

Livestock are considered the main source of livelihoods in Isiolo and the main products are also from agriculture – particularly livestock and livestock products. The CIDP highlights the opportunity to develop processing industries as a value addition for these products that could increase farmers' and pastoralists' income and provide employment for local people (GoK 2013a). Isiolo is a growing centre for transport, trade and tourism: agriculture and its associated processing industries provide the products, amenities and social safety nets that drive and sustain each of these sectors.

Improving roads, energy and communications infrastructure and realising the Lamu Port Southern Sudan-Ethiopia Transport Corridor project should help reduce the costs of doing business in Isiolo, increasing external and internal investment (GoK 2013a). A tarmac road between Isiolo and Moyale is expected to increase trade between Kenya and Ethiopia fivefold. New jobs in construction material and service provision, plumbing, electrification, vehicle maintenance, IT support and other services will accompany the planned expansion of infrastructure. The Isiolo County government also plans to upgrade existing informal trading activities, and increase industrial processing of local raw materials – including hides and skins, milk and forest products – to raise pastoralist households' income and provide additional employment opportunities.



Construction site in Isiolo town. Photo credit: Caroline King-Okumu

4 Research methods

4.1 Overview of the study approach

For this study, we collaborated with the Ada consortium[2] and the Isiolo County Adaptation Planning Committee in their participatory monitoring of adaptation and resilience at ward and community levels. IIED held two workshops in Isiolo County with key stakeholders in the Isiolo economy – on 6 August 2012 (Lunduka 2012) and 6 August 2015 (Jarso 2015). These workshops identified the principal provisioning services – water, food, wood and other services – that people get from Isiolo's ecosystem. Workshop participants described other aspects of the economy –the non-farm (retail shops and small-scale business), transport and services sectors – in addition to the land-based sectors.

We held periodic meetings and consultations with key individuals at the Resources Advocacy Programme (RAP), the Merti Integrated Development Programme (MID-P) and the Isiolo County government over 2014–15. A desk review of available literature identified economic uses of Isiolo's ecosystems and current and future scenarios for economic development, population growth, water demand and availability. A review of institutional arrangements for green growth in the water and rangeland sectors in May 2015 identified additional key informants and secondary data sources (King-Okumu 2015b). In April–August 2015, a series of participatory workshops by RAP and researchers from the University of Nairobi's Department of Land Resource Management and Agricultural Technology (LARMAT) identified economic uses of plants found in a series of rangeland vegetation types in the rural Isiolo (Wasonga *et al.* 2016).

Engaging with the international scientific community was an essential part of our study approach. This was done through a collaborative brainstorming and knowledge exchange in 2015 with researchers participating in an initiative on sustainable dryland landscapes led by the International Union for the Conservation of Nature's (IUCN's) Eastern and

2 For more information, see: www.adaconsortium.org

Discussion held under a tree during a visit to Cherab ward. Photo credit: Caroline King-Okumu

Southern Africa Regional Office. We held two consultative meetings with researchers from the International Livestock Research Institute (ILRI) in 2014 and several informal knowledge exchanges with researchers from the Stockholm Environment Institute.

4.2 Calculating ecosystem service flow volumes

4.2.1 Water

To calculate the volume of human and livestock water use, we used estimates of water demand developed for the Water Resources Management Authority (WRMA 2013). This study included estimates of both supply and demand. We selected the demand estimates to use in our assessment of water use volumes due to problems concerning the supply estimates. The supply estimates were based on an incomplete survey of waterpoints that overlooked many of the ephemeral water sources identified through participatory mapping undertaken around the same period (GoK 2015). These sources provide a significant proportion of the water that is used by the rural communities and their livestock.

The estimates are based on the understanding that human water demand in the county is around 40 litres per capita per day, except for Isiolo Town, where it is closer to 70 litres per capita per day (WRMA 2013). This estimated household water demand is far higher than survey reports on water consumption in the rural areas, which indicate daily per capita rates of around 7 to 10 litres (NDMA 2014, 2015a 2016a). Estimates for livestock water demand are based on herd size estimates and generic assumptions concerning daily livestock water requirements (Table 1).

Table 1: Livestock water requirements

Type	Litres per capita per day
Sheep or goat	3.5
Cattle	23.25
Camel	33.5

Source: WRMA (2013): 50

These approximated daily consumption estimates do not take into consideration inevitable variations due to species, breed, age, gender, lactation, pregnancy, water quality, climate and seasonal effects, animal activity diet, or watering regimes (see discussions in King 1983, Herlocker et al. 1993).

In addition to these problems concerning the consumption rates for humans and livestock, there are also issues relating to the assumed numbers of consumers. The human population numbers are based on households identified during the 2009 population census (KNBS 2009). However, in pastoral areas, households and livestock from other counties also migrate in and consume water. These will not have been included in the census counts.

4.2.2 Livestock

To prepare for this study, we explored and compared a range of approaches that have been used to assess livestock numbers in Isiolo, including participatory assessments with rangeland users (as reported in Tari *et al.* 2015) and the county livestock services' use of an annual increment to adjust census data on livestock owned by households in the county[3].

From this review, it was apparent that the livestock numbers we used to generate the estimates of water demand (as in WRMA 2013) were lower than those that appeared in the national census, and subsequent calculations of the Isiolo livestock department.

3 From a previous study by Silvestri et al. (2013), we also identified aerial surveys by the Department of Remote Sensing and Resource Surveys, including flyovers conducted during 2013 and 2015 as an additional possible source of data on livestock numbers. However, this dataset and information concerning methods used to generate it were not available for use in this study.

Watering livestock in Isiolo. Photo credit: Caroline King-Okumu

Furthermore, the national census estimates still excluded livestock that migrate into the county from surrounding areas.

