Economic Importance of Goods and Services Derived from Dryland Ecosystems in the IGAD Region

Case Studies

IGAD Region

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ECONorthwest specializes in the economic and financial analysis of public policy. ECO has analyzed the economics of resource-management, land-use development, and growth-management issues for municipalities, state, and federal agencies, and private clients for more than 30 years.

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Acronyms and Abbreviations

$	US Dollar, of 2008 unless otherwise indicated
GDP	Gross Domestic Product
ha	hectare
km	kilometer
IGAD	Intergovernmental Authority on Development
IUCN	The World Conservation Union

INTRODUCTION AND BACKGROUND

The Intergovernmental Authority on Development (IGAD) is an international body that promotes peace, prosperity, and regional integration among its member nations: Djibouti, Eritrea, Ethiopia, Kenya, Somalia, Sudan, and Uganda. About 3.4 million km^2, or 80 percent of the IGAD region's total area, consists of lowlands with arid, semi arid, or dry sub-humid climates, where precipitation is lower and more uncertain than elsewhere, and drought is common. These drylands are home to almost 70 million residents, most of whom practice a pastoral way of life or live in small urban centers, and to much of the region's wildlife. When rain falls, the pastoralists, livestock, and wildlife disperse over the landscape to feed on the sparse grass; when it doesn't, they congregate at the few rivers and wetlands where there is some forage and water.

Although the pastoralists have maintained their way of life for centuries, severe droughts create a precarious existence and produce pressure for change, made more intense by fear that past and continuing emissions of carbon dioxide and other greenhouse gases will bring about changes in climate that entail even more severe droughts. Recurrent famines in the region have induced many, in and out of the region, to conclude that the drylands cannot sustain current pastoral practices. Moreover, the costs associated with providing emergency assistance during droughts support a belief that the drylands have become a burden on economic development elsewhere in the region, and prompt proposals to change the use of the drylands. These include proposals to siphon off water from the region's few rivers before it reaches the drylands, to convert the region's wetlands to irrigated agriculture, and to focus economic development in the drylands on mining and other industrial activities.

There is a widespread belief that irrigated agriculture offers opportunities to increase the amount of food available to residents of the IGAD nations and to boost the overall economic benefits derived from drylands that otherwise would yield much smaller benefits through pastoralism. Ethiopia, for example, has about 3,328,910 ha of irrigable land, but only about 214,720 ha is irrigated, and Kenya has about 540,000 ha of irrigable land, but irrigates only about 52,000 ha (Saundry 2007). Recent years have seen numerous large-scale acquisitions of drylands by foreign investors for industrial agricultural developments. One survey of these acquisitions found they accounted for more than 600,000 hectares in Ethiopia and almost 500,000 hectares in Sudan (Cotula et al. 2009).

Against this backdrop, the World Conservation Union (IUCN) commissioned research to describe the economic importance of goods and services derived from the region's dryland ecosystems. An important element of the research was three case studies that aim to increase understanding of the potential economic consequences of common, major proposals for changing the management of drylands in the IGAD region. The first considers the overall effects of dispersed water diversions to support irrigated agriculture by small landowners, in the Garbatula area of Kenya. Of particular interest are the benefits realized among irrigators in the Rapsu community and the losses realized by pastoralists from reductions in flows the nearby Ewaso Ng'iro river delivers to Lorian Swamp, an area that provides refuge for pastoralists, livestock, and wildlife during dry periods. The second looks at proposals to develop large-scale, irrigated agriculture in the delta of the Tana River, Kenya, and diminish the supply of goods and services for pastoralism, tourism, fishing, and other activities. These two cases studies

examine issues associated with a widespread belief that irrigated agriculture will substantially increase the amount of food and the level of economic benefit derived from drylands. They also address issues associated with concerns about large foreign investments that are converting lands in Africa to industrialized agriculture. The third examines the potential benefits and losses associated with oil development, focusing on the Albertine Rift, in Uganda. It examines issues associated with concerns that oil/gas production might not yield the economic benefits that many expect from the production of valuable mineral resources and about the potential economic harm that might materialize if oil/gas development significantly harms the environment and displaces communities from their current livelihoods. Each case study compiles and interprets information from on-site observations, key-person interviews, governmental data, and the reports of past studies.

This report contributes to IUCN's overall objective, to provide macroeconomic planners and others making decisions about the management of dryland ecosystems with useful information about the value of dryland ecosystems under alternative resource-management regimes, to clarify the tradeoffs among the alternatives, and improve understanding of sustainable investment options.

The preparation of this report is part of a project, funded by the International Development Research Centre (IDRC), entitled, Making the Linkages – Conservation as a Core Asset for Livelihood Security.[1] It aims to improve understanding of the linkages in eastern Africa between sustainable management of natural resources and the well-being of rural communities, where the latter is indicated by their ability to enjoy both secure livelihoods—sustainable capacity to generate and maintain a desired means of living for themselves and future generations—and economic growth. IUCN gives this definition of livelihood: "a livelihood comprises the capabilities, assets - including both material and social resources - and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capacities and assets both now and in the future, while not undermining the natural resource base."[2] The project focuses on important linkages between poverty and the environment, including those between resources and the security of the livelihoods of communities in dryland areas.[3]

The major activities of the project are:

1. Community workshops, and dissemination of the lessons learned at them, to improve the understanding and awareness on the linkages at the community level.
2. In-depth studies—including this report—on the linkages.
3. Community-level dialogues and interactions to improve the understanding of the linkages and their policy implications.

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[1] For more information about the project, see http://cms.iucn.org/about/union/secretariat/offices/esaro/our_work_drylands/drylands/making_the_linkages__idrc___project_overview/.

[2] IUCN. no date. "Sustainable Livelihoods." Retrieved 7 April 2010 from http://cmsdata.iucn.org/downloads/mbsustliveli.pdf

[3] The project also focuses on linkages between HIV/AIDS and the environment, and between marine resources and the security of the livelihoods of nearby communities.

4. Efforts to influence policy at the IGAD level through studies and conferences of directors of conservation, health and economic planners to facilitate the dialogue between senior decision-makers for different sectors.

The project embodies a number of other testable assumptions, one of which is that rural communities have rich knowledge about their natural resources and about how to manage them effectively, and with appropriate support they can become important agents of change to improve the sustainability and security of their livelihoods. It is further assumed that if policy and decision-makers are given the opportunity to witness poverty-environment linkages first hand and discuss this with communities then it will influence their behavior and understanding to the extent that they will make better policy and planning decisions in future. The project also assumes that, for development to yield meaningful benefits for people in poor, rural communities, the communities must have support to engage in policy-making processes, from drafting of policy documents through implementation and monitoring of policy impacts. It is further assumed that changing policy to provide meaningful benefits for poor, rural communities requires changing attitudes and practice in government and empowering champions for these communities, both within and out of government.

