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A framework to assess returns on investments in the dryland systems of Northern Kenya

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- Building capacity to act on the implications of changing ecology and economics for equitable and climate resilient development in the drylands.

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The potential for economic growth and development in the arid and semi-arid lands of Northern Kenya is arguably higher than in more humid parts of the region. Local governments must identify those investments which will benefit local people most. In the absence of frameworks to compare the benefits of proposed investments with those provided by the existing, largely pastoral economy, the wrong decisions could be made, especially given the changing climate. This working paper is intended to stimulate and contribute to a discussion of how the returns on land-based investments in the drylands should be evaluated. It presents an assessment framework for weighing the total economic value of the ecosystem services provided by pastoral and mixed land-use systems under anticipated climate changes and variability.

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Summary

Governments need quantitative assessments of the outcomes of proposed investments so they can weigh the merits of each option. Without these, there is a risk that some proposed changes could in fact *reduce* rather than increase benefits to the economy and society. At present, there is no definitive framework for assessing the returns to Northern Kenya's predominantly pastoralist land use, nor any prediction of its returns under anticipated climate changes. There is therefore no possibility of comparing returns between this and any alternatives.

Flagship projects planned to accelerate economic development in Northern Kenya include an international transport corridor, a resort city and an international airport. In addition, mineral deposits are being discovered, towns are growing across both arid and semi-arid areas, and land speculation is increasing. The county governments are faced with the task of prioritising investments which can do the most to improve living standards for local people.

This paper is intended to stimulate and contribute to a discussion of how the returns on land-based investments in the drylands should be evaluated. It presents an assessment framework for weighing the total economic value of the ecosystem services provided by pastoral and mixed land-use systems under anticipated climate changes and variability. The proposed framework draws on contributions from previous research at IIED and by other research partners focusing on ecosystem service assessment in Northern Kenya and surrounding dry regions. The paper reviews the current state of knowledge on the returns from pastoral and other land uses in the region, identifies research gaps and highlights the next steps needed for implementing the framework.

The valuation framework

Based on established precedent in the literature, the framework for valuation of the ecosystem services provided by current predominantly pastoral land uses would involve four main steps:

1. Specification of land-based system boundaries and interactions with the global climate system
2. Biophysical assessment of ecosystem services
3. Valuation using monetary or other indicators
4. Aggregation and review

The paper outlines how each of these steps can be applied to calculate a total ecosystem valuation for the three main types of ecosystem services:

1. Provisioning: such as water supplies, minerals, plant products, and livestock.
2. Supporting and regulating: such as water storage, soil formation, carbon sequestration, conservation of seedbanks, waste removal, and climate regulation.
3. Cultural: scenic, recreation and spiritual benefits provided by landscapes, springs, wildlife and communal resource stewardship traditions.

While much of the necessary data can be drawn from existing research, some ecosystem services have so far received less research attention than others. The introduction of a climate lens to the assessment heightens the need to systematically monitor, model and value the critical regulating services provided by pastoralism in the drylands that ensure water availability and climate regulation, as well as the provisioning services.

Next steps

What are the next steps needed to fill these gaps and move the assessment forward?

- **Build research capacity** with partners and stakeholders across the region and beyond in order to enable local planners to apply the framework.
- **Increase the use of participatory GIS.** This can be used to map and quantify the extent, composition and values of vegetation and responses to climatic variability. GIS tools and methods could also help to overlay and balance the missing values associated with water, minerals and carbon storage.
- **Generate estimates to model current and anticipated future water use** patterns under planned scenarios for industrialisation and urban development in northern Kenya.
- **Pay more attention to valuing water storage services**. The valuation of livestock resources in pastoral systems has received much greater attention than their subsurface water and mineral wealth. The critical importance of groundwater storage in drylands under climate variability is a strong justification for according this service its own place within the assessment framework.
- **Consider the negative value of emissions in the economic valuation of provisioning services** such as crops and livestock. The assessment framework should also include space to capture the carbon sequestration services that can counterbalance these emissions as a by-product in the same production processes.
- **Give strategic attention to the social and temporal distribution of returns** to investments and ensure that the aggregated assessment does not overlook the potential cost of increasing social inequality.

