The Economic, Cultural and Ecosystem Values of the Sudd Wetland in South Sudan:

An Evolutionary Approach to Environment and Development

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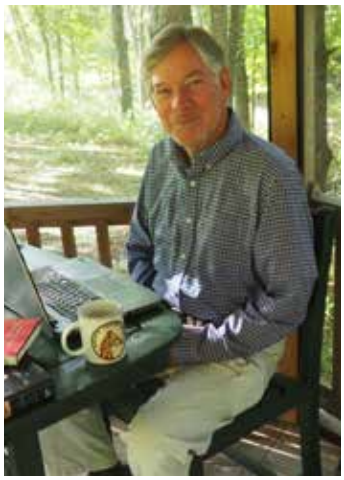

John Gowdy is Professor of Economics and Professor of Science and Technology Studies at Rensselaer Polytechnic Institute. He has authored or co-authored 10 books and 190 articles. His research areas include biodiversity valuation, the human economy as an ultrasocial superorganism, and evolutionary models of economic change. He was a Fulbright scholar at the Economic University of Vienna and a Leverhulme Visiting Professor at Leeds University. He received the Herman Daly Award for his contributions to ecological economics. His research includes the effects of climate change on the coastal village of Keti Bunder, Pakistan, and the environmental, social, and economic values of the Sudd Wetland in South Sudan.

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"All day long we were bewildered, not only by the multiplicity of channels, but by masses of grass, papyrus, and ambatch, which covered the whole stream like a carpet, and even when they opened gave merely the semblance of being passages. It is quite possible that the diversion of its course to the east, which for sixty miles the Nile here takes, may check the progress of the stream, and be in a measure the cause of such a strange accumulation of water-plants."

—Dr. Georg Schweinfurth 1869, in Africa as Seen by its Explorers

Key Findings of this Report

- The Sudd wetland is potentially the greatest economic asset in South Sudan. Unlike the country's rapidly depleting petroleum resources, the wetland, if properly managed could provide income, jobs, and irreplaceable ecosystem services indefinitely.

- We estimate the potential economic contributions of the Sudd to be almost 1 billion US$ per year. The final amount of ecosystem services from the Sudd amounts to 990.94 million US$ per year using the method of transfer valuation and a meta-study of similar wetland areas.

- This figure, which represents only a fraction of the total value of the Sudd's non-economic values, include its potential as a symbol of national identity, its role in climate change mitigation, regulation of the flow of the White Nile, and supporting South Sudan's unique wildlife and cultures.

- Major threats to the Sudd fall into two broad categories: (1) Major drainage projects like the proposed Jonglei canal and (2) small but cumulatively devastating projects like small-scale canals, unsustainable logging, and illegal poaching of wildlife.

- We introduce the concept of an evolutionary path toward sustainability. We point out the danger of "the tyranny of small decisions" and the advantages of long-range planning and comprehensive public policies.

I. Introduction

The Sudd wetland is one of the world's most unique and valuable ecosystems. It can cover as much as 90,000 km² in the wet season and is second only to the Patanal in South America in size. The importance of the wetland to the world's cultural and environmental heritage was recognized in 2006 when the Sudd was officially designated a Ramsar site—a wetland area of international importance—by the United Nations. Nevertheless, the Sudd ecosystem and its unique cultures are threatened by a variety of development pressures including a plan to almost completely drain the wetland to divert water for agriculture downstream. The development pressures on the Sudd illustrate how unrestrained economic and political forces can threaten the degradation of a valuable and irreplaceable ecosystem and major disruptions to the cultures that have thrived for centuries. The case of the Sudd also illustrates how a broader and more dynamic concept of "value" than the one usually employed in static cost-benefit analysis can enrich our understanding of the importance of irreplaceable environmental features and unique human cultures, and point the way to more rational, more nuanced, and more proactive environment and development policies.

In this study we consider the value of the Sudd in three broad dimensions—economic, cultural, and ecological (Gowdy 1997). Some components of value can be expressed in monetary units—the potential of Sudd for agriculture, fisheries, forestry, and eco-tourism, for example. Some components may be quantified but not easily expressed in monetary units—for example, the number of people whose livelihoods depend on the wetland or variety and kinds of species inhabiting the wetland. At the ecosystem level, some critical features of the wetland can be described but not precisely quantified—for example, how it functions as a stabilizer of the microclimate, or how it dampens the effects of the seasonality of the flow of the White Nile. We stress the importance of uncertainty and precaution. The importance of the Sudd to the people and wildlife that live there is obvious. This unique natural feature has provided for the cattle cultures of South Sudan for millennia and we should err on the side of caution when considering degrading its known services for an unknown future without them.

The value of the Sudd should be seen in the context of global economic pressures on the world's ecosystems. As the human impact on the natural world accelerates, the conflict between economic activity and environmental integrity becomes more and more obvious. The development pressures on the Sudd are driven by sweeping changes in the world economy. In recent decades market capitalism has rapidly replaced all other systems of economic organization. In the period since WWII, sometimes called the Great Acceleration, world economic output has grown by five-fold, energy consumption has quadrupled and the world's population has doubled because of the force of this powerful economic system (Steffen et al. 2004). In a market system economic activity is driven by the quest for profit. In economic terms this means maximizing the discounted flow of income or output (Gross Domestic Product). But it is increasingly recognized that traditional myopic measures of economic activity do not fully capture the full social and environmental costs and benefits of production and consumption (Stiglitz et al. 2012).

How does all this relate to the valuation of the Sudd wetland? If we take as our starting point that economic activity is only about the need to maximize GDP, then the ecosystem valuation question is narrowed to become: "How much do particular features of the natural world (ecosystem services) contribute to the discounted flow of economic output?" If ecosystem services are degraded, will overall income diminish or increase? In this narrow framework, the social value of goods should be reflected in their market price. Economic theory recognizes that markets work properly only when price signals are "correct" and that *market failures* can occur when prices fail to register true value. Ecosystem services do not traditionally have prices so there is no way that their social value is reflected in market outcomes. Correcting market failure is the justification for putting prices on ecosystem services that contribute to economic well-being but are outside the realm of market exchange.

There is no doubt that nature's services are being used unsustainably in part because of low prices. But it should be recognized that the market failure approach to environmental policy (*internalizing externalities*), has its limits. First, there is a problem of finding the "correct" price for environmental features. The second problem is the danger in trying to treat problems that are more fundamental in nature (for example, economic growth coming up against biophysical limits) as if they were simply problems of static allocation at the margin within a near-to-equilibrium system. A third problem is that valuation is done from the perspective of a self-regarding individual making investment decisions in the immediate present. Valuation by an individual-at-a-point-in-time may be appropriate for personal financial investment decisions but it is inappropriate for social decisions involving very long run consequences, irreversible intergenerational choices, and pervasive uncertainty.

Economic measures of environmental value (demand and production function approaches) mostly capture the market aspects of provisioning. They do not include so-called "natural capital" which in some sense is the economic equivalent of a supporting function. Economic supporting functions might be related to the concept of "inclusive wealth" (Dasgupta and Mäler 2000) but that concept only applies to outcomes captured (or with the potential to be captured) in a market framework. "Supporting" in the inclusive wealth sense means supporting economic output. But supporting should include not only economic functions but also functions that sustain environmental and cultural viability.

Bringing the idea of preserving supporting functions fully into economic theory and policy frameworks will not be an easy task. Sustaining the supporting functions of the world's biophysical systems implies in many cases maintaining them intact, including their evolutionary potential to adjust to large and sudden changes. Maintaining the evolutionary potential of ecosystems to withstand large disruptions is not a matter of trade-offs at the margin. As the Millennium Ecosystem Assessment (2005, p. 1) states, it will involve substantial changes in political systems, individual attitudes, and social institutions:

> The challenge of reversing the degradation of ecosystems while meeting increasing demands for their services can be partially met under some scenarios that the MA has considered, but these involve significant changes in policies, institutions, and practices that are not currently under way. Many options exist to conserve or enhance specific ecosystem services in ways that reduce negative trade-offs or that provide positive synergies with other ecosystem services.

The first purpose of this study is to describe the role of the Sudd wetland in supplying the year round ecosystem service requirements of its inhabitants for the goods and services the Sudd provides. This account details how nature has configured the ecological systems of the Sudd and the unique cultures that inhabit the area. This includes a description of how the seasonal flows of the Nile affect the seasonal movements of people and their use of the marsh. In its pristine state, the Sudd wetland adequately fulfils year round resource requirements for the complex social systems of the people who inhabit the area. Another purpose is to outline a new approach to ecosystem valuation that takes into account the dynamic, evolutionary nature of ecosystems and the human activities they support. Many of these ideas have been expressed in other forms—adaptive management, coupled human and natural systems, resilience, multi-criteria assessment—but our purpose is to use these and other diverse approaches to frame a specific and innovative valuation method that can be applied to a wide variety of environment/development policy issues. Our aim is to broaden the consideration of ecosystem services in the economic development plans of South Sudan. We focus on the long run and on a truly social approach to valuation and planning.

Our approach recognizes (1) the role of ecological process in maintaining the integrity of life support systems, (2) the role of these life support systems in maintaining human societies, (3) the conflict between local ecosystem integrity and the expansion of global markets, and (4) the positive role governments can play in shaping markets and development paths. Our approach does not restrict public policy to correcting market failures. An important point that comes out of this study is the importance of stable institutions in supporting conservation efforts. Successful conservation efforts (Africa's world famous national parks in Botswana, Kenya, Tanzania and South Africa for example) have all taken place within a framework of transparent legal systems, security, and sound integrated planning. Likewise, the worst cases of environmental abuse (The draining of the Aral Sea and the Mesopotamian Marsh, for example) have occurred when there is a lack of institutions that allow stability, a lack of cooperation among competing interests, and a lack of far-sighted and comprehensive planning.