CASE STUDY #1: SMALL-SCALE, IRRIGATED AGRICULTURE AND OTHER REDUCTIONS IN WATER SUPPLY—GARBATULA AREA, KENYA

Introduction

Difficult economic conditions are common across the drylands of the IGAD region: the 2005-06 drought, for example, critically affected the health and well-being of 88,000 in Djibouti, 2.8 million in Ethiopia, 2.95 million in Kenya, and 1.8 million in Somalia (USAID 2006). Worse conditions during the past three years affected even more. In many of the drylands, conditions are made more dire as rivers that once sustained life during dry periods are empty. Some of the flow reduction stems from changes in climate, but much stems from land-use changes in highlands that reduce the runoff reaching the rivers, as well as increased diversion of water from the rivers for small-scale irrigated agriculture. These changes are tolerated, even endorsed by national governments and international agencies, reflecting two widespread beliefs: (1) the drylands are wastelands, and (2) diverting water for irrigated agriculture rather than allowing it to flow into drylands to support pastoralists necessarily yields more food and makes a greater contribution to gross domestic product (GDP).

These beliefs overlook the important economic contributions drylands—and especially their rivers—make to local households, communities, and the national economies. This case study examines the validity of these beliefs, looking at the goods and services the ecosystem provides pastoralist livestock producers and the potential consequences when water is diverted for small-scale, irrigated farming. It focuses on the area that includes and surrounds Garbatula District, in northeastern Kenya.

The Focus Area

Drylands make up 84% of Kenya's total land surface and support approximately 34% of the national population (Barrow and Mogaka, 2007). Garbatula District and the surrounding area, in Kenya's Eastern province, is representative of drylands throughout the IGAD region and provides an appropriate case study of the downstream unintended consequences of river diversion for small-scale irrigated agriculture. The district has an area of 9,817 km^2 and a population of 31,995, with 71 percent living in absolute poverty (Ministry of State for Planning, National Development and Vision 2030, 2008b). Garbatula (also

Garbatulla or Garba Tula) District was split from Isiolo District in 2007. In some cases, available data reflect the larger, consolidated district. For more than 60 percent of the district's population, the primary economic activity is agriculture, especially pastoral livestock keeping (Ministry of State for Planning, National Development and Vision 2030, 2008b). The Borana are the dominant ethnic group in the district.

The average annual temperature of the district is 27° C and its average annual rainfall ranges from 120 mm to 350 mm (Ministry of State for Development of Northern Kenya and Other Arid Lands, 2009). The main perennial rivers are the Ewaso Ng'iro and Bisanadi.

Natural Resources and Economic Activities

The natural resources of Garbatula District include wildlife, water, pasture, forests/woodland, fish, minerals, solar and wind energy (PricewaterhouseCoopers, 2005). However, economic activity in the district largely involves wildlife tourism and agriculture (livestock and crop production).

The area is home to extensive wildlife populations that provide the basis for tourism activities. Wildlife management and tourism in Garbatula District currently focus on Meru National Park, Bisanadi National Reserve, Buffalo Springs National Reserve and Shaba National Reserve. Bisanadi National Reserve is managed by Garbatula District and serves as a buffer zone and a wildlife dispersal area for Meru National Park. Wildlife in the Buffalo Springs and Shaba National Reserves is similar to that found in Meru National Park and depends on the Ewaso Ng'iro that divides both reserves.

In Garbatula district, as in the rest of Kenya, much of the wildlife that has great biodiversity and tourism value resides outside national parks and other protected areas. For the nation as a whole, 25 percent of wildlife is found outside national and private protected areas (Western et al., 2006). In the Garbatula area the unprotected areas are even more important, as many species found in the protected areas spend some part of their life history elsewhere, mostly on communal land the Borana rely on for their pastoral way of life and livestock production. Thus, although the protected areas receive most of the attention from tourists and others concerned about viewing and sustaining the existence of wildlife, these goals cannot be accomplished without appropriate, coordinated management of the communal lands.

Livestock production is the most common economic activity in Garbatula District. Governmental data show the district has about 40,000 cattle, 20,000 camels, 250,000 goats and 250,000 sheep (Ministry of State for Planning, National Development and Vision 2030, 2008b). Many community leaders, however, believe actual numbers are higher, except after extreme events, such as prolonged drought or disease outbreak. During wet periods, pastoralists disperse throughout the area to find forage and water for their livestock. During dry periods, they travel 50–75 km (Mati et al. 2005) to congregate where rivers or wetlands continue to provide these resources. The most notable areas are Lorian Swamp and the Bisanadi River. If conditions are severe, they illegally seek forage in the Bisanadi National Reserve and Meru National Park. The efforts of livestock producers to graze animals in protected areas highlight what many see as a conflict between managing land and water to produce wildlife and support

the tourism industry, and managing the resources to produce livestock and support local pastoral communities.

Over at least the past decade, local residents have observed declines in the flows of the Ewaso Ng'iro, and of the Bisanadi River. The declines are attributed to changes in climate, which has increased the frequency of drought, and to upstream diversions of water. Almost two-thirds of the water in the Ewaso Ng'iro is diverted for upstream irrigation before it reaches Garbatula District (Mati et al. 2005). Total water withdrawals from the area's rivers exceed 25 percent of annual surface flows in the Ewaso Ng'iro basin, and up to 60 percent of the diversions are unauthorized (UNESCO 2005). Past attempts to develop large-scale irrigated agriculture have failed, but the government anticipates renewed efforts in the near future (Ministry of State for Planning, National Development and Vision 2030, 2008a). The total area under crop production within Garbatula District is estimated at 1,200 acres, employing 6,500 people with the average farm size being 0.5 acres (Ministry of State for Planning, National Development and Vision 2030, 2008b).

Other current and potential economic activities from natural resources include mining (blue sapphire, red and green garnet, mica, marble, limestone, stone aggregate, and sand), honey production, and harvesting of gum Arabic from trees that are common in the district (Ministry of State for Planning, National Development and Vision 2030, 2008b). Petroleum exploration is also currently taking place in the district.

Residents of the area have limited access to public services, such as health care, education, communication, and transportation. These limitations inhibit economic development. Livestock producers and farmers have few options for selling their products into national markets, for example, and, as a result, receive lower prices than likely would exist if transportation and communication services were better.

Ecosystem Goods and Services

The water in the Ewaso Ng'iro and Bisanadi River contribute to the dryland ecosystem's ability to provide goods and services that are economically important locally, nationally, and globally. The irrigation scheme in the Rapsu community, southwest of Garbatula town, illustrates the economic value of using water for small-scale irrigation. Initiated in the 1970s, the scheme aims to provide alternative economic opportunities for members of the pastoral community with few or no livestock. The scheme currently involves 2,000 people irrigating 176 hectares that yield crops that sell for about $23,000, equivalent to about $10 per person or $130 per hectare per year. [$23,000/yr ÷ 176 ha = $130/ha/yr] The crops also provide food for household consumption. This value does not, however, account for the full costs of making irrigated agriculture sustainable in the long run. The infrastructure is deteriorating, and community elders report that flows in the river from which they obtain water have been declining. If the current rate of decline continues, they expect that, within a decade, the flows will no longer be sufficient to support this irrigation scheme or others downstream. The majority of the elders expressed the desire to abandon the scheme and return to livestock production as their primary livelihood.

Lorian Swamp northeast of Garbatula town illustrates the economic importance of using water to support pastoral production of livestock. Table A shows the government's estimate of

livestock production in the district, with a total value of about $37 million. On average, approximately 10 percent of the animals might be sold to market each year, indicating the annual value of commercial livestock production supported by the area's overall dryland ecosystem is about $3.7 million, equivalent to about $4 per hectare per year and $190 per person per year. [$3.7 million/yr ÷ 981,700 ha ~ $4/ha/yr. $3.7 million/yr ÷ (31,995 total population x 60 percent pastoralist = 19,197 pastoralist population) ~ $190/pastoralist/yr] In addition, the livestock, together with other products from the ecosystem provide food for domestic consumption worth about $63 per household (Davies 2007). Lorian Swamp, by providing water and forage during dry periods, plays a key role in this livestock production and demonstrates the value of water in drylands.

Table A. Value of Livestock in Garbatula District

	Number in the District	Average Unit Price	Total Value
Cattle	40,000	$300	$12,000,000
Camels	20,000	$240	$4,800,000
Goats	250,000	$40	$10,000,000
Sheep	250,000	$40	$10,000,000
TOTAL			**$36,800,000**

Source: ECONorthwest, with data from Ministry of State for Planning, National Development and Vision 2030 (2008b).

Although governmental data indicate the district contains about 40,000 cattle, elders in nearby communities expressed their belief that, in the past—before the flow of Ewaso Ng'iro declined—Lorian Swamp would directly support as many as one million cattle during dry periods and allow a larger ecosystem, extending more than 50 kilometers away and covering about 1 million hectares, to support this number over the long run. These numbers embody considerable uncertainty—many pastoralists believe the governmental data underestimate the current herd size, and the estimate of the past herd size does not reflect an actual count, only a general memory. These numbers, taken at face value, indicate the swamp, which covers about 231,000 hectares (Mepham et al. 1992) was capable of providing goods and services essential to the survival of cattle with a value of $300 million, and reductions in the flow of water to the swamp have reduced this value by 96 percent. Actual reductions may be substantially different. Over the long run, diversions that reduce water supplies in the swamp have reduced the area's ability to deliver cattle to market from about 100,000 cattle per year with a value of about $30 million to about 4,000 cattle per year with a value of about $1.2 million. Spread over the entire area of the swamp, diverting water from the swamp has reduced the value of its long-run ability to support livestock production by about $125 per hectare per year.

These assessments roughly indicate that, when small-scale diversions of water from arid streams reduce supplies of water in downstream wetlands important to livestock and wildlife, the economic losses may equal or outweigh the gains. The estimated rate at which irrigation produces irrigated crops for sale to markets at Rapsu, about $130 per hectare per year, roughly equals the estimated rate at which de-watering of Lorian Swamp reduces the production of cattle for sale, about $125 per hectare per year. These estimates embody the measurement uncertainties inherent in research that relies on unverifiable reports from local producers, but there is no reason to assume one is more or less reliable than the other. Nonetheless, the actual

relationship between the value of water for irrigation and for livestock may differ considerably from place to place and over time. The estimate from Rapsu, however, likely overestimates the true value of water diverted to irrigation by overlooking the full costs irrigators would have to incur to secure water supplies and maintain infrastructure needed to sustain irrigation over the long run. In contrast, the estimate from Lorian Swamp likely understates the true value of water diverted away from key wetlands by overlooking losses associated with other livestock other than cattle, and by spreading the losses over the entire wetland rather than over just the de-watered portion. In addition, the estimates fail to account for the effects of water diversions on wildlife.

As reductions in river flows diminish the ecosystem's ability to support livestock production, so too do they diminish the ecosystem's ability to support wildlife. Wildlife managers and livestock producers, who often have seen one another as competitors for land and water resources in the past are increasingly realizing that they are better off working together to prevent reductions in river flows. According to the Ministry of State for Planning, National Development and Vision 2030 (2008b), at least 1,000 tourists per month visit the three national reserves in the district, earning the district council about $120,000 per month in revenue. Kenya Vision 2030 has recognized that the national parks in the south of the country, which have received so much attention in the past, lack the ability to generate continued growth in tourism. Hence, it looks to protected areas and communal lands northern Kenya, including those in Garbatula District, as the new tourism frontier, and calls for major investment to develop the region's tourism potential. The Garbatula area cannot meet the challenge if its rivers lack adequate water to sustain viable wildlife populations.

Conclusions

At first glance, many residents of the IGAD region, investors, and representatives of international agencies conclude that investments in irrigated agriculture offer a quick and sure way for the region's nations to improve food production and promote economic development. This case study indicates that the actual outcomes may be just the reverse. The rivers that flow through the Garbatula area play a key role in sustaining households, livestock production, and wildlife across vast areas by providing water and forage during stressful dry periods. Diverting river water to support small-scale irrigated agriculture necessarily diminishes this on-going activity. Increased production of irrigated crops can come only with losses to the commercial livestock and tourism industries, accompanied by the displacement of thousands of people in pastoralist households.

Proposals to divert water for irrigation often aim to lessen the persistent poverty of pastoralists and reduce the number of people exposed to the horrors of drought. The evidence reported here, though, indicates that the earnings lost by pastoralist from diverting water away from livestock production may equal or outweigh the earnings gained by irrigators. Moreover, the threats of drought affect irrigators and pastoralists in this region equally (KFSSG 2006). Diverting water away from the area also can adversely affect wildlife populations important to the tourism industry and undercuts plans for major investments to promote tourism in this part of the country. More research is required to reduce uncertainty in this case study's findings, and to determine the likely site-specific benefits and costs of small-scale irrigation.

CASE STUDY #2: LARGE-SCALE, IRRIGATED AGRICULTURE IN THE TANA RIVER DELTA, KENYA

Large-scale, irrigated agricultural projects are being planned in the drylands of several IGAD countries. There is widespread concern that such projects would do more economic harm than good by consuming precious water and damaging the ecosystem, but little research has attempted to quantify this concern. This case study examines the issues, focusing on the Tana River Delta, where several proposals have recently been put forward.

Over the last five years, the Government of Kenya, through the Tana and Athi Rivers Development Authority (TARDA), has been engaging private investors to develop large-scale irrigated agriculture in the Tana River Delta. One proposal would occupy about 20–30,000 hectares and use one-third of the river's volume to produce cane sugar, ethanol as a biofuel for domestic consumption, molasses for livestock feed, and electricity (Mumias Sugar Company Limited 2007); another would be four times as large and produce fruits and vegetables for both domestic consumption and export (Wadhams 2009). Justification for such development has three major elements:

a) It would increase the nation's supply of goods, such as sugar and fuel, reducing the demand for imports and increasing the nation's exports and foreign-exchange earnings.

b) It would improve local economic conditions by providing jobs and diversifying the economy in one of the country's poorest areas.

c) It would increase the net economic benefits derived from the delta's land and water resources.

The first element of this reasoning appears straightforward—new agriculture development certainly could generate products for consumption and/or export—but past efforts to develop large-scale irrigated agriculture in the area have failed, indicating there is some uncertainty about the feasibility of future developments. This uncertainty is exacerbated insofar as anticipated declines in the river's future flows, stemming from changes in upstream use and climate, would reduce the supply of water for large-scale irrigation.

The other two elements of this reasoning are undermined by the likelihood that large-scale agricultural development would have significant, adverse impacts on the delta's ecosystem. Harm to the ecosystem would

diminish its ability to provide valuable goods and services that provide essential support for important industries—livestock, tourism, and fishing. Thus, although a large-scale agricultural development would create some jobs and economic benefits, these would be offset, more or less, by diminishing the ability of the ecosystem to produce jobs and benefits in other ways. Damage to the ecosystem also would reduce its ability to sustain thousands of families living in the delta itself and throughout a much larger, surrounding area. Thus, development of large-scale, irrigated agriculture in the delta would benefit some, but only by harming others.

The Focus Area

The Tana River Delta covers approximately 135,000 hectares. Although its central feature is water, it embraces bushlands, grasslands, and woodlands, as well as riverine forests, lakes, mangroves, dunes, estuaries, and beaches (Mumias Sugar Company, Limited, 2007). Rainfall is bimodal and erratic (Kenya Food Security Meeting, 2006) and the area experiences both drought and flooding. The average annual temperature is 27^0C.

The 2005 population of the Tana River District, which extends upriver of the delta, was estimated to be 217,219 and growing 3.4 percent per year. A 1994 analysis found another 800,000 pastoralists from outlying drylands, plus part-time fishers and fish-traders seasonally depend on the area for subsistence and commercial earnings (Emerton 1994). This number probably exceeds one million today. The major ethnic groups are the Pokomo, who are largely farmers, and the Orma and Wardei, who are primarily pastoralist. Typical population density ranges from 2.2 people per square kilometer in the arid areas to 25.5 people per square kilometer in some areas adjacent to the river. Densities swell seasonally and during droughts, when pastoralists and others come to the area. Two-thirds of the district's population lives in poverty (Kenya Food Security Meeting, 2006). During extreme dry periods, the delta provides the only reliable access to fresh water and forage within a radius of 100 km or more, extending into Ethiopia and Somalia.

Natural Resources and Economic Activities

The Tana River Delta is the terminus of Kenya's longest river. It supports important biological diversity associated with the juxtaposition of a large delta and estuary with a semi-arid and arid hinterland. About 80 percent of the estuarine/deltaic ecosystem is intact and functional (East African Marine Ecoregion Programme 2007). It has unique freshwater, brackish, and coastal forest habitats that host a wide variety of rare, threatened, and endangered wildlife species, including two endemic and critically endangered primates: the Tana River red colobus and Tana crested mangabey. It also is home to elephants, the elephant shrew, and endemic species, such as the Tana River bushbuck and Ader's duiker (Mohamed, 2004). It supports at least 40 fish species. Its beaches are one of Kenya's most important nesting grounds for two endangered sea turtles: the green and hawksbill. The delta's unique dune system also serves as a crocodile breeding area. The delta hosts a large number of permanent and migratory bird species (Mohamed, 2004). It has been identified as an important resource for the survival of 22 bird species, and provides one of the few breeding sites for herons and storks in East Africa (Tana River Delta Campaign 2009).

The delta has more than 10 percent of Kenya's mangroves, whose roots and habitat act as nursery grounds for a variety of fish and the mangrove crab. The extensive seagrass beds that form the basis of Ungwana Bay are not only feeding and refuge grounds for the sea turtle, but also home to the threatened dugong (Mohamed, 2004). The off-shore Ziwayu and Tenawi islands were formed as a result of the deltaic environment and are important nesting grounds for the Arctic tern and feeding areas for whale sharks (Mohamed, 2004).

Agriculture is the main economic activity in Tana River District; directly or indirectly, it is responsible for approximately 85 percent of annual household earnings (Kenya Food Security Meeting 2006). Livestock production by nomadic pastoralists is the most prominent activity, which occupies more than half the population. A report developed in support of the proposed sugar plantation states that 15–20,000 cattle reside permanently in the area and another 40–45,000 move in during dry periods (Mumias Sugar Company Limited Limited 2007). Others have found much higher numbers: about 1 million livestock (cattle, sheep and goats) on an on-going basis (Kenya Food Security Meeting 2006), with this number swelling to about 2.5 million during dry periods, including more than one million cattle (Emerton 1994). With severe, prolonged drought, grazing in the delta changes from seasonal to year-round.

Crop production is practiced along the Tana River in dilapidated irrigation schemes at Bura and Hola, and along the delta coast. Maize, rice, cowpeas and bananas are the main food crops, while cotton, coconut and mango are common cash crops. Fishing, forestry and agro-forestry are also important activities in the delta.

Tourism activity in the delta area is limited, with little infrastructure and contributing about $7,000 annually to incomes in local communities (Mireri et al. 2008). The area has considerable promise, however, as it lies between two major destinations, Lamu and Mombasa, and offers a combination of major attractions: big game wildlife, birds, endemic and endangered species, cultural diversity, and coastal beaches.

