Water Resource Accounts for Uganda: Use and Policy Relevancy

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Abstract

The increasing variability in the climatic pattern and its adverse effects on the Ugandan economy has become a major development challenge. For example, a key but climate sensitive sector like agriculture is increasingly experiencing severe disruptions as a result of its reliance on rainfall which has increasingly become unpredictable. Recent studies indicate a seemingly decreasing trend in the number of rainy days during the months which are crucial for crop growth. This trend is severely disrupting agricultural activity across the country.

Since water is a vital input in many economic activities, we need to clearly understand the available supply of water resources and the level of utilization by the different sectors of the economy. This is with the view to establishing whether or not, there is room for increased utilization; within the framework of Integrated Water Resources Management. It is the objective to the study to provide this understanding through a water resource accounting framework. However, no developed water resource accounts exist for the Ugandan economy. Hence the task of the study was to develop the water resource accounts for Uganda. The results show evidence of under utilization of the available water resources. The under utilization is prevalent across all productive sectors of the economy and is likely to constrain the scope for productivity improvements, economic growth and other development outcomes.

JEL Classification code: E01, Q56

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Key words: Water Accounts; Water utilization; Economic performance

1 Introduction

According to OECD (2008), over half of the world's population will be living under water scarcity due to the effects of climate change by 2030. This is likely to have far reaching implications for the social-economic set up of the global economy. Already, climate change is fast becoming one of the major risks facing developing countries given that the biggest proportion of their economies are deeply rooted in climate sensitive sectors like agriculture. Therefore, changes in rainfall patterns and increasing temperatures are swiftly translating into yield reductions in many crops [Glantz *et al.,* (2009)]. Many developing countries rely; in varying degrees on agricultural exports as a source of foreign exchange and this sector has multiple linkages with other sectors of the economy. In addition, it is a major source of employment. Historically, changes in weather and rainfall have generally had major spillover effects on the rest of the economy due to their effects on the agricultural sector. A number of empirical studies have shown that the agricultural sector is a key sector of the economy in most developing countries [Kalpana *et al.,* (2012)]. In the case of most developing countries like Uganda, agriculture contributes substantially to the economy's aggregate output.

In a study on climate trends in Uganda, FEWSNET (2012) shows that for the period 1975-2009, the country witnessed an increase in temperature and a reduction in rainfall, with recent record temperatures of more than 0.8 degrees Celsius ($^\circ$C) for both rain seasons (March–June and June–September). The study notes that given that the standard deviation of annual air temperatures in the mostly affected regions is low (approximately 0.3°C), the reported increases in temperature represent a large (2+ standard deviations) change from the historical climatic set up *(figure 1).* In fact, the study highlights that both spring and summer rains had decreased during the past two and a half decades. A trend analysis of air temperature data shows that the degree of recent warming is vast and unprecedented within the past 110 years.

The 1900–2009 rainfall time series data obtained for the crop growing regions in Uganda indicates that rainfall has been approximately 8 percent lower on average than for the period 1920-1969. Unlike the June–September rainfall which appears to have been declining over a longer time horizon, the decline for the March–June season has only occurred of recent. These declines have been mapped in *appendix 2* as a contraction of the regions receiving adequate rainfall for viable agricultural activity. Similarly, the figure shows the nation-wide mapping of actual and projected changes. The March-June season, normally registers rainfall totals of more than 500mm, which is adequate for crops and livestock. For the period 1960-1989, the regions receiving this amount of rainfall (on average) during March-June are shown in light brown in the left panel of *appendix 2* and these lie beneath the dark brown and orange areas. According to the study, the past 25 years have seen this region shrink (the dark brown polygon), leaving the central and western parts of the country with rainfall deficits. FEWSNET (2012) therefore projects that if the current rainfall trends continue, by 2025; the drying impacts will likely lead to a further contraction of the orange polygon. The polygons in the right panel are for the June–September season. Most of the areas in the north of the country are likely to be affected by the earlier than usual end of this June-September rain season. These rainfall reductions were projected for the 2010–2039 period, assuming persistence in the observed trends in *figure 1.*