Our estimates of livestock value produced are therefore likely to be highly conservative. We focused on a limited set of domestic livestock types, and only considered two of the many products that can be derived from them. We did not attempt to include wildlife and wildlife products in our calculations.

To calculate the volume of livestock milk production and offtake for meat, we used the following rates in relation to herd numbers in arid areas, as identified by Behnke and Muthami (2011):

For milk production:

- cattle: 59 litres per head for cattle herds (McPeak and Doss 2004)
- camels: 186 litres per head (Musinga *et al.* 2008, who estimated 34 per cent of the total herd lactating and 547 litres per lactating camel per year)
- shoats: 51.2 litres per head (Field 1985, assuming 40 per cent of flock are does or adult females, each producing 0.351 litres per day).

For meat offtake:

- cattle: 15 per cent (McPeak *et al.* 2011), acknowledging that offtake rates for cattle in arid areas are highly variable (Fratkin *et al*. 1999, McCabe 1987)
- sheep: 13.2 per cent (Agriconsortium 2003)
- goats: 13.7 per cent (Agriconsortium 2003)
- camels: 1.7 per cent (Agriconsortium 2003)

We did not include camel sales in this assessment, because these are rare in Isiolo. The offtake rates we used may be considered conservative for arid conditions; all the more so for this study, because some parts of Kinna ward could be considered semi-arid, implying higher rates of offtake.

4.2.3 Vegetation

Vegetation in Isiolo transitions from woody bush grasslands, bushland and bush grasslands in the southwest, to shrubland, shrub grassland and shrub annual grasslands in the north and east (see Table 2).

In an interview in March 2015, Turo Buke, treasurer of the Merti and Sericho Rangeland Users Association, identified classes of vegetation in order of preference for grazing. Ibrahim Jarso from RAP supplemented this information in April 2015. Preliminary findings from fieldwork by LARMAT and RAP researchers (Wasonga *et al.* 2016) provided further information on vegetation uses in selected parts of the county. Using this data, we identified various direct uses of vegetation in the Garbatulla grazing unit – characterised as *Commiphora-Acacia tortilis* deciduous bushland – which covers the present Kinna and Garbatulla wards (Table 3).

Since Isiolo County has a broad diversity of vegetation types, species and economic uses, we were only able to assess the value of a few key species identified by RAP and LARMAT as having high economic value during this study. To estimate the rate of wood fuel use across the county, we used WRMA's estimates for 2013 population numbers (updated from the 2009 census). Assuming that households include an average of eight persons and using the information from local resource users, we estimated that each household would consume one backload of firewood every five days, amounting to 72 loads per year.

Table 3 indicates that the highest-value plant products in Garbatulla on a volumetric basis were gums and resins, including opoponax (Box 1).

Table 2: Vegetation types in Isiolo range units

Name	Area (km²)	Main type	Vegetation type Other	Other
Former Garbatulla district				
Nyambeni	1,220	Bush grassland (100%)	-	-
Garbatulla	2,970	Bushland (80%)	Shrub grassland (5%)	Unsurveyed (15%)
Mado Gashe	1,600	Shrubland (50%)	Shrub annual grassland (30%)	Shrub grassland (20%)
Subtotal	5,790			
Former Isiolo district				
Ewaso Ng'iro (drought reserve)	2,225	Annual grassland (40%)	Deciduous woodland (30%)	Annually flooded grassland (30%)
Hadado West	810	Shrub annual grassland (80%)	Bush grassland (20%)	
Yamicha	1,670	Shrub annual grassland (70%)	Dwarf shrub annual grassland (20%)	
Matokone	2,320	Shrubland (95%)	Shrub annual grassland (5%)	Wooded grassland (small areas)
Barchuma	1,950	Shrub grassland (70%)	Perennial grassland (25%)	Shrub annual grassland (5%)
Kom	1,330	Shrubland (50%)	Bushland (30%)	Dwarf shrub grassland (20%)
Isiolo w	1,925	Bush grassland (40%)	Bushland (20%) Wooded grassland (20%)	Bush annual grassland (10%) Shrub grassland (10%)
Mado Ketu	75	Unsurveyed		
Subtotal	12,305			

Source: Schwartz and Walsh (1993)

Table 3: Rangeland vegetation in Garbatulla

Plant type/species	Identified uses	Local market value		
		KSh	US$	Per (unit)
Trees				
Acacia tortilis	Bark for ropes Wood for fencing and axe handles Pods for animal feed supplement Charcoal Fuelwood	 400–700 750 400–1000 400	 4.55–7.96 8.53 4.55–11.37 4.5	 50kg 50kg donkey cart backload
Commiphora erythraea	Gum arabic Opoponax or '*hur*' Water troughs Milking containers	500 500 300–400	5.69 5.69 3.41–4.55	kg trough container
Commiphora spp.	Resins used for chewing gum and incense			
Boswellia spp.	Fire starter			
Boswellia neglecta	Frankincense			
Shrubs				
Cordia sinensis	Fruits edible for humans and livestock	20	0.23	kg
Blepharispermum pubescens				
Acacia recifiens	Bark for ropes and thread; wood for fencing			
Acacia senegal	Gum arabic	115	1.31	kg
Bauhinia sp.				
Dwarf shrubs				
Indigofera spinose				
Indigofera cliffordiana	Causes bloating, deworms goats			
Forbs				
Blepharis linariifolia	Highly preferred forage, even when dry			
Heliotropium sp.				
Crotalaria sp.				
Grasses				
Oropetium capense				
Aristida adscensionis (A)	Preferred forage species. Can fatten stock in dry season			
Tetrapogon cenchriformis (A)				

Source: based on Herlocker, Geodata (unpublished) and Wasonga *et al.* (2016).