As mentioned above, the standard economic approach to environmental policy is based on correcting "market failure." The underlying mindset is that there is a dichotomy between "the market" and "the government." Policy decisions are cast as choices

between allocation of resources by "free market" solutions or by the "command and control" of the government. Within this narrow framework the proper role of government is limited to smoothing out the operation of the market by making sure externalities are properly priced and that property rights are fully assigned. Since the 1980s the prevailing ideology has been to constrain the role of government and to shift more and more decisions to the market. But in fact the sharp distinction between the state and the private sector is misleading. Markets have always been shaped, supported, and constrained by government actions. As Karl Polanyi (1944) put it: "The road to the free market was opened and kept open by an enormous increase in continuous, centrally organized and controlled interventionism." Mazzucato (2015) argues that inclusive and sustainable development requires rethinking the role of government and public policy—supporting not only innovation but also its direction. It requires shaping and creating new markets. South Sudan is a new country and it has a chance to chart a new development path. One that is inclusive of all the diverse ethnic groups within its borders and one that is not afraid to actively guide the country toward sustainability and social equality. Long-run public prosperity can take the place of short-term private greed.

Key drivers of environmental degradation and social instability are the growth of the human population, the growth of world economic output, and the penetration of the market economy into every ecosystem and culture on earth. The market economy has become a single worldwide unified and highly integrated system (Gowdy and Krall 2015). As the economy becomes a larger and larger part of the finite planet, the pressure on the earth's natural resources intensifies and resources that were once taken for granted—water, soil, forests—become ever scarcer. But all economic activity does not have the same effect on the environment so a detailed analysis of specific cases, is important in gaining an understanding of the problem of ecosystem degradation.

In the pages below we explore some of the theoretical and practical issues involved in valuing the natural world in general and the Sudd wetland in particular. In this report we focus on economic value, but we take a broad view incorporating new developments in economic theory and policy. In particular, we use findings from behavioral, institutional economics, and evolutionary theory to broaden the scope of "value" beyond market or quasi-market values. The Sudd wetland in South Sudan offers an excellent case study of the challenges and opportunities of ecosystem valuation. The Sudd is an area of immense biological, cultural and economic importance. The conflicts there between different visions of value, and by implication different visions of development, could not be sharper and they starkly illuminate the consequences of policy decisions that are sometimes hard to see in more developed economies.

II. The Sudd

The Sudd Wetland is one of the largest freshwater ecosystems in the world with estimates of an average area of 30,000 km² to 57,000 km² . In the wet season the areas of the wetland may grow up to 90,000 km² depending on the level of water discharge from Lake Victoria, the source of the White Nile which enters South Sudan from Uganda (Dumont 2009). The extent of the Sudd can vary greatly from season to season and from decade to decade. From 1961 to 1964 the area of the Sudd increased by almost 300%, apparently from increased rainfall in the headwaters around Lake Victoria (WWF 2015). From 1965 to 1978 the maximum area gradually decreased to about 42,000 km² (Lamberts 2009, 4). The Sudd begins north of Bor when the White Nile widens into a floodplain. Further downstream the Bahr el-Zeraf ("Sea of the giraffes") splits off from the Bahr el-Jebal to the east adding to the floodplain area. The Bahr el-Jebal rejoins the White Nile just south of Malakal. The White Nile and Blue Nile meet at Khartoum to form the main Nile River. The Blue Nile contributes more water but the water from the White Nile is more dependable (less seasonable), because of the immense storage capacity of the Sudd.

It is estimated that about 50% of the water flowing into the Sudd is "lost" through evaporation (Lamberts 2009, 4), although there seems to be little hard documentation for this often-cited figure. The number appears to come from estimates that the average water flow from the Nile into the wetland is about 1,048 m^3 per day and the average flow when it leaves the wetland is about 510 m^3. If totaled over a year this is about 15 cubic kilometers per year but as Keys (2011) points out, "lost" is not an appropriate term since research suggests that a large amount of the growing season precipitation originates as terrestrial evaporation over the Sudd. Altering the flow of the Sudd would most likely have large negative implications for agriculture in the region. Also, part of the loss is likely due to groundwater absorption by aquifers under the Sudd.

The Sudd supports one of the largest collections of wildlife in the world. It is important to recognize that the Sudd is part of a much larger ecosystem, the Jonglei plains. This is Africa's largest intact area of Savannah, forming an area three times the size of the Serengeti National Park (Furniss 2010). An aerial survey of the Sudd by the WCS in 2007 confirmed the existence of more than 1.2 million white-eared Kob and an abundance of Tiang antelope and Mongalla gazelle. An estimated 8,000 elephants were also present in the Sudd wetland then. With proper security and institutions in place to protect and monitor the region's wildlife areas, safaris, bird watching, ecotourism, and research activities could provide a large and steady income indefinitely. Economic estimates of the value of wildlife, particularly large charismatic game animals, show that their value is enormous (Geist (1994). Local studies have shown the impressive economic contributions of wildlife-based tourism (Tisdell (2007).

Developing countries that have chosen to protect large ecosystems to promote tourism (Botswana, Costa Rica, Kenya, and Tanzania for example) have reaped extraordinary economic benefits. Tourism is Kenya's leading foreign exchange earner. The revenue from

tourism has a very high multiplier effect because of its connection with other sectors of the economy (Udoto 2012, p.54). Kenyan tourism directly accounts for 10% of Kenya's GDP but its impact is much higher because of the number of people who visit Kenya for wildlife viewing and then stay for other activities (as in the Tisdell 2007 study). An incipient ecotourism industry exists in South Sudan but is currently on hold because of the conflict on-going since December 2013. The first tourist guide to South Sudan was published in October 2013 (Lovell-Hoare and Lovell-Hoare 2013). The key feature of the guide is the descriptions of the abundant wildlife in the Sudd and elsewhere. A key component to the future economic health of South Sudan is the preservation of its absolutely unique wildlife heritage.

South Sudan is a new country struggling to establish a national identity among the diverse ethnic groups living within its borders. The Sudd has the potential to become the national symbol of South Sudan much as the wildlife in the Serengeti of Tanzania and the many parks of Kenya are the focus of the national identities of those countries. The value of the Sudd is much more than the potential income it could generate. It could play a key role in institution building and the unification of the diverse cultures of South Sudan.

III. Human Presence in the Sudd

Ecologically speaking, the demands downstream for water for economic development, are at odds with the Sudd's ecology because the expansionary path of economic development requires increasing demand for water and alters the hydrological cycles of the Nile River drainage system. The more traditional economies of the Sudd region, and in particular the pastoral/ agricultural economies of the Dinka, the Nuer and the Shilluk, also demand water but their traditional economic strategy has been to adapt their demands to the seasonal (and longer) the fluctuations in water. They have a complicated pattern of cultural practices, land use, and migration patterns that allows them to navigate and adapt to their economy to the ecology of the Sudd. Theirs is not a strategy of control but rather a strategy of adaptation and co-evolution.

The majority of the indigenous people of the Sudd region are Nilotic speaking people who are pastoralists/agriculturalist who have adapted their economies and cultures to the demands of the hydrological cycles of the Nile. The ecology of the rural economy of the Sudd area is defined by droughts and floods, pastoralism, production of crops and a supplement of wild meat and fish. It is essentially a subsistence economy. Howell et al. (1988, 226) describe the economy of the Nuer, and Dinka:

> To differing degrees the economy of the Dinka and Nuer involves transhuman animal husbandry, moving according to the seasons over high land, intermediate land and toch, in association with crop production restricted to the marginally better drained land during the rains, supplemented by fishing in the rising and receding waters of the rivers, and hunting the abundant wildlife during the dry season.

More specifically there exists an annual cycle of migrations in order to feed the herds of cattle coupled with more permanent settlements where crops are grown. More permanent settlements occur in the highlands where crops are planted around "homesteads".

A standard economic argument is that concern for the environment is a "luxury good", that is, only when incomes are high enough can people afford environmental quality (the so-called environmental Kuznets curve). The argument is that the poor are not concerned with environmental quality because they either lack awareness of environmental quality or they are too poor to pay for a clean environment (Martinez-Alier 1995). In fact the world's poorest have been at the forefront of third world environmental movements (the Chipko movement in India, the rubber tapper movement in Brazil, the battle of small island nations against climate change and sea level rise). It has been show that the world's poorest (about one billion people) in contrast to affluent countries, receive most of their economic well-being (50–70%) directly from nature (Pavan Sukdev Green India project). The value of the Sudd is much more than a resource to be exploited so that extracted rents can add to the wealth of private individuals. The value of the Sudd includes its value to traditional cultures, its role in sustaining the natural processes of the Jonglei Plain ecosystem, and its potential

contribution to the sustainable economic development of South Sudan. Additionally, preserving the Sudd can protect irreplaceable natural resources like clean water.

Finally, something should be said about the effects of the civil war in Sudan on the Sudd's wildlife. Ironically, biodiversity loss and ecosystem destruction has been slowed by the civil war. This is not unique. Areas of human conflict, especially "no man's land" between warring factions, have been havens for wildlife because of the absence of humans. But South Sudan must have a plan to preserve the Sudd's resources after peace comes. A window of opportunity will exist, but regulations, monitoring, and enforcement must be in effect soon.

IV. Development Threats to the Sudd

The Jonglei Canal

A proposal with its origins in colonial Africa is to dig a canal that would make the White Nile by-pass the Sudd in order to get more water downstream to Sudan and Egypt for agriculture. Such a canal was proposed by William Garstin in 1904. Called the Garstin cut, it would have diverted 28 billion m^3 of water per year from the Sudd (Collins 1996, 101). Great Britain, the former ruling colonial power over Egypt and Sudan, resurrected the idea of a canal in the 1930s but nothing came of the proposal. But the canal project was again taken up again in the 1970s by the Nimeiri military government of Sudan and was actually begun in 1978 with little debate and no environmental impact study. The canal was to go from Bor, just north of Juba, to Malakal near the border of Sudan. Digging the canal was well underway until a Southern People's Liberation Army missile disabled the digging machine in 1983. Construction was halted and today the excavated portion of the canal has been partly reclaimed by nature. The uncompleted canal is about 240 kilometers long, about two-thirds of the planned 360 km canal (Keys 2011). The canal is about 75 meters wide and has a depth that varies between 4 to 8 meters (WWF 2015). The partially completed canal has apparently had an adverse effect on the migration patterns of antelopes and other species (Lovell-Hoare and Lovell-Hoare 2013).

Figure 1. South Sudan Showing the Sudd and the Proposed Jonglei Canal

According to Ahmed (2008), the canal would increase water flow to the south by 20 million m^3. Furniss (2010) reports that the finished canal would produce an additional 3.5–4.8 x 109 m^3 of water per year, equal to an increase of around five to seven percent of Egypt's current supply. The first phase of the project would have shrunk the wetlands by about 40% and the second phase would have completely dried out the wetlands. The canal's benefits would be shared by Egypt and Sudan, with the expected damage falling on South Sudan.

The effects of the canal on the local ecosystem and cultures would have been devastating—a loss of grazing land, removal of water that all life in the wetland depends on, and changes in the timing of seasonal activities. The economic impacts of a changing microclimate would be felt throughout East Africa. Were it not for the interruption of civil war and political strife the Jonglei Canal would have been completed. At present the project is at a standstill both from the political uncertainties in Egypt and Sudan, and because of opposition within South Sudan and from other countries in the upper Nile basin. The Jonglei Canal project and opposition to it embodies the conflict between traditional economies tied to local ecologies and economies impacted more directly by global market forces. The needs of traditional economies and the goal of conservation are closely aligned in the Sudd and they stand in opposition to the more dominant approaches to economic "development".

The future of the Jonglei canal is uncertain. Given the political turmoil in Egypt and Sudan, the primary backers of the canal, it may not be built. Geopolitical power also seems to be turning in favor of the other Nile Basin countries of the Upper Nile. Even if the canal will never be built, the history of the project is useful as an example both of the power of special interests and politics over the best interests of the people of South Sudan. It illustrates the kinds of development decisions that are frequently made—with a lack of transparency, a lack of long range planning, and a lack of democratic decision-making. But a decision not to dig the canal should be more than a simple "no". A development alternative should be presented that shows the value of using the ecological and cultural resources of the Sudd in a sustainable way. This means charting a path that expands the opportunities for the majority of the people of South Sudan.

The Bor-Malakal Dyke Reconstruction and Rehabilitation Project

This project was proposed by the Government of South Sudan and was to be implemented with the help of the German Development Cooperation International Services (GTZ-IS) and funding from the United States Agency for International Development (USAID). The proposed dyke was to extend over three counties (Duk, Twic East, and South Bor) and branch off Jalle, meeting the old dyke from 1983 at Maar. After a large flooding of the area in the 1960s and recent civil wars large parts of the local population were displaced. The dyke would assist in the resettlement of those populations and protect from further flooding. Mungatana and Njenga (2006), Marneweck (2006), and Wahungu (2006) assess that the building of the dyke would have a wide variety of negative impacts. It is estimated that flooding on the east side of the dike would be reduced and about 197,000 ha of highly productive grazing land would transform in less productive dry areas, reducing the grazing capacity for cattle raising. The reduction of river flooding east of the dyke would also decrease fish biomass and hurt the aquatic biodiversity in the region, however it should be mentioned that controlled flooding could reduce these negative impacts. While dykes and canals would increase the amount of land available for settlement and agriculture, they are also natural barriers for wildlife migration and would most likely hurt the numbers of animals dependent on those migratory routes.

Petroleum Extraction

Before the succession of South Sudan, oil made up 90% of exports from Sudan and led to an average real GDP growth of close to 8% between 2004 and 2008. Before the first oil exports Sudan's growth only averaged 3% between 1980 and 1998. Oil development was mainly financed by national oil companies from China, Malaysia, and India, where most of the oil exports have been going. Despite the great inflow of foreign currency the oil resources have spurred the conflict between North and South Sudan, led to an appreciated value of the Sudanese Pound and to extensive environmental pollution (Patey 2010). South Sudan holds most of the oil reserves, whereas the North has access to the ocean and the only pipeline from the fields to its port. Since South Sudan's separation the North has charged a transfer fee for the use of the pipeline, which has led to a recent dispute about the pipeline charges. South Sudan is considering building a pipeline either to the Kenyan Port of Lamu or to the Port of Djibouti via Ethiopia, however the civil conflict has stalled such plans.

Oil extraction has brought a number of problems to South Sudan. Due to the infrastructure and development of the oil fields thousands of villagers were forcefully evicted according to a 2008 article in the Sudan Tribune (http://www.sudantribune.com/spip.php?article26231). The article mentions that pollution from the oil refineries are also responsible for contaminated water that has led to the sickness of more than 1,000 people, the death of 27 adults and 3 children and countless livestock. A recent article in the Star Africa indicates that several pipelines were damaged and damaged oil wells were abandoned due to the ongoing conflict and have caused a widespread fear of environmental pollution (**http://en.starafrica.com/news/ssudan-oil-leaks-cause-pollution-fears.html**).

Summary of threats to the Sudd

The Sudd faces a number of development threats that could result in either the wholesale destruction of the wetland (the Jonglei canal) or the degradation of the Sudd's ecosystem services through projects relatively small in scope and duration. In some ways the small scale projects are more threatening. The Jonglei canal is a massive project having highly visible negative impacts, and immediate opposition will arise if plans to resurrect the project materialize. On the other hand, small scale projects are unlikely to be noticed and they will not be subject to close scrutiny by those who wish to protect the Sudd. The effects of petroleum extraction on local economies are so well-known and so pernicious as to generate a vast literature on what has come to be known as the "resource curse" (Burgis 2015; Sachs and Warner 1995). All this points again points to the need for a comprehensive plan for the wetland, administered by a government authority with monitoring and regulatory power.

“A MAJOR PART OF THE LIVELIHOOD OF THE PEOPLE IN THE SUDD ARE CATTLE HERDS, SOME OF WHICH CAN REACH UP TO 500 COWS. THE CATTLE ARE...TREATED AS A FORM OF CURRENCY AND OBJECTS OF BEAUTY AND PRIDE.”

V. Value Transfer as a Framework for Valuing the Sudd Wetland

The Sudd does not lend itself to traditional economic valuation measures. Markets are not well-established and the concept of the services of nature as commodities to be traded is largely unfamiliar to the wetland's inhabitants. Few markets exist for most of the services of the wetland, property rights do not conform to western notions of ownership, and basic requirements of welfare economics—marginal analysis, individual-based preferences, discounting the future—do not apply. Of the widely used methods to estimate costs and benefits of environmental features, value transfer seems the most appropriate for the Sudd wetland. Furthermore, the complex relationship between the hydrology of the Sudd and the characteristics the plants and animals there, and the relationship of the biology and hydrology to the area's indigenous cultures, make market demand and supply valuation techniques virtually useless. Fortunately some indirect techniques exist to make some preliminary calculations of its value. Going beyond direct market valuation techniques also opens the door to some qualitative, but perhaps more useful, measures of value.

Value transfer can be quite useful in a general way to look at some possible worst case consequences of losing the Sudd, and the benefits of preserving it. On the negative side, two cases of draining a water basin on such a massive scale are the Aral Sea and the Mesopotamian Marsh. Although the Aral Sea and the Mesopotamian Marsh may seem to be very different cases from the Sudd, they are instructive because they show the devastating and unintended consequences of intentional massive ecosystem destruction. Two positive cases of preserving a valuable ecosystem, the Serengeti and the Okavango Delta, can provide indirect data about the benefits of preserving the Sudd.

Value Transfer and Negative Examples of Ecosystem Destruction

The Aral Sea

The Aral Sea was once one of the four largest lakes in the world with an area of 68,000 km^2. The construction of irrigation canals in the Aral Sea region began in the 1940s. But the major effects on the Sea began in the 1960s when the Amu Darya and Syr Darya rivers that flowed into the Aral Sea were diverted by the former Soviet Union for agricultural projects. Most of the diversion canals are unlined to prevent leakage and much of the diverted water escapes before reaching their destination. Irrigation water is used to grow rice, melons, cereals, and cotton. By 1988 Uzbekistan was the world's largest cotton producer but production has declined in recent years. By 2007 the Sea had declined to about 10% of its original size. Its water volume decreased from 1,066 km^3 in the 1960s to 304 km^3 by 1990.

The effects on the local people have been devastating. The once thriving fishing industry has disappeared. About 4 million people have lost their livelihoods due to the collapse of the fishing industry and the degradation of soils from increased salinity (Barghouti 2006). The Aral Sea region is heavily polluted, with serious health problems apparently arising from the desertification of the former sea. The loss of the Sea has left large plains covered by salt and toxic chemicals. Health effects include high rates of certain forms of cancer, respiratory illnesses, digestive disorders and anemia. Liver, kidney and eye problems have also been

attributed to toxic dust storms. Infant mortality rates rose from an average of 45/1000 live births in 1965 to 72/1000 in 1986, an amount about 3–4 times the national level in the former Soviet Union and 7–10 times of the United States (Micklin 2007). Average life expectancy has dropped to 61 years from 65 years. Biodiversity in the region significantly declined with over 70 species of mammals and 319 species of birds living in the delta prior to 1960, and only 32 species of mammals and 160 species of birds remaining in 2007. The increased salinity of the water led to the loss of 26 fish species and only 6 remaining today. An estimate of the annual economic losses from the disappearance of just the 522,500 ha of wetlands suggests a value of 100 million USD per year (Trevitt et al. 2010). Local climate changes have also been reported with hotter and drier summers and longer and colder winters.

Although these losses were offset to some extent by gains in agricultural output from irrigation, these gains have proven to be temporary because of poor management of the irrigation systems and increasing salinity. Some success has been seen in recent years in partially restoring the Sea. In 2008 the water level had risen by 12 meters, salinity had dropped, and fish are returning to the Sea in sufficient numbers to allow some commercial fishing.

The Mesopotamian Marsh

The Mesopotamian Marsh is part of the Tigris and Euphrates river system, the largest in southwest Asia. Its area is 20,000 km² compared to Sudd's 57,000 km² so in terms of scale they are comparable. As in the case of the Aral Sea, dams and drainage systems have drastically altered a major ecosystem and the cultures embedded within it. The main sub-marshes of the system are the Hawizeh, Central and Hammar. All three have been drained at different times beginning with a British project in 1951. The draining of the central marsh was originally intended to increase agricultural production but the destruction of all three marshes became a tool of war and revenge. After the First Gulf War (1991) the Iraqi government diverted water from the Tigris and Euphrates rivers away from the marsh in retaliation for a failed uprising. The result was the loss of two-thirds of the central marsh by early 1993. The central marsh was "completely desiccated" by the late 1990s and UNEP estimated that in the year 2000 the Mesopotamian marsh had shrunk to 14.5% of its 1976 size (Partow 2001).

The loss of this marsh is now recognized as an ecological and humanitarian disaster. Partow (2001) writes:

> At the dawn of the new millennium, the tragic loss of the Mesopotamian marshlands stands out as one of the world's greatest environmental disasters. Dams and drainage schemes have transformed one of the world's finest wetlands, the fabled Eden of the Fertile Crescent that has inspired humanity for millennia, into salt encrusted desert. The ecological life-support system of a distinct indigenous people dwelling in rare water-world of dense reed beds and teeming wildlife has collapsed. Humanity's impact on the planet's fragile ecosystems could not be more dramatically illustrated.

For the so-called Marsh Arabs, the Ma'dan, the drainage of the marsh has meant the loss of the economic benefits of that ecosystem including fish, game, reeds for constructing houses, and rice cultivation. The original population of the Ma'dan is estimated to be about 500,000

people. With the loss of the Marsh, the population was reduced to as few as 20,000 in Iraq. An estimated 80,000 to 120,000 fled to refugee camps in Iran. By 2003, as few as 1,600 were still living their traditional lifestyles.

The effect on wildlife has been equally devastating. Several species of birds and mammals have become extinct or are severely threatened. The marsh once acted as a stopover area for intercontinental migrating birds. The loss of habitat has placed some 40 bird species at risk. Coastal fisheries in the Persian Gulf have lost productivity because of the drainage of the marsh (Partow 2001, ix–x). Both the human population and wildlife have suffered because of higher soil salinity, desertification of over 19,000 km^2, and saltwater intrusion.

After the Second Gulf War in 2003 efforts began to restore the marsh. About half the original area has been reflooded. Fish, wildlife, and people are slowly returning. A 2010 study found that most plant species had reappeared but plant quantities and diversity were low. Water quality is an on-going problem. Marshland water is still not safe for humans, including use for agriculture. Increased salinity is a major problem. There have been declines in fish species that need clean water.

An important lesson is to be learned from the restoration effort. The cumulative effects of small damages can be as harmful as single massive perturbations. The biggest obstacle to complete restoration is the lack of adequate water flows because of upstream dams. The root cause of the continuing degradation of the Mesopotamian marsh is a lack of institutions for the countries in the watershed to equitably manage the flow of the major rivers there. Over and over again in cases of major ecosystem collapse, working institutions—from stable governments to a working legal system—could have prevented major catastrophes.
Value Transfer and Positive Examples of Ecosystem Preservation

The Serengeti

The Serengeti in Tanzania with its 1.5 million hectares of savanna teeming with wildlife is one of the world's most famous natural wonders. As of the 2002 Tanzania National Census the population of the Serengeti District was 176,609. The Serengeti and the adjacent ecosystems of Grumeti, Maswa, Ikoronga Game Reserves, and the Maasai Mara National Reserve in Keyna is an intact ecosystem with no barriers to the movement of migratory animals. As early as 1929, 228,600 hectares of the central Serengeti was declared a game reserve. The entire Serengeti has been a protected area since 1940. National park status was given in 1959 and the reserve was accepted as part of a UN World Heritage Site in 1981 (UNESCO 2014a). The area is especially famous for the annual migration of wildebeest, Burchell's zebra, and Thomson's gazelle with predators like lions, hyenas, and jackals following them. Although the Serengeti is not considered a Ramsar site itself, it contains multiple wetlands and borders Lake Natron, a Ramsar site since 2001 (Ramsar Website 2015).

The Serengeti Park receives around 300,000 visitors each year. The entire Serengeti ecosystem including parts of Kenya attracts about 800,000 visitors annually. Tourism directly accounts for about 17% of the Tanzanian economy and it employs about 8% of the population. Emerton and Mfunda (1999) estimated that in 1989 tourism in the Serengeti National Park resulted in a total of about 1.4 million US$ a year to TANAPA, Wildlife

Department and the District Councils in Park entry fees, hunting charges, and lodge and camp concessions Councils (Emerton and Mfunda 1999). Today's figure is estimated to be higher than 18 million US Dollar considering the $60 conservation fee per visitor to the Serengeti National Park and more than 300,000 tourists annually. In addition visitors are charged overnight and camping fees, for every car that enters, and extra for canoeing, guided safaris, and night game drives (**www.tanzaniaparks.com/parkfees/applicableFees2013-06.pdf**). The indirect impacts on the economy are much larger through multiplier effects. Emerton and Mfunda (1999) estimate that a local farmer could make up to 14,000 US$ per year by providing beef, chicken, fruit and vegetables to three tourist establishments. In addition government schemes and private sector arrangements such as community cropping and land lease ensure the proper management of the wildlife and provide additional income.

A number of threats face the Serengeti. A proposed road through the park would link the heavily populated areas of Lake Victoria to the west with the port city of Dar es Salaam. That project has apparently been abandoned, but other development pressures remain. Poaching of elephants has increased dramatically. The numbers of wildebeests have decreased dramatically in recent years. The decline of the Serengeti could make the wildlife in the South Sudan all the more valuable.

The Okavango Delta

The Okavango Delta has been well-studied and provides the best comparable example of the benefits of preserving the Sudd. It is located in northern Botswana at the northernmost edge of the Kalahari. The waters of the delta are fed by the Okavango River whose headwaters are in Angola. It was declared one the Seven Natural Wonders of Africa in 2013 and is, just like the Sudd, considered a Ramsar Site and Wetland of International Importance. In addition it is a World Heritage Site under the UNESCO for being home to some of the world's most endangered species and an exceptional example of the interaction between climatic, hydrological and biological processes (UNESCO 2014b). The size of the Delta increases from about 5,000 km^2 to 12,000 km^2 in the flood season depending on the amount of rainfall upstream. The Okavango River flows directly into Kalahari Desert where it is ultimately evaporated and absorbed. With an average rainfall of only 500mm per year, evaporation accounts for 95% of water loss. Animals include the African Bush elephant, African Buffalo, Hippopotamus, Lechwe, Wildebeest, Giraffe, Nile crocodile, Lion, Cheetah, Leopard, Hyena, Rhinoceros, Wild dogs, and Zebra. The delta also supports over 400 bird species. Most of these animals are not year-round residents but come there only when the delta floods.

An extensive study of the economic value of the Okavango Delta was completed in 2006 (Turpie et al. 2006). The study identified five main ecosystem functions (groundwater recharge, wildlife refuge, carbon sequestration, water purification, and scientific and educational value) and two direct use values (Tourism and natural resources). The valuation methods used were Total Economic Value (TEV) and a National Accounting Framework. TEV excluded non-use values (option and existence values), although it was recognized that "As an internationally renowned object of natural wonder it also generates significant non-use values in the global context" (Turpie et al. 2006, 1).

One of the two direct use values, wildlife based tourism in Botswana, is the second largest income earner after diamond mining, accounting for 5% of Botswana's GDP in 2005 (Mbaiwa 2005). Tourism was almost non-existent in 1970s and has since grown with a focus on high quality/low volume. Among other restrictions this policy meant keeping the lodge sizes limited and only allowing 4x4 vehicles to enter the park. The Okavango Delta report by Turpie et al. (2006) estimates the economic output of tourism to be between 195 million to 215 million US$. The direct GNP contribution accounts for about 73 million US$ and about 60% of the jobs in the delta area are generated by tourism. The second direct use value, natural resource use, accounts for about 5.5 million USD per year and, including agricultural activity, increases to about 17.3 million USD.

The remaining ecosystem services evaluated in this study and its respective values are the following:

- Groundwater recharge—2.1 million US$
- Carbon sequestration—14.4 million US$ to 240 million US$
- Wildlife refuge 15.4 million US$ per year
- Water purification 36,000 US$ per year
- Income from research and educational activity 4.4 million US$ in 2005

While flood attenuation and sedimentation have significant values for the Sudd and its outflow into the Nile River, the value for the Okavango Delta is minimal since most of the possible overflow would be channeled into the Boteti River and Lake Ngami. Both have been dry since the 1990s and would be able to absorb most of the outflows.

In total the indirect use value of the Okavango Delta is estimated to be about 42 million US$, however the authors point out that some of these estimates were made with soft data. Therefore a range of about 26.4 million to 81 million US$ is given as a more informative number. While other studies show significantly higher values for wetlands (9,990 US$/ha Costanza quoted in SIWI 2004), the Okavango Delta study by Turpie et al. (2006) estimates an average value of 12 US$/ha for the wetland and 9 US$/ha for the entire Ramsar site. The authors mention that this difference results from the minimal impact of flood attenuation and sedimentation due to the Delta lack of outflow. Furthermore water purification is relatively small in this study due to the low human density in the Delta.

Even though this study shows the extensive and sustainable value of the Okavango Delta, it faces a number of threats including climate change, increasing numbers of cattle encroaching on the delta and a plan by the Namibian government to build a hydroelectric dam in the Zambesi region which would affect the flow of water into the Okavango.

The Major Categories of Benefits of Preserving the Sudd

The four case studies discussed above can be used to get some ball park estimates of the economic benefits of preserving the ecosystem services of the Sudd as well the costs of the destruction of that ecosystem. We summarize here the benefits and potential benefits of preserving the ecosystem using mainly the Okavango Delta value. These values have been adjusted for inflation where necessary, e.g. the Okavango Delta study has been adjusted for the inflation rate of the US dollar from 2005 to 2015.

Tourism

In order to transfer the values of other studies to the Sudd wetland a few assumptions were needed. Currently there is no international tourism industry present in the Sudd as well as in South Sudan in general. For the transfer value estimation we have to assume that a well-managed and stable tourism industry can be built up. The success and generated value of the tourism industry depends on a variety of factors, however the demand for a safe and unique experience of African wildlife is rising considering that other ecosystems are experiencing greater environmental pressures. Additionally the Sudd offers a massive migration that is assumed to be greater than the great migration in the Serengeti, one of its biggest selling points. These factors make a direct comparison very difficult and the estimated value has to be understood as such.

Tourism in the Okavango Delta produced approximately 200 million US$ in 2005 (Turpie et al. 2006), while the estimation for the Serengeti only gives lower threshold of at least 18 million US$ in just park fees. Considering that the Sudd is considerably bigger in size and extremely unique the potential for a tourism industry can be expected to be far greater than in the Okavango Delta. We estimate that a well-managed high-quality, low volume tourism industry could generate over 600 million US$ per year. Again, it has to be emphasized that this number is just an estimation and could be even greater depending heavily on the political situation and the sustainable management of the wetland.

Household Resources

The average of a little less than 7 people per household in the counties around the Sudd are comparable to the counties used in the Okavango Delta evaluation that averaged 7.2 to 8.3 people per household. Households in the Okavango Delta derive their livelihoods from gathering, hunting, fishing, livestock, arable farming, crafts, and the formal sector. Similarly to the Sudd most arable farming is carried out for subsistence purposes. 75% of the households in the Okavango Delta are crop farmers, which compares to the average of Jonglei's 73%, Lakes' 82% and Unity's 59% of households being crop farmers. The Sudd has an estimated 140,877 households that depend on agriculture for their living. The main difference here is again the size. The Okavango Delta has a population that is only about 1/10th of the size of the Sudd and hence the Sudd's value for household resources is estimated to be considerably larger. Taking the population size as the relevant factor for the multiplication of the transfer value and adjusting for inflation, we estimate that the wetland produces household resources valued about 207.6 million US$ per year. Similarly to tourism this value can vary depending on the sustainable management of fishery, agriculture, and forestry. In a time of food insecurities the value for household resources given above seems very conservative.

Groundwater recharge

The value of groundwater recharge in the Okavango Delta, Turpie et al. (2006) is estimated by taking the annual amount of groundwater abstraction and then multiply it with an estimated willingness to pay of about 0.36 US$ per cubic meter. The annual groundwater abstraction is estimated for domestic use, businesses and livestock and therefore closely related to the population size. Turpie et al. (2006) estimate 5.8 Mm^3 of water being used by 111,000 people. While there is no data available on the value of a cubic meter of water in the Sudd or the amount of water used per a certain time period, we know from the Statistical

Year Book for Southern Sudan (2010) that more than 68% of the population in Jonglei and Lakes receive their drinking water from deep boreholes and hand pumps. Similar numbers can be found for Unity, where a greater part of the population, about 30%, have open water as their primary drinking water source. Due to the similarities in the household activities of the Okavango Delta and the Sudd the closest estimation is that the population uses about 58 Mm^3 at a value of 25.1 million US$.

Carbon sequestration

While we do not have specific data on the biomass of the Sudd wetland and neither did the Okavango Delta study, wetland carbon sequestration can be estimated by using a leaf area index (LAI). This index finds that a normally flooded area, at least the Ramsar site of 57,000km^2 in the case of the Sudd, will sink about 1.3510 T/ha, while a seasonally flooded area, at least 30,000km^2 in the case of the Sudd, will sink about 1.3920 T/ha of carbon per year. Turpie et al. (2006) assume three different estimates, whereas we will only estimate the amount using the lowest number, 6 US$ per ton, to give a minimum value for carbon sequestration of the Sudd. Using the same assumptions and a conservative estimate of 30,000km^2 seasonally flooded areas in addition to the 57,000km^2 flooded area we find that the wetland's carbon sequestration ability amounts to at least 71.26 million US$ per year. The true size of the Sudd and its different forms of wetlands could be far greater and, hence the values should only be considered a minimum of the true amount.

Wildlife Refuge

Similar to the Okavango Delta's wildlife, the Sudd's animals migrate beyond the boundaries of the wetland. The value of the Sudd supporting this wildlife for the neighboring regions, e.g. the Bandingilo National Park, Boma National Park and Southern National Park, is indirect and not included in the tourism or household resources estimation. The Wildlife Conservation Society has conducted aerial surveys of several regions in South Sudan and reported one of the world's largest animal migrations with about 1.3 million antelope. The migratory routes are estimated to go through Boma National Park, Bandingilo National Park, and the Sudd. In the 2010 Aerial Survey of Wildlife the Wildlife Conservation Society estimated over 400,000 Tiangs, 165,000 Mongolla Gazelles, 112,578 White-eared Kob and over 10,000 of the endangered Nile Lechwe in one part of the Sudd (WCS 2010). The hard-to-reach wetland has given many animals a refuge from wartime hunters and post-war poachers and is an important feeding ground for many migratory birds.

The estimated value of the Sudd as a wildlife refuge depends on the amount of wildlife that the wetland can support and its hunting and eco-tourism value for the neighboring regions. The Okavango Delta study by Turpie et al. (2006) estimates that an area of 28,782 km^2 has a hunting value of about 9.5 million US$ per year and an eco-tourism value of about 4.2 million US$ per year. The area includes a large region that is rarely flooded and as the Sudd provides an area at least 4 times as large as the size used by Turpie et al. (2006), we can estimate a value of about 45.6 million US$ per year in hunting value and 20.16 million US$ per year in eco-tourism for the neighboring regions. Again the total value of about 65.76 million US$ per year is just lower boundaries of the possible benefit of the wildlife value supported by the Sudd wetland.

Water purification / Filtering / Water Supply

Most households receive their drinking water either directly from the river or from groundwater wells that are recharged by the Nile. In addition over 88% of the population has no toilet facility, which means that the wetland swallows a considerable amount of waste and is the main source of water purification and filtering. Turpie et al. (2006) estimate the cost of wastewater treatment supported by the Okavango Delta based on the amount of camps, tourists, and workers. While there is currently no tourism and camps found in the Sudd, the local population would require a different source for their clean drinking water. The cost of local water treatment plants, transportation of water, the possible health consequences for the part of the population that could not have the same access to clean water, and displacement of people is difficult to estimate due to the lack of data. Turpie et al. (2006) estimate about 740,000 US$ per year for the Okavango Delta, which seems extremely low in the unique case of the Sudd, especially with a large portion of the water supporting the regions downstream of the Nile. Again we take the population size as the relevant multiplication factor and find that a lower bound for the ecosystem service in water supply and filtration of the Sudd is about 8.88 million US$.

Scientific and Educational Value

Research and education has great potential in the Sudd due to its unique flora and fauna. Developed research programs in the Okavango Delta created a benefit of about 4.4 million US$ in 2005. The estimated value for the Sudd is at least as large and can have further benefits in raising awareness for the region and supporting local employment and educational opportunities for students. Due to its size, the lack of past research and the potential for the discovery of new species we estimate that the wetland could account for at least 12 million US$ per year if managed properly.

Flood control

The Okavango Delta has no outflow so that an estimation of the wetlands flood control is not necessary. The Nile flowing through the Sudd on the other hand outflows in Malakal and strongly regulates the amount of water. During the wet season the Sudd expands and saves a great amount of the Nile's water, so that it can be released steadily during the dry season. While the Blue Nile has a great fluctuation throughout the year, the White Nile's flow remains balanced due to the Sudd's ability to absorb a lot of the extra water. The Sudd is a natural dam and as such the population and wildlife have adapted to its seasonal behavior. If a similar infrastructure had to be built the cost could be comparable to that of the Aswan Dam or the Grand Ethiopian Renaissance Dam. Both projects are estimated to have or will cost billions of US$ in construction and require constant upkeep.

The Economic Value of Preserving the Sudd

Based on the calculations above, the (potential) direct use value of the Sudd amounts to about 807.6 million US$ per year coming from tourism and household resources. For the indirect value of the Sudd we find a value of at least 183.34 million US$ per year in addition to the unknown value for flood control. Adding the values the Sudd produces an estimated 990.94 million US$ per year or 173.85 US$ per hectare per year. An estimation of wetland economic values for freshwater wetlands using a global database Schuyt and Brander (2004) estimate a value of about 196.79 US$ per hectare per year in 2015 dollars, hence a very close estimate considering the lower bound estimations for most of our transfer values.

The Sudd

General Information:

Population size: 1,182,804 (2010 Census) (~10 times the Okavango Delta, ~ 5 times the Serengeti)

Area size: 40,000km²–90,000km² (57,000km² Ramsar site) (~ 6 times the Okavango Delta, ~4–5 times the Serengeti)

Agriculture: 86% of households, total: 140,877

Cattle farming: est. 3,956,000 cows

Direct Use:

Tourism: ~600 million US$

Household resources: ~207.6 million US$

Total: 807.6 million US$ per year

Indirect Use:

Groundwater recharge: ~25.1 million US$

Carbon sequestration: ~71.6 million US$

Wildlife Refuge: ~65.76 million US$

Water purification: ~8.88 million US$

Scientific and Educational Value: ~12 million US$

Flood control: (No estimated value)

Total: 183.34 million US$ per year

Total: 990.94 million US$ per year

Per hectare: 173.85 US$ per year (Ramsar site only)

The values we find in this transfer value study for the ecosystem services of the Sudd are a rough estimate and represent only a lower bound of the true value. However, it is not a rough estimate that the Sudd supports the livelihood of more than a million people and a unique wildlife and ecosystem. A more detailed analysis would require field research, which is difficult at this time due to the ongoing conflict in South Sudan.

Other Benefits of Preserving the Sudd

National Identity

The cases of the Serengeti and the Okavango Delta have shown that the major direct benefits of ecosystem preservation are the possibility for a tourism industry and the agricultural and resource related values. In the case of the Sudd the tourism industry would not only create jobs for locals, but give ex-combatants the chance to transition out of the live as a soldier and use their skills as rangers. A well-managed tourism industry can provide a sustainable and secure future for many of the locals and a basis for peace. The pride of a magnificent wildlife can create a sense of national identity that reduces the tension between conflicting groups in the country.

Culture and social activities

A major part of the livelihood of the people in the Sudd are cattle herds, some of which can reach up to 500 cows. The cattle are often at the center of the local culture and are treated as a form of currency and objects of beauty and pride. Cattle herders will move with the herds into higher regions during the rainy season and return to the Sudd during the dry season, when the retracting waters have left rich vegetation, while the rest of the country becomes dry. The return to the Sudd is often used as social gathering with festivities and cultural events where economic, political, and social topics are discussed. It is also used to meet potential partners and have weddings. Often the groom's family will give the bride's family a significant amount of cows as a reversed dowry payment.

Climate

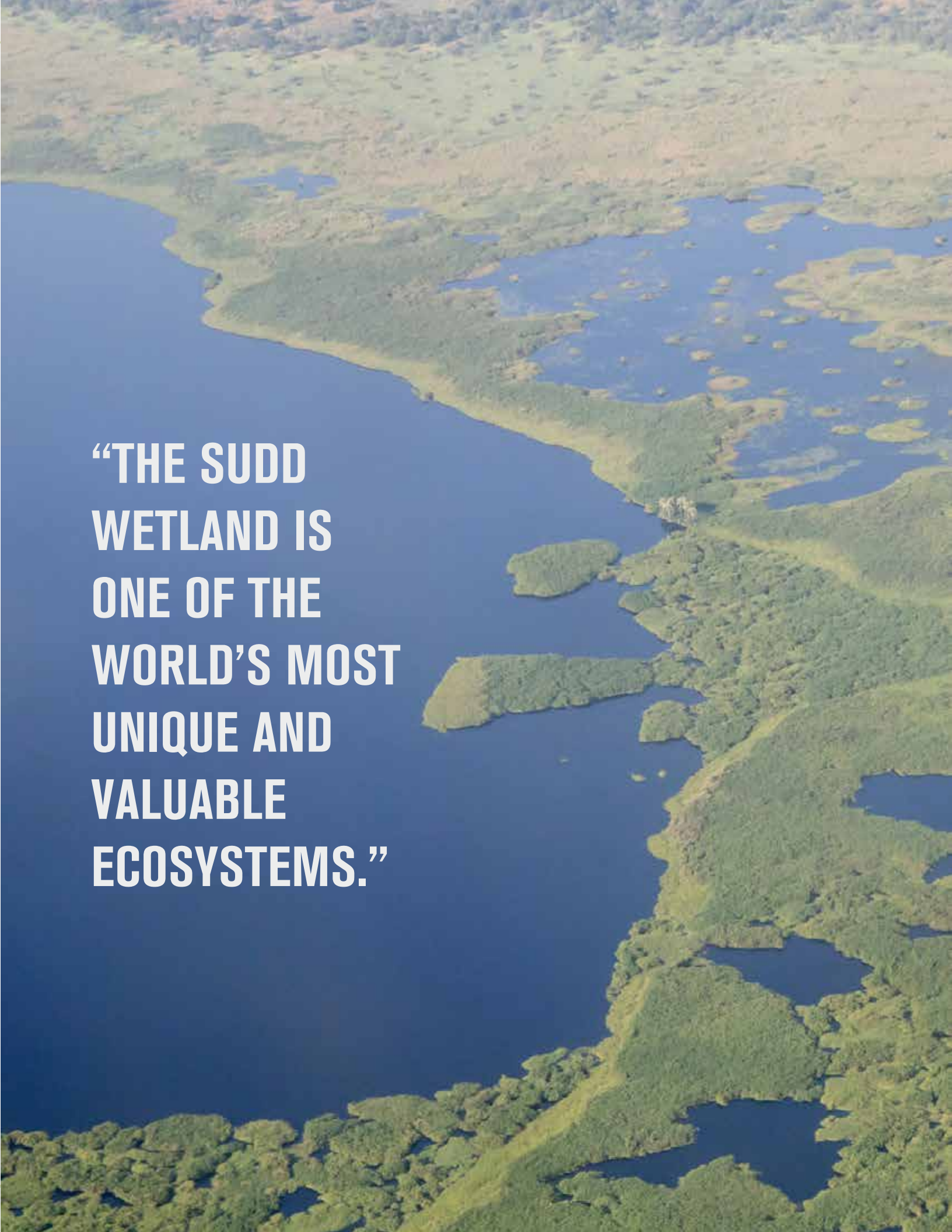
The ecosystem services of the Sudd have a great influence not only on the area, but affect regions downstream and in central Africa. The existence of the Sudd results in a lower ground temperature of up to 2°C and the rainfall in the local area (by up to 40%) and surrounding areas (e.g. over central Sudan by up to 15%). Van der Ent et al. (2010) find that almost all evaporation over east and central Africa returns as precipitation over the continent. They point out that measures that result in the decrease of evaporation in such areas would enhance droughts in downwind areas. The Sudd's "lost" evaporation is therefore not really lost, but actually the source for a great amount of rain in other regions.

Displacement

In the case of the Aral Sea an estimated 4 million people lost their livelihood (Barghouti 2006) and about 500,000 Marsh Arabs are considered environmental refugees due to the drying out of the Mesopotamian Marsh (Partow 2001). A region that already suffers from displacement and a significant number of refugees the additional displacement due to the potential reduction of wetland in the Sudd could have dramatic consequences for the livelihood of the Sudd's and its neighboring populations.

Diversity and Risk

The Sudd faces environmental pressure from the focus on developing short-term profitable economic sectors like the oil industry, the benefits from the Jonglei canal, and similar projects. Whereas the Sudd provides a variety of economic sectors—tourism, agriculture, cattle farming, fishery, hunting, research and education—these other developments reduce South Sudan's economic diversity to only a few sectors. In times of climate change and political and economic instability of trade partners, the importance of a resilient and sustainable economy is becoming greater. Such sustainability is achieved by strategies and policies that support diversity and resource use efficiency in the country's economy (Templet 1999). Greater diversity in the economic sector also increases economic output for a given level of energy throughput, an especially scarce resource in South Sudan. In the case of the Sudd the energy input for its economic sectors come from renewable sources from the ecosystem, which allows it to create some of the high non-market values found in the study above. In this sense the ecosystem of the Sudd is a renewable low-cost energy plant that provides the basis for the livelihoods of about 1 million people.



“THE SUDD WETLAND IS ONE OF THE WORLD’S MOST UNIQUE AND VALUABLE ECOSYSTEMS.”

VI. Maintaining the Ecosystem Services of the Sudd: An Evolutionary Approach to Development and the Environment

The standard economic approach to environmental policy begins with the assumption that markets know best, that is, the market mechanism is the most efficient way to allocate societies' scarce resources as long as price signals accurately reflect consumer demand preferences and producer supply costs. After prices are corrected to reflect market failures, the market is again the key to maximizing social welfare. But markets do more than allocate resources. They also shape human institutions, value systems, and world views. Markets are a powerful evolutionary force. They are efficient in allocating resources toward the goal of maximizing surplus value. Like other evolutionary forces, markets cannot see very far ahead. The inability of markets to take into account looming environmental crises like climate change and biodiversity loss is a case in point. Scientists tell us that we are so seriously destabilizing the earth's life support systems, that the collapse of human society is a real possibility (Lenton et al. 2008). A realistic policy approach to the Sudd Wetland should recognize the limits of markets in making long-term choices that are in the best interest of human societies. An evolutionary approach uses scientific knowledge and human foresight not only to promote market efficiency but more importantly to actively guide the direction of economic development.

The choice between letting the destruction of the Sudd continue as dictated by the whims of market forces, or to preserve its unique environmental and cultural features for the benefit of society is clearly framed by the Jonglei canal proposal. A business-as-usual approach will result in the destruction of a unique and irreplaceable piece of the natural world that could enhance the well-being of the citizens of South Sudan for generations to come. To avoid this outcome requires active intervention on the part of policy makers. Such an intervention need not destroy the creative power of individual and community initiatives. Government policy can set the top-down parameters within which market forces work and then let bottom-up creativity work within that framework. This is illustrated by Figure 2.

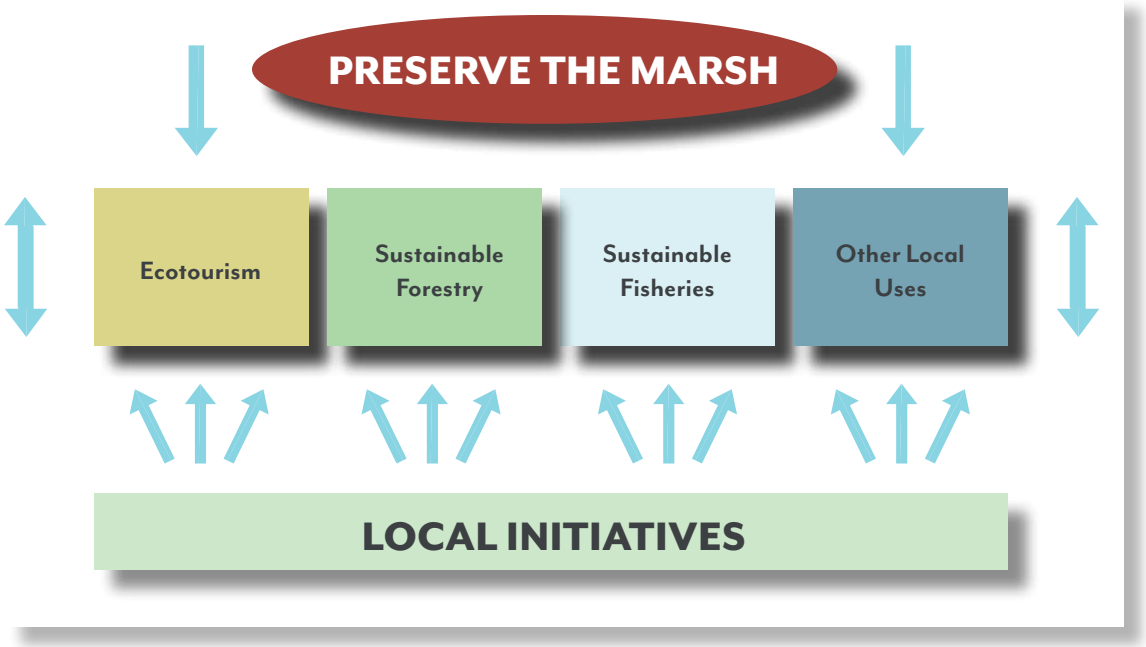


Figure 2. Top-Down Parameters and Bottom-Up Initiatives

The fundamental policy question is whether or not to preserve the wetland. This decision should be made after careful democratic deliberation by all the parties potentially affected. Economic, social and environmental considerations must be taken into account using both qualitative and quantitative indicators of the value of the Sudd and the effects of alternative uses of it, as described in this report. If the decision is to preserve the wetland, this sets the basic parameters of its future use. Future uses should preserve the integrity of the Sudd including its hydrological functions, its biodiversity, and its contribution to the livelihoods of local cultures. This requires top-down regulations to insure the sustainability of those functions. The next step in policy formulation is to identify and promote uses of the wetland that can increase the well-being of the people of South Sudan in the context of preserving the sustaining functions of the Sudd. Possible uses might be sustainable forestry, sustainable fisheries, ecotourism and yet unknown local uses that could provide income without drawing down South Sudan's natural capital. These uses could be promoted by government policies, local initiatives, and initiatives supported by NGO and other outside donors. Identifying and promoting broad types of use is both a top-down and bottom-up process. Finally, the success of any of these initiative depends on local entrepreneurs thinking through and carrying out specific projects. Given encouragement, technical advice and financial support, individual and local communities could make the Sudd wetland a major driver of development in South Sudan.

Policy choices toward the environment are frequently characterized as "command and control" versus "free market" solutions. This is a mischaracterization of the choices. First of all, market capitalism has thrived because of massive government investments in infrastructure, communications, education, and institutions and laws conductive to capital accumulation (Mazzucatto 2013). Secondly, a lack of government intervention does not mean a lack of control. Ultrasocial systems like the human economy are characterized by "control without hierarchy" (Gordon 2007, Gowdy and Krall 2015). The human economy is guided by an invisible hand but one of a very different sort than that envisioned by Adam Smith (or at least by his present day followers) (Wilson and Gowdy 2015). The drive for economic surplus has "downward effects" on social organization and individual behavior. In the human economy the imperative of surplus production pulls along political and religious institutions, legal systems, and even individual belief systems, that tend to reinforce the process of wealth accumulation. This interlocking system has evolved over hundreds of years and is a major reason why it is so difficult to break out of accepted ways of doing things that are frequently detrimental to the common good.

Two Development Paths

1. Business as usual and the tyranny of small decisions

Alfred Kahn (1966) described the "tyranny of small decisions" as a situation where a number of small seemingly insignificant decisions accumulate and result in an undesirable long-run outcome. Such situations abound in environmental issues. William Odum (1982) applied the principle to the marshlands along the coast of Massachusetts and Connecticut in the U.S. which were reduced by 50% between 1950 and 1970 because of small incremental decisions on the part of landowners. Another example is the Florida everglades which have "suffered, not from a single adverse decision, but from a multitude of small pin pricks. These include

a series of independent choices to add one more drainage canal, one more roadway, one more retirement village, and one more [water] well to provide Miami with drinking water. No one chose to reduce the annual surface flow of water into the Everglades National Park, to intensify the effects of droughts, or to encourage unnaturally hot, destructive fires. Yet all of these things have happened, and, at this point, it is not clear how the "decision" to degrade the Everglades can be reversed" (Odum 1982).

A business as usually policy will result in the continued degradation of the Sudd and the loss of its potential as an intact ecosystem. There is a disconnect between the spatial and temporal decisions made by individuals and decisions that could be made in the best interests of the public at large and future generations. It should be recognized that a decision not to intervene and protect the wetland is still a "decision."

2. Establishing an Evolutionary Path toward Sustainability

The policy decision to preserve the Sudd wetland or not is in many ways typical of the decisions worldwide having the greatest impact on the environment and human livelihoods. These include dams financed by NGOs like the World Bank, government agencies granting concession to Palm Oil plantations in Malaysia, governments in Canada promoting development of the Alberta tar sands, communities deciding how to regulate fracking, and decisions at all governmental levels about climate change policies. These are non-marginal choices and which ones are picked will set into motion an irreversible change of events that can only vaguely be predicted. Whichever paths are chosen will have large and irreversible consequences for the environment, equity, and institutions. These kinds of projects change the constraints and incentives—the forces guiding natural section—on a large scale in a given area.

This is not a bottom-up free market approach. Constraints are imposed top-down by a government agency with enforcement powers. The over-reaching constraint is protecting and maintaining the Sudd's ecosystems and their functions. Within that constraint, specific uses may be allowed, also with constraints and the power to enforce them. This approach fully recognizes the conflicts between economic development and the environment, and between economic development and human well-being.

The benefits and cost of conserving the Sudd or losing this ecosystem to projects like the Jonglei Canal can be summarized by looking at the two general paths these decisions can put its development on. If the Jonglei Canal was completed or if it was developed in an unsustainable way the wetland would slowly reduce in size and desertification of the region would increase. A great amount of arable and grazing land would be lost and with it the livelihood of a great amount of the Sudd's population. The reduction in wetland size or its pollution would also have a direct effect on the other source of nutrition in the region – fishery. The loss of the livelihood for most of the Sudd's population will force the people to move to other regions, as seen in the case of the Mesopotamian Marsh, creating an even greater stream of refugees in an area that already suffers from population displacements.

Indirectly the wildlife that relies on the Sudd as a stop on their migratory routes, as a nutritious refugee in the dry season, or simply as their living space, will be reduced dramatically and

many species might even face extinction in the region. Climate models estimate that temperatures would locally increase and precipitation would decrease in the neighboring regions. In addition, water, especially clean drinking water would become scarce, and the consequences of flooding and threats to health are uncertain.

The unsustainable development path is shown on the right side in Figure 3 below. The left side in the figure shows that sustainable development and conservation of the Sudd will maintain and even improve the local livelihoods through agriculture, cattle farming, and fishery, as well as the potential for high-quality, low quantity eco-tourism. The interest of the scientific community in the Sudd's unique fauna and flora would bring additional development through research and educational opportunities.

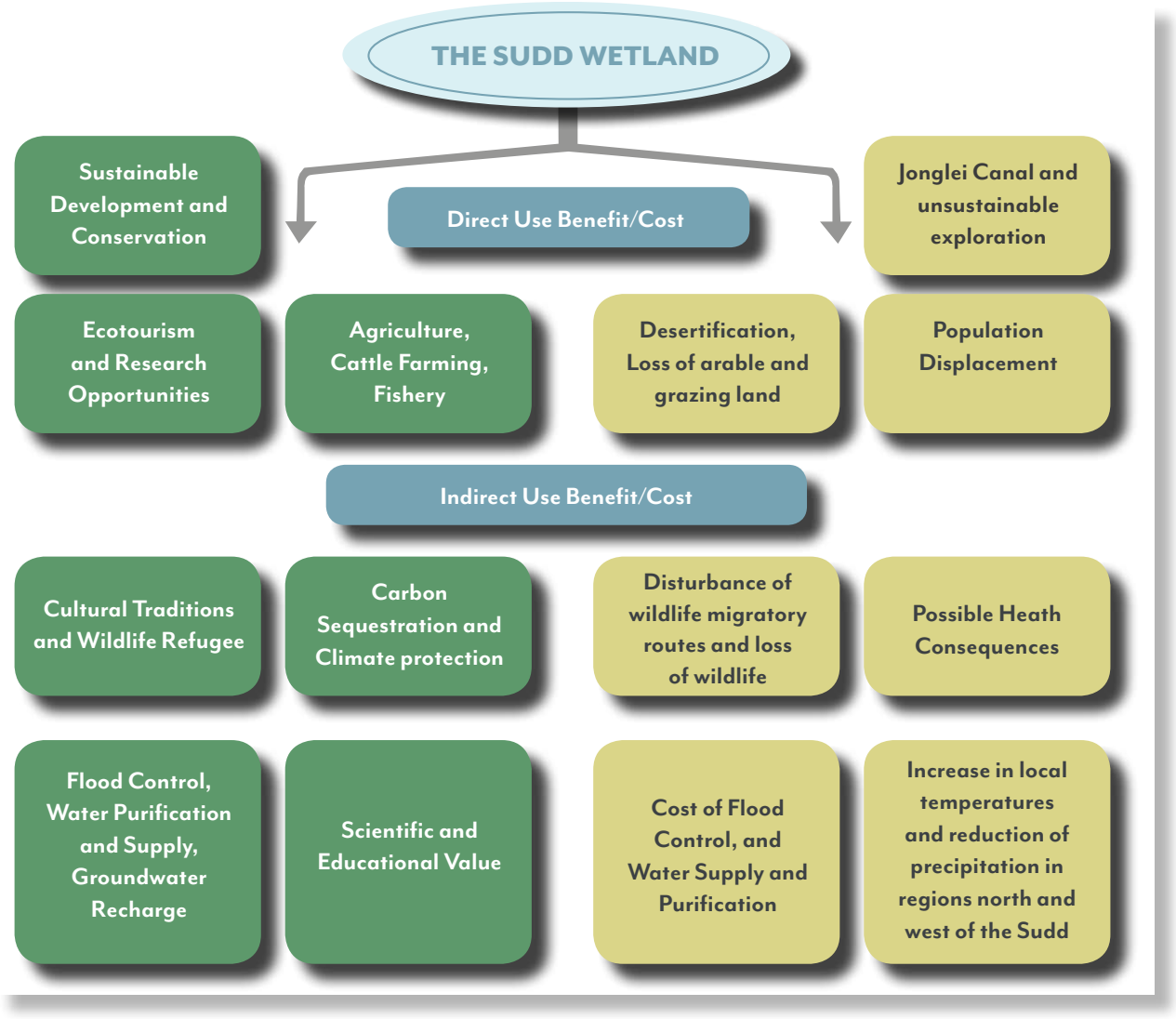


Figure 3. Overview of the two development paths of the Sudd

This path would also allow the local population to continue their rich cultural traditions. The unique wildlife of the region and the migrating animals would continue to have their refuge and the ecosystem would continue to provide safe drinking water and recharge the groundwater.

In times of continuing climate change the Sudd would keep capturing and storing carbon and improve the local climate and precipitation. Finally, the local as well as the global community would be able to benefit from the findings of research conducted in the Sudd wetland.

The Sudd wetland is a poster child for the challenges facing not only Sub-Saharan Africa but also the entire human species in an era of unprecedented globalization. The world's ecosystems and its unique human cultures are being degraded both by small, seemingly rational decisions as well as massive projects undertaken without a clear understanding of their long-term consequences. The fate of the Sudd depends on the ability of the people of South Sudan to take control of their own future and avoid the mistakes others have made, and to learn from the success stories of enlightened government processes.

VII. Summary

The Sudd wetland is one of the world's most unique and valuable ecosystems. It is threatened by a variety of development pressures from small-scale drainage and water diversion to a plan to almost completely drain the wetland to provide water for agriculture downstream. The development pressures on the Sudd illustrate how economic and political drivers can lead to the destruction of a valuable and irreplaceable ecosystem and major disruptions to the cultures that have thrived there for centuries. The case of the Sudd also illustrates how a broader and more refined approach to development and the environment can be based upon an understanding of the importance of large ecosystems and point the way to more balanced, more nuanced, and more long-term policies.

The key to all human uses of ecosystems, and indeed human life are the supporting functions described as "those that are necessary for the production of all other ecosystem services, such as primary production, production of oxygen, and soil formation" (MEA 2005, p. 8). These functions are the basic biophysical life-support systems of the planet that make all other functions, indeed life itself, possible. Supporting functions make possible economic functions captured in the category "provisioning" services. These include the products directly obtained from ecosystems including market and quasi-market goods and services such as food and fiber, fuel, medicines, and fresh water. Bringing the idea of preserving supporting functions fully into economic theory and policy frameworks is not an easy task. Sustaining the supporting functions of the world's biophysical systems implies in many cases maintaining them intact, including their evolutionary potential to adjust to large and sudden changes.

In this report we explored some of the theoretical and practical issues involved in valuing the natural world in general and the Sudd wetland in particular. In our monetary estimates of the value of the Sudd we focus on economic value, but we take a broad view incorporating new developments in economic theory and policy. In particular, we use findings from

behavioral economics, behavioral science, institutional economics, and new approaches from evolutionary economics and evolutionary biology, to broaden the scope of "value" beyond market or quasi-market values. The Sudd wetland in South Sudan offers an excellent case study of the challenges and opportunities of ecosystem valuation. The Sudd is an area of immense biological, cultural and economic importance. The conflicts there between different visions of valuation, and by implication different visions of development, could not be sharper and they starkly illuminate the consequences of policy decisions that are sometimes hard to see in more developed economies.

Our approach recognizes (1) the role of ecological process in maintaining the integrity of life support systems, (2) the role of these life support systems in maintaining human societies, and (3) the conflict between local ecosystem integrity and the continued expansion of the global economy. An important point that comes out of this study is the importance of stable institutions in supporting conservation efforts. Successful conservation efforts (Africa's world famous national parks in Botswana, Kenya, Tanzania and South Africa for example) have all taken place within a framework of transparent legal systems, mechanisms to control civil strife, and sound integrated policy planning. Likewise, the worst cases of environmental abuse (The draining of the Aral Sea and the Mesopotamian marsh, for example) have occurred when there is a lack of institutions that allow stability, a lack of cooperation among competing interests, and a lack of comprehensive planning.

We apply a transfer value method to estimate the value of the wetland's ecosystem services. A study of the ecosystem services of the Okavango Delta (Turpie et al. 2006) is used to find comparable amounts for the direct benefits, such as potential ecotourism, household resources, agriculture, and cattle grazing. Added are the adjusted values for indirect benefits of the same study - groundwater recharge, water purification, carbon sequestration, wildlife refuge and the scientific and educational value. We also find that the Sudd wetland provides further benefits such as flood control, a potential for National Identity building, the basis for cultural and social activities, and a regulator for the local climate, however monetary values for these benefits could not be estimated.

The policy decision to preserve an ecosystem like the Sudd wetland or not is in many ways typical of the decisions having the greatest impact on the environment and human livelihoods. Globally, large projects affecting the environment set into motion an irreversible chain of events whose consequences can only vaguely be predicted. Whichever path is chosen for the Sudd will have large and irreversible consequences for the environment, equity, and institutions. If the Sudd is severely degraded options for sustainable development will be eliminated. This loss of options will result in a loss of economic diversity and increase the risk of disruption due to volatility in markets, political stability, and increased susceptibility to exogenous events lying beyond the control of the local population. Our approach emphasizes the value of a system's resilience and allowing for the reversibility of decisions. Ultimately, a sustainable South Sudan depends on institutions able to promote gender equality, income security, regulate the commons, and a stable and reliable security and legal system. Development decisions should be made in a way that shapes markets and leads to a sustainable evolutionary path.

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