1 Introduction

The potential for economic growth and development in the arid and semi-arid lands of Northern Kenya is arguably higher than in more humid parts of the region because of their relative under-development in terms of economic activities and natural resource endowments (Fan and Hazell, 2001; RoK, 2012). The northern county governments are faced with the challenge of leading and prioritising those investments by the public and private sector which can do the most to improve living standards for local people.

Governments need quantitative assessments of the outcomes of proposed land-based investment options so they can weigh the merits of each option. Understanding the material differences that development projects are likely to make to the various sections of the population in the long term is complex and sometimes contentious. At present, there is no definitive framework for assessing the returns to Northern Kenya's current predominantly pastoralist land use under anticipated climate changes. There is therefore no possibility of comparing returns between this and any alternatives. Without such a framework, there is a risk that some proposed changes that are assumed to be progressive could in fact *reduce* rather than increase benefits to the economy and society, sometimes in the short term. On the other hand, investments that could generate a high return might be overlooked.

This working paper is intended to stimulate and contribute to a discussion of how the returns on land-based investments in the drylands should be evaluated. It presents an assessment framework for weighing the total economic value of the ecosystem services provided by pastoral and mixed land-use systems. The framework must also anticipate the value of the systems under predicted future climate changes and variability. It draws on contributions from previous research at IIED and by other research partners focusing on ecosystem service assessment in Northern Kenya and surrounding dry regions. The paper reviews the current state of knowledge on the returns from pastoral and other land uses in Northern Kenya, identifies research gaps and highlights the next steps needed to implement the framework.

2

The drylands of Northern Kenya and future development options

Drylands can include hyper-arid, arid, semi-arid and dry sub-humid areas (Safriel *et al.*, 2005). Seventy percent of Kenya, mostly in the north, is considered to be arid and 19% is semi-arid (RoK, 2012). The economy and current land uses of the arid areas are dominated by mobile pastoralism, while in the semi-arid areas, pastoralism is mixed with rainfed and irrigated agriculture, small-scale businesses based on dryland products, and conservation or tourism-related activities. Security concerns periodically constrain access to land in some areas, or create the need for military land uses.

At present, much of the land in Northern Kenya is under traditional community ownership. Land registration is considered to play an important role in enabling economic development and investment. A community land bill has been published which describes provisions for community land to be converted to private land or for investments to be put up in areas of community land (RoK, 2014). In such cases, the bill requires that every investor in community land shall spend at least 30% of the net income on the provision of services to the community, laying infrastructure, education and capacity building, or payment of royalties.

Studies exploring the potential to accelerate development in the drylands have often focused on irrigation (e.g. Ocra, 2014). Nevertheless, the Vision 2030 Development Strategy for Northern Kenya and other arid lands highlights a wider range of possible land-based investments (RoK, 2012). Flagship projects include a Lamu Port-Southern Sudan and Ethiopia Transport corridor (LAPSSET) across Northern Kenya and beyond, a resort city and an international airport. In addition, mineral deposits are being explored, and across both arid and semi-arid areas, towns are growing, with the lifestyle and aspirations of the urbanised population creating new demands for natural resource and land-use patterns. These developments are encouraging land speculation.

For pastoralists, different areas of rangeland are important at certain times of the year, including some which are reserved for periods of drought stress (RoK, 2012). Because these lands are left empty at other times, to outsiders they may appear to be unused and ripe for alternative forms of production and investment, whereas in fact they are growing and conserving stocks of vegetation for use during drought periods. Areas of land along watercourses, in the hills, or in alluvial grasslands are particularly attractive to other forms of land use, such as cultivation or settlement. However, this places them permanently beyond the reach of livestock. But seasonal access to these lands is what allows livestock and pastoralist households to make productive use of much larger areas of rangeland throughout the year.

3

Ecosystem valuation framework

The ecosystem services from drylands under pastoral and other land uses can be classified into three main types (after Costanza *et al*., 1997; Safriel *et al*., 2005):

1. Provisioning: such as water supplies, minerals, plant products, and animals (Havstad *et al*., 2007; Kreuter *et al*., 2001; Swinton *et al*., 2007).
2. Supporting and regulating: such as water storage, soil formation, carbon sequestration, conservation of seedbanks, waste removal, and climate regulation (Reed *et al*., 2015).
3. Cultural: scenic, recreation and spiritual benefits provided by the open pastures, springs and communal herding traditions.

A framework for valuing the ecosystem services provided by pastoral land uses would involve four main steps (Figure 1):

1. Identification of the system boundaries and mapping of the services to be assessed
2. Biophysical modelling of productivity and climate effects on the availability of services
3. Valuation of services to human well-being
4. Aggregation and comparison of the different values

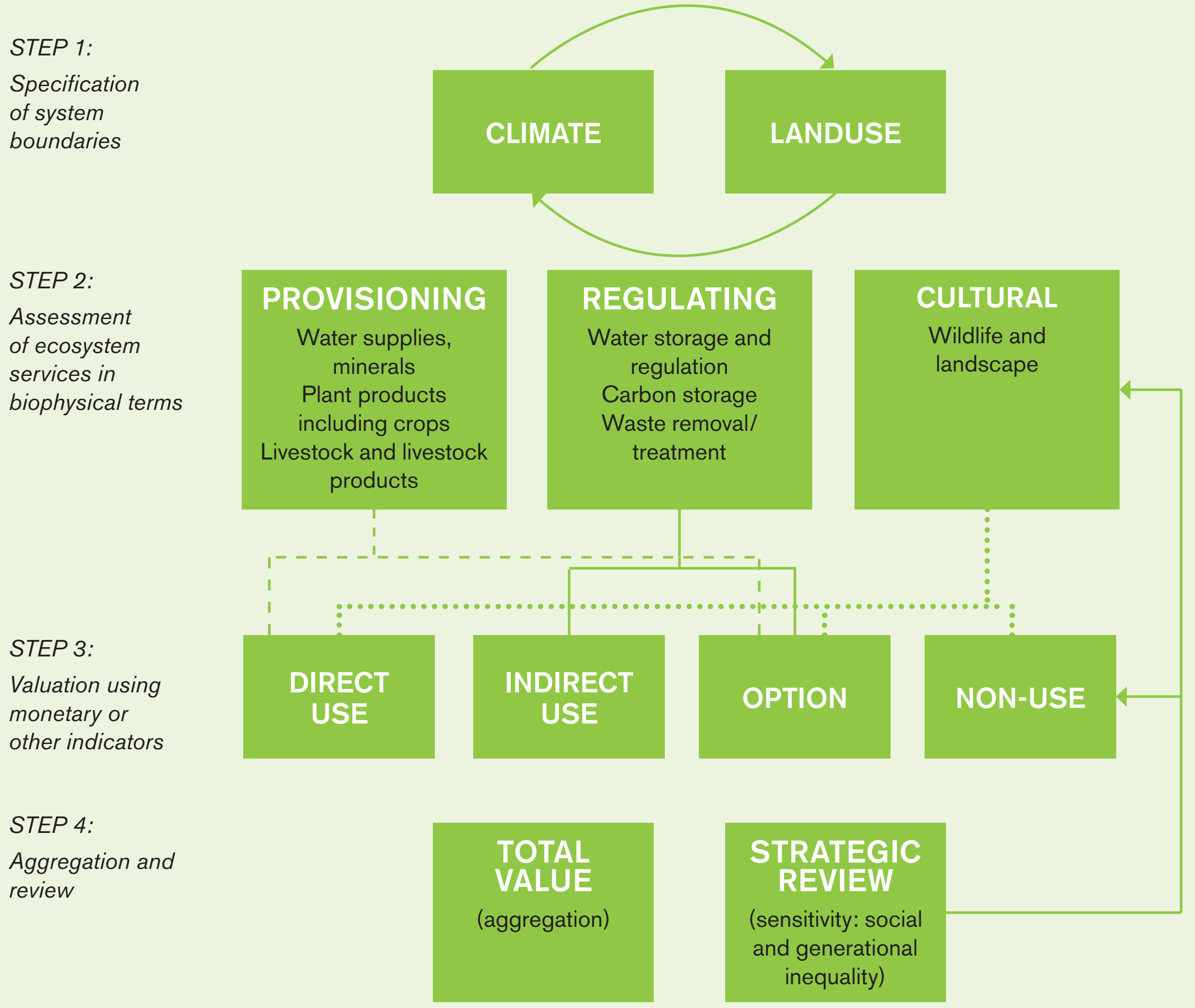
A participatory approach is essential at every stage of this framework (Ash *et al*., 2010).