Overall, FEWSNET (2012) indicates that farmers have realized the change in temperature and rainfall patterns. In a related study by Osbahr *et al.,* (2011), it was found that although farmers perceived changes in climate based only on temperature and not in seasonality, rainfall distribution, amount and intensity; they were reported to have experienced that the first rainy season (March-May) had become both more variable and less reliable than the second season (September-December). Those findings are in line with the study by Mubiru *et al.,* (2012), which indicated that the first season rains were delayed for as many as 30 days (only starting in mid-April). They however note that the end of the rainy season had more or less stayed the same, irrespective of when it started. The implication of this trend is that the crop growing season has become shorter. Specifically, monthly data indicated a seemingly decreasing trend in the number of rainy days during the months which are crucial for crop growth during the first season. This makes rain-fed agricultural activity to be susceptible to the effects of this increasingly unreliable rainfall pattern. This calls for the need to develop and expand reliable alternative sources of water for economic activity in the country.

Rationale

In Uganda, the variability in rainfall patterns has become a major development policy challenge for the economy. For example, a key but climate sensitive sector like agriculture is increasingly experiencing severe disruptions as a result of its reliance on unpredictable rainfall. This sector contributes approximately 13.9 percent of GDP [MFPED, (2011)], and employs over half of the country's labour force. This challenge is further exacerbated by the inadequate interventions for predicting and managing these adverse climatic conditions. These unpredictable patterns in rainfall have resulted in economic activity being undermined considerably and in some cases; entire livelihoods have been adversely affected. As a consequence, these adverse effects are being reflected in rising food prices[1], agricultural input prices used by other sectors like agro processing; famine, unemployment and reduced agricultural export growth.

However, these unpredictable rainfall-related challenges are occurring amidst the fact that the Uganda is endowed with fresh water resources. These alternative sources of water need to be utilized since water is a crucial input in the production function. Hence, we need to clearly understand the available supply of water resources and the level of utilization by the different sectors of the

[1] Headline inflation reached double digit from early 2011 (MFPED, 2011).

economy. This will be achieved through having a developed water resources accounting framework. This framework provides a clear mechanism for analyzing water supply and use in an economy and its related impacts. However, whereas the "System of Environmental Economic Accounting for Water" (SEEAW)[2] which provides a detailed framework for analyzing the important interactions between the economy and the environment exists, the Ugandan economy has no developed water resource accounts. This partly constrains economic analysis of water related impacts. The SEEAW was developed by the United Nations Department of Statistics in order to provide a detailed framework for analyzing the important interactions between the economy and the environment. It was developed out of the need to co-ordinate the management of water resources with other sectors of the economy through the concept: "Integrated Water Resources Management" (IWRM)[3]. According to the United Nations, IWRM is a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner; without compromising the sustainability of vital ecosystems [UN, (2009)]. IWRM is therefore based on the appreciation that water is part and parcel of our ecosystem, a natural resource and a public and economic good; whose quantity and quality determine the nature of its utilization.

Furthermore, conventional measures of macroeconomic performance do not present information on the state of the environment regarding the welfare and sustainability aspects with as much accuracy and yet the economy is so dependent on it [King and Crawford (2001)]. Therefore these conventional measures cannot be relied upon in conveying projections regarding long-term trends. The consequences depending on conventional measures may manifest in incorrect policies, development plans, sub-optimal resource allocations and unsustainable extraction and use patterns [Hassan *et al.,* (2000)]. It is therefore the role of National Resource Accounting to provide a critical tool for assessing and reporting the environmental impacts of economic activities. For Uganda which is currently a water resource abundant country, water accounting identifies the extent to which sustainable economic growth and future development depend on this natural resource. The high dependency on rainfall amidst the existing fresh water resources is currently threatening and inhibiting expansion of certain water dependent sectors and the ultimately, the performance of the economy.