Box 1: Gums and resins collected in Isiolo County

These products can be obtained from the *Acacia, Commiphora* and *Boswellia* species. They include myrrh and frankincense (Chikamai and Gachathi 1994, Wekesa *et al*. 2013, Gachathi and Eriksen 2011). Gums are mainly produced by *Acacia* species; gum resins are extracted from *Commiphora* (Salah 2014). The most common gum found in the Garbatulla area is gum arabic, extracted from *Acacia senegal (L.), Willd. var. kerensis* or *Acacia seyal Del. var. seyal*. Resins include myrrh from *Commiphora myrrha (Nees) Engl*., opoponax, or sweet myrrh from *Commiphora holtziana Engl.* and frankincense from *Boswellia neglecta S. Moore*.

Opoponax is locally referred to as *hur* in the Borana language or *hagar* in Somali. A recent study of its collection and uses in Garbatulla (Salah 2014) indicated that it is mainly used as a pesticide against ticks or to treat snake and scorpion bites, footrot and mange in animals, chest congestion, common colds, amoebas and lymph node swelling. It can also be used as an appetiser. The same study observed that the amount of opoponax individual *Commiphora holtziana Engl.* trees produce in Garbatulla ranges from 40 grams to 2 kilograms. The yield depends on the season, the age of the tree and whether or not the tree is damaged by making a cut on the stem or branches. Old trees produce more than young trees. 59 per cent of households in four surveyed villages in Garbatulla collected opoponax, collecting an average of 38 kilograms per month.

To find out how much opoponax is collected in Garbatulla as a whole, we assumed that 59 per cent of all 2,383 rural households in the division collected 38kg every month (after Salah 2014). To compare the total volume collected versus the potential, we estimated the density of trees, productivity and offtake rates. We then multiplied these by the extent of the vegetation type, as indicated in the Rangeland management handbook (Herlocker *et al.* 1993).

We used estimates for present and future irrigated production from available literature (WRMA 2013, Ocra 2014). Based on advice from the County Irrigation Officers, we assumed that irrigation is applied for eight hours every seven days throughout the six month long dry season.

Eating wild fruits in Isiolo. Photo credit: Peter Cacah

4.3 Identifying economic values for direct use of services

We began by identifying the valuation approaches available in scientific and grey literature for the ecosystem services under consideration, from a range of different markets and payment systems. Most goods and services identified had a market price, but subsistence uses were more frequent than marketing uses. In such cases, we used the available local market prices to value the products consumed. Market prices are subject to inter-annual variation. These variations affect the financial value of resources and private profitability. However, in our calculation of use value to society we did not include an analysis of them. Such an analysis could be desirable in future studies - particularly if intended to assess the effects of investments in improved market infrastructure or provision of credit.

We collected livestock and milk price estimates from a series of participatory meetings in Isiolo (Tari *et al.* 2015) and compared these to information on livestock sales and prices collected from the County Government, as well as unpublished ILRI market survey data (Table 4). We used the locally estimated market prices for our calculations, but a series of studies by University of Nairobi students (Elhadi and Wasonga 2016, Mwaura *et al.* 2015, Gituku *et al.* 2015, Iruata *et al.* 2015) provides information on value chains and indirect induced effects within Isiolo's economy that could further supplement our assessment of these values to society and the national economy.

We identified market values for irrigated crop production in Isiolo from a recent study (Ocra 2014). Other studies mentioning an economic value per hectare were identified (Silvestri *et al.* 2013 and Niemi and Manyindo (2010).

We used field studies by RAP and LARMAT for updated information on local market values for other climate-dependent services provided by vegetation and recreational uses – for example, based on information from local resource users, RAP estimated that each backload of firewood would fetch US$3.41 (Ksh300).

Table 4: Comparison of information from different sources on livestock prices per head in Isiolo County, 2013-14

	Participatory assessment, 2014		NDMA household surveys		Unpublished ILRI market data, Isiolo Town, 2013–14		
	US$	Ksh	Max. Ksh	Min. Ksh	Max. Ksh	Min. Ksh	Mean Ksh
Cattle	455	40,000	16,568	11,423	70,000	19,000	41,632
Sheep	34	3,000	2,394	2,065	5,700	2,800	4,862
Goat	34	3,000	3,500	2,500	9,000	2,200	7,718

Source: based on Tari et al (2015), NDMA (2016a&b) and unpublished data provided by ILRI.

We supplemented this information from the literature, where price information was available for other services, such as the price paid for opoponax per kilo:

- agents and traders pay gum and resin collectors in Garbatulla US$0.68–1.14 (KSh60–100) (Salah 2014)
- agents sell on to traders at US$1.14–1.36 (KSh100–120) (Salah 2014)
- traders who transport the goods to Nairobi or Mombasa sell to exporters for US$2.05–2.84 (KSh180–250) (Salah 2014)
- exporters sell the bulk of opoponax to China for US$3.41–5.12 (KSh300–450) (Salah 2014)
- Ethiopian exporters to the Middle East sell the same products for around US$15.66 (Ksh1,377) (Aboud *et al*. 2012).

This suggested that our estimated value for opoponax of US$ 5.69 (Ksh 500) per kg (see Table 3) was higher than the local market prices. In 2013–14, however, it was still lower than the international export value.

We used a range of published sources to calculate income streams from tourism. In 2014, the Northern Rangeland Trust (NRT) in Isiolo reported an income of US$23,320 (KSh2,050,298) from tourism (Table 5). This includes conservancy entrance fees, and fees paid to the conservancies by the hotels. The latter are usually a small proportion of the price of accommodation, negotiated by NRT with the hotel companies.