Ecosystem Goods and Services

Large scale irrigated agriculture in the Tana River Delta is likely to affect the supply of ecosystem goods and services, especially those associated with small-scale agricultural (livestock and crop) production, fisheries, mangrove forests, water, and wildlife. Proponents of the development have not made public an economic assessment of its expected benefits and costs, but opponents commissioned an analysis by independent economists (Mireri et al. 2008). The authors do not fully show all their data and calculations, limiting opportunities for verifying their validity but, in general, their findings seem in line with those of other research described in the Garbatula case study and main report.

They begin by observing that information provided by the proponents indicates that expected revenues from the development over a 24-year period would exceed investors' costs, with an overall, net present value, at a 15 percent interest rate, of about $45 million. [Ksh3,176,875,000 (Mireri et al, p. 2) @ Ksh70/$1 ~ $45 million] (Net present value is a single number equivalent to a stream of costs and benefits over time, and reflecting an interest rate indicative of the expected rate of return on alternative investments.) Over the 20–30,000 hectare developed area, this translates into an average net yield on investment of about $230–$350 per hectare per year.

These numbers, however, embody little cost to investors for the land, water, and other elements of the ecosystem that will be consumed. Hence, the authors then provide information for comparing the estimated earnings by investors against three different perspectives of the value of the ecosystem goods and services that would be lost, i.e., costs to society that would not be borne by investors under the development proposal. One indicates the value of the goods and services 3,000 households would derive from the affected wetlands, absent the development, would be about $140 per hectare per year. [Ksh295 million/year (Mireiri et al, p. 31) ÷ Ksh70/$1 = $4,214,286/yr ÷ 30,000 ha ~ $140/ha/yr.] Another concludes the true value of the land that would be occupied would be about $280 per hectare per year more than is reflected in the development proposal. The last estimates that the value of the water diverted from the river to irrigate sugar cane would have a value of about $320 per hectare per year. [Ksh662,475,000/yr (Mireri et al, p. 33) ÷ Ksh70/$1 = $9,643,929/yr ÷ 30,000 ha ~ $320/ha/yr.] The aggregate, estimated value of the land and water that would be consumed is about $600 per hectare per year. Table B summarizes these estimates.

Table B. Potential Benefits and Costs of Proposed Development of about 20–30,000 Hectares to Support Irrigated Sugarcane in the Tana River Delta

	Economic Value ($/ha/yr)
Average Annual Yield to Investors	$230
Additional Potential Costs to Society[a]	
Forgone wetland goods and services	$140
Cost to society of land	$280
Cost to society of water	$320
Cost to society of land and water	$600
Costs that cannot be estimated	
Biodiversity (aquatic, estuarine, & terrestrial)	- -
Spiritual and cultural resources	- -
Sediment movement and soil formation	- -
Nutrient cycling	- -
Tourism	- -
Impacts of development-related pollution on human health, livestock, fish, etc.	- -
Loss of carbon sequestered in vegetation and soil	- -
Etc.	- -

Source: ECONorthwest, derived from Mireri et al. (2008). Assumes $1 = Ksh70.

[a] Based on alternative analytical perspectives. These estimates should not be combined without further investigation, to avoid double-counting. They do not incorporate a full accounting of potential costs to society.

Investigation related to the case study determined that, by providing a refuge during dry periods, the 130,000 hectare delta enables pastoralists up to 100 km away to derive consumption and production amenities over a semicircular dryland area of about 1.6 million hectares. At $45

per hectare (Davies 2007), the total value of these amenities derived form this area is $72 million per year. If development of industrial agriculture on 20–30,000 hectares, or 15–23 percent, of the delta were to reduce its ability to support the production of amenities over the larger area by the same percentage, the annual loss would be about $17–11 million. In other words, the total loss would be about $550 per year per hectare of wetland converted to industrial agriculture.

These numbers embody considerable uncertainty, reflecting limited information about the goods and services the delta would produce absent the proposed development, the details of the development, and the future evolution of numerous factors, such as the market price of sugar and other products; the impact on sensitive species; the reaction of communities displaced by the development; and the impacts of climate change on plant growth, river flows, and the delta's susceptibility to flooding. Nonetheless, these numbers suggest the value of the ecosystem goods and services that would be diminished because of the development would roughly equal, and perhaps exceed, the net value to investors of the sugar, molasses, ethanol, and electricity produced. This conclusion is reinforced insofar as there is insufficient information to estimate additional costs to society, for relocating displaced persons, establishing infrastructure and services to accommodate all the population growth induced by the development, increased conflict between wildlife and the growing human population, and other impacts that likely would be triggered by the proposed development.

Conclusions

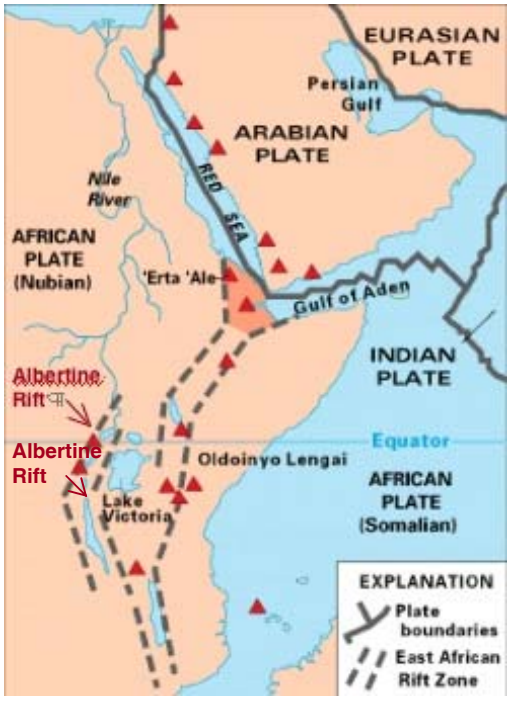
The ecosystem of the Tana River Delta provides numerous goods and services that have great economic value: locally, nationally, and globally. Local communities have developed diverse activities, such as pastoral livestock production, small-scale farming, and fish production, to take advantage of these goods and services. New efforts are seeking to capture additional value through tourism. Proposed development of large-scale, irrigated agriculture in the delta has the potential to yield considerable economic benefit for some, but only by degrading the ecosystem and disrupting existing economic activities. Existing evidence indicates that, at all levels—local, national, and global—the losses from such development could outweigh the gains. Further research is required to clarify these estimates, and to determine the potential benefits and costs of any specific proposal for large-scale irrigated agriculture in the Tana River Delta.

CASE STUDY #3: PETROLEUM DEVELOPMENT IN UGANDA'S ALBERTINE RIFT

Petroleum exploration and production has the potential to affect the mix and value of goods and services derived from dryland ecosystems throughout the IGAD. Recent exploration in the northern Albertine Rift region of Uganda indicates two billion barrels of oil be commercially viable, with a market value of more than $100 billion. Available data, though scarce, indicate that oil exploration/production activities in this area might adversely affect the ecosystem's ability to provide goods other than oil and services by reducing biodiversity; degrading air quality and water quality; limiting the productivity of fisheries; generating wastes harmful to the health of humans livestock, and wildlife; converting forests woodlands, grasslands, wetlands, and other areas to industrial uses, roads, and other developed uses; inducing in-migration and related residential/commercial development; generating increased traffic; altering the socio-economic institutions and relationships in existing communities; and diminishing the area's attractiveness to tourists. In sum, although the exploration/production activities offer the prospect of considerable economic benefits, they can adversely affect the economic well-being of many local residents by impeding the ecosystem's ability to:

- Provide the basis for daily subsistence, human health, social cohesion, and cultural continuity
- Generate opportunities to earn income from agriculture, fisheries, forestry, and tourism
- Offer food security, medicines, and economic relief for disadvantaged individuals and households, especially during periods of drought, flooding, and economic stress.

This case study describes the economic importance of some of the ecosystem goods and services that might be affected by the potential impacts of oil exploration/production on the ecosystems of Lake Albert and the Albert Nile, and the focus area's forests and wetlands. It also examines the value associated with fish production and tourism.



The Focus Area

The Albertine Rift is the western segment of the East Africa's Great Rift System. It has no precisely defined borders but generally extends from north of Lake Albert to Lake Tanganyika, and forms the boundary between the Democratic Republic of the Congo and its western neighbors, Uganda, Rwanda, Burundi, and Tanzania.

Uganda's northern Albertine Rift is administratively divided into five districts. Petroleum is being explored in all five districts and beyond. This case study, however, focuses on Hoima and Masindi districts that constitute Bunyoro Kingdom where the majority of petroleum deposits have so far been discovered. (Recently Bulissa District was carved out of Masindi District, but, in general, data for the latter encompass the former.)

This focus area lies within an altitude range of 621–1,158 meters above sea level, and the region is divided into three major climatic (rainfall) zones: high rainfall (>1000mm), medium rainfall (800-1000mm) and low rainfall (<800mm). The climate and soils are favorable for agriculture. It covers 15,258 sq km, of which water bodies (mostly Lake Albert) occupy 3,068 sq km. Areas protected for wildlife occupy approximately 5,528 sq km, and forest occupies 2,774 sq km. The population reported in 2002 was 819,069, but rapid population growth, approximately 5 percent annually (UBOS 2002), likely has pushed this to about 1.25 million.

Natural Resources and Economic Activities

The focus area comprises three major ecoregions: Lake Albert, the East Sudanian savanna that occurs at lower elevations near the lake and along the Albert Nile River that flows out of the lake, and Albertine Rift montane forests that occur at higher elevations. Overall, the Albertine Rift is among the continent's richest areas in terms of the total number of species and the number of species endemic to just this region. Research so far indicates the region contains 39 percent of all the mammalian species found in Africa, 52 percent of its bird species, 14 percent of its reptiles, 19 percent of its amphibians, and 14 percent of its plants. Lakes in the rift contain more than 400 species of fish (Wildlife Conservation Society 2009). The focus area contains a considerable portion of these species, though the specifics have not been mapped.

The conservation importance of the area is indicated by the designation of the Murchison Falls–Albert Delta Wetland System, at the northern end of Lake Albert, as a Ramsar wetland of international importance.

> *The site stretches from the top of Murchison Falls, where the River Nile flows through a rock cleft some 6m wide, to the delta at its confluence with Lake Albert. The convergence between Lake Albert and the delta forms a shallow area that is important for waterbirds, especially the Shoebill, Pelicans, Darters and various heron species. The delta is an important spawning and breeding ground for Lake Albert fisheries, containing indigenous fish species; the rest of the site is dominated by rolling savannas and tall grass with increasingly thick bush, woodlands and forest patches in the higher and wetter areas to the south and east. It forms a feeding and watering refuge for wildlife in the National Park during dry seasons. Murchison Falls are one of the main tourist attractions and recreation areas in Uganda, and the site is of social and cultural importance to the people of the area: livestock grazing; fishing, with fish exported to DR Congo and also used to feed the refugees in camps in northern Uganda; illegal hunting for game, etc.* (Ramsar Convention on Wetlands 2006)

Lake Albert also represents one of Africa's most important sources of fresh water species. Of the 53 species of fish recorded in Lake Albert, at least 10 are endemic.

Agriculture is the main economic activity in the focus area, with about 80 percent of the households actively engaged in crop cultivation. Common food crops include bananas, beans, cabbages, cassava, cowpeas, ground nuts, Irish potatoes, pigeon peas, simsim, finger millet,

maize, onions, pineapples, sorghum, soya beans, sunflower, sweet potatoes, tomatoes, and yams. This region is one of the leading producers of maize in the country. Cash crops grown in the focus area include sugar, tobacco, cotton, tea and coffee.

Livestock production also is an important activity. The focus area produces cattle, goats, pigs, sheep, exotic and local chickens, ducks, turkeys, guinea fowl, and geese. The area produces about 210,000 litres of milk and 580,000 eggs per week, and 87,000 kilograms of honey per year.

Lake Albert historically has represented about 10 percent of Uganda's total fish industry (UNDP 2006), and a substantial, but unknown portion of this occurs in the focus area. The overall percentage, applied to national data for 2005, indicates that the lake produced about 42,000 tons of fish, provided protein-rich food for 1.7 million Ugandans, directly provided employment for 30,000 workers, and provided income supporting 120,000 people (Nyeko 2005). Though not robust, available data suggest that the annual catch has risen to unsustainable levels, however (Sarnowski 2004). About 5,700 fishing craft ply the water on the Ugandan side of the lake and, in some areas—especially the shoreline areas of the northern lake and the Albert Nile—more than half the population depends on fishing and fish-mongering for subsistence food and income (Namulemo et al). Downstream fish production, on the Albert Nile, is roughly 25 percent of the level on the lake itself (Emerton and Muramira 1999).

Much of the focus area—more than 6 percent—is set aside as natural forest reserves, wildlife reserves and national parks, reflecting their economic and ecological value regionally, nationally, and globally. This value arises largely because the area has some of the highest concentrations of fauna and flora in the country. As a result, the focal area also has some of Uganda's highest levels of tourism and tourism-related revenues.

Ecosystem Goods and Services

Oil exploration/production activities can affect the supply of goods and services from several components of the focus area's ecosystem. There exists little information regarding most potential effects, so this discussion focuses on providing an overview of the factors that likely will determine the extent to which oil production yields tangible economic benefits that offset the economic losses associated with harm to the ecosystem, looking especially at the potential harm to goods and services derived from fish production, forests, wetlands, and tourism, for which there exists information about economic values.

Oil Production

The prospect of oil production has generated great enthusiasm among many Ugandans, who anticipate enjoying a share of the anticipated revenues from the sale of the nation's oil to an oil-hungry world. Prices rose above $100 per barrel before the current global economic crisis, and many expect they will return to this level with economic recovery. There is considerable uncertainty, though, about how much of the revenue from selling oil produced in Uganda would accrue to Ugandans, rather than to foreign investors and vendors, and about the extent to which Uganda's share would yield meaningful improvements, rather than reductions, in the economic well-being of individual Ugandans.

Neither the oil companies exploring for oil nor the government has clearly and fully revealed the terms of the Production Sharing Agreements that will govern the distribution of revenues from the future sale of oil. The government has announced that it would receive 80 percent of the accrued revenue and produce perhaps 4,000 barrels per day (Baguma and Bahikaho 2008), which superficially suggests that, if the price were $100 per barrel, the government would receive about $120 million per year. [4,000 bbl/day x 365 days/yr x $100/bbl x 0.8 share to gov't. ~ $116.8 million to gov't.] Limited review of the agreements, however, indicates the government's take will depend on many factors, and it could fall below 50 percent of total revenue (PLATFORM 2009). Revenues would be even lower if oil prices should fall or production costs should rise to unexpected levels, or if natural and civil events should disrupt oil production.

Whatever the level of revenues, the government also will incur costs related to the production and transport of oil and additional costs if the oil is processed in the country. These costs likely will be required to acquire land, develop and maintain roads, establish new infrastructure for communities near oil installations, provide security, respond to environmental damage from spills and the emission of harmful materials, and generally oversee the government's interests in oil-related enterprises. The net amount left over, after these costs have been incurred, remains unknown, but they likely will be significantly smaller than the government's gross receipts.

Events in other oil-producing countries indicate there is a substantial risk that the production of oil in Uganda will diminish, not enhance economic well-being for many citizens (Butkiewicz and Yanikkaya 2010). Some researchers have observed that there seems to be a "resource curse," particularly with respect to oil, because countries whose exports are highly dependent on oil tend to experience:

- Slower economic growth (measured by GDP, GDP per capita, and income per capita).
- Less frequent peaceful change in government.
- Higher incidence of corruption.
- Higher levels of governmental indebtedness.
- Lower quality of life (measured by higher infant mortality, higher child malnutrition, lower life expectancy, poorer health care, higher incidence of prostitution and sexually transmitted diseases, and higher incidence of crime).
- Lower expenditures on quality of life (measured by lower percentage of GDP spent on education).
- Higher cost of living.
- Severe environmental degradation (measured by habitat destruction, discharge of oil salty water, discharge of toxic drilling mud, emission of airborne pollutants, oil spills and sludge pits).
- More frequent armed conflict.
- Higher military expenditures. (Karl 1997, 2007b)

These correlations do not prove that oil production necessarily causes such outcomes (Brunnschweiler and Bulte 2009). They do, however, indicate there is a not insignificant likelihood that Uganda might experience these outcomes unless it takes effective steps to prevent them. Recommendations include transparently disclosing of information regarding oil-related costs and revenues, relying on democratic institutions to manage governmental receipts,

creating incentives for oil companies to reduce their costs, including environmental costs, and measuring the performance of oil companies and government officials and institutions with respect to indicators of the population's overall well-being (Mehlum et al. 2006, Moreen 2006, Karl 2007a).

Oil production promises to reduce the supply and value of goods and services thousands of households derive from ecosystems affected not just by oil production; the displacement of existing communities; and the development of new roads, a pipeline and other infrastructure, and new communities. Reductions could occur through:

- Habitat conversion, degradation and fragmentation;
- Aesthetic destruction;
- Changes in the wildlife grazing arrangements, breeding capacity, and migration patterns;
- Contamination of fisheries resources;
- Air pollution from vehicle emissions, petroleum-operated engines on drill pads, and dust raised from traffic on access roads;
- Water pollution caused by hydraulic fracturing operations and the disposal of drilling fluids and produced water;
- Ground water level fluctuations that affect wildlife habitat and community water consumption;
- Soil compaction and pollution on drill pads;
- Noise and light pollution;
- Deforestation;
- Soil erosion and sedimentation of waterways;
- Contamination from improper waste disposal or oil spills;
- Introduction of invasive alien species; and
- Loss of productive capacity and degradation of ecosystem functions – both onshore and offshore. (Emeseh 2009, Gratzfeld 2003, Johnson 2009, and USGS 2008).

Fish Production

The findings of Nyeko (2005) indicate that the sale of fish caught in Lake Albert, together with related economic activities, constituted about 0.6 percent of national GDP—about $87 million of economic activity when the percentage is applied to 2008 GDP (IMF 2009). Downstream fish production, on the Albert Nile, is roughly 25 percent of the level on the lake itself (Emerton and Muramira 1999). Hence, the total value of the Ugandan fishery in this region that might be affected, if oil exploration/production were to affect the entire lake and downstream, is about $100 million per year. The focus area likely would account for a substantial portion of this amount. If there were impacts on the fishery in the D.R. of Congo, they would be additional.

Forests

Bush et al. (2004) estimated the contribution of goods and services derived from different types of Ugandan forests to the economic well-being of local households and to the national economy as a whole. The analysis considered both goods and services that become consumption amenities, i.e., are consumed directly by households, and those that are production amenities,

i.e., are sold at market. Two elements of the analysis apply directly to this case study: Budongo Forest, which lies within the focus area, and Kasagala Forest, which lies nearby and represents savannah woodland/bushland common in the focus area and in drylands elsewhere in Uganda and the IGAD region.

Data in Bush et al. (2004) indicate goods and services derived from Budongo Forest contributed about $6 to mean annual income—about 8 percent of the total—for nearby households in 2003. About two-thirds of this contribution materialized as consumption amenities, the other third arose from goods and services households collected from the forest and sold, generating cash receipts. Goods and services derived from the savannah woodland/bushland make a larger contribution to the well-being of nearby households: about $96, or 11 percent of total mean annual income. This contribution was about roughly evenly distributed between goods and serviced directly consumed by the households cllecting them and those sold at market.

These findings are similar to those of earlier research that interviewed persons living in or near Budongo Forest to determine the extent to which local households derived economic benefit from the forest (Budongo Forest Project 2000). More than 45 percent of households reported cash income derived from the forest, and forest income is more important for small landowners than for large landowners. Average total income per year was $489, while the average value of fuelwood and charcoal extracted from the forests, for domestic consumption and sale, was $88, or 18 percent of total income. For smaller households (up to 8 people,) the value of the forest-related goods was 22 percent of total income. The value of fuelwood and charcoal derived from the forest equaled more than 30 percent of the total income for households with lowest incomes, indicating these goods help reduce income inequalities among the households.

Local communities also received more than 20 percent of total revenue from tourist sites in the forest and the sites have helped establish primary schools and health centers in the area. The tourism-related receipts are about 9 percent of total household income in the area. Local residents see the forest as more important than just a source of income, however. More than 90 percent of respondents to the interviews indicated that the forest should be conserved and supported their positions with arguments recognizing not just their use of forest resources but also the forest's ecological importance.

Bush et al. (2004) estimated the value of goods and services derived per hectare from the two forests. Table C shows the findings. Overall, the analysis found that the value of the contribution to local households was $10 per hectare per year for Budongo Forest, and $30 for savannah woodland/bushland. These numbers reflect differences in the types of goods and services (savannah woodland/bushland tends to provide more goods and services supporting the production of livestock, for example), the size of the nearby population, and the level of protection against unauthorized use of forest resources. Some of the values may not be sustainable in the long run insofar as the level of use exceeds the forests' ability to provide specific goods and services. Nonetheless, the values in Table C represent a first approximation of the economic loss that local communities and the nation as a whole would realize if oil exploration/production were to impede the flow of these goods and services in the area.

Table C. Annual Value of Goods and Services Derived from Forests in the Focus Area

	Budongo Forest	Savannah Woodland/Bushland
Contribution to Well-Being of Local Households, Overall Average, All Areas & All Goods and Services	$10/ha	$30/ha
Illustrative Goods and Services		
Soil Fertility		
High livestock population	$8/ha; $50/hhld	$100/ha; $500/hhld
Low livestock population		$30/ha; $100/hhld
Carbon Sequestration		
Primary forest	$2,000/ha	$100/ha
Degraded forest	$1,000/ha	
Biodiversity	$2	$2/ha
Livestock Forage	- -	$2/ha
Water Supplies (local use)	$20/hhld	$7/hhld
Timber	$5	$20
Non-Timber Forest Products	$1	$8
Charcoal/firewood	NA	NA
Materials for crafts	NA	NA

Source: ECONorthwest, with data from Bush, et al. (2004). Numbers rounded. NA = not available.

Access to forest goods and services is especially important to some groups—landless households, internally displaced persons, and those living in areas prone to natural disasters—struggling to survive short-run difficulties, such as periods of drought. Others—poor women, poor smallholder farmers, cattle keepers, and residents of adjacent communities—permanently rely on forest resources to survive. Both groups could be deeply disadvantaged if oil exploration/production were to impair their access to forest resources.

Wetlands

The Ministry of Finance, Planning, and Economic Development reports research indicating that the annual value of goods and services directly derived from the country's wetlands is about $300-600 per hectare, and the value of services that are less tangible, such as water purification and carbon sequestration, may be as high as $10,000 per hectare (UMFPED 2004). Costanza et al (1997) suggests that the value may be about $30,000 per hectare. Notable are wetlands' ability to produce honey, fishing and hunting opportunities, and food and fiber. Nearly all parts of the focus area have the potential to generate some revenue from harvesting papyrus, and Bulissa District has the highest potential: up to $1.3 million per year (Wetlands Management Department et al 2009).

Tourism

Tourism has long contributed to the economy of the focus area. Revenue generated from tourism at Murchison Falls National Park and Kaiso Tonya Wildlife Reserve for the most recent year exceeded $1.2 million. This amount does not account for tourism expenditures separate from but related to these two areas: expenditures on food, transportation, lodging, and crafts away from the areas, for example. In addition, tourism at Budongo Forest has generated about $6,000 in revenue per year (Mbabaliaulo 2001).

Oil exploration and production pose several risks to tourism in the Albertine Rift. Tourists may opt no to come to the Albertine Rift areas if they encounter exploration and production activities they perceive to be incompatible with their travel/tourism objectives. This outcome can occur if industrial activities and infrastructure occur in close proximity to wildlife, interfere with scenic vistas, for example. It also can occur if activities associated with the industry, and the economic activity it induces, disturb the biological productivity of highly sensitive and valuable wetlands near Lake Albert and the Albert Nile by occupying, disrupting, and polluting these areas. Already, degradation of wildlife habitat as a result of oil exploration has resulted in loss of wildlife in Murchison Falls National Park (Tugume and Obore 2010).

These actions will reduce the ecosystem's ability to produce goods and services on which local communities depend for their livelihood, and they may diminish the attractiveness of key attractions that generate jobs and incomes in the tourism industry. Of special concern is the possibility that pollution might adversely affect important fisheries, degrade habitat for wildlife, and impair the health of those living nearby, downstream, and downwind.

Conclusion.

Many look at the numbers—large amounts of oil and high prices per barrel—and envision a future where oil production will pour money into Uganda and boost economic well-being for all Ugandans. A closer look, however, reveals uncertainty over the level of oil revenues Ugandans will derive from oil, how the money will be used, and the unforeseen consequences that might accompany oil production. Experience elsewhere suggests the government will have to use a substantial portion of its revenue to cover oil-related costs, and oil production may negatively affect economic well-being for those not directly benefiting from the oil. Reductions in well-being could occur if oil production were to retard overall economic development, increase the cost of living, degrade the quality of life, encourage conflict, and weaken democratic institutions. In addition, oil production, plus ancillary activities, likely will reduce the supply and value of goods and services Ugandans derive from fish production, forests, wetlands, and tourism.

Insufficient information exists to quantify most of these potential effects, so this case study focuses on documenting different issues and concerns. Extensive, additional analysis is required to understand the full magnitude of the ecosystem values at risk, especially in the context of global efforts to reduce consumption of fossil fuels and the potential that Uganda's oil reserves might be exhausted within a few decades.

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