National water resource accounts are vital for any country since they facilitate the tracing and analysis of water resource flows within the economy. However, a limited number of countries e.g. Australia, the Republic of Moldova, South Africa, Chile, Namibia, Botswana, Morocco and most of European countries have developed national water accounts. On the other hand, countries such as Uganda are without developed accounts and no known attempts have

[2] See the UN, IMF, IBRD and OECD. (2003) *Handbook on Integrated Environmental and Economic Accounting* for a thorough insight.

[3] This was adopted by Agenda 21(a 1992 UN action plan concerning sustainable development), the EU Water Framework Directive and the 2003 Third World Water Forum in Tokyo.

been made to develop them so far. The objective of this study is to develop a national water resource accounting framework for the Ugandan economy. Such a framework is envisaged to provide a basis for future analysis that links water resources utilization and the economy. Since the study is the first of its kind for Uganda, the ultimate objective is to provide a basis for future research and policy making. However, it is important to note that developing the national accounts depends on the needs of a given economy. In water scarce economies, the accounts focus on water supply and use. On the other hand, industrialized economies mainly emphasize the aspects of pollution and emission when developing their accounts. In addition, some countries have water resource accounts at river basin level e.g. The Netherlands, Sweden and Australia. Regardless of the scope and emphasis, the role of the national accounts is to facilitate accounting and modelling of water resources [UN, IMF, IBRD and OECD, (2003)]. The study therefore seeks to develop water resources accounts to enable economic analysis of water resources utilization in the Ugandan economy with the view to feeding into policies that are linked to the economy and water resources.

2 Situational Analysis of Water Resources in Uganda

This section provides insights into the state of water resources in Uganda with the aim of providing a basis for the need to develop a link between water resources and the economy. Approximately 25 percent of country's surface area (241,000 square kilometers) is covered by lakes and rivers. From a biophysical perspective however, much of the country experiences high rates of potential evaporation– approximately 75 percent - within the range 1350 – 1750 mm/yr [DWRM, (2011)]. Similarly, Van Steenbergen and Luutu (2012), indicate that a big proportion of rainfall fall (approximately 70-90 percent) goes back into the atmosphere through evapotranspiration. Only a small proportion of this rainfall stays on the land surface and contributes to surface flow via runoff and to groundwater recharge via infiltration through the unsaturated zone. They further note that given the nature of the aquifers, groundwater is largely recharged mostly during heavy rainfall events. As such, these evaporation rates have implications for the economy with regard to crop production, groundwater recharge, and range land productivity [DWRM, (2011)]. The country receives mean annual rainfall of 1200 mm. However, only the Lake Victoria shores and the mountainous areas (Mt Rwenzori, Mt Elgon, and the Kisoro-Kabale region) experience – on average – an annual rainfall surplus (i.e. annual rainfall that exceeds potential evaporation). The average deficit is less than 200 mm/yr in 20 percent of the country, while a further 35 percent has a deficit between 200-400 mm/yr. The average annual deficit in the north-east and sections of the Rift valley is beyond 600 mm. The study notes that "a rainfall deficit does not necessarily translate into an equal amount of moisture deficit during plant growth, as traditional agricultural production systems are well adapted to the seasonal weather patterns" [DWRM (2011), p.8]. This observation notwithstanding, the prevalence of rainfall deficits in the absence of reliable alternative sources of water for production is likely to have implications for economic performance.

In terms of surface water, River Nile flows exceed 25 cubic Kilometres per year, coupled with large combined storage capacities in the lakes: Victoria, Albert, Edward and Kyoga [DWRM (2011), p.7] However, while Uganda is generally endowed with water resources, economic activity still continues to depend on rainfall. As noted earlier on, studies show that rainfall is on the decline and this is likely to pose social-economic challenges in the medium to long term. In fact, this view has been reinforced by recent experiences in the areas of demography and climate. Specifically, the country is registering rapid population growth of 3.2 percent [MFPED, (2011), p.80] and climatic volatility which is being attributed to climate change[4]. Droughts have become frequent and severe thereby posing a threat to prospects for stable long term economic performance *Figure 3* shows that the spatial pattern of warming corresponds largely to the areas associated with reduced rainfall. Temperatures are reported to have increased by up to 1.5 $^\circ$C across much of the country, with typical rates of warming of approximately 0.2 $^\circ$C per decade. This trend is envisaged to continue as well as the expansion of warm areas in the medium to long term, as the earth's temperature continues to rise. The western and northwestern regions of the country are cited as the most affected by these changes. The increasing temperatures pose a threat to coffee production, a key cash crop for the economy. Therefore, the effects of a warmer climate are likely to exacerbate the impact of this decreasing rainfall and periodic droughts. This would ultimately have an adverse impact on the economy. Generally, the FEWSNET (2012) findings show that the country is becoming drier and hotter.

More worrying is the fact that some of these droughts are being experienced in the coffee growing areas which is likely to jeopardize the economic viability of such a vital commodity. *Figure 4* shows the coffee growing areas of the country[5]. Uganda's coffee production accounts for approximately 2.5 percent of global coffee production and it is Africa's largest producer of Robusta coffee [World Bank, (2011)]. The coffee sector is extremely important for the economy in terms of employment and foreign exchange earnings. However, the increasing variability in climatic patterns is bound to put the sector's resilience into serious jeopardy if there are no measures to proactively manage these potential risks going forward. A case in point was the lack of timely measures to stem the outbreak of the Coffee Wilt Disease which is estimated to have caused losses to the coffee sector of approximately US$800 million over the past decade in lost export earnings [World Bank, (2011)]. It is therefore important to have measures in place that will mitigate any adverse effects of the observed climatic changes on the key sectors of the economy.

[4] The country is increasingly experiencing severe and regular waves of hydrologic droughts in the different regions.

[5] Compare *figure 3* and the *figure* in *appendix 2* to appreciate the extent to which the declining rainfall and increasing temperature is hitting the coffee and maize growing areas. These commodities constitute some of the country's major exports.

Notes: Two types of coffee namely Robusta and Arabica are produced. Robusta coffee is indigenous and grows at high altitudes of between 1,000 and 1,300 metres. Arabica coffee, originally from Ethiopia and Malawi is grown on the slopes of Mountains: Elgon on the Uganda-Kenya border and the Rwenzori on the border with the Democratic Republic of Congo.

Previous studies have indicated that climatic change will have an adverse impact on the coffee growing regions of Uganda [AFCA, (2012)]. As a leading export generating approximately 20 percent of the foreign exchange earnings, a reduction in coffee output will result in a negative impact on the economy [UCDA, (2012)]. Note that coffee accounts for more than 60 percent of cash crop earnings and fetches over US $300 million (40 percent) of export revenue for the economy [MFPED, (2011), p.17]. In addition, the coffee sub-sector, directly and indirectly employs over 3.5 million households [UCDA, (2012)]. It is worth noting however that coffee production relies on farmers on small land holdings. These small holder farmers according to Morton (2007) are cited as the most vulnerable to changes in climatic conditions. The increased climatic variability necessitates interventions which will ensure that production activities in the sector are not adversely affected. Any disruption in the performance of strategic commodities such as coffee has implications for escalating poverty levels and unemployment in the economy.

Läderach *et al.,* (2011) assert that these climatic changes are likely to make some areas to become more suitable for coffee production while others will experience diminished suitability. According to the study, most of the coffee growing areas will become unsuitable. They further note that the areas which will become more suitable for coffee will have to compete with other crops. In areas where the suitability for coffee will reduce, adaptation strategies will need to be undertaken in order to sustain its production. Climatic variability as noted earlier on has got economy wide effects. For instance, previous experiences cite the 2004-2005 drought which adversely affected the water levels in Lake Victoria causing a reduction in water supply to the hydro-electric power stations downstream. The drop in water levels led to severe economy-wide disruptions in social and economic activity.

Despite these developments in the water sector and the recognition of the indispensable role which water resources play in the economy, no empirical studies exist in the case of Uganda that link water resources with the economic and social activity. Existing studies in water resources have tended to focus on different aspects like hydrology and water quality. For instance, a *Rapid Water Resources Assessment* study carried out about a decade ago was no longer seen to represent the current developments in the sector as well as data in the country [DWRM (2011), p.7]. As a result a *National Water Resources Assessment* study was embarked upon in 2009 by the Government of Uganda under the Ministry of Water and Environment[6]. The findings were envisaged to facilitate

[6] DHI in association with COWI Consult and COWI Uganda, DHI signed a contract (MWE/SRVCS/08-09/00184) with the Ministry of Water & Environment on 11th March 2009 for the provision of Short Term Advisory services [See annex 1.1 of DWRM, (2011) for details of the ToR)].

the development and optimal use of the water resources for the benefit of the country. In addition, the study would provide data to inform national positions regarding negotiations on water allocation among the shared basins with other countries. Despite the above mentioned efforts, no study has so far been undertaken to empirically link the water resources in Uganda to the economy. Any existing evidence to this end is by and large, anecdotal. The current study seeks to develop the water resource accounts for Uganda. These accounts are aimed at facilitating future analytical work on studies which will link water resources and the economy.

3 Methodology

The water resource accounts have been developed using data from various departments in the Ministry of Water and Environment, the water distribution agency – National Water and Sewerage Corporation (NSWC) and the FAO-AQUASTAT Database. The data include: sources of water, supply of water as well as uses of water by the different sectors of the economy. These data were used within the SEEAW framework to develop the physical Supply and Use tables (SUTs) for Uganda. The tables describe the water flows in millions of cubic meters, from the environment, within the economy and between the environment and the economy *(see figure 6).* The accounts trace water from the initial stage of abstraction from the environment, supply and use within the economy to the final stage of discharge back into the environment. However, uses of water which do not involve direct abstraction, such as recreation or transportation, are not considered in water resource accounting (UN, IMF, IBRD and OECD, (2003)]. Similarly, the storage and release of water in dams is considered to take place within the hydrological system and not within the economy. This is because it may not be easy to distinguish between the direct economic uses of water in this case and what is required for regulating the discharge of the rivers for purposes of flood prevention and run off during rainy seasons. The SEEAW framework makes the linkage between water resources and the economy possible because the water SUTs have the same structure as the Social Accounting Matrix (SAM). This implies that economic policy analysis through integrated natural resource modelling is possible.

The SUTs allow for the evaluation and monitoring of the extent of utilization of the available water resources in the economy. As seen in *figure 6,* we can then identify the economic agents involved in the abstraction, distribution, use as well as discharge of water back into the environment. Discharge into the environment can be through waste water to aquifers, rivers, lakes and oceans, returns to soil and water bodies from irrigation activities and losses in transportation (leakages from water supply pipes). Imports and exports of water to and from the economy are taken as direct flows into or out of the economy and other economies.

Asset Classification

According to the 1993 System of National Accounts, asset classification includes only a small portion of the total water resources. Only "aquifers and other groundwater resources to the extent that their scarcity leads to the enforcement of ownership and/or use rights, market valuation and some measure of economic control" are within the SNA asset boundary. The SEEAW includes all water resources that provide both direct use and nonuse benefits. By implication, the asset category "water resources" (EA.13) includes all the water resources which can be extracted in the current period (direct use benefits) or might be of use in the future benefits [UN, (1993)]. The SEEAW accounting involves asset classification of water resources as follows:

Surface water constitutes of all water which flows over or is stored on the ground surface [UNESCO and WMO (1992)]. Depending on data availability and national priorities, surface water can further be disaggregated. For example, reservoirs can be classified by use; that is: for human, agricultural, electric power generation or mixed uses. Rivers can be classified on the basis of regularity of runoff.[7]

Groundwater comprises of all water which collects in porous layers of underground formations technically referred to as aquifers. Aquifers may be unconfined; i.e. have a water table and an unsaturated zone or may be confined when they are between two layers of impervious or almost impervious formations. Unconfined aquifers are recharged during the water cycle by the percolation of rain or melted snow and thus hold renewable groundwater. Other components of the hydrological system such as soil water, glaciers, permanent snow fields, ice, and marine water are not part of the classification of stocks largely because water cannot be abstracted (such as soil water) or the case where abstraction does not have an effect on the size of the stocks (glaciers, marine water etc). However, some countries such as France, Moldova, Spain, and Chile have compiled accounts for soil water, permanent snow fields and ice [UN, IMF, IBRD and OECD (2003)].

Physical flows of Water resources

When water is abstracted and processed, it is considered a product and it enters the economic sphere. This product can be delivered to other industries or to final consumers. When water is no longer useful in its current state, it is considered to be a residual. Some flows of residuals are recorded within the economy (for example, the routing of waste water to treatment plants) but ultimately all residuals are returned to the environment (See *figure 7*). These flows do enter the economy; hence the return of water to the environment is recorded as a residual flow. In the case of Uganda, water used for hydropower generation and the water extracted by agriculture for irrigation is considered as water returned to the hydrological system.

Industry classification

The SEEAW is designed to fit into the SNA framework which makes use of the International Standard Industrial Classification (ISIC) to classify economic sectors. Within the ISIC, a number of activities are defined as they link with water supply. The classification includes: operation of irrigation systems (ISIC

[7] See Lange (1997); Tafi and Weber (2000) and Margat (1992) for a detailed breakdown.

0140); collection, purification and distribution of water (ISIC 4100); transport through pipelines (ISIC 6030); public administration of water (ISIC 7512); and sewerage and refuse disposal, sanitation and similar activities (ISIC 9000). In order to facilitate the economic analysis of water, adjustments can be made to the UN system with the view to providing effective integration of water sources and economic data.

Data

The following data sources were used to develop the water supply and use tables. Data was obtained from the Directorate of Water Resources Management and the Small Towns Water and Sanitation programme under the Ministry of Water and Environment. In addition, commercial water data was obtained from the National Water and Sewerage Corporation (NWSC) the commercial water distribution agency as well as the AQUASTAT data published by the Food and Agricultural Organization (FAO).

4 Development of the Water Supply and Use Tables

The framework uses the SEEAW procedure of partitioning SUTs by their key components i.e. from "the environment" and "between the environment and economy" and "back to the environment". Therefore, the tables have been adapted to integrate the environment and the economy. The following components were included within the environmental sphere to reflect the key elements which are at the core of water resources management in Uganda:

- *From the environment:* This is the source of all water resources and the ultimate repository to which all used and non-used water resources return;
- *The natural mean annual runoff (MAR)*: This receives water from the environment and redistributes to surface water and ground water and back to the environment. In our case, rather than have this component being explicit in our SUTs, it is presented as part of surface water and ground water yield by the DWRM. In line with our definition, recharge studies on Uganda indicate that a big proportion of rainfall fall (approximately 70-90 percent) goes back into the atmosphere through evapotranspiration. Only a small proportion stays on the land surface and contributes to surface flow via runoff and to groundwater recharge via infiltration through the unsaturated zone. Van Steenbergen and Luutu (2012) observe that given the nature of the aquifers, groundwater is largely recharged mostly during heavy rainfall events.
- *Surface water yield,* collects from MAR and redistributes to available yield;
- *Groundwater* sources are replenished by MAR and contributing to available yield;

- *Soil water* collects precipitation from MAR to support evapotranspiration activities through natural and cultivated agriculture. This is accounted for under ground water;
- *Consumption* is measured as water that is not returned to water bodies because it has either been absorbed by plants (crop water), livestock, humans (households) and industry. This component is presented accordingly in our SUTs.

Supply table

The supply table comprises of three parts; first, tracing flows from the environment, second, flows leaving an economic unit supplied to other units within the economy (water distribution by economic units to other industries, households and the rest of the world) and third, the one describing flows leaving economic units back to the environment (return flows). *Table 2* details the water resource flows from the environment to the economy which is a total of 43 billion m^3. *Figure 8* shows the volume of water supply by source. The second component shows flows of water (as a product) and waste water (a residual) within the economy (4.6 billion m^3). These flows are accounted for by the water distribution agencies, industries, final consumers and the rest of the world. The third component shows the eventual return of waste water to the environment and the economic agent responsible for the return. This includes water used for hydro-electricity generation (80 million m^3) and fisheries (105 million m^3) and irrigation water (151 million m^3).

The flows from the environment to the economy are disaggregated by source as follows: ground water (9.5 billion m^3), surface water (13 billion m^3) and net exports (3.3 billion m^3). This implies that the country is a net exporter of water. Some 1.3 billion m^3 is abstracted for use by the different sectors within in the economy of which only 83.4 million m^3 is formally abstracted for distribution to third parties by the water distribution agencies. In the supply table, this is done by the NWSC and STWSP. From the data, it is evident that despite the enormous amount of fresh water resources available from the environment, only a small proportion (approximately 3 percent) is used within the economy. Furthermore, a much smaller proportion out of the water supply within the economy is distributed through the formal piped network (approximately 7 percent). This presents a constraint to the economic sectors of the economy that need water as input into their production processes. Data on flows of water from the economy to the environment is limited. This would have included residual water flowing to the environment come from the economy. The only data available in the category of returns of water to the environment is for the agricultural sector, i.e. water used for irrigation (151 million m^3) which returns to the ground and water used for hydroelectricity generation (80 million m^3) which is returned to the environment through surface water after use. If data were available, more disaggregation would be necessary in order to allow for more detailed accounting

Use table

The use table is a counterpart to supply table and shows how the different sectors use water in the economy. The table is divided into two parts, one tracing flows of water from the environment (source) to the economy (abstraction by the other sectors of the economy) and the flows of water within the economy (water used by other economic units and the rest of the world). Specific data on abstraction for own use was unavailable from the relevant data sources. Hence, we only present water for hydro-electricity power generation in the abstraction for own use category (80 million m^3). About 83.4 million m^3 is abstracted for delivery to third parties. This is done by the NSWC and the Small Towns Water and Sanitation Programme (STWP) which distribute commercial water in some urban areas of the country. This has been categorized as DWR total in *Table 3*.

From the data, it is evident that total supply of distributed water within the economy through the water distribution network is very small (only 6.4 percent) compared to the amount of total water use. This highlights the existence of a limited formal water distribution infrastructure in the country, hence inhibiting the scope for water utilization in the economy. In fact, a large percentage of water use is from other sources like water springs, boreholes and deep wells which is approximately 94 percent (1.2 billion m^3) of water used in the economy. Previous studies indicate that water consumption in Uganda is estimated at 21 m^3 percapita, far below the global average of 599 m^3. This implies that on average, less water is being consumed across all sectors of the economy. Statistics show that 63 percent and 72 percent of the rural and urban population respectively have access to safe water, with 30 percent of the total population with no access to water for domestic use [NPA, (2010)]. The findings suggest that water use in Uganda is suboptimal.

The Water Resource Flow Matrix

The resource flow matrix is an Input-Output table that describes the water supply and use transactions in one table. It avoids the problem of double accounting during the interpretation and application of the water resources figures within the accounting framework. Water supply and use within sectors is defined following the ISIC. However, some adjustments were made to the SUTs. This was with regard to aggregation and disaggregation where necessary, given the limitