Maintenance of Hydropower Potential in Rwanda Through Ecosystem Restoration

World Resources Report Case Study

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OVERVIEW

In Rwanda, hydroelectric power production is widely recognized as having a significant role to play in achieving its economic development and poverty reduction goals. The "Land of a Thousand Hills," with its numerous rivers and lakes, is highly suited to the establishment of hydropower to meet the growing demand for electricity from its expanding population,[1] industries/factories in urban areas and rural agro-processing investments. Only 10 to 11 percent of households in Rwanda presently have access to electricity—and 60 percent of these households are located in the capital of Kigali. Rwanda's 2011-2017 Energy Policy and Strategy sets a target of ensuring 50 percent of households have access to electricity by 2017, which would amount to a five-fold increase in energy demand in seven years (MINIFRA, 2010a).

Although hydropower plants have the lowest production costs for electricity in Rwanda, its reliance upon this energy source presents some challenges. Among these is that it makes the country vulnerable to changing hydrological conditions—whether caused by climate change or other factors. This vulnerability was demonstrated in the mid-2000s when Rwanda experienced an electricity supply crisis that adversely affected its development prospects. This crisis was spurred in large measure by a steep decline in generation capacity at Ntaruka hydropower station which, along with the downstream Mukungwa station, provided 90 percent of the country's electricity. Ntaruka's reduced electricity generation was attributed to a significant drop in the depth of Lake Bulera, which acts as the station's reservoir. This decline in water levels in turn was precipitated by a combination of factors, including: poor management of the upstream Rugezi Wetlands, the headwaters of the watershed; degradation of the surrounding Rugezi-Bulera-Ruhondo watershed due to human activity; poor maintenance of the station; and reduced precipitation in prior years.

At the time, concern was expressed that this reduction in precipitation might foreshadow the future impact of climate change in Rwanda. Climate projections suggest that average maximum annual temperatures will increase in Rwanda by 1.5 to 3.0°C by the 2050s, but there is less certainty regarding future changes in precipitation (SEI, 2009). Although some researchers have stated that climate change will likely cause prolonged droughts in the country (particularly in the southeastern

[1] Rwanda's current population is just over 11 million and growing at an estimated rate of 2.82 percent per year (CIA, 2010).

region; MLEFWM, 2005), others suggest that average annual rainfall will increase (SEI, 2009). Despite these divergences between projections, most models do agree that there will be an intensification of rainfall during the rainy season, potentially leading to flooding, increased risk of landslides and erosion (MLEFWM, 2005; SEI, 2009). Although it is not possible to state with confidence how climate change may alter precipitation patterns in Rwanda, it is clear that this process will affect the management and generation capacity of its hydroelectric sector in the future. Resiliency needs to be built into the hydroelectric system to enable it to adapt to either future increases or decreases in precipitation on an annual and seasonal basis.

In response to its electricity crisis, the Government of Rwanda sought to restore the degraded Rugezi-Bulera-Ruhondo watershed by halting on-going drainage activities in the Rugezi Wetlands and banning agricultural and pastoral activities within and along its shores, as well as along the shores of Lakes Bulera and Ruhondo. These actions were enabled first by the country's existing Environment Policy (2003) and subsequently by its National Land Policy (2004), Environment Law (2005) and Land Law (2005). These response measures, however, also meant that rural households in the region were no longer able to access key resources, adversely affecting the productivity of their livelihoods. Recognizing this, the Government implemented a suite of agricultural and watershed management measures to offset the initial adverse impacts of their watershed protection policies and render rural livelihoods more sustainable in the longer-term. These measures included the construction of erosion control structures; the establishment of a belt of bamboo and Pennisetem grasses around the Rugezi Wetlands; planting of trees on the surrounding hillsides; the distribution of improved cookstoves; the promotion of integrated and environmentally sound farming practices; and promotion of income-generating activities such as beekeeping.

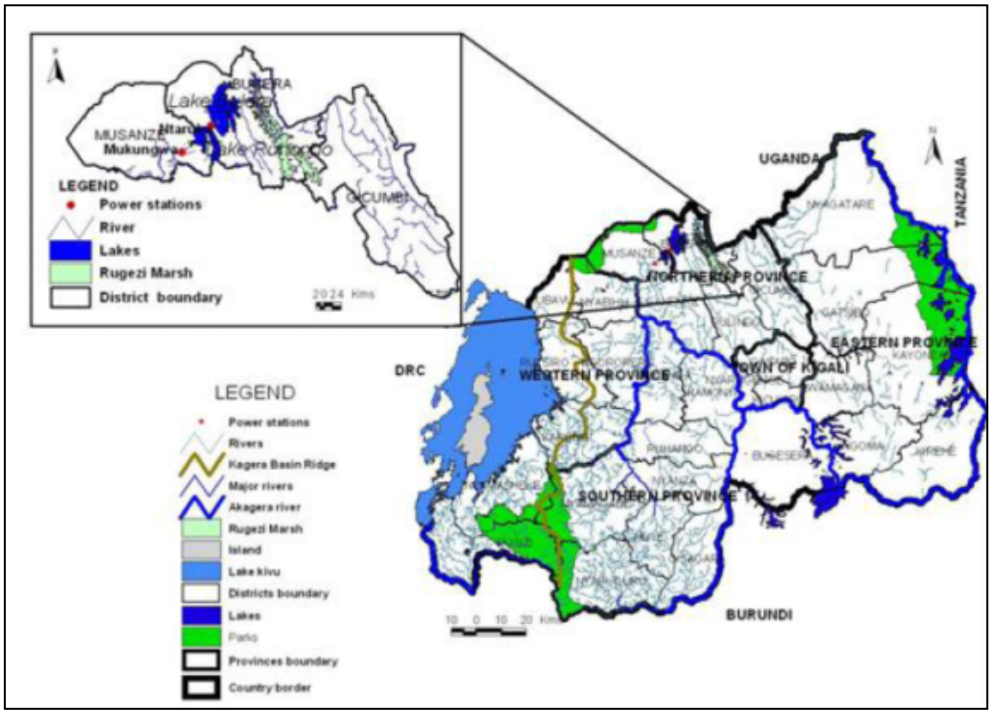

Figure 1. Map of Rwanda (Hategekimana and Twarabamenye, 2007: 3)

Today, through protection of the watershed surrounding the Ntaruka hydropower station, the plant has returned to full operational capacity. But the electricity crisis also spurred Rwanda to diversify its energy portfolio with support from the private sector. These initiatives include the capture of methane gas from Lake Kivu, use of geothermal energy and promotion of the country's abundant peat deposits for electricity production. The story of Rwanda's electricity sector demonstrates the need for diverse approaches to addressing complex problems and, in particular, the importance of integrated watershed management in promoting energy security. Through appropriate investment strategies, the well-being of the watershed and its lakes can be improved such that the efficiency and sustainability of hydropower sources are maximized. These actions also help reduce vulnerability to future climate changes that may adversely affect the country's hydro-potential.

SETTING

In the early part of this century, the energy profile of Rwanda was dominated by the use of biomass (firewood, charcoal and agricultural residues) for cooking, lighting and other needs. Approximately 97 percent of the country's total energy was supplied through these traditional sources (MINIFRA, 2009). The remainder of the country's energy came from electricity generated by seven hydropower production stations located in the western half of the country. The electricity generated through these hydro stations was used, and continues to be used, primarily to support commercial, institutional and household activities in Rwanda's urban areas—particularly in the capital, Kigali. By way of illustration, in 2006, only 0.5 percent of rural households in Rwanda had access to electricity for lighting, while the corresponding figure in urban areas was 23 percent (CITT, 2006).

The primary generators of hydroelectricity in Rwanda were, and remain, the Ntaruka and Mukungwa power stations located in Rwanda's Northern Province. Together, these two stations supplied 90 percent of Rwanda's domestic hydroelectric capacity (CITT, 2006). Ntaruka was the country's first hydropower station, built by Belgium in 1959, and has an installed capacity of 11.25 MW. Mukungwa was built in 1982 and has an installed capacity of 12 MW for an annual production capacity of 48 GWh of electricity.[2]

The Ntaruka and Mukungwa stations are located within and rely upon the Rugezi-Bulera-Ruhondo watershed (see Figure 1). Located in the highlands of Rwanda's Northern Province, this watershed is dominated by the Rugezi Wetlands, a Ramsar-recognized Wetland of International Importance. The wetlands is one of the headwaters of the Nile River Basin, which covers about two-thirds of Rwanda's surface area and holds 90 percent of the country's water (Hategekimana and Twarabamenye, 2007; Liu, 2008; RMNR n.d.). The Rugezi Wetlands cover an area of 67.35 km² with a catchment area of 190.70 km² (Hategekimana and Twarabamenye, 2007), all of which is located in Rwanda. Water from the Rugezi Wetlands flows downstream first into Lake Bulera[3]—supplying nearly half of its inflow[4]—and then into Lake Ruhondo[5] before entering the Mukungwa River. The Ntaruka hydroelectricity plant is located between Lakes Bulera and Ruhondo, and the Mukungwa plant is situated downstream from Lake Ruhondo on the Mukungwa River (UNEP, 2006). The Rugezi Wetlands play a key role in determining the rate, quantity and quality of water flow into Lake Bulera and, therefore, the hydropower potential of its downstream power stations. As such, they are intrinsically tied to Rwanda's energy security and economic development.