Table 5: Commercial revenue to community conservancies in Isiolo County, 2014

Conservancy name	Tourism (KSh)	Livestock levy (KSh)	Total (KSh)	Total (US$)
Biliqo-Bulesa	–	562,000	562,000	6,392.17
Mpus Kutuk	116,000	356,000	472,000	5,368.52
Leparua	–	436,000	436,000	4,959.05
Nakuprat-Gotu	1,934,298	378,000	2,312,298	26,300.02
Nasuulu	–	424,000	424,000	4,822.57
Totals	2,050,298	2,156,000	4,206,298	47,842.33

Source: Based on NRT data in King-Okumu (2015b)

We calculated the value of recreational uses of the ecosystems for tourism in Isiolo per unit of water, based on the total numbers of visitors, type and duration of their stay in the ASALs and estimated water consumption rates. We assumed that tourists in high class hotels use 600 litres each a day, those in medium class use 300 and those in low class hotels use 50 (after GoK 2005).

For services such as water, some studies (Favretto *et al.* 2014, Myint and Westerberg 2014) rely on the market price and/or the price that users are willing to pay. Water has a range of different prices: some get it free from source, others pay to pump it from boreholes, and others to transport it via truck. We used summaries of survey data published by NDMA to identify the price of water and selected foodstuffs (for example, NDMA 2014, 2015a, 2016a), together with internal monitoring and evaluation reports from the Ada Consortium for additional reflections on the price of water and water infrastructure. From these sources, we concluded that market prices for these services are affected by public or donor assistance and subsidies for infrastructure, fuel and other operating costs associated with water supply and treatment.

For our study, we used an alternative non-market route to valuing water provisioning services that focuses on the value of the intended use rather than the market cost of the water. It is important to assign a value to human water use that we can compare to the values of other uses, such as irrigation and livestock, because without these values, previous studies have concluded that upstream water extractions for irrigation and intensive livestock production are more valuable than downstream uses in extensive pastoral systems (Silvestri *et al.* 2013). This partial economic analysis overlooks the point that in the remote areas, livestock water use fees cover the costs of pumping the water that humans use for their domestic needs.

Since economic assessment plays a role in justifying water management and allocation decisions for economic uses, is very important to be able to understand the full value of these uses. If excluding consideration of the economic value of water supply to humans from the calculation results in a higher priority given to economic uses upstream than downstream, decision-makers might mistakenly consider this finding to justify the absence of effective measures to prevent continued increases in extractions for economic uses in the upstream areas of the catchment. This is already believed to be affecting the volume of water supplies reaching the downstream areas of the catchment, not only for livestock, but also for humans (WRMA 2013).

We took a generic value from Kenya's per capita gross domestic product (GDP) – US$1,337.90 (KSh117,628) (IBRD 2015) – to reflect an average member of society's contribution to the economy, irrespective of age and wealth. This contribution to society and the economy is dependent on the individual receiving sufficient water supplies to maintain health, lead an active life and achieve their full potential contribution to the economy (Hutton 2015). Assuming that in order to lead a healthy life, each person requires 40 litres of water a day, 365.25 days a year, they will use 14.61 cubic metres a year to generate the average contribution to the economy of US$1,337.90. This would place the value of domestic water supplies at around US$90 (KSh7,913) per cubic metre.

This is may be considered a conservative estimate, since it is based on an estimated volume of water that is relatively high, and an average per capita GDP that is relatively low. On the other hand, according to the logic of the argument that is presented here, if the entire population had access to sufficient water to fulfil their basic needs for health and lead economically productive lives, both total and per capita GDP could be expected to increase.

Controversies associated with valuing a productive human life have received attention in international literature and in the context of Kenya's arid lands (Luedeling *et al.* 2015). Using GDP as a total sum of national productivity has also attracted criticism because it does not include many dimensions of value or account for externalities from economic activities.

It is important to note that the domestic use value of water that we identified using the method above is higher than the market value most people are willing to pay for their domestic water supplies. In most of Isiolo for most of the year, the market price of a 20-litre jerrycan of water pumped from a borehole is around US$0.03 (KSh3). This can rise to US$0.34 (KSh30) per 20 litres and US$17.06 (KSh 1,500) per cubic metre in water-scarce areas such as Modogashe, Sericho ward (NDMA 2014, 2015b, 2016a). For the sake of comparison, if the price of bottled water from a supermarket is US$2 (KSh176), this would amount to US$2,000 (KSh175,840) per cubic metre.

Discussion held under a solar panels during a visit to Cherab ward. Photo credit: Caroline King-Okumu

5 Assessment of direct use values

5.1 Water supply

We estimated water demand (and assumed supply) at over 4.5 million cubic metres a year, with a value to society of more than US$240 million (over KSh21 billion) (Table 6). This is the estimated value of annual water provisioning services to humans and livestock in Isiolo; water for livestock was worth over US$20 million (nearly KSh1.8 billion). This works out to a value of US$13–22 per cubic metre of water provided for livestock to drink. This is noticeably higher than published estimates of water productivity for livestock raised in more intensive systems (e.g. in van Breugel *et al.* 2010) because these offset the economic value of livestock against the water used for both forage production and drinking. In the pastoral systems, on the other hand, livestock rely almost entirely on extensive grazing, rather than on forage crops. Since no water is extracted from the system to provide rainfed vegetation, our calculation considers only the water requirements for livestock to drink.

Extraction of water from boreholes can place pressure on aquifer systems, causing negative indirect use values through falling water tables and salinisation. If we were to subtract these negative indirect use values, the total value estimate would be lower than the direct use value. But groundwater can be pumped on demand during drought periods so, the longer the water is conserved in these sources, the more option value for insurance against drought emergencies it will provide.

Collecting water in Isiolo. Photo credit: Peter Cacah

Communities can invest in improving ephemeral water sources to maximise the amount of rainfall captured in them and the duration for which it can be stored without contamination. By minimising the extraction of groundwater resources, they can also conserve their option value for use during drought periods. Better understanding of the volumes and value of water sourced from ephemeral water points would enable the quantification of potential benefits to society from these investments.

In Section 4.2.1 we have already identified a range of factors affecting the volumes of water required by humans and livestock, and the balance between demand and supply at various across the county at different times of the year. Also, our field investigations indicated that in the more arid parts of Isiolo during the dry season, livestock watering, and often also collection of water for pastoralist households, may be limited to once every few days. The estimates of water volumes available and used in this study therefore merit more in-depth investigation to identify the full extent of variations due to climatic and other factors.

Table 6: Estimated direct use value of water provisioning for humans and livestock in Isiolo, 2013

Area	Demand category	Population number	Unit value (US$)	Total use value (US$)	Water requirement (m^3/day)	Water requirement (m^3/yr)	US$ per m^3/yr
Isiolo	Domestic – urban	62,931	1,337.90	84,195,385	4,284	1,564,731	54
	Domestic – rural	11,654	1,337.90	15,591,887	466	170,207	92
	Cattle (for meat + milk)	20,566	455/head + 0.68/l	2,231,570	478	174,648	13
	Sheep and goats (for meat + milk)	64,119	34/head + 0.45/l	1,788,943	224	81,968	22
	Camels (for milk only)	28,282	0.91/l	4,786,581	947	346,055	14
	Subtotal			108,594,366	6,400	2,337,608	
Oldonyiro	Domestic – urban	11,382	1,337.90	15,227,978	455	166,189	92
	Domestic – rural	5,551	1,337.90	7,426,683	222	81,086	92
	Cattle (for meat + milk)	10,000	455/head + 0.68/l	1,085,077	233	84,921	13
	Sheep and goats (for meat + milk)	50,000	34/head + 0.45/l	1,395,018	175	63,919	22
	Camels (for milk only)	5,000	0.91/l	846,224	168	61,179	14
	Subtotal			25,980,980	1,252	457,293	
Merti	Domestic – urban	14,785	1,337.90	19,780,852	591	215,863	92
	Domestic – rural	9356	1,337.90	12,517,392	374	136,604	92
	Cattle (for meat + milk)	5,000	455/head + 0.68/l	542,539	117	42,643	13
	Sheep and goats (for meat + milk)	16,800	34/head + 0.45/l	468,726	59	21,477	22
	Camels (for milk only)	500	0.91/l	84,622	17	6,118	14
	Subtotal			33,394,131	1,157	422,704	

Area	Demand category	Population number	Unit value (US$)	Total use value (US$)	Water requirement (m^3/day)	Water requirement (m^3/yr)	US$ per m^3/yr
Garbatulla	Domestic – urban	29,880	1,337.90	39,976,452	1,195	436,474	92
	Domestic – rural	19,066	1,337.90	25,508,401	764	279,051	91
	Cattle (for meat + milk)	18,290	455/head + 0.68/l	1,984,606	427	155,988	13
	Sheep and goats (for meat + milk)	78,000	34/head + 0.45/l	2,176,228	275	100,355	22
	Camels (for milk only)	17,690	0.91/l	2,993,940	593	216,453	14
	Subtotal			72,639,628	3,253	1,188,320	
Total				240,609,105		4,637,036	

Source: Based on WRMA 2013 p71 and own calculations

5.2 Energy and plant products

Energy from solar and wind power is not yet widely harnessed or used in Isiolo County, but their potential has been gaining increased attention. In the rangeland areas, at some boreholes – such as Urura and Gafarsa – the pumping systems are powered with photovoltaic panels instead of diesel generators. In 2013, solar energy powered the pumps at 17 water points. A similar number relied on diesel and electricity, 44 still had natural pressure and 73 were powered manually (NWSB 2013). Of these, the power provided by artesian pressure and solar energy could be considered as ecosystem services, but there is no value assigned to these services other than the cost of equipment used to capture the solar energy.

Although we have not been able to calculate the value of these services, it would be desirable to do so. As the County continues to invest in replacing diesel pumps with solar powered ones, there may also be scope to consider changes in indirect (ecosystem resilience) values achieved due to reduced emissions. Where off-grid energy supplies are available for pumping water in the rural areas, they can sometimes also be accessed for other domestic uses.

At the time the Isiolo CIDP was being prepared, only 2,500 households had access to electricity: 70 per cent of households, 85 per cent of trading centres and most schools and health facilities relied on firewood as their main source of power (GoK 2013a), which

Collecting firewood in Isiolo. Photo credit: Peter Cacah

meant trees had been over-harvested in many areas of Isiolo. Our estimate of the market value of fuelwood for households (Table 7), does not include wood used by businesses or sold to households outside the county, either as fuelwood or charcoal. Nor does it take into account the indirect (ecosystem resilience) cost of the loss of vegetative cover and habitats where wood has been over-harvested. The cost of these are a reduction in the future availability of woodfuel and other actual and potential economic uses of vegetation.

Our calculations indicate that around 1,406 households in Garbatulla collect 456 kilograms of opoponax a year – that's an annual total of 641,136kg, worth US$3,646,133.85 (KSh320,568,000). We estimate that there are around 1,000 *Commiphora holtziana Engl.* trees in each square kilometre of bushland. So, as bushland covers 80 per cent of the 2,970km^2 Garbatulla grazing unit, there could be as many as 2,376,000 trees. If each produces around 1kg of opoponax per year, they have a potential value of US$12,716,105.55 (KSh1,118,000,000) a year. But because there are no well-developed systems to collect, process and deliver it to market (Mwongela 2012), only about a quarter of the potential is collected and marketed.

Table 7: Estimated market value of fuelwood for Isiolo households, 2013

Area	Demand category	Population number	Dependent households	Backloads per year	Market value (KSh)	Market value (US$)
Isiolo	Domestic – urban	62,931	7,866	386,379	115,913,700	1,318,399.68
	Domestic – rural	11,654	1,457	104,886	31,465,800	357,891.26
	Subtotal				147,379,500	1,676,290.95
Oldonyiro	Domestic – urban	11,382	1,423	102,438	30,731,400	349,538.22
	Domestic – rural	5,551	694	49,959	14,987,700	170,469.75
	Subtotal				45,719,100	520,007.96
Merti	Domestic – urban	14,785	1,848	133,065	39,919,500	454,043.45
	Domestic – rural	9356	1,170	84,204	25,261,200	287,320.29
	Subtotal				65,180,700	741,363.74
Garbatulla	Domestic – urban	29,880	3,735	268,920	80,676,000	917,606.92
	Domestic – rural	19066	2,383	171,594	51,478,200	585,511.83
	Subtotal				132,154,200	1,503,118.74
Total					390,433,500	4,440,781.39

Source: Authors' own calculations

To assess the indirect (induced economic) benefits of opoponax production, we based our estimates on the assumption that people trade this product alongside others, rather than as their sole business. Local collectors receive a better price for opoponax when they collect it in larger volumes. Individual collectors would bring 0.5–20kg of gums and resins to the trading centres for each sale. The price some pay for gums and resins depends on the amount brought to the market: they pay a higher price for larger quantities because by buying in bulk, they can immediately transport it to Nairobi for sale. This enables higher stock turnover, more profit and better relations with buyers. Collecting smaller quantities over longer periods of time for less frequent sales is less profitable and more troublesome (Salah 2014). Based on this information, traders may see an opportunity cost in trading small volumes of opoponax – particularly if they are also engaged in other trades.

Skillful tapping of gums and resins and tree management can ensure that the harvesting of these products does not result in loss of tree cover (Njenga *et al.* 2013). Cuts and damage to the trees increase opoponax production unless the tree is unable to survive. This means that producing opoponax does not necessarily have a negative indirect (ecosystem resilience) cost. The income generated from this non-destructive use, with the future option of using the larger trees for wood or fuel, could offset the foregone income from conserving, rather than cutting down, trees. But the option value that communities can derive from reserving the option to cut trees in the future, rather than immediately, depends on their ability to ensure that outsiders do not come and cut them first. In many parts of Isiolo, this is a problem.

Acacia, Commiphora and *Boswellia* are well-adapted species for dry conditions and usually survive, even through drought periods. The dry season is the period of highest opoponax production. However, excessively dry conditions have a negative effect, even on these species.

In Table 6 we presented the estimated use value of water used for livestock. This is based on the estimated annual market value of livestock offtake, which includes the value of vegetation used for grazing. People tend to collect wood, gums and resins alongside raising livestock, rather than as a separate activity. Other uses of rangeland vegetation – observed in GeoData's participatory resource mapping activities (Hill *et al.* 2014, 2015) and ongoing work by LARMAT (Wasonga *et al.* 2016) – include grazing, fruits, sisal, incense, thatch, dyes, poisons, medicines for headaches from malnourishment and anaemia in children, deworming goats, making drinking cups, containers, troughs, pestles and mortars for grinding maize and poles for construction. It was difficult to identify a market value for many of these valuable resources (see Table 3), so our assessment does not consider them all.

Households do use irrigation to support the production of forage and other crops. A 2015 survey by the University of Nairobi's Department of Urban and Regional Planning revealed that availability of household water supplies in the urban area has enabled households to plant kitchen gardens, flowers and trees where water is available from the piped network (DURP 2015). But the productivity of these gardens has not been recorded.

Developing irrigation schemes is considered a promising strategy for community development in many parts of Isiolo (see e.g. NRT 2015b, Gotu WRUA and WRMA 2013). It is also high on the list of the Kenya Food Security Group's recommended interventions to improve food security in the county (NDMA 2015a, 2016a).

Irrigation is mostly understood to require diversion of fresh surface or groundwater through communal irrigation schemes (WRMA 2013). The longest-established large irrigation scheme in Isiolo is at Rapsu (Box 2). Relatively less attention has been paid to the potential for reusing wastewater or harvesting water for small scale to use in crop production. Even less information is available concerning pastoral communities' opportunistic cultivation of flood recession areas and the use of supplemental watering practices, to ensure the survival of indigenous species during extreme dry periods.

Box 2: Study of Rapsu irrigation scheme, Garbatulla

A previous study observed that 2,000 persons (330 households) in the Rapsu pastoral community, growing irrigated crops on 176 hectares, were earning US$23,000 (KSh2 million) gross – US$130 (KSh11,430) per hectare – a year from crop sales. They were also growing enough for their own consumption. But because they were diverting water from the Ewaso Ng'iro river for irrigation, pastoralists found that the goods and services they were obtaining from the downstream Lorian swamp had been reduced.

Pastoralists within a radius of more than 50 kilometres had historically depended on this wetland as a source of water and forage during dry periods. They estimated the value of these goods and services at about US$125 (KSh10,990) per hectare per year. The basis for this estimate is not known.

Since the area of the swamp (231,000 hectares) was far larger than that of the irrigation scheme, the pastoral community did not consider the trade-off between their loss of services and the gain of irrigated production to have been worthwhile.
Source: Niemi and Manyindo (2010)

Most community-managed irrigation schemes in Isiolo County are either furrow or basin irrigation technologies that are relatively cheap, compared to pressurised systems such as sprinkler or drip irrigation. Farmers can easily adopt and manage them as they are simple to operate and maintain. But their efficiency is generally assumed to be about 50 percent (Ocra 2014) due to water losses along the lined canals and in the simple earthen channels for distribution and application.

An economic assessment of the potential value of furrow irrigated agriculture in Isiolo County projected that exploiting the county's total potential irrigation at a cropping intensity of 130 per cent over a cropping area of 5,850 hectares would generate US$10.16 million (nearly KSh893 million) a year. The same study calculated the gross irrigation water requirement at 3.1×10^7 litres per hectare per year, or 31,000 cubic metres per hectare per year. This was anticipated to generate a profit of some US$1,736 (KSh152,650) per hectare per year (FAO 2013 unpublished forthcoming p44). This is far more than previously observed (see Box 2), but still amounts to only US$0.06 (less than 5 shillings) of use value for every cubic metre of water.

According to the Irrigation and Drainage Database (Isiolo), the total irrigated area in 2013 was 2,879.6 hectares, with a water demand of 3,578 cubic metres per day (WRMA 2013 p71). This amounts to 1.24 cubic metres per hectare, per day. If irrigation is applied once a week throughout a six month season, this would amount to a total water requirement of 29.82 cubic metres of water per hectare, per year. If the income per hectare was only US$130 (KSh11,430) (see Box 2), this would amount to a gross income of US$4.36 (Ksh 383) per cubic metre of water (before deduction of costs). However, more recent estimates of crop productivity and values and effective calculation of the gross margin after deduction of costs, might enable identification of an updated figure.

It is possible to get 'more crop per drop' by using pumps and drip irrigation systems to increase control over water distribution and application. The sources of water and systems that farmers use will affect the costs and determine the level of externalities in relation to the water and carbon balances. But importing foodstuffs also creates a (possibly larger) energy demand from transportation and storage. These indirect effects associated with different configurations of direct resource uses are not well understood.

5.3 Recreation

Recreational uses of ecosystems in Isiolo are important, and can generate income streams through tourism enterprises. Previous studies have estimated the value of tourist uses of the ecosystem services associated with wildlife in the Ewaso Ng'iro Basin by multiplying the number of visitors by the conservancy entrance fees (Ericksen *et al.* 2011, Silvestri *et al.* 2013). By this calculation, the conservancy entry fees in sub-catchment 5 – where Shaba, Buffalo springs and Nakuprat Gotu conservancies are located – generated US$1.26 (KSh111) per hectare per year.

The indirect (induced economic) value of nature tourism may be higher than its direct use value from hotels, restaurants and travel costs. The wildlife tourism sector has been estimated to contribute over half of all earnings in Kenya's trade, restaurant and hotel sectors (Mogaka *et al.* 2006). In 2013, Isiolo had:

- one 5-star hotel (bed capacity: 34)
- two 4-star hotels (joint bed capacity: 78)
- three 3-star hotels (total bed capacity: 250)
- one 2-star hotel (bed capacity: 311)
- three 1-star hotel (total bed capacity: 348)
- several unclassified hotels and restaurants (GoK 2013).

We estimated the gross income and income per unit of water that the hotels would generate at full occupancy (Table 8). Although our calculation of value achieved per unit of water is an overestimate because we could not subtract other input costs from the gross income, the value is clearly less than is achieved through livestock production or irrigation.

Table 8: Estimated annual gross hotel income per unit of water

Hotel type	Star rating	Number	Capacity	Price (Ksh)		Water litres per day		Value per unit of water	
				per bed	total	per bed	total	Ksh/ litre	US$/ litre
High class	5	1	34	25,000	850,000	600	20,400	42	0.48
	4	2	78	5,000	390,000	600	46,800	8	0.09
Medium class	3	3	250	3,000	750,000	300	75,000	10	0.11
	2	1	311	2000	622,000	300	93,300	7	0.08
Low class	1	3	348	1000	348,000	50	17,400	20	0.23
	0	6	300	500	150,000	50	15,000	10	0.11
Total					3,110,000		267,900	12	0.14

In 2014, the fees the hotels paid the NRT did not cover the conservancies' operating costs, leaving them dependent on donor support. Total 2014 income to NRT operations in nine counties from international donors was US$1,735,334.43 (KSh152,570,603). Although these funds are not necessarily spent in Isiolo, we could consider donor support to NRT as an induced economic benefit to the wider economy.

6

Total values: Summary and discussion

Although still not a complete and exhaustive assessment of all direct use values of ecosystem services in the Isiolo economy, by capturing those of the main climate-dependent provisioning services – water, energy, fibres and foods – we aim to advance the current state of knowledge. The profile of direct use values we have identified for 2013–14 includes:

- livestock production: US$20,384,075 (KSh1.8 billion) per year
- fuelwood: US$4,440,781 (KSh390 million) per year
- opoponax: US$3,646,133 (KSh321 million) per year
- irrigated crops: US$374,348 (KSh33 million) per year, and
- tourism: US$35,373 (KSh3.2 million) per year.

If we add this to the value of productive human lives supported in the county (estimated at US$220,225,030 (KSh19 billion), the total value of these services amounts to US$249,105,740 (KSh21.9 billion a year). This profile includes various overlaps and tradeoffs among the values considered. We have also not yet accounted for the full extent of variations that are due to the climate and a range of other factors that we have identified to affect the volumes of water available and used by the human and livestock populations over the seasons and across the county. Many questions remain about total rainfall volume, available water resources and water resources used. These could be addressed through further work on hydro-meteorological monitoring and modelling, field surveys and ethnographic observation.

Our assessment approach differs from previous TEV studies in the county because we have quantified water-related services and also explored other service values per cubic metre of water, rather than focusing on values per hectare of land. Based on the county's average rainfall and surface area, we could calculate Isiolo's rainfall at 149,111,400m^{3}. But the direct use values we identified in this study still account for only the small fraction of this water that is accessed through the waterpoints. We have not yet attempted to value the water that is stored and used in different parts of the system, including in plants and soils. Although we have valued some components of the rangeland vegetation, we have not included the rainwater that they consume in our calculations of value per unit of water. We also assigned a value to water for human use that is higher than those used in other studies that have relied more on market valuation methods. This non-market valuation is is in line with the stated principles of catchment-level water allocation (Mutiga, *et al.* 2010), but could have controversial implications for the current catchment management practices.

The mixture of non-market and market valuation approaches we use in this study reflects choices of social rather than market values, wherever possible and available. Further adjustment of these to take into consideration the indirect values would be desirable. We have observed that there are market chain studies for some key products, but not for others. To improve understanding of induced economic benefits, there is a need for these value chains to be further explored and their inputs assessed – for example, through the water, energy, transport and construction sectors. There is also scope to consider externalities and loss of value and to adjust for the ecosystem resilience benefits (and costs) associated with different patterns of direct uses. This would require further use of spatial monitoring, mapping and modelling tools, which have been previously developed and applied in Isiolo (for example, in WRMA 2013, Hill *et al.* 2014).

We identified the important effects of option value in adjusting the direct use values that are obtained from ecosystem services through the nature and timing of their direct use. Although these are difficult to build in to a generalised profile of the system focusing on a single year (as in this study), they will be critical for both anticipatory or retrospective evaluation of different management scenarios.

7

Beyond the profile of direct use values in 2013–14: next steps

The assessment framework should be used by decision-makers to explore the effects of investments creating changes in the system. These might include public investments planned under the current CIDP (2013–17), the proposed Strategic Plan for the Water and Irrigation, Energy, Environment and Natural Resource Sector or the Isiolo Climate Adaptation Fund. This assessment approach could also be introduced to county investment forums. Effective accounting for ecosystem services at the County level could enable better tracking of green growth at the national level.

To support the county government's use and progressive improvement of the assessment framework we recommend:

- improving statistical processes for tracking direct use values of ecosystem services in Isiolo – for example, information databases for population, water, livestock products, horticulture, fish, trees and others
- where resources cross county boundaries, collaborating beyond the county level
- improving mapping tools and studies to assess indirect effects of different resource uses and values on ecosystems, and the tradeoffs between them
- improving planning and documentation of different options at county level and using participatory research to understand decisions taken at community and household scales, to help understand the timing and uses of options, and

- extending the profile developed so far through a longer-term scenario to take into account the likely effects of climate change and variability.

An important strategic consideration concerns whether to assess scenarios for ecosystem values under different management systems on an annual basis – as we did for the direct use values in this report – or on longer timeframes (e.g. 5–10+ years). Decision makers often require assessments of the returns on their investments to be available over short timeframes. However effects on ecological processes can take longer to appear. Selecting a four- to five-year timeframe (such as 2013–17) would be in line with economic decision making under the CIDP, whereas national strategic planning extends to 2030 (GoK 2012).

The longer the assessment timeframe, the greater the challenge to accommodate uncertainties of various kinds. Use of a probabilistic approach, incorporation of outputs from downscaled climate and hydrological models and discounting could help to account for some of the uncertainties in long term planning scenarios (for further discussion of the use of statistical techniques to accommodate and account for uncertainties see discussion in Luedeling *et al.* 2015, Shepherd *et al.* 2015, Hubbard 2014).

Overall, we take the view that using a provisional assessment framework and 'best available' supporting evidence base is preferable to having no framework or evidence for decision making. Progressive use of the framework and underlying datasets will encourage greater scrutiny and possibly also some updating, which could enable improvement. In the meantime, we hope that researchers and decision makers will apply the TEV framework in an exploratory and discursive manner. We do not advocate using it to programme automated decision-support applications because this would reduce the emphasis on human judgement, and scope for critical reflection and debate.

Public debate around the relative value of different benefits to society remains essential for the framework's sound development and application. Many controversial questions may arise around who decides what, how to prioritise gaps, etc. It is important that these should be handled transparently, enabling iterative deliberation and progressive adjustments.

8 Conclusion

The profile we have described in this report demonstrates an application of the TEV assessment framework. The direct use values that we consider represent an improvement on the frequent limitation to market values in cost-benefit assessments. The suggestion that indirect (induced economic and ecosystem) use values and option values could also be considered, depending on the timeframe of interest, is also progressive.

The county government could take action to improve the assessment and its potential to support decision-making through more systematic recording, mapping and prediction of ecosystem service flows and values. Applying this framework in an exploratory and discursive way – even with its gaps – provides informative comparisons of service values associated with different uses and raises questions that will contribute to further elaboration of the assessment approach. Researchers and practitioners should use it carefully as a discursive tool, ensuring regular opportunities for public review and comment.

If the county government were to generate assessments of ecosystem service values using this framework, the findings could be used to better inform decision-making. This could include not only the County level decision-making, but also national level plans for green growth, and international thinking on environment and sustainable development issues.

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Research Report

February 2016

Green economy; Drylands and pastoralism

Keywords: Climate change, watersheds, economic value of pastoralist services, ecosystem services, valuation

This research builds a profile of the current direct use values of ecosystem services in the economy of Isiolo County. Particular consideration is given to climate-sensitive service values achieved per cubic metre of water, in addition to values per unit of land under pastoral rangeland and other uses. Higher direct use values were observed per cubic metre of water for domestic uses and livestock water provisioning than for irrigated agricultural uses and tourism. Other dimensions of value that can supplement these direct-use values are identified through a Total Economic Valuation (TEV) approach. These findings highlight the need for an iterative public debate to refine the assignment of values to ecosystem services and enable cost benefit analysis by decision-makers.

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