Identifying and mapping the services to be assessed

Calculating the returns to pastoral and mixed land uses requires the identification of a manageable number of services, before calculating and adding the value of each one. Some services are more important to some people than others (Kaye-Zwiebel and King, 2014; Oteros-Rozas *et al*., 2014). Sometimes people who live inside the boundaries of the system are interested in different services than international communities. A participatory research approach is recommended to identify which services are important to the various stakeholders, and how the services may be perceived and characterised (e.g. as in Ash *et al*., 2010; Wittmer *et al*., 2010).

Applying a climate lens to the assessment of dryland ecosystem services aims to assess the likely effects on the productivity of services of both long and short-term variability in temperature, rainfall and other climatic effects. This assessment encourages planning for extremes, and planning which allows for uncertainty. This lens also introduces a multi-scale perspective, in which global climate processes are recognised to interact with local climatic conditions (after Stern, 2006).

Figure 1: Ecosystem valuation framework including a climate lens



Source: modified from Hein *et al.*, 2006

Biophysical modelling of productivity and climate effects

Based on previous work in the pastoral systems of Northern Kenya, including IIED's own participatory action research activities to date (ADA, 2013a, 2013b, 2013c, 2013d; Lunduka, 2012), a provisional consensus group of essential ecosystem services can be identified.

Determining how much of each of the services are produced can involve the use of maps. Geographic Information Systems (GIS) are a convenient tool for mapping and calculating the yields of different land uses (e.g. extensive rangeland, agropastoral systems, irrigated land, etc.) and returns over a large spatial area (Konarska *et al.*, 2002; Trabucchi *et al.*, 2014). Depending on the availability of resources, time, datasets and expertise, these can range from very simple schematic participatory assessments to more complex modelling exercises.

The climate lens can require that landcover mapping and productivity models in GIS be connected to watershed models and downscaled global climate predictions (Droogers and Bouma, 2014; Droogers *et al.*, 2012; WLI, 2013). These models will integrate assumptions concerning the relationship between climate, vegetation and livestock productivity in order to generate predictions of the effects of climate change on productivity.

Valuation of services to human well-being

The outputs from integrated modelling of biophysical effects on productivity can be valued directly using a range of valuation methods (e.g. Bateman *et al*., 2011; TEEB, 2011; Unai and Muradian, 2010; Wainger and Mazzotta, 2011). These can include use of market or non-market values. Value chain approaches can be used to capture additional value over and above local market prices. For non-market values, many options are available, including stated or revealed preference and replacement costs. These values are intended to be used by decision-makers in order to compare the outcomes of different configurations of services under different land-based investments.

Provisioning services that are produced in mixed pastoral dryland systems sometimes have a market price. However, because they can contribute to the economy and society in a range of different ways, the total value of these contributions may exceed the market price that users initially pay for them. This is particularly the case for water, which often has no price, or is priced according to the costs involved in pumping it using subsidised fuel and equipment (CVG, 1997).

Total economic valuation is an approach to valuing ecosystem services that seeks to capture the full value of natural resources to the economy, including direct use values, indirect use values and option values (Bateman *et al*., 2011; Pearce, 1989; TEEB, 2011; Unai and Muradian, 2010). It also encompasses non-use values associated with the existence and bequest value of resources.

Aggregating or comparing the different values

The final stage in the assessment involves calculating all the values of ecosystem services under one scenario and comparing them to the combined value of services under another. Predictions of the net present value of the baseline land-use scenario and alternative options should be oriented to local planning timeframes (e.g. 2017, 2030 or 2050).

If simple aggregation is used, this may suggest that an increase in the productivity of relatively wealthy crop farmers can be more valuable than maintaining the productivity of resource-dependent pastoralists. However, this may raise questions related to equity and social development. Possible unevenness in the distribution of ecosystem services and their economic value may be explored through a sensitivity analysis (either qualitatively or quantitatively). This could take into consideration the benefits to society that are derived by ensuring that women and marginalised groups maintain access to ecosystem services from public goods.

For calculating the net present value of ecosystem services under future land-use scenarios, a discount rate can be applied, if appropriate (see discussion in Chambwera *et al*., 2014). For infrastructure projects, discount rates may be around 12–15%. Higher discount rates make future value worth less than present value, while lower rates place more value on the future uses.

In the literature on ecosystem service assessments, the selection of the discount rate is viewed as an ethical matter and the case for lower rates is given serious consideration (Gowdy *et al*., 2010). In Europe, lower discount rates are used for assessing benefits from social projects (e.g. around 3–5%). To account for threats to human security, climate change scenarios have sometimes used discount rates still lower than this (IBRD, 2010; Stern, 2006). The UK Treasury now mandates the use of declining discount rates for long-term projects, as suggested by behavioural studies and by theoretical analysis (Arrow *et al*., 2012). If multiple discount rates are included in the study, a sensitivity analysis should demonstrate the difference that they make to the calculation of the return on the investment.

4

What do we know and what are the gaps?

Considerable progress has been made in identifying and valuing a critical set of ecosystem services from the region's mixed pastoral dryland systems. The current knowledge status is reviewed here, along with the gaps that still remain to be filled.

Climate change impacts in Northern Kenya

Climate predictions for dryland East Africa, including Northern Kenya and Southern Ethiopia, foresee higher temperatures and increased evapotranspiration, as well as possible increases in rainfall and climatic variability (Herrero *et al*., 2010; Kabubo-Mariara, 2009). Most assessments of climate change in this region focus on impacts on crop production, rather than rangeland productivity (Waithaka *et al*., 2013). The likely effects of possible temperature and evapotranspiration increases on the production of pastoral rangeland vegetation are not known (Herrero *et al*., 2010). However, the effects of increasing frequency of drought on the livestock sector have been modelled, showing the depletion of herd numbers during drought periods, and insufficient time for herd recovery before droughts return (Herrero *et al*., 2010; Kabubo-Mariara, 2009; Nicholles *et al*., 2012a and 2012b).

Climate change impacts on livestock production and other ecosystem services in drought-prone environments are mediated by human and technological adaptation capacities (Seo and Mendelsohn, 2008; UNDP, 2013). For example, if they have sufficient resources to do so, people can often ensure that their animals have enough water and feed despite increasing temperatures and drought frequencies. However, population and water availability projections under anticipated climatic changes in Northern Kenya foresee an increasing imbalance between water supply and demand during both drought and normal conditions (IBRD, 2010; RoK, 2013c; WRMA, 2013). Furthermore, local water management scenarios and infrastructure planning do not fully take into account the growing water demand for economic uses that is likely to compete with livestock and domestic needs (WRMA, 2013), or the national predictions for temperature increases (RoK, 2013b).

A watershed model of the Ewaso Ng'iro basin in north-eastern Kenya (Mutiga *et al*., 2010) has previously been connected to climate predictions up to 2050 from the 7th Intergovernmental Panel on Climate Change (IPCC) assessment report. This was used to assess the productivity of ecosystem services including water, livestock and wildlife (Ericksen *et al*., 2011; Leeuw *et al*., 2012). Scenarios for the future appeared to indicate increasing maize production in higher elevated areas, but no changes in crop productivity in lower areas (Ericksen *et al*., 2011). This framework has also been used to calculate the effects on ecosystem service provision of a proposed water transfer project (Leeuw *et al*., 2012). In the these studies, water was valued as a provisioning service and as an input to crop and livestock production, but no value was assigned to water storage. The value of water uses by people and livestock in the Northern dryland areas was considered to be less than the value of water used for irrigation in the elevated areas.

Provisioning services

Water supplies

Basin-level water resource assessments have been generated for the Ewaso Ng'iro Basin, which covers much of Northern Kenya (RoK/WRMA/JICA, 2012). These have been complemented by additional studies of the water balance and future population water demand scenarios (WRMA, 2013). County planners and local NGO staff have been trained to conduct participatory assessments of the productivity of wells, pans and other water sources in Isiolo (GEODATA, 2014) and Wajir. The basin level assessments do not explicitly include projections of water extraction for use in sectors other than livestock (e.g. industry, tourism, trade, hospitals, etc.). Participatory review of these estimates could be useful to raise awareness of this gap in natural resource management in a region that is planning rapid industrialisation (RoK, 2013a). The existing water balance scenarios model the depletion of groundwater resources under anticipated climatic changes (WRMA, 2013), but no economic assessment has yet been attached to these scenarios, e.g. using replacement costs.

Water is usually valued either through any costs paid by water users, or the productive value of the water as an input to crop, livestock or other production. For domestic uses, the pastoral systems across much of Northern Kenya supply water free of charge or at relatively low cost to households that have access to rivers, shallow wells or pans. The price of water purchased from vendors offers a simple valuation method that would reflect the replacement cost of water from these sources. During dry periods, the households in rural areas that are unserved by piped water supplies pay this cost. In addition, the local authorities and National Drought Management Authority (NDMA) often subsidise the costs of infrastructure and fuel for water pumping as well as vehicles and other costs for transporting water to communities in need. Scenarios for the future might reflect the value of other anticipated productive water uses, e.g. for domestic uses, industry, tourism, etc.

Minerals

The County Integrated Development Plans (CIDPs) for the counties of Northern Kenya include some limited assessments of the extent and value of the mineral resources available in the counties. For example, the Isiolo CIDP describes a sapphire mine and oil exploration areas (RoK, 2013a). Other less precious minerals, e.g. salt and sand, may also be routinely extracted from parts of the pastoral systems for use in construction and other industries. The costs to society and the environment that may be incurred through the extraction of these resources should be subtracted from their market value in the economic assessment of their direct use value.

Rangeland vegetation

The rangeland vegetation types in Northern Kenya have been characterised, mapped and translated into their potential for livestock production (Herlocker, 1993). This can be used to calculate the potential economic value of each vegetation type, based on the level of biomass production and value of the livestock that could be supported. Participatory resource mapping has identified the rangeland plant species associated with the various soil types (GEODATA, 2014). Other possible and actual economic uses of the rangeland vegetation have also been identified through participatory mapping with local communities in Isiolo (GEODATA). Some of the most widely recognised options include uses of wood for charcoal-burning, and harvesting of gums and resins (Chikamai and Gachathi, 1994; Lunduka, 2012). Further participatory research would be desirable to review the typology of vegetation classes, management and offtake rates, economic uses and market or other values of selected species.

To examine intra- and inter-annual changes in vegetation condition and value, vegetation mapping could be integrated with the 250m resolution MODIS satellite imagery used on a monthly basis by the NDMA to calculate a Vegetation Condition Index. This index is based on the relative change in the Normalized Difference Vegetation Index (NDVI), compared to the minimum and maximum historical NDVI value. The NDVI of a given week is compared to the minimum NDVI found in the archive of that week (NDVImin) and the maximum NDVI found for that week (NDVImax). At present, the historical record of the Vegetation Condition Index in the Early Warning Bulletins for Northern Kenya dates back to 2001.[1] The images that are used on a monthly basis (high temporal resolution)

[1] See www.ndma.go.ke/index.php?option=com_k2&view=itemlist&layout=category&Itemid=137.

remain at the relatively spatially coarse resolution of 250m; however, it could also be possible to relate them to analysis of effects on NDVI at a higher spatial resolution at critical times of the year (e.g. using Landsat or SPOT images).

Irrigated crop production

There is both large and small-scale irrigated agricultural production in various parts of Northern Kenya, for crops, fodder for livestock, or often a mixture of these products (Ocra, 2014). However, in many parts of the region, water is not available for irrigation because human and livestock uses are prioritised. Market prices are most often used to calculate the value of irrigated crops (Ocra, 2014). A valuation of the ecosystem services from irrigation should also consider externalities from the use of water, energy and chemicals in crop and livestock production (King and Jaafar, in press 2015). Irrigation systems can vary widely in their water and energy use efficiencies and agrochemical requirements (El-Qousy *et al.*, 2006; García *et al.*, 2014). Although reusing domestic water for irrigating fodder, kitchen gardens or fruit trees would prevent irrigation from raising water demand, such systems have not featured in recent strategic assessment work and water use projections (WRMA, 2013).

For the time being, irrigated crop production in Northern Kenya is oriented to local demand for food, and therefore the associated value chains may be assumed to involve relatively low energy demands for transportation, cooling, etc., in comparison to those created through irrigated agriculture for export in other dryland regions. Where irrigated crops are inputs to livestock production, the productive value of the water is a function of the value of the livestock.

Livestock production

Numbers of livestock in Northern Kenya are surveyed through the national population census (KNBS, 2009), and monitored by the County Livestock Services. However, the frequent movement of animals across national and administrative borders makes accurate assessment of numbers difficult (Krätli, 2014). For more accurate verification of herd sizes and valuation at specific locations and points in time, researchers at the International Livestock Research Institute (ILRI) have explored the use of aerial counts (Silvestri *et al.*, 2013). These datasets could enable assessment and modelling of herd size and composition under varying climatic conditions, but key informant interviews, literature reviews, and possibly additional participatory research may be needed to understand stocking and marketing decisions.

Market data concerning livestock and milk marketing and prices can be used to generate value estimates for livestock products (after Behnke and Muthami, 2011). This information is collected by the Kenya Meat Marketing Board and ILRI, as well as by the NDMA through household surveys for early warning of drought indicators at selected 'sentinel' sites. Other economic benefits to society of livestock production in Northern Kenya have been explored in various studies (Behnke and Muthami, 2011; Davies, 2007). The total economic value of livestock can be derived from: cash income from sales of animals and their products and services, as well as non-income functions e.g. savings, insurance, transport, and social and cultural functions (see discussion in Hesse and MacGregor, 2006).

Livestock production and processing have both negative (e.g. carbon emissions and water resource depletion) and positive biophysical impacts (e.g. dung production can contribute to soil formation, fertilisation and carbon sequestration) (McGahey *et al.*, 2014). Pastoral production systems also have very low externalities in terms of energy emissions and other forms of pollution (McGahey *et al.*, 2014). In order to weigh the value and costs to society of livestock and livestock products, valuations should consider all these effects (King and Jaafar, in press 2015). Livestock water requirements are included in water resource planning for northern Kenya (RoK/WRMA/JICA, 2012; WRMA, 2013).

Information is less readily available on the energy requirements for marketing livestock and milk, including transportation and refrigeration. These externalities and additional services could either be directly factored into the valuation of the provisioning services, or of supporting and regulating services (but not both).

Regulating and supporting services

Regulating and supporting services of pastoral areas can include water storage, soil formation, carbon sequestration, conservation of seedbanks, waste removal, and climate regulation. Different land uses can either increase or decrease the extent and effects of these services. The value of these services has not been taken into consideration in any assessments of ecosystem service provision in Northern Kenya because it has been assumed that their value is already captured in the valuation of the provisioning services. However, the discussion of externalities associated with crop and livestock production and value chains above reflects the interest and concern in both the scientific literature and local planning debates that more should be done to evaluate these services.

When ecosystem service provision is viewed through a climate lens, supporting services such as water storage and carbon sequestration emerge as essential for the sustainability of the system (RoK, 2013b). Water storage is critical for local adaptation to climate variability, while carbon sequestration is important to balance emissions and contribute to climate regulation nationally and globally.

Water storage

Scenarios that capture the rate of depletion of the groundwater table have been explored for Northern Kenya (WRMA, 2013), and are highlighted as a concern in local development planning (e.g. RoK, 2013a). At present, no systematic framework or monitoring system for water resource accounting is in place for Northern Kenya. This would require local co-ordination and information systems to be enhanced. Instead, periodic assessments are generated on an *ad hoc basis* wherever donor support is available.

Water storage maintains the water balance and ensures water availability during drought periods. Valuation of this service can be based on the costs that would be incurred if the water table becomes depleted – such as the cost of digging new wells and pumping water from increasing depths (Croitoru and Sarraf, 2010; CVG, 1997; King and Salem, 2012). Although the economic valuation of provisioning services such as crops and livestock should and sometimes does include consideration of any costs for pumping water as a direct input to production, it is very unusual for such assessments to also subtract the value of effects on future costs to access water for other purposes. In light of this common oversight, and the critical importance of this service in drylands under climate variability, there is a strong justification for according this service its own place within the assessment framework.

Carbon sequestration

As described above, the economic valuation of provisioning services such as crops and livestock should, and sometimes does, consider associated emission costs. To capture the carbon sequestration services that can counterbalance these emissions as a by-product in the same production processes requires a dedicated place in the assessment framework.

There is no local management system for carbon accounting that could balance the level of carbon emissions and sequestration in the rangelands in Northern Kenya. However, this issue has attracted considerable scientific attention in other regions because carbon sequestration can be assigned a market value that can generate an income. To fill this space in the framework, national and international scientific co-ordination and support would be needed.

Cultural services

Cultural services in the region include the scenic, recreation and spiritual benefits provided by the open pastures, springs and communal herding traditions. Literature review and participatory assessment could do more to identify and value the cultural services associated with some of the following:

- wildlife landscape and hunting
- traditional arts (wood carving, painting, jewellery, etc.)
- sports, dances, camel races
- production of other media, including music, film and photography

Although cultural services are difficult to measure and value, previous studies have succeeded in valuing them through local hotel occupancy rates (Ericksen *et al.*, 2011; Silvestri *et al.*, 2013) or entrance fees to parks (see above; Silvestri *et al.*, 2013). Other ways of valuing tourism could include accounting for meals in local restaurants and travel costs.

Wildlife tourism can have externalities in terms of water and energy demand (WRMA, 2009). An assessment of the present and future wildlife populations has been generated for Isiolo County and surrounding areas, including estimation of associated water requirements (WRMA, 2013). Energy demand would depend on distances travelled, as well as the type and duration of accommodation. Wildlife management practices might also create some additional energy demands.

Various studies in other parts of Kenya and in Tanzania have explored the feasibility, cost and returns of paying pastoralists for conserving nature as an ecosystem service (Bulte *et al.*, 2008; Osano *et al.*, 2013). These services are sometimes of interest to people who do not necessarily travel to the area but are concerned with the existence value of wildlife.

5

Next steps: Filling the gaps and building capacity

This paper has proposed an outline framework for a total economic valuation of the comparative returns of land-based investments in the drylands of Northern Kenya under conditions of increasing variability and longer-term climate change. While much of the necessary data can be drawn from existing research, some ecosystem services have so far received greater research attention than others. The introduction of a climate lens to the assessment heightens the need to systematically monitor, model and value the critical regulating services that ensure water availability and climate regulation. What are the next steps needed to fill these gaps and move the assessment forward?

- **Build research capacity** with partners and stakeholders across the region and beyond in order to enable local planners to apply the framework.
- **Increase the use of participatory GIS.** This can be used to map and quantify the extent, composition and values of vegetation and responses to climatic variability. GIS tools and methods could also help to overlay and balance the missing values associated with water, minerals and carbon storage.
- **Generate estimates to model current and anticipated future water use** patterns under planned scenarios for industrialisation and urban development in Northern Kenya.
- **Pay more attention to valuing water storage services.** The valuation of livestock resources in pastoral systems has so far received much greater attention than their subsurface water and mineral wealth. The critical importance of groundwater storage in drylands under climate variability is a strong justification for according this service its own place within the assessment framework.
- **Consider emissions in the economic valuation of provisioning services** such as crops and livestock. The assessment framework should also create space to capture the carbon sequestration services that can counterbalance these emissions as a by-product in the same production processes.
- **Give strategic attention to the social distribution of returns** to investments and ensure that the aggregated assessment does not overlook the potential cost of increasing social inequality.

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The potential for economic growth and development in the arid and semi-arid lands of Northern Kenya is arguably higher than in more humid parts of the region. Local governments must identify those investments which will benefit local people most. In the absence of frameworks to compare the benefits of proposed investments with those provided by the existing, largely pastoral economy, the wrong decisions could be made, especially given the changing climate. This working paper is intended to stimulate and contribute to a discussion of how the returns on land-based investments in the drylands should be evaluated. It presents an assessment framework for weighing the total economic value of the ecosystem services provided by pastoral and mixed land-use systems under anticipated climate changes and variability.

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Knowledge Products

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