The Rugezi-Bulera-Ruhundo watershed is also one of the most densely populated regions of Rwanda—which in turn is the most densely populated country in Africa (RMNR, n.d.). Burera District, which contains much of the watershed, currently has a population density of about 522 people per square kilometer (Burera, n.d). In 2000, the population of the Rugezi Wetlands' catchment area was about 517,715 people and expanding (Hategekimana and Twarabamenye, 2007).[6] This situation has promoted fragmentation of land holdings; the average size of

[2] The country's two other significant hydropower stations in the 2000s were Gihira (1.8 MW) and Gisenyi (1.2 MW) (MINIFRA, 2010a).

[3] Lake of Bulera occupies a total area of 5,280 hectares and has a maximum depth of 174 meters (CITT, 2006).

[4] Source: Hategekimana and Twarabamenye, 2007.

[5] Lake Ruhondo has a total area of 2,610 hectares and a maximum depth of 68 meters (CITT, 2006).

[6] Between 1978 and 2000, the population density in the Rugezi area grew by over 70 percent, rising from 337 to 577 inhabitants per square kilometer (UNEP, 2006; Hategekimana and Twarabamenye, 2007).

land holdings in the highland zone of Rwanda ranges from 0.15 to 0.2 hectares per household (CITT, 2006). With 90 percent of the population surrounding the wetlands depending upon agricultural activities for their livelihoods, this land fragmentation combined with over-cultivation has led to soil degradation. This, in turn, has pushed the growing population to increasingly cultivate the watershed's steep slopes, some of which exceed 60 degrees (CITT, 2006). The fragile soils on these slopes are easily eroded by runoff during the rainy season, causing declines in crop and livestock productivity that further push farmers to seek new land for cultivation (CITT, 2006). Rural dependency on biomass for cooking and light has only exacerbated this degradation by putting immense pressure on the country's forest resources; approximately two-thirds of Rwanda's natural forest cover has been depleted since 1960 (FAO 2010). Collectively the region has experienced a downward spiral of deforestation, soil degradation, declining agricultural productivity and deepening poverty. Indeed, the population surrounding Rugezi is among the most impoverished in the country, with 60 percent of the population considered to be malnourished (REMA, 2009).

FACTORS LEADING TO THE 2004 ENERGY CRISIS

In 2003-04, Rwanda experienced a significant electricity supply—and by extension, economic—crisis. This crisis was triggered by a decision by Electrogaz, a parastatal organization mandated to produce and distribute power and water in Rwanda (now known as RECO-RASCO), to significantly reduce production from the Ntaruka hydropower station. As the depth of water in Lake Bulera had fallen too low for Ntaruka's three turbines to be safely operated, Electrogaz began to operate only one turbine at a time. The potential for an electricity supply crisis had been looming for a number of years due to the continued over-exploitation of the country's hydropower resources and degradation of the Rugezi-Bulera-Rohundo watershed. Electrogaz's decision was therefore the culmination of a series of events and circumstances that collectively undermined Rwanda's capacity to produce sufficient energy to meet its growing needs.

A central contributing factor to this crisis was the declining state of Rwanda's electricity generation capacity. Existing hydropower stations suffered from inadequate servicing and maintenance, due to a combination of poor planning and limited human and financial resources. For example, the Government had not invested in the Mukungwa station was built in 1982 (CITT, 2006). This situation was compounded by the Ntaruka station being overbuilt for the average inflow it receives.[7] The fragility of the country's electricity system was compounded in the late 1980s when Rwanda's economy began to grow, leading to over-use of existing capacity to meet growing demand (CITT, 2006).

A second factor contributing to the country's electricity crisis was land degradation within the Rugezi-Bulera-Ruhondo watershed. Population growth, limited governance capacity and unclear tenure regimes contributed to cultivation on steep slopes which, combined with deforestation, increased surface runoff, soil erosion and siltation of the wetlands. In addition, since the 1960s, irrigation canals had been built in certain arms of the wetlands to support the cultivation of cash crops (Hategekimana and Twarabamenye, 2007).[8] The watershed has also been infested by water hyacinth and other aquatic weeds that increased turbidity and caused water loss through evapotranspiration (CITT, 2006). Furthermore, eucalyptus trees, which

[7] Built by the Belgians during colonialism, the Ntaruka station contains three turbines that require a flow rate of 12 cubic metres per second for the station to achieve its full capacity of 11.25 MW. However, the Rusumo tributary links the Rugezi Wetlands to Lake Bulera has a flow rate of only 2 cubic metres per second during the rainy season. As such should the station be operated at its full potential it has the potential to directly contribute to a decline of the water level in Lake Bulera (CITT, 2006).

[8] For example, in 2000, the Buberuka Rural Spaces Management project created a deep central canal in two arms of the Rugezi Wetlands to enable potato and corn production (Hategekimana and Twarabamenye, 2007).

draw significant amounts of water, were planted within and around these water bodies. Collectively these processes of drainage, siltation and greater evapotranspiration contributed to a decline in the wetlands' water table (CITT, 2006; Hategekimana and Twarabamenye, 2007). The declining health of the wetlands disrupted fishing, transportation, handicrafts, and other important local livelihood activities.[9]

An additional source of stress was declining rainfall in preceding years. Based on information collected at Rwanda's only source of long-term climate data,[10] a meteorological station at Kigali airport, the period of 1991 to 2000 was the driest since 1961 (Mukubwa, 2009).

Collectively these ecological and climate conditions led to a drop in water levels in Lakes Bulera and Ruhondo. Hydroelectric production capacity at Ntaruka and Mukungwa stations declined substantially from 1998-2000, as illustrated in Table 1. By 2000, Electrogaz was experiencing water shortages at the Ntaruka power plant that prevented efficient operation of its three turbines. In response, Electrogaz undertook additional efforts in 2000 to drain the Rugezi Wetlands (Hategekimana and Twarabamenye, 2007). This shortsighted measure further reduced water levels in Rugezi, opening up new areas of the wetlands for cultivation and cattle grazing.[11] It also reduced the supply of water from Rugezi to Lake Bulera in subsequent years, resulting in a further decline in the lake levels. By 2004, water levels in Lakes Bulera and Ruhondo had fallen to 50 percent of their average depth between 1957 and 1970 (UNEP, 2006). Under these circumstances, Electrogaz was forced to significantly restrict power production from Ntaruka station.

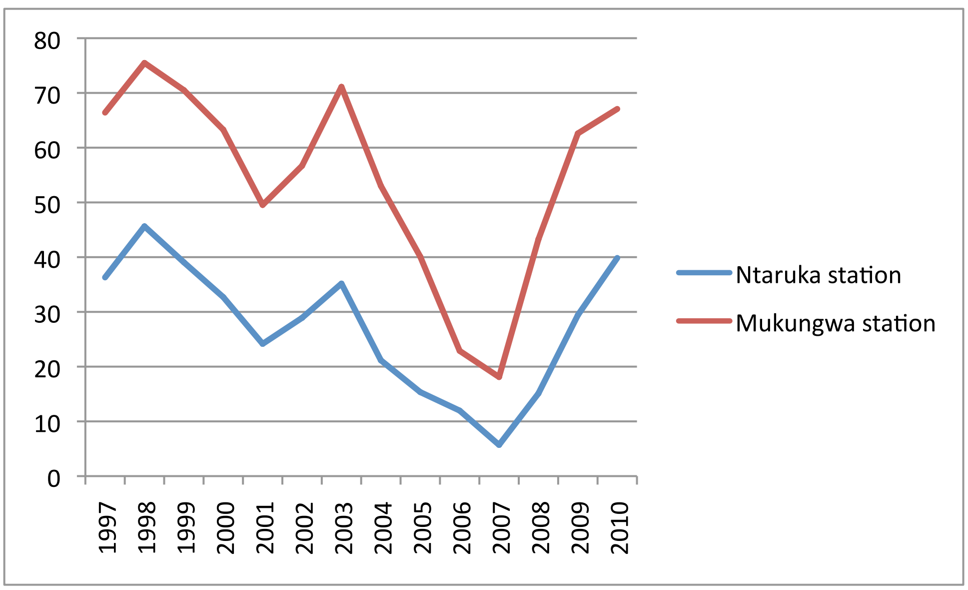

Figure 2. Power production from the Ntaruka and Mukungwa hydropower stations (GWh/Annum) (RECO, 2011)

With a significant drop in its internal capacity to produce electricity, Rwanda experienced widespread and sustained load shedding in 2004 and subsequent years. The country was also forced to install diesel generators to compensate for the electricity shortfall. Starting from zero in 2004, thermo-electricity constituted 30 percent of the country's power generation in 2005, and 56 percent in 2006. Operation of these generators cost the country up to USD 65,000 per day (UNEP 2006). These events had significant immediate economic costs for the country. Electricity rates doubled in 2004-05, from

[9] According to a report by UNEP (2006), fishing activity in the area fell by 87 percent, and 72 percent canoeists stopped their daily activity and lost their incomes, among other factors.

[10] Monitoring the degree to which precipitation patterns in the Rugezi-Bulera-Ruhundo watershed have changed and their contribution to the country's 2003-04 electricity crisis is difficult given the absence of long-term data sets. During the 1990 to 1994 war and genocide, over 90 percent of Rwanda's (then) 50 meteorological stations were destroyed or vandalized, and have largely not been re-established (CITT, 2006). Thus precipitation data at the Mukungwa station is not available between 1992 and 2002 (Mukubwa, 2009).

[11] Personal communication, representative of the Rwandan Ministry of the Environment, December 4, 2010.

7 to 14 US cents/kWh, and rose again in 2005-06 to 22 US cents/kWh. Rwandans continue to have among the most expensive electricity rates in the world (GoR, 2010).[12]

RESTORATION EFFORTS

As Rwanda's hydroelectric potential decreased and the cost of accessing electricity increased, the Ministry of Environment, Lands and Mines approached the Cabinet to make the case that restoring the Rugezi Wetlands would help address the situation.[13] In doing so, the Ministry called for the enactment of certain provisions within existing and emerging policies developed since the late 1990s to address environmental and land tenure issues.

The Ministry of the Environment, Lands and Mines had long recognized the strain that unsustainable land use practices were placing on the country's natural environment, and especially on its wetlands. As a result, in the early 2000s and parallel to the events leading to the electricity crisis, the Ministry[14] undertook a series of consultations with state institutions, United Nations agencies, and Rwandan civil society to formulate an environmental protection policy. Rwanda's National Environment Policy was subsequently released in 2003, and entails a series of policy statements and options for the restoration of the natural environment through land-use management, natural resource management, and other measures (MLRE, 2003). The policy contains an entire section on wetlands in which a number of commitments are made, including establishing measures to protect wetlands and prevent their further degradation; and establishment of wetlands as state-owned property (MLRE, 2003).

Many of these principles were later promulgated in Rwanda's *Organic Law N° 04/2005: "Determining the Modalities of Protection, Conservation, and Promotion of the Environment in Rwanda"* or the Environment Law (GoR, 2005a). The law entails a number of specific measures aimed at reversing the degradation of wetlands. In particular, articles 85 and 86 of the Environment Law limit agricultural and pastoral activities around bodies of water, requiring these activities be undertaken at a distance of 10 meters from the banks of streams and rivers and 50 meters from the banks of lakes (GoR, 2005a). Article 87 of this law also stipulates that it is "forbidden to construct houses in wetlands (rivers, lakes, big or small swamps) in urban or rural areas" (GoR, 2005a).

At the same time the environment policy and law were being developed, Rwanda was pursuing efforts to formalize land ownership. A series of internal and external consultations were undertaken to formulate the Rwanda Land Policy in 2004, the stated purpose of which is to "guarantee a safe and stable form of land tenure, and bring about a rational and planned use of land..." in the country (MLEFWM, 2004). The land policy states that wetlands constitute a special category of public land, the classification of which is the responsibility of the Ministry of Lands and Environment, and that "all marshlands must be governed by a special legislation which must be vigorously enforced" (MLEFWM, 2004, p. 44). The policy acknowledges that although certain wetlands may be used for agricultural purposes they must first undergo an adequate planning and environmental impact assessment. And the policy implies that the Rugezi Wetlands and other similar ecosystems should be left undisturbed through the statement: "any form of disturbance of very fragile environmental sites should be avoided, such as highly peaty zones and marshlands found on high land which often

[12] Still, the production of macro hydropower remains among the least cost options in Rwanda. The production cost of macro hydropower (1 MW and above) ranges from 5.4 to 10 US cents per kWh, compared to: micro hydro (less than 1 MW) at an average of 15 cents per KWh; methane gas at 12 cents per KWh; and geothermal at 5 to 10 cents per kWh (MINIFRA, 2010b).
[13] Personal communication, representative of the Rwandan Ministry of the Environment, December 4, 2010.
[14] Then called the Ministry of Lands, Resettlements and Environment.

constitute water reservoirs or water towers" (MLEFWM, 2004, p. 45).[15]

Following publication of the Land Policy in 2004, Rwanda's parliament passed the *Organic Law (N° 08/2005) "Determining the Use and Management of Land in Rwanda*," or the Land Law. This legislation sought to establish more formalized land tenure and management practices in the country that would complement customary law, and aimed to modernize Rwanda's agricultural sector. Among other measures, this law designates lakes and swamps as state land. The law also makes the controversial assertion that land may be confiscated if its owners are found to be managing it in an unsustainable manner.[16]

With Rwanda's Environment Policy in place, the Ministry of Environment called upon the Cabinet in 2003 to enact some of its provisions to ensure restoration of the Rugezi Wetlands—and thereby address one of the critical factors leading to the country's electricity crisis. In particular, Ministry officials argued that the scale of the crisis required dramatic action to protect the wetlands and prevent their further degradation. These actions included implementation of the provisions restricting agricultural activities within and surrounding the wetlands and the removal of existing drainage channels. On the basis of the Environment Policy, approval of this plan of action was granted by the Cabinet.[17]

The subsequent passage of the Environment Law on 1 May 2005 further strengthened the legal authority of the government to control activities within the Rugezi Wetlands and along the shores of Lakes Bulera and Ruhondo. Specifically, this law enabled the government to restrict agricultural and pastoral activities to 10 meters away from the banks of streams and rivers and 50 meters away from the banks of lakes. In 2008 the Government also declared the Rugezi Wetlands a protected area.

Perhaps the most significant challenge facing the Government as it began to act upon its Cabinet decision was the need to gain the support and cooperation of the population living in and relying upon the wetlands, including some large landholders. The introduction of these restrictions naturally had a significant adverse impact in the short-term on the livelihoods of the population that had depended on the wetlands and lake shores for cultivation and grazing purposes (McGray et al, 2007). According to one source, nearly 70 percent of the population of Rugezi cultivated a parcel of land in or near the wetlands prior to the government's interventions (Willetts, 2008). Another source suggests that restrictions on cultivation near the shores of Lakes Bulera and Ruhondo led to a 10 percent increase in the landless population in these areas (CITT, 2006). Those who lost access to land due to the enforcement of these rules were not provided compensation for their loss.[18]

Building upon prevailing practices in Rwanda, among the first steps taken by the Ministry of Environment to address this situation was to raise local awareness and initiate community engagement by leading community work ("travaux communautaires UMUGANDA") within Rugezi on World Environment Day on 5 June 2004. This involved engaging the local population in efforts to fill in existing drainage ditches and cut down and remove the roots of eucalyptus trees. This step was

[15] The policy also discusses the factors that hindered the effective use of land in Rwanda at the time, including: limited land resources, the country's dependence on agriculture, a land tenure system characterized by customary law, landless persons, and antiquated land registration systems, among other issues (MLEFWM, 2004).

[16] For information regarding Rwanda's water, agriculture and energy policies at this time, see Willetts (2008).

[17] Personal communication, representative of the Rwandan Ministry of the Environment, December 4, 2010.

[18] The government has introduced similar restrictions on the cultivation of lands near other water bodies, such as Lake Kivu. In this case, the government awarded compensation to local populations displaced as a result of the implementation of the 10 and 50 metre rule. Compensation was not provided to farmers in the Rugezi-Bulera-Ruhondo watershed (personal communication, ibid).

followed by a number of initiatives aimed at improving agricultural production, protecting hillsides and diversifying incomes in the Rugezi-Bulera-Ruhondo watershed. Implementation of these activities involved various government ministries, including those responsible for the environment, agriculture, livestock, forestry and defense.[19]

For example, the Ministry of the Environment provided funding to Helpage Rwanda, a local non-governmental organization, to undertake a project focusing on reforestation, anti-erosion measures and rehabilitation of the hillsides surrounding the Rugezi wetlands (REMA, 2009). Through these conservation efforts, the project had created employment for around 13,000 people by March 2009 (Helpage, 2010). In addition, the World Agroforestry Centre, OXFAM, Care International and Hydropower International have implemented projects in the Rugezi area aimed at restoring the wetlands, including activities related to agroforestry, sustainable pastoralism, anti-erosion measures and social development (REMA, 2009).

Restoration of the Rugezi Wetlands has further been promoted through the Integrated Management of Critical Ecosystems (IMCE) project.[20] Implemented through the Rwanda Environmental Management Authority, the IMCE project aims to assist farmers around four critical ecosystems, including Rugezi, to implement sustainable agriculture measures and improve their livelihoods. Through this project Rwanda has established local watershed management committees and developed community-based management plans for endangered swamps. It has also supported the construction of terraces to reduce soil erosion, established a belt of bamboo and Pennisetum grasses around Rugezi, and put in place a system to decrease the flow of water through the wetlands' central channel (Uramutse, 2009). These and other initiatives continue to be implemented in the watershed in an effort to simultaneously rehabilitate the watershed, improve agricultural and land management practices, and enhance the sustainability of local livelihoods.

OUTCOMES

> *"We simply could not continue with business as usual. In the case of the Rugezi Wetlands, resettlement of human population, removal of cattle, and tree planting has seen the resurgence of this national asset with multiplier effects on other socioeconomic sectors," President Kagame said. "Not only is the biodiversity recovering, so is the economic infrastructure that had previously ceased to operate. Today the hydropower plants supported by the Rugezi marshland are operating at nearly full capacity, reducing by half the use of diesel generators."* (Kagire, 2010)

Over time, the combination of policy interventions and complementary restoration activities initiated by Rwanda in 2004 has contributed to the gradual rehabilitation of the Rugezi Wetlands and an increase in hydroelectricity production in the country. The actions taken within the wetlands enhanced their filtering capacity, reducing siltation rates and increasing water flow into Lake Bulera. Combined with strong rains in 2006-07 and, in particular, restricting generation from the Ntaruka power station by alternating use of one of its three turbines, water levels in Lake Bulera have risen. A key milestone in Rwanda's efforts occurred in October 2007 when the Ntaruka hydropower station again began to operate fully. By 2009, its power production had reached 7 MW and the Mukungwa station's was 11 MW (MINIFRA, 2009). Rwanda's achievements with respect to restoration of the

[19] Personal communication, representative of the Rwandan Ministry of the Environment, December 4, 2010.
[20] Funding for this project was provided by the Global Environment Facility, and is being implemented through the World Bank.

Rugezi Wetlands were internationally recognized in 2010 when it was awarded the Green Globe Award (Kagire, 2010).

It should be noted that the degree to which the specific laws of 2005 are responsible for the ecosystem's restoration is debatable; certain sources indicate that the 10 meter and 50 meter rules were not adequately enforced in Rugezi in the years following their adoption, and the government's State of the Environment report makes the same admission with respect to the application of these rules within Rwanda's wetlands as a whole (RMNR, n.d.; Willetts, 2008). However, it has also been suggested that local authorities have considerable discretion over the interpretation and implementation of laws (Pottier, 2006), creating the possibility for more strict enforcement of the provision contained in the Environment Law in Rugezi given its importance to the country's broader energy concerns.

The impact of efforts to restore the Rugezi-Bulera-Ruhondo watershed on the local population is a more challenging question to answer. Initially, the livelihoods of many in the area were adverse affected as households lost access to land for cultivation. Since this time, however, the restoration efforts appear to have started to provide some benefits. Radical terracing and agroforestry activities have increased crop productivity; grasses planted on managed terraces and lake banks are providing fodder for livestock; flora and fauna has increased in the Rugezi Wetlands; and eco-tourists are now visiting the area.[21] Thus although the local population largely did not benefit from the country's improved production of electricity,[22] these changes have the potential to restore livelihoods that were lost due to the degradation of the Rugezi Wetlands (fishing, handicrafts, honey production, etc.) as well as introduce new opportunities (in the area of tourism, for instance). Efforts to improve agricultural production, combined with the on-going process of land titling, may also further improve livelihoods and increase capacity to deal with future climate shocks and climate change. The full consequences of efforts to restore the Rugezi-Bulera-Ruhondo watershed on the local population will only be known over time and will depend in part on broader population growth and socio-economic factors within the region.

FACTORS THAT FACILITATED GOVERNMENT ACTION

The ability of Rwanda to act swiftly and implement decisive and, at the time, controversial actions (such as resettlement of people living within the Rugezi-Bulera-Ruhondo watershed) in order to restore the ecological services provided by the Rugezi Wetlands may be attributed to a number of sources. First and most prominently was the urgency created by the 2004 electricity crisis. The high cost of diesel-powered electricity, the lack of energy alternatives and the disruption in economic activity created an environment ripe for considering strong action. As well, discussion around land use management and its impact on natural resources had ensued for a number of years in the country as its National Land Policy and Land Law were being formed. Land use management was (and is) of great national concern in Rwanda, and the government was expected to establish new measures in these areas. In addition, there was considerable international interest in efforts to rehabilitate the Rugezi Wetlands, as witnessed by the number of international donors willing to fund projects that would serve to reinforce and enhance implementation of the country's Environment and Land Laws. The considerable authority of the executive arm of Rwanda's government over legal decisions and policy implementation also enabled the advancement of these policy decisions.

[21] Personal communication, representative of the Integrated Management of Critical Ecosystems project, December 2010.

[22] As noted previously, about 10 to 11 percent of households in Rwanda have access to electricity, and the majority of these households are in Kigali and other urban centres (MINIFRA, 2010a). The rural communities in the Rugezi-Bulera-Ruhundo watershed generally do not have access to electricity.

BARRIERS TO ADOPTING AND ADVANCING THE INTERVENTION

A number of barriers may have interfered with the government's adoption and advancement of its efforts to restore its northern watershed. Although these barriers were generally overcome, it is possible that they slowed adoption of the government's interventions and made their implementation more onerous.

Early action by the government to prevent the electricity crisis might have been impeded by a lack of coordination between Electrogaz and Rwanda's Ministries responsible for infrastructure, environment, agriculture, economic planning etc. (Willetts, 2008). Greater exchange of information on current power demand, and corresponding needs with respect to water resources, may have led to more timely interventions.

This situation may have been compounded by the absence of meteorological information in the Rugezi area, along with information on water flow and other relevant data. Following the crisis, this lack of meteorological and hydrological data may have made it difficult for the Ministry of Environment to effectively monitor and enforce interventions undertaken in the wetlands. In its National Adaptation Programme of Action Rwanda identified the installation and rehabilitation of hydrological and meteorological stations as a key adaptation priority (MLEFWM, 2006), and a project currently being funded by the Least Developed Country Fund is contributing to the achievement of this objective.[23]

The "continuous modification" of Rwanda's environment policy framework since the beginning of this century also created challenges (Willetts, 2008). Government ministries had been shuffled considerably in the years preceding the intervention, resulting in unclear designations of responsibility at times.

A lack of institutional capacity to oversee, implement and monitor the intervention is also noted as a barrier to the effective implementation of the 10 and 50 meter rule by certain sources (ARD Inc., 2005), although the government has indicated a greater commitment to ensuring compliance with the country's Environment Law.[24] The absence of monitoring also impedes a comprehensive assessment of the impact of the government's interventions on the local population.

In addition to the above, the high population density of the area and the country's reliance on agriculture for local livelihoods was a key barrier to the adoption and implementation of land use management measures in the Rugezi Wetlands. The country's agricultural policy at the time encouraged the cultivation and drainage of wetlands to expand arable land in the country and, as mentioned above, a number of agricultural projects in the area—some with funding from international donors—had a stake in the ongoing cultivation of the wetlands (Hategekimana and Twarabamenye, 2007). It is likely that the combination of these factors interfered with the adoption and implementation of land use management policies in the Rugezi Wetlands.

[23] This project is entitled "Reducing Vulnerability to Climate Change by Establishing Early Warning and Disaster Preparedness Systems and Support for Integrated Watershed Management in Flood Prone Areas," and is being implemented by UNEP and UNDP. Further information is available here: http://www.thegef.org/gef/node/3340

[24] In a February 2011 announcement by the Rwandan Policy Force and the Rwanda Environmental Management Authority (REMA), the government committed itself to enforcing the Environment Law. The Director General of REMA note that "We have been sensitizing the public about this law but some people decided to give us deaf ears" and that punishment could no longer be avoided. The police are noted to have a responsibility to protect and prevent environmental degradation through the Environment Protection Unit under the Criminal Investigation Department (see: http://www.police.gov.rw/spip.php?article237)

CONCLUSIONS AND LESSONS LEARNED

The factors leading to Rwanda's 2004 electricity crisis, and the multiple actions taken by the Government in response, provide a number of lessons-learned for adaptation decision-making. One of these lessons is the value of an integrated approach to solving complex problems. Restoration of the Rugezi-Bulera-Ruhondo watershed required interlinked efforts to address ecological, social, economic and cultural issues, and needed to be complemented by actions within the electricity sector to improve its performance and management. This situation also points to the need for effective interaction and cooperation across ministries and between the national, district and local levels for success to be achieved.

The 2004 electricity crisis also emphasized the need for and reinforced Rwanda's commitment to diversifying its energy portfolio. Since this time, Rwanda has embarked on an ambitious and progressive effort to diversify its energy supply through development of its methane gas, geothermal, peat, solar and biogas resources.[25] The country has set a goal of generating 1,000 MW of power for domestic use and export by 2017, and is making progress towards achievement of this target.[26] Hydropower remains an important part of Rwanda's energy mix, providing half of the country's total electricity generation capacity (which is now 85 MW (MINIFRA, 2010a). Rwanda has also identified 333 micro-hydro sites that have a combined capacity of 96 MW. Twenty-eight of these sites are currently under construction and will provide the country with an additional 20 MW of electricity. The Government has also put in place strategies to ensure effective routine maintenance, rehabilitation and replacement of spare parts for all existing power plants. Today Rwanda's electricity sector is one of the most effective by regional standards, although progress in generation and access needs to speed up to meet a number of government targets (MINIFRA, 2010a).

Finally, it should be recognized that although the policies and actions taken by Rwanda were not explicitly designed to promote adaptation to climate change, improving the health and function of the Rugezi-Bulera-Ruhondo watershed should make the country more resilient to the longer-term effects of climate change. Land-use management practices that minimize soil erosion and protect sensitive ecosystems are often critical to reducing vulnerability to future climate shocks and stresses. Similarly, integrated watershed management can also support adaptation to climate change, particularly with respect to the maintenance of hydropower potential.

This case study also points to the potential for trade-offs between short- and long-term adaptation goals, and the need for intermediary measures to mitigate some of the adverse short-term impacts. The loss of agricultural plots in and around the wetlands led to short-term economic costs for the community. However, over the longer term and if combined with efforts to diversify the local economy, these land use management measures have the potential to contribute to improved livelihoods in the area through enhanced soil quality and agricultural productivity as well as the restoration of other wetland-based livelihoods (such as fishing) that were lost due to its degradation.

[25] It is intended that these energy sources will be used as follows: (1) methane gas – for electricity, fertilizer and converted to liquid for use as gasoline and diesel; (2) geothermal – for electricity and for production of heat and steam for heating, drying, food processing, etc.; (3) peat – for electricity, charcoal/briquettes suitable for households, and peat-fired steam/heat generation for processing industries (boilers); (4) solar – for electricity and heating (e.g., solar water heaters); and (5) biogas – for lighting and heating at the household and institutional level (Personal communication, representative of the Ministry of Infrastructure, February 2011).

[26] For example, Rwanda has begun to exploit the potential generation of 300 MW of methane gas from Lake Kivu; a plant producing 4.2 MW of energy is now operational. The country is also seeking opportunities to exploit the geothermal potential west of the Karisimbi Volcano, which has an estimated potential of more than 300 MW, and its 150 million tons of peat that could produce more than 100 MW. Biomass remains the country's largest source of energy, accounting for about 86 percent of the energy balance in Rwanda and over 95 percent of households energy demand (MINIFRA, 2010a).

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