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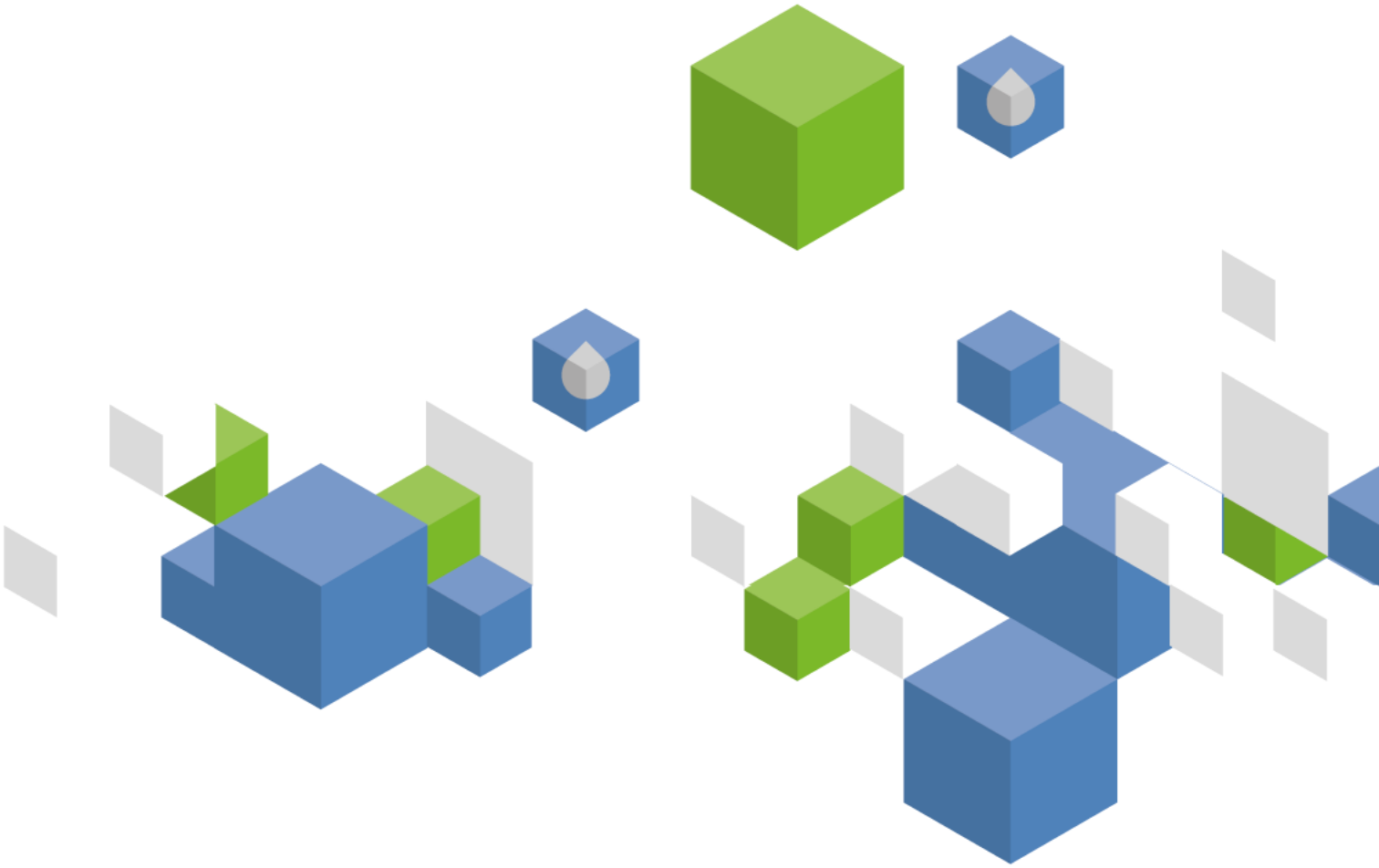

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Uganda

GEOGRAPHY, CLIMATE AND POPULATION

Geography

Uganda is a landlocked country in Eastern Africa located at the equator. It has a total area of 241 550 km^2, a north-south extent of about 650 km and a maximum east-west extent of about 500 km. The country borders South Sudan to the north, Kenya to the east, the United Republic of Tanzania and Rwanda to the south, and the Democratic Republic of the Congo to the west.

Most of Uganda forms part of the interior plateau of the African continent, with an average altitude of 1 200 m due to open plains in the north and flat-topped hills in the central, western and eastern parts of the country. Rise of the plateau both in the east and west creates mountains along the borders: Block Mountains of the Rwenzori and the Mufumbira volcanoes, including Mount Stanley (5 109 m), in the west; and Mounts Elgon (4 321 m), Moroto, Morungole, Timu and Kadam in the east (NEMA, 2010).

The country is underlain by some of the world's oldest rocks, which have been modified by deep-seated mountain-building activity. These rocks are overlain by predominantly ferrallitic soils, and to a lesser extent ferruginous soils, occurring in both forest and savannah ecosystems in the country. The profile of these soils consists of a thin (20-30 cm) topsoil and a deep (5-10 m) subsoil. Organic matter and nutrients are strongly concentrated in the topsoil. These soils range in texture from clay loam to sandy loam, although red clay loam tends to predominate in the wetter regions.

It is estimated that 14 million ha is cultivable. In 2012, the cultivated area is 9.15 million ha or 37.8 percent of the area of the country, of which 6.75 million ha arable land and 2.2 million ha under permanent crops (Table 1). Another 17.3 percent of the total area of the country is inland water with in particular five major lakes (Victoria, Albert, Kyoja, Edward and George), around 10.9 percent is covered by swamps, 12 percent by forest–sharply declining from 24 percent in 1990 (MWE, 2013b)–and the remaining being mostly grasslands (NEMA, 2010).

The country can be subdivided into two major agro-ecological systems:

- the highly productive area referred to as the 'tall grass zone' of the south and southwest in the Lake Victoria crescent, associated with bimodal rainfall and perennial cropping;
- areas classified as difficult—the 'short–grass zone' where only annual crops may be cultivated. Farming systems within the two main zones are further subdivided into seven agro–ecological zones (Table 2) (FAO, 2004).

FIGURE 1
Map of Uganda

UGANDA

FAO - AQUASTAT, 2015

TABLE 1
Basic statistics and population

Physical areas:			
Area of the country	2012	24 155 000	ha
Agricultural land (permanent meadows and pasture + cultivated land)	2012	14 262 000	ha
• As % of the total area of the country	2012	59	%
• Permanent meadows and pasture	2012	5 112 000	ha
• Cultivated area (arable land + area under permanent crops)	2012	9 150 000	ha
- As % of the total area of the country	2012	38	%
- Arable land (temp. crops + temp. fallow + temp. meadows)	2012	6 900 000	ha
- Area under permanent crops	2012	2 250 000	ha
Population:			
Total population	2013	37 579 000	inhabitants
- Of which rural	2013	83.6	%
Population density	2013	155.6	inhabitants/km^2
Population economically active	2013	16 715 000	inhabitants
• As % of total population	2013	44.5	%
• Female	2013	48	%
• Male	2013	52	%
Population economically active in agriculture	2013	12 197 000	inhabitants
• As % of total economically active population	2013	72	%
• Female	2013	49.4	%
• Male	2013	50.6	%
Economy and development:			
Gross Domestic Product (GDP) (current US$)	2012	19 881	million US$/year
• Value added in agriculture (% of GDP)	2011	23.4	%
• GDP per capita	2012	558	US$/year
Human Development Index (highest = 1)	2013	0.484	-
Gender Inequality Index (equality = 0, inequality = 1)	2012	0.529	-
Access to improved drinking water sources:			
Total population	2012	75	%
Urban population	2012	95	%
Rural population	2012	71	%

TABLE 2
Agro-ecological zones of Uganda

Systems	Ecological characteristics	Farming
Banana/Robusta coffee system	1,000–1,500 mm rainfall Medium/high productive soils	Banana, Robusta coffee, root crops
Banana/millet/ cotton system	Less stable rainfall	Staple food (millet, sorghum, maize), cotton, tobacco
Mountain system	Cool weather, high rainfall	Banana, staple food (potatoes, cassava), Arabica coffee
Teso system	Bimodal rainfall Medium/low productive soils	Millet, maize, cotton, livestock
Northern system	Monomodal rainfall with long dry season	Drought tolerant crops (millet, cassava), sesame, sorghum, tobacco, cotton
West Nile system	Monomodal rainfall (along the river)	Cassava, fishing, sorghum, peas, tobacco, livestock
Pastoral system	Semi-arid 500-600 mm rainfall	Pastoral (livestock)

Climate

Uganda has an equatorial climate with small regional variations in annual temperature and humidity. Precipitation varies from 750 mm/year in the Karamajong pastoral areas in the northeast to 1 500 mm/year in the high rainfall areas on the shores of Lake Victoria, around the highlands of Mount Elgon in the east, the Ruwenzori Mountains in the southwest, Masindi in the west and Gulu in the north. Mean annual rainfall is estimated at 1 180 mm. The southern part of the country is generally well-watered with two rainfall peaks occurring in March-May and August-November without any

pronounced dry season in between, whereas in the north there is a marked dry season from November to March. Seasonal and spatial variability of precipitation causes specific problems as the country encompasses both humid and semi-arid areas. There are not only differences between distinct wet and dry years, but there are also considerable variations in the timing of the onset of seasons and in the amount of rainfall and hence stream flow. Even in the high rainfall areas around Lake Victoria there is a moisture deficit during the periods December-February and June-September. The mean annual temperature over most of the country is in the range of 18 °C to 35 °C, while the corresponding minimum range is 8° C to 23 °C. Relative humidity is high, ranging between 70 percent and 100 percent and the mean monthly evaporation rates are between 125 and 200 mm.

Population

The total population of the country is estimated at 37.6 million (2013), of which 83.6 percent are rural (Table 1). The annual population growth rate is 3.4 percent in 2012, the third highest in Africa, and is forecasted to remain high in the next decades. This will add a significant pressure on an already very densely populated country with an average of 155.6 inhabitants/km^2. The population is concentrated on the shores of Lake Victoria, Albert, Edward and George.

In 2013, the Human Development Index ranks Uganda in 163th place among 177 countries. In 2012, the life expectancy in Uganda was 58.6 years and the under-five mortality was 70 per 1000 births, both progressing from 46 years and 170 per 1000 in the 1990s. HIV prevalence is still 7.2 percent in 2011, but lowered from 13 percent in the 1990s. Primary education is attended by 90 percent of the children in 2011, with no significant distinction between boys and girls (WB, 2014), but attendance drops to 28 percent for secondary education. Adult literacy is 73 percent in 2010, with a strong gap between female literacy (65 percent) and male literacy (83 percent) (UNDP, 2014).

Poverty concerns 24.5 percent of the population but is mainly a rural phenomenon: 27 percent of the rural population lives below the national poverty line against 9 percent in urban areas. However, poverty was successfully reduced from 56 percent in 1992 and 39 in 2002, but the absolute number of poor people has increased due to population growth (WB, 2014). In addition, there are important regional disparities, with especially the northern region lagging behind (WFP, 2012). In 2012, 95 percent of the urban and 71 percent of the rural population were using improved drinking water sources, that is 75 percent of the total population This represents a major improvement since 2002 when only 56 percent of the population had access to an improved drinking water source (Table 1).

ECONOMY, AGRICULTURE AND FOOD SECURITY

The gross domestic product (GDP) of Uganda is US$19 900 million in 2012, of which 23 percent is originating from agriculture. This is in sharp decline compared to the 1970s when agriculture represented over 70 percent of the economy of the country. However, the sector provides occupation for over 12.2 million people or 72 percent of the total economically active population, equally divided between men and women. As a result, the Ugandan agriculture served as a major contributor to the poverty reduction of the country in the 1990s and 2000s. It also supplies almost half of Uganda's export value in 2011, the traditional export crops−coffee, cotton, tea, tobacco−representing over 30 percent of the exported value (UBOS, 2012). Food crop production dominates the agriculture sector contributing over 55 percent of the agricultural GDP, while cash crops contribute 17 percent, livestock 15 percent, fisheries 10 percent and forestry 3 percent. (MAAIF, 2010). Ugandan agriculture is almost completely dependent on rainfed agriculture by small- and medium-scale farmers with a national average holding size of 1.1 ha (UBOS, 2010). Due to very limited use of irrigation, as well as other modern agricultural practices and inputs such as pesticides and fertilizers, improved varieties and mechanisation, the agricultural productivity is low (Office of the Prime Minister, 2012; FAO, 2013).

The main crops are cereals (maize, sorghum, millet, rice) on over 1.7 million ha for the two cropping cycles, or almost 32 percent of the area cropped in 2008-2009 (UBOS, 2010), root crops (25 percent), bananas (17 percent), as well as pulses, oil seeds, coffee, vegetables and fruits. In addition to the

traditional exports crops, cut flowers and cocoa are now also exported. Most bananas and coffee are cropped in relatively high rainfall areas, while tea estates enjoy the benefits of the highland area climate and sugarcane is produced under wetland conditions.

Livestock and fisheries are also key components of the primary sector. The first consists in over 34 million head in 2012 (UBOS, 2013), not including poultry. The latter's importance is due to the extent of the land area covered with water in the country. The main export is Nile perch from Lake Victoria. Fish represents around 8 percent of the total exports in 2010 (MAAIF, 2011a).

In 2011, 30 percent of the total population is undernourished in Uganda. Since the early 2000s, the prevalence of undernourishment has been increasing and the country is unlikely to achieve the MDG hunger target by 2015. This upward trend results from the growth in food production failing to keep up with population growth. Food insecurity varies across the country: rural areas are more food insecure than urban areas and considerable differences are observed between regions (FAO, 2013).

WATER RESOURCES

The Nile basin constitutes about 98 percent of the total area of the country, while a fringe of 5 849 km^2 along the country's border with Kenya belongs to the Rift Valley basin. About 8 percent of the Nile basin lies within Uganda (NBI, 2012).

The Ugandan part of the Nile basin shares a large part of the extensive interconnected system of the Equatorial lakes that forms the upper part of the White Nile. Lake Victoria, which drains a total area of about 184 000 km^2 in Rwanda, Burundi, the United Republic of Tanzania, Kenya and the entire southern part of Uganda, has its outlet at Jinja. Passing the Owen Falls Dam, the water flows through the Victoria Nile into Lake Kyoga and subsequently into the northern end of Lake Albert. The other branch of the Lake system, i.e. Lake George and Lake Edward, is connected via the Semliki river, which flows into the southern end of Lake Albert. From Lake Albert, the Albert Nile flows northwards towards South Sudan.

The Ugandan Nile basin is divided into eight sub-basins, which are relatively small contributors to the Nile flow, but their yields dominate the water resources potential within Uganda. While the Nile and its flow characteristics are important from both an international and national point of view, the Ugandan catchments are important from a district and local point of view. The eight sub-basins are detailed in Table 3.

TABLE 3
Ugandan Nile sub-basins (Source: MWE, 2013a)

Sub-basin	Area (km^2)	% of total area of country
Lake Victoria	61 886	26
Lake Kyoga	57 236	14
Victoria Nile	27 961	12
Lake Edward	18 946	8
Lake Albert	18 079	7
Albert Nile	20 727	9
Achwa	27 637	11
Kidepo	3 229	1
Total	**235 701**	**98**

Productive aquifers are mainly found in the weathered bedrock layer overlying the crystalline basement rock, and in faults and fractures in the basement. In mountain areas, however, aquifers occur in volcanic formations and groundwater occurrence is often in the form of springs. Ongoing studies are still carried out to map out ground water resources in the country.

Uganda's wetlands are widespread and hydrologically connected to rivers and lakes. In 2008, almost 11 percent of the country, or 26 308 km^2, was covered by wetlands (swamps), of which about one fifth is permanently flooded (NEMA, 2010). In the south and west of the country, they form an extensive low gradient drainage system in steep V-shaped valley bottoms with a permanent wetland core and relatively narrow seasonal wetland edges. In the north, they mainly consist of broad flood plains. In the east, they exist as a network of small, vegetated valley bottoms in a slightly undulating landscape. The most common wetlands are papyrus, reed and grass swamps. Vegetation in wetlands ranges from floating plants, short or tall grasses, reeds, sedges, shrubs to trees. There are 12 Ramsar sites in 2013, covering 454 303 ha, which is equal to 17 percent of all wetland areas in Uganda.

Internal renewable surface water resources are estimated to be 39 km^3/year while renewable groundwater resources are believed to be around 29 km^3/year, but all of this is considered to be overlap between surface water and groundwater, keeping the total IRWR at 39 km^3/year (Table 4). External water resources of 21.1 km^3/year comprise inflow from Lake Victoria, of which 10.7 km^3/year from United Republic of Tanzania and 8.4 km^3/year from Kenya, as well as 2 km^3/year inflow via Lake Edward and Lake Albert from the Democratic Republic of Congo. The dependency ratio is thus around 35 percent and the total renewable water resources are 60.1 km^3/year, or 1 599 m^3/year per capita in 2013. The ouflow of surface water leaving the country through the White Nile in South Sudan is estimated at 37 km^3/year.

TABLE 4
Water resources

Renewable freshwater resources:			
Precipitation (long-term average)	-	1 180	mm/yr
	-	285 000	million m^3/yr
Internal renewable water resources (Long-term average)	-	39 000	million m^3/yr
Total actual renewable water resources	-	60 100	million m^3/yr
Dependency ratio	-	35	%
Total actual renewable water resources per inhabitant	2013	1 599	m^3/yr
Total dam capacity	2013	80 082	million m^3

TABLE 5
Major lakes in Uganda

Name	Total surface areas (km^2)	Total volume (km^3)	Total catchment area (km^2)	Maximum depth (m)	Altitude (m)	Part in Uganda (%)
Lake Victoria	66 400	2 750	184 000	84	1 134	40
Lake Albert	5 300	280	-	56	615	55
Lake Edward	2 325	39.5	12 096	112	912	29
Lake George	250	0.8	9 705	4.5	914	100
Lake Kyoga	1 720[1]	-	75 000	5.7	914	100
Lake Kwania	465[2]	-	-	-	-	100
Lake Bisina	192[3]	-	-	Shallow	1 030	100

1. Other sources give 2 700 km^2
2. Including associated swamp the surface area is about 1 700 km^2
3. Other sources give 160, 250 and 308 km^2

The major lakes in Uganda are given in Table 5. Adding the over 160 minor water bodies gives a total inland water area covering 41 740 km^2, which is equal to 17 percent of the country area. There are also over 1 000 dams and valley tanks for both aquaculture and livestock watering. Their cumulative storage capacity is 27.5 million m^3 in 2013 (MWE, 2013b), including the Ongom and Owameri dams deserving the Ongom irrigation scheme, and with a capacity of 0.25 million m^3 and 0.125 million m^3 respectively (MAAIF, 2013). The Government carries out regular programmes to construct additional dams and valley tanks and to increase the water capacity for agricultural production (Republic of Uganda, 2010).

The Owen Falls Dam is located at the outlet of Lake Victoria. Lake Victoria is a natural lake, but it is considered that due to the Owen Falls Dam there is an additional capacity of 200 km^3. Also considering that 50 percent of the total surface area of Lake Victoria is located in the United Republic of Tanzania,

40 percent in Uganda and 10 percent in Kenya, the part of the reservoir capacity considered in Uganda is 40 percent of the total of 200 km^3, or 80 km^3. Completed in 1954, it serves the Nalubaale hydropower plan which had an installed hydropower capacity of 180 MW, extended later by 90 MW with the Kiira hydropower plant. The 250 MW Bujagali hydropower plant near Jinja, about 8 km north of Lake Victoria, and completed in 2012, has a reservoir capacity of 54 million m^3. The 600 MW Karuma hydropower plant is under construction on the Victoria Nile and will be the largest in the country once completed. Other projected schemes located along the Nile include Ayago (240/300 MW), Arianga (400MW) and Isimba (180MW). There are also various mini hydropower plants, already completed, under construction or in projects.

INTERNATIONAL WATER ISSUES

Uganda is a member of the Nile Basin Initiative (NBI), an inter-governmental partnership launched in 1999, together with the nine other Nile riparian countries. Because both the 1929 and 1959 Nile Water Agreement assigned the Nile's water to Egypt and Sudan without including Uganda and the other riverside nations, the NBI was intended to strengthen the cooperation within the basin. The NBI, whose headquarters are in Entebbe, Uganda, prepared a Strategic Action Programme, which consists of two sub-programmes: the Shared Vision Programme (SVP) and the Subsidiary Action Programme (SAP). The SVP is to help create an enabling environment for action on the ground through building trust and skill, while the SAP is aimed at the delivery of actual development projects involving two or more countries. Projects are selected by individual riparian countries for implementation and submitted to the Council of Ministers of the NBI for approval.

The NBI is intended to be a transitional institution until the Cooperative Framework Agreement (CFA) negotiations are finalized and a permanent institution created. This new Nile CFA was signed in 2010 by Uganda and four other countries–Ethiopia, Kenya, Rwanda and United Republic of Tanzania–and in 2011 by Burundi. Egypt strongly opposed this agreement which gives deciding power over large-scale hydraulic projects to a commission representing all the signatories, hence cancelling Egypt's historical right of veto. Sudan, South Sudan, and the Democratic Republic of the Congo are still to decide upon the CFA signature. The CFA was put on hold due to the Egyptian revolution.

Uganda is also member of the Lake Victoria Basin Commission (LVBC) established in 2004 by the East African Community and formerly known as the Lake Victoria Development Programme (MWE, 2013b). The LVBC's objective is to coordinate the various interventions on the lake and its basin, which is considered an area of regional economic interest to be developed jointly by the five members-Burundi, Kenya, Rwanda and United Republic of Tanzania, together with Uganda.

WATER USE

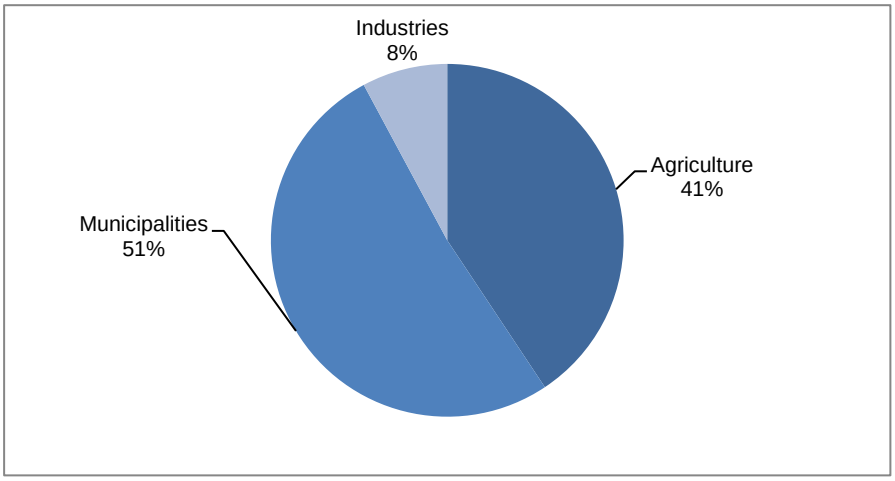
Total water withdrawal of the country increased from 300 million m^3 in 2002 to 637 million m^3 in 2008 (Republic of Uganda, 2010). The greatest water user was the municipal sector withdrawing 328 million m^3, followed by irrigation and livestock withdrawing 259 million m^3, and industry withdrawing 50 million m^3 (Figure 2). Only 1 percent of Uganda's total renewable water resources renewable water resources are withdrawn (Table 6). Underdeveloped, they are nonetheless under increasing pressure, especially from population growth.

Groundwater represents the main source of municipal water supply for the rural population of Uganda. It is also important for livestock use, particularly in the drier regions. Groundwater extraction takes place from springs, boreholes and to a lesser extent from hand dug wells. Surveys have identified some 12 000 springs in Uganda, of which more than 4 500 have been developed and protected for safe use. About 9 000 boreholes, typically drilled to a depth of 60 to 90 meters, are equipped with hand pumps. Rates of actual extraction are low and most boreholes are fitted with hand pumps with capacities between 0.6 and 1.2 m^3/hour depending on the pumping head.

TABLE 6
Water uses

Water withdrawal:			
Total water withdrawal	2008	637	million m^3/yr
- irrigation + livestock	2008	259	million m^3/yr
- municipalities	2008	328	million m^3/yr
- industry	2008	50	million m^3/yr
• per inhabitant	2008	20.3	m^3/yr
Surface water and groundwater withdrawal	2008	637	million m^3/yr
• as % of total actual renewable water resources	2008	1	%
Non-conventional sources of water:			
Produced municipal wastewater	2012	7	million m^3/yr
Treated municipal wastewater		-	million m^3/yr
Direct use of treated municipal wastewater		-	million m^3/yr
Desalinated water produced		-	million m^3/yr
Direct use of agricultural drainage water		-	million m^3/yr

FIGURE 2
Water withdrawal
Total 0.637 km^3 in 2008



Around 7.62 million m^3/year of wastewater is produced, but only 7 percent of Kampala City is connected to sewerage network and at national level only 2 percent of the inhabitants in 17 cities (UNWAIS, 2012). The Bugolobi sewerage treatment plant is the only one in Kampala; it has a design hydraulic capacity of 33 000 m^3/day (but currently treating 15 000 m^3/day) for secondary treatment (Twinomucunguzi, 2011). Additional treatments plants are planned for the capital: the Lubigi treatment plant, located in the middle of the Lubigi swamps in the outskirts of Kampala, will treat 5 400 m^3/day; the Nakivubo plant is under construction; and the Kinawataka and Nalukolongo are planned. Once completed, they will be able to treat 30 percent of Kampala's wastewater.

IRRIGATION AND DRAINAGE

Evolution of irrigation development

Past estimates of irrigation potential varied between about 200 000 ha and 400 000 ha, with the largest potential areas in the Lake Kyoga basin, the Western Region, the Albert Nile Valley and in the Jinja and Iganga districts on Lake Victoria in the southeast of the country. In contrast, a 2003 study identified only 90 000 ha of irrigation potential (MWLE, 2003). But the 2011 Irrigation Master Plan classified 567 000 ha in two types of irrigation potential: 295 000 ha close to surface water resources and thus does not needing any storage facilities and 272 000 ha that would require storage to be developed (MAAIF, 2011, but suggested by the revised 2009 Water for Production Sector Investment Plan, which itself is based on the 1995 Water Action Plan).

Cultivation of rice in unequipped wetlands is traditional, especially in Eastern Uganda (Carruthers, 1970). Only in the 1940s, small-scale informal irrigation started, most of it was located on the on the fringes of swamps. It is considered 'informal irrigation' as smallholders developed it spontaneously without planning and with little or no technical assistance; often the technology used is basic and sometimes inappropriate.

There had been attempts to develop formal irrigation at a very limited scale in the 1950s, with flood diversion structures on less than 14 ha in Ngiminito, Nadunget and Namalu and on 20 ha in Oruchinga Valley and Nyakotonzi, but after few years all of these developments were abandoned.

Larger irrigation schemes were developed from the 1960s onwards by the government (Table 7). The Kiige, Odina, Labori, Ongom and Atera schemes were government farms for the promotion of citrus production, mangoes and, to a lesser extent, cashew nuts. They have been abandoned and are thus non-functional in 2013. A feasibility study explored their potential rehabilitation in 2013, especially the Kiige scheme, the rehabilitation of which is also prioritized in the National Development Plan (NDP) 2010-2015 (MAAIF, 2013).

TABLE 7
Irrigation schemes developed by the government

Irrigation Scheme	District	Source of water	Command Area (ha)	Equipped area (ha)	Construction	Irrigation method	Status in 2013
Kiige	*Kamuli*	*Lake Kyoga**	*369*	*60*	*1967*	*Sprinkler*	*Not functional*
Odina	Soroti	Lake Kyoga	365	67	1967	Furrow, sprinkler	Not functional
Labori	Serere	Lake Kyoga	284	162	1962	Sprinkler	Not functional
Ongom	Alebtong	Ongom and Owameri dams	300	0	1967	Sprinkler	Not functional
Atera	Apac	Lake Kyoga/Nile river	809	150	1970s	Furrow	Not functional
Doho	*Butaleja*		*-*	*965*	*1970s*	*-*	*Rehabilitated*
Mubuku	*Kasese*	*Sebwe and Mubuku rivers*	*-*	*672*	*1970s*	*Surface, Sprinkler*	*Rehabilitated*
Agoro	*Kitgum*	*Agoro river*	*-*	*650*	*1970s*	*-*	*Rehabilitated*
Olweny Swamp	*Lira/Dokolo*		*-*	*500*	*1990s*	*Flooding (rice)*	*-*
Kibimba	Iganga		-	665	1970s	Flooding (rice)	Functional

Note: * locally named Lake Nabigaga
Italic font indicates schemes rehabilitated (or to be) under the NDP 2010-2015.

In the 1970s, the Chinese initiated the development of rice schemes, with the Kibimba rice scheme as a rice technology development scheme and the Doho rice scheme for seed multiplication and popularization of production. The latest government constructed and implemented scheme, the Olweny swamp rice irrigation project with a command area of 500 ha, went into operation in 1997 (nucleus site) and 2001 (Itek and Okile), and is also to be rehabilitated under the NDP. Formal irrigation is limited both in extent and success, certainly due to the top-down approach adopted in most schemes. The farmer-based (or self-help) schemes of Mubuku, Doho and Agoro were considerably more successful.

In addition to the schemes detailed in Table 7, there are around 300 ha of formal small-scale irrigation and 7 100 ha of commercial irrigation, including 1 500 ha and 322 ha of central pivot to irrigate seedlings of sugarcane at the Kakira and Lugazi sugar estate respectively. Floriculture private-sector farmers started greenhouses in the 1990s; they concentrate in the Lake Victoria area, close to the Entebbe airport. The area of these flower farms ranges from 3 to 40 ha, for a total of 230 ha exclusively under localized irrigation.

Informal small-scale irrigation has been increasing, especially for rice, vegetable and fruit production. The increased area of informal rice production is a result of technology adoption from the Chinese in the Kibimba rice scheme. In 2010, between 53 000 ha (MAAIF, 2011) and 67 000 ha (MAAIF, 2010) of fringes of swamps were cultivated in Tororo, Pallisa, Iganga, Budaka and Buteleja around streams flowing into Lake Kyoga (Table 8). The Irrigation Master Plan uses a baseline of 53 346 ha in 2010 (MAAIF, 2011; MWE, 2013a).

TABLE 8
Informal non-equipped cultivated wetlands (Source: MWE, 2013a)

District	Water Source	Area (ha)
Tororo	Mpologoma Lumbika Nanafwa	24 500
Iganga	Mpologoma Kitumbezi Lumbuye	2 400
Pallisa	Mpologoma	10 800
Others	-	15 646
TOTAL		**53 346**

In 2012, the area equipped for irrigation was 11 137 ha including 2 421 ha of equipped wetlands (Table 9 and Figure 3). The abandoned government farms on 379 ha (Odina, Labori and Atera schemes) are not included in the equipped area, as most of it has been dismantled during conflicts in the 1990s, except for the Kiige scheme the rehabilitation of which is programmed. In 2010, 2 850 ha were not functional. In 2013, after completion of the rehabilitation of the Doho, Mubuku, Agoro schemes, only 560 ha remain not functional (Olweny and Kiige schemes). Most of the irrigated area is located in the southeast part of the country in the districts between Lake Victoria and Lake Kyoga (Table 7).

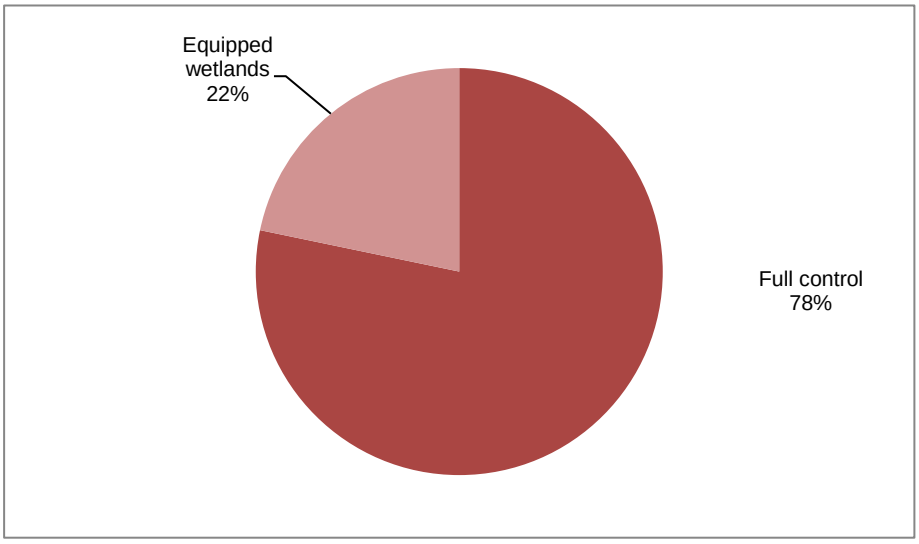
TABLE 9
Irrigation and drainage

Irrigation potential	-	90 000	ha
Irrigation:			
1. Full control irrigation: equipped area	2012	8 716	ha
- Surface irrigation	2012	6 321	ha
- Sprinkler irrigation	2009	2 165	ha
- Localized irrigation	2012	230	ha
• Area equipped for full control irrigation actually irrigated	2013	8 656	ha
- As % of area equipped for full control irrigation	2013	99	%
2. Equipped lowlands (wetland, ivb, flood plains, mangroves)	2012	2 421	ha
3. Spate irrigation		-	ha
Irrigation:			
Total area equipped for irrigation (1+2+3)	**2012**	**11 137**	**ha**
• As % of cultivated area	2012	0.1	%
• % of area irrigated from surface water		-	%
• % of area irrigated from groundwater		-	%
• % of area irrigated from mixed surface water and groundwater		-	%
• % of area irrigated from non-conventional sources of water		-	%
• Area equipped for irrigation actually irrigated	2013	10 580	ha
- As % of total area equipped for irrigation	2013	95	%
• Average increase per year	1998-2012	1.4	%
• Power irrigated area as % of total area equipped for irrigation		-	%
4. Non-equipped cultivated wetlands and inland valley bottoms	2010	53 346	ha
5. Non-equipped flood recession cropping area		-	ha
Total agricultural water managed area (1+2+3+4+5)	**2012**	**64 483**	**Ha**
• As % of cultivated area	2012	0.7	%
Size of full control irrigation schemes: **Criteria**:			
Small schemes < - ha		-	ha
Medium schemes > - ha and < - ha		-	ha
large schemes > - ha		-	ha
Total number of households in irrigation	2009	31 000	

TABLE 9 (Continued)
Irrigation and drainage

Irrigated crops in full control irrigation schemes:			
Total irrigated grain production		-	metric tons
• As % of total grain production		-	%
Harvested crops:			
Total harvested irrigated cropped area	2012	15 150	ha
• Temporary crops: total	2012	15 150	ha
- Rice	2012	12 000	ha
- Maize	2012	400	ha
- Vegetables	2012	300	ha
- Fruits	2012	200	ha
- Sesame	2012	200	ha
- Sugarcane	2012	1 820	ha
- Flowers	2012	230	ha
• Permanent crops: total	2012	-	ha
Irrigated cropping intensity (on full control area actually irrigated)	2012	175	%
Drainage - Environment:			
Total cultivated area drained	2009	36 000	ha
• Non-irrigated cultivated area drained		-	ha
• Area equipped for irrigation drained		-	ha
- As % of total area equipped for irrigation		-	%
Area salinized by irrigation		-	ha
Area waterlogged by irrigation		-	ha

FIGURE 3
Distribution of the irrigation area
Total 11 137 ha in 2012



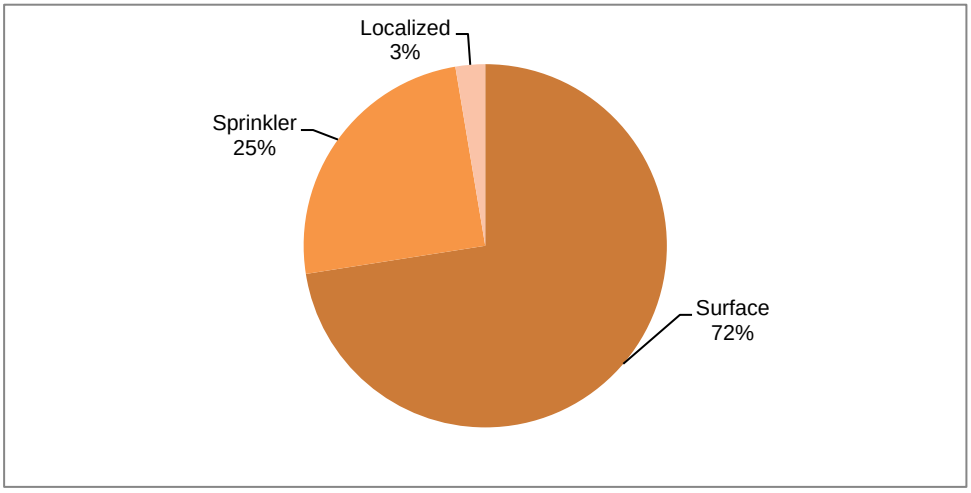
Surface irrigation is the main irrigation technique, while in addition to the 1 822 ha of sugarcane seedlings, 343 ha were equipped for sprinkler irrigation in 2008/09 (UBOS, 2010) and localized irrigation is practised in flower farms only (the 5 057 ha of 'localized irrigation' in the census is considered to be watering with bucket, thus falling into the surface irrigation according to the AQUASTAT variables) (Figure 4). Water for irrigation originates mainly from surface water–by gravity, pumping–and groundwater–either shallow or deep wells–, as well as harvested rainwater and in a lesser extent municipal water supply (Table 10).

TABLE 10
Origin of irrigation water (Source: UBOS, 2010)

Origin of irrigation water	Number of Irrigated households	Percentage
River / lake / pond (by gravity)	5 864	15.7
River / lake / pond (by pumping)	1 304	3.5
Dam / reservoir	1 274	3.4
Deep well / Tube well	5 063	13.5
Shallow well	16 482	44.1
Municipal water supply	880	2.4
Harvested water for irrigation	2 086	5.6
Other	4 427	11.8
TOTAL	**37 380**	**100**

Note: Each irrigated households may have more than one type, which explains why total irrigated households is superior to 31 000 previously indicated.

FIGURE 4
Distribution of the techniques in full control irrigation
Total 8 716 ha in 2012



No estimation of the area under rainwater harvesting, also practiced as indicated in Table 10, is available. Demonstration sites for this technique have recently been constructed in the Kween, Kayunga, Isingiro, Kabale, Hoima, Apac and Yumbe districts (Office of the Prime Minister, 2012).

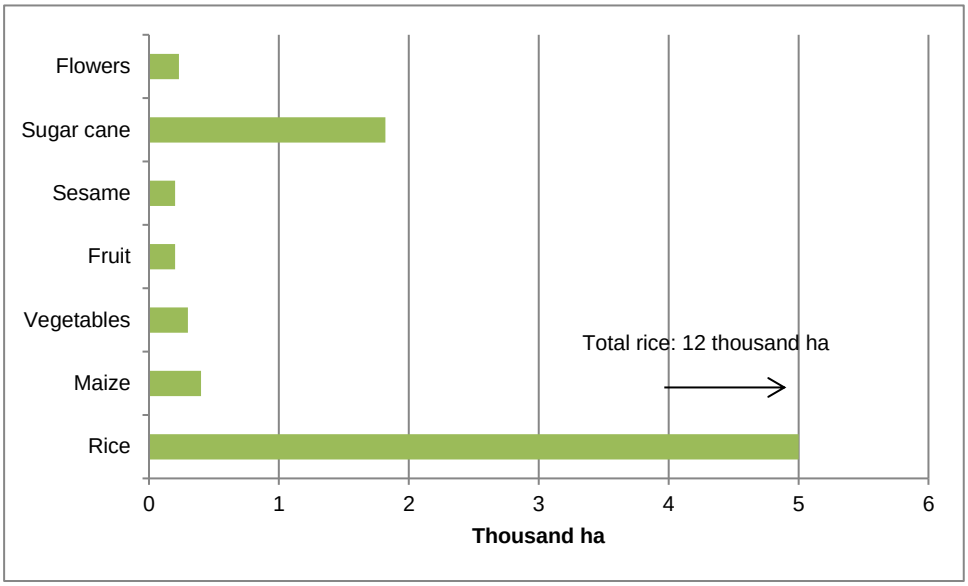
Role of irrigation in agricultural production, the economy and society

Only 31 000 agricultural households out of nearly 3.6 million nationally, or 0.9 percent, reported in the 2008/09 census practising full control irrigation (UBOS, 2010). But non-equipped wetlands, also called locally managed wetlands, is of much more considerable significance with 767 000 households practising some forms of water management (UBOS, 2010).

Double-cropping of rice has been practised for more than a few decades. Most of the farmers live in nearby villages and grow various crops in their upland fields, in addition to rice grown in lowland plots in the Doho rice scheme.

In 2012, 8 656 ha of the area equipped for full control irrigation were functional and considered actually irrigated, on which an estimated 15 150 ha of irrigated crops were grown (Figure 5). The crop calendar is based on the Irrigation Master Plan (MAAIF, 2011): rice, maize and sesame have double cropping each year; vegetables have three crops per year while fruit (citrus, mangoes) and sugarcane are permanently irrigated. The harvested areas for each crop have been estimated based on the FAO (2011) Nile Project report (70 percent of rice, 7 percent of vegetables, fruits, etc.) as well as the available information on existing irrigation schemes (1820 ha for sugarcane and 230 ha of flowers in MWE, 2013a). As a result the cropping intensity is 175 percent on the full control irrigation area actually irrigated. Irrigation is practiced all year round enabling multiple cropping.

FIGURE 5
Main irrigated crops under full control irrigation in 2012
Total 15 150 ha harvested irrigated crop in 2012
(cropping intensity on actually irrigated area: 175 percent)



In equipped wetlands mainly rice, but also green maize, some vegetables and other cash crops are grown.

Mubuku irrigation scheme is considered to be the food basket for the Kasese district. This is because, in addition to the provision of employment, farmers from different highly populated districts moved to settle in the scheme. The scheme also acts as a seed multiplication centre for maize, soybeans and groundnuts. It has currently accessed European markets for the export of okra and French beans in addition to supplying the tomato sauce factory in Kasese with raw materials (tomatoes and papayas). Kibimba rice scheme (private sector) provides work for to the surrounding community while Doho rice scheme has substantially raised the standard of living of its farmers. This is demonstrated by the sprouting permanent buildings, rice milling machines and changed eating habits of the farmers coupled with the education of children. Rice from Doho also finds its way to Rwanda and occasionally to the Democratic Republic of Congo.

Women and irrigation

In Uganda, women have no or restricted access to land leasing or ownership, including in irrigated areas (Scow, 2015). In addition, traditionally men control cash crop farming and revenues, while women provide most of the labour of food crops produced for home consumption. So introduction of irrigated cash crops could increase gender inequality if not carefully considered, with workloads increasing for both men and women, while increasing revenues only for men (FAO, 2004). A recent study on sweet potatoes farmers found out that while 10 percent of their men sample irrigated their crop, mainly in sweet potatoes nurseries, none of the women did, even though only performed with water cans (Okonya and Kroschel, 2014). Although limited in scope and sample, this shows how women in Uganda generally have less access to improved input in agriculture.

Status and evolution of drainage systems

According to the 2008/09 census of agriculture, around 36 000 ha of agricultural land are drained as detailed in Table 11 (UBOS, 2010). It is not indicated whether these include drainage of irrigated land or not.

TABLE 11
Geographical repartition of agricultural land drained in 2009

Region	Area (ha)	Percent
Central	3 207	9
Eastern	18 619	52
Northern	8 525	24
Western	5 587	15
Uganda	**35 938**	**100**

WATER MANAGEMENT, POLICIES AND LEGISLATION RELATED TO WATER USE IN AGRICULTURE

Institutions

The responsibility in water for production in Uganda is shared between the Ministry of Water and Environment and the Ministry of Agriculture, Animal Industry & Fisheries. The first is responsible for development of off-farm water facilities while the latter for water use and management of on-farm agricultural water facilities.

The Ministry of Water and Environment (MWE) has the responsibility for setting national policies and standards, managing and regulating water resources and determining priorities for water development and management (MWE, 2009 and 2013); and within the MWE:

- The Directorate of Water Resources Management (DWRM) is responsible for developing national water laws, policies and regulations; managing and monitoring water resources; issuing water permits; integrated water resources management (IWRM) activities; coordinating transboundary waters resources. It comprises three departments:
    - Water Resources Monitoring and Assessments,
    - Water Resources Regulation,
    - Water Quality Management.
- The Directorate of Water Development (DWD) is responsible for providing overall technical oversight for planning, implementation and supervision of the delivery of urban and rural water and sanitation services across the country, including water for production.
- The Directorate of Environmental Affairs (DEA) is responsible for environmental policy, regulation, coordination, inspection, supervision and monitoring of the environment and natural resources as well as the restoration of degraded ecosystems and mitigating and adapting to climate change.
- The National Water and Sewerage Corporation (NWSC) is a parastatal that operates and provides water and sewerage services in 28 large urban centres across the country including Kampala.
- The National Environment Management Authority (NEMA) is responsible for the regulatory functions and activities that focus on compliance and enforcement of the existing legal and institutional frameworks on environmental management in Uganda.

The Ministry of Agriculture, Animal Industry & Fisheries (MAAIF) has the responsibilities to support the development of infrastructure and use of water for agricultural production along livestock, crop and fisheries value chains. With its two commodity-based Directorates (Animal Resources and Crop Resources) each with three Departments, as well as 8 specialised Agencies, it aims to:

- provide technical assistance with respect to the design and construction of on-farm irrigation systems (including tertiary canals, distribution/field channels, control structures and drainage channels);
- promote appropriate technologies for efficient and effective use in irrigation;
- establish efficient and effective management structures;
- support the operation and maintenance of the on-farm systems;

- provide extension services and advice to farmers on irrigation systems;
- support the supervision and monitoring of water use and managements.

The Water Policy Committee (WPC) was established, by the Water Act, to promote inter-ministerial and inter-sectoral coordination over water resources management and development issues. It also advises the MWE.

At sub-national level, the four Water Management Zones (WMZs) of Kyoga, Victoria, Albert and Upper Nile perform since 2011 water resources management functions that were formerly performed by DWRM at central level.

At district level, the District Water Offices manage water and sanitation development and oversee the operation and maintenance of existing water supplies in the District. At community level, District Water and Sanitation Coordination Committees (DWSCCs) have been established in all districts to strengthen collaboration across sectors and between different players and a water user committee (WUC), which is sometimes referred to as a Water and Sanitation Committee (WSC), should ideally be established at each water point (MWE, 2013b).

Over 200 non-governmental organizations (NGOs) are working in water supply and sanitation. The Uganda Water and Sanitation NGO Network (UWASNET) is a national network organization established in 2000, with the aim of strengthening the contribution of NGOs and community based organizations (CBOs) in achieving the Water and Sanitation Sector goals.

Water management

Water is managed in the country either in terms of water and sanitation or in terms of water for production. The latter integrates irrigation, livestock watering and aquaculture with considerations to stock reservoirs and valley tanks–meant for small-scale irrigation and livestock watering–with fish.

Uganda's water sector was reformed in 1998, but implementation of catchment or basin based water resources management, as a means of promoting effective management and development of the country's water resources and sustainability of water-based infrastructure and services, is recent. The DWRM de-concentrated in July 2011 some water management functions, such as compliance monitoring, compliance assistance and awareness raising to four Water Management Zone (WMZs): Kyoga, Victoria, Albert and Upper Nile. The respective Catchment Management Organisations under each WMZ are to develop catchment management plans. This transfer already demonstrated an improved performance in terms of water permits issuance and compliance monitoring and enforcement (MWE, 2013b). In addition, catchment based management is also ongoing in the six sub-catchments of Rwizi, Mpanga, Semliki, Aswa, Awoja and Okok, and has been initiated in four other sub-catchments. However, despite those efforts, water management is curtailed by limited institutional and human capacity skills, weak policy, regulatory and legal framework, weak enforcement of laws and policies, and lack of data and information according to the NDP (Republic of Uganda, 2010).

At local level, in 2013 there are 278 'water for production' facilities under community management with established water user committees (out of 711 constructed since 2000). These water user committees are actively functioning at 78 percent. This is an indicator reviewed every year as part of the will to encourage the formation of water users associations (WUAs) for both irrigation and livestock farmers.

In the past, from the 1960s onwards, the Government of Uganda applied top-heavy approaches in developing irrigation schemes. In the early 1990s the first effort to introduce farmer participation in small-scale irrigation schemes was undertaken with the development of Kekite, Gayaza and Zirobwe schemes. Another effort to introduce farmer participatory approaches was made with the development of Olweny pilot rice irrigation project; where, however, the technologies introduced (pumping for both irrigation and drainage water) were imposed on the farmers.

Transfer of the irrigation schemes to the farmer cooperatives is discussed since the 1960s, but is not implemented everywhere. In Doho rice scheme, the farmers lease their field for 99 years but the scheme remains property of the government, who also provides the management officers. Cleaning of the irrigation and drainage channels (from main to tertiary level) is the responsibility of the farmers, either collectively or individually depending on the level. The Doho rice scheme farmer's association is in charge of mobilizing farmers for cleaning, monitoring it, and collecting the water fees, which are used for the operation and maintenance of the scheme. However, at field level operations are constrained by the lack of clear rules regarding water distribution, as well as by the infrastructure (most of the water gates controlling the water flow were damaged before the scheme's rehabilitation in 2013). The water drained downstream of the scheme is reused by farmers called 'out-growers' on around 200 ha of informally irrigated crops (Nakano *et al.*, 2010). Management of Agoro scheme is similar. In Kibimba rice scheme the management of the scheme failed after the departure of the Chinese technical assistance team in 1991, and the infrastructure was deteriorating up until 1997 when it was privatized. Since then, the performance of the scheme has improved substantially.

Finances

During the 2008/09 census of agriculture, only 3 732 out of the 31 000 households using full control irrigation, or 12 percent, indicated to pay for the water they use for irrigation, almost equally divided between payment by area, by volume or other form of payment. However, payment by area takes place mostly in the eastern region, while payment by volume happens mainly in the central and western regions (UBOS, 2010).

The average cost of irrigation development in equipped wetlands is estimated at between US$500 and 1 140/ha. The cost of irrigation development with open channel ranges from US$1 750 to 5 700/ha, while the cost of installation of pressurized irrigation is US$5 400/ha (MAAIF, 2011b).

Policies and legislation

The law related to irrigated agriculture is scattered over many pieces of legislation. There is no legislation that deals specifically with irrigated agriculture:

- The *Constitution of Uganda 1995* vests in the State the duty to protect important natural resources including water and to take all practical measures to promote a good water management system.
- The *draft Water (Amendments) Act 2013* (Avery, 2014), which is to replace the *Water Statute 9/1995* or *Water Act 1995* provides for the use, protection and management of water resources and supply and for the constitution of water and sewerage authorities. The objectives of the statute are, inter alia, to allow for the orderly development and use of water resources for purposes other than municipal use, such as irrigation and agriculture, in ways that would minimize harmful effects to the environment. Extraction of water is prohibited unless authorized. The following regulations implement the Act:
    - *The Water Resources Regulations 33/1998* provides for the procedure to obtain a water permit;
    - *The Water (Waste Discharge) Regulation 32/1998* establishes the need to apply for a permit when discharging effluent or waste into the aquatic environment or on land;
    - The *Water Supply Regulations 1999;*
    - The *Sewerage Regulations 1999.*
- The *National Water and Sewerage Corporation Act 1995* revises the objectives, powers and structure of the National Water and Sewerage Corporation.
- The *National Environment Statute 4/1995* provides for the sustainable management of the environment and establishes the National Environment Management Authority (NEMA).

- The *Environmental Impact Assessment Regulations 13/1998* requires an environmental impact assessment to implement a project.
- The *Land Act 1998* protects natural lakes, groundwater, natural streams, wetlands and any other land reserved for ecological purposes for the common good of the citizens of Uganda.
- The *Local Governments Act 2010* is to guide implementation of water for agricultural production locally.

The major policies of the Government of Uganda impacting on irrigation development are:

- The *Draft National Irrigation Master Plan (DNIMP) for Uganda (2010-2035)* identifies drivers of irrigation development in Uganda, namely: (a) the National Development Plan, (b) climate change, (c) new markets; and (d) increasing international investments in agriculture in the region. As a result, it defines four stages of the Irrigation Framework Master Plan (IFMP): i) capacity building and studies (2011-13); (ii) reinvigoration of the irrigation sub-sector (2014-18); (iii) spatial and market expansion (2019-23); and (iv) integration and commercialization of production models (2024-35).
- The *National Water Resources Development and Management Strategy*, based on the findings of the National Water Resources Assessment, is current developed and will aim at providing a framework for integrated management and development of the country's water so as to effectively contribute to the realisation of the objectives of the National Development Plan. The strategy will set the stage for the development and management of Uganda's water resources up to the year 2040 (MWE, 2013b).
- The *National Water Quality Management Strategy* (2006)
- The *National Water Policy* (1999) resulting from the 1998 water sector reform.
- The *Uganda Water Action Plan* (1995).

Both the Water Policy and the Water Legislation are currently amended to include issues arising out of the previous water sector reforms as well as those from emerging global and national challenges (MWE, 2013).

In agriculture, following the *Plan for Modernization of Agriculture* (2000) and the first *Development Strategy & Investment Plan 2005/06-2007/08* for Agriculture, were defined in 2010 the *National Agricultural Policy* (NAP) and the *Agricultural Sector Development Strategy & Investment Plan: 2010/11-2014/15* (MAAIF, 2010a), the sectorial approach of the National Development Plan (Republic of Uganda, 2012). The latter in particular aims at rehabilitating government irrigation schemes, transfer the management of irrigation schemes to lowest appropriate level, establish new irrigation schemes (informal, small scale, commercial), and increase water storage for livestock and wildlife.

In addition, the *National Policy for the Conservation and Management of the Wetlands* (1995) gives a basis for the planning and development of rice irrigation. More recently, the *Environment and Natural Resources Good Governance Action Plan 2013-2016* was prepared to promote good governance in the sector.

Finally, the *Draft National Land Policy 2012* recognizes land as the most basic resource in terms of the environmental resources that it contains and supports (MAAIF, 2013).

ENVIRONMENT AND HEALTH

The xponentially rising rates of demography, urbanization and associated socio-economic activities are directly contributing to the degradation of the natural resources and the loss of specific ecosystems.

Agriculture is responsible for decline of Uganda's forest cover (from 24 percent in 1990 to 12 percent in 2010), together with the lack of enforcement of policies and conflicts. Deforestation, combined with farming practices, population pressure, soil type and overgrazing has led to 62 percent of the country

being already severely degraded (MAAIF, 2010; Ruettinger *et al*, 2011). The Karamoja region in the north, bordering Kenya, in particular, is environmentally fragile. In the more humid areas, pressure on wetlands is also increasing due to expansion of urban and industrial areas, as well as the off-season cultivation in wetlands (Office of the Prime Minister, 2012). As a result, their extent is in decline compared with the 1990s where it covered up to 15.6 percent of the country for only 10.9 percent in 2008 (MWE, 2013b).

Pollution of water resources is concentrated in the Lake Victoria regions. The main source of pollution is untreated wastewater discharge from Kampala, as well as poor farming practices, industrial waste discharge and mining activities, leading to eutrophication. The level of compliance with national wastewater discharge standards is estimated at only 40 percent (NEMA, 2010). In general, the water used for irrigation in the country has no salinity problem, except for some groundwater in semi-arid areas. Waterlogging has been observed before rehabilitation in Mubuku irrigation scheme.

Partial and total sedimentation of dams and valley tanks has occurred in most structures of the 1960s (over 1 000) and it is a common phenomenon in the Karamoja area where most of the soils are sandy-sandy loam in nature. This has substantially curtailed the storage capacity in the area.

Swamps, valley tanks and dams, are breeding grounds for mosquitoes, hence the high prevalence of malaria as well as bilharzia among the surrounding communities.

Finally, large areas of land in Uganda have been leased or sold to foreign investors for food production, oil palm plantations or carbon off-sets. This is also the case in every country of the Nile river basin, due to the large water resources available on those lands. Areas under foreign land deals are estimated at to 860 000 ha (GRAIN, 2012; Rulli, 2013) or almost 3.5 percent of the total area of the country. It includes 800 000 ha allocated to Egypt in 2008 in various part of the country.

PROSPECTS FOR AGRICULTURAL WATER MANAGEMENT

Uganda is endowed with abundant water resources, however due to the very high population growth, the total renewable water resources of the country are expected to drop by 2030 to 948 m^3/year per capita (based on UNDESA population prospects 2012), almost corresponding to the water scarcity threshold. At the same time, the total demand for water for production is projected to rise to 994 million m^3 in 2015, 1 266 million m^3 in 2020 and 2 113 m^3 in 2035 (MWE, 2009).

With regards to irrigation development, the government, under the Agricultural Sector Development Strategy & Investment Plan (MAAIF, 2010) and the National Development Plan (Republic of Uganda, 2010), is to reduce the dependency on rainfed agriculture through the:

- Establishment of four new medium-size irrigation schemes each with 2 000 ha for promotion of irrigation;
- Completion of the rehabilitation of Olweny swamp, the last of five planned to be rehabilitated (Mobuku, Doho, Kibimba, Agoro);
- Transfer of management of public irrigation schemes to the lowest appropriate level once they are reorganized in order to ensure the sustainability of the schemes;
- Establishment of thirteen irrigation research and development sites;
- Building of a monitoring framework for the supply, utilisation and management of water for crops;
- Scaling up of conservation agriculture;
- Promotion of small-scale irrigation practices;
- Promotion of appropriate technology for household-level irrigation;
- Strengthening of public-private partnership in construction and maintenance of irrigation schemes;

- Provision of backup support including promotional activities, guidelines, regulations, standards designs and manuals, and technical assistance;

The overall objective is to increase the area under irrigation from 15 538 in 2010 to 22 000 ha in 2015. To reach this objective, an inventory of the existing water sources was made, identifying the potential for irrigation, livestock watering and aquaculture at specific project sites within the country. In particular, this feasibility study examined the interest of rehabilitating five additional governmental schemes–Kiige, Odina, Labori, Atera, Ongom–, as well as establishing six new irrigation schemes–Katete, Katerera, Igogero-Naigombwa, Rhino Camp, Labwor, and Biiso–and new infrastructures to store water for livestock (MAAIF, 2013).

In the longer term, the National Irrigation Master plan (MAAIF, 2010) defined, after a first stage of studies, three additional stages for the development of irrigation:

- 2014-2018: reinvigoration of the sector with efforts of physical investments, supported by a wide range of institutional capacity building, and possible restructuring.
- 2019-2023: spatial and market expansion with i) physical investments with attention to bulk service infrastructure and ii) institutional adaptation to new challenges, including efficient allocation of scarce water; service tariff recovery and possible public/private partnerships in both service delivery and production.
- 2024-2035: commercialisation of the sector and integration with global markets: physical investment will continue nonetheless, while institutional measures will be focussed at ever improving service delivery and possibly, water markets.

Regarding water management, the National Irrigation Master plan advocates three measures: i) a meaningful water allocation mechanism, taking into consideration both economic efficiency at sectorial level and physical water efficiency at scheme level; ii) the economic pricing of water; and iii) conjunctive use of groundwater and surface water (MAAIF, 2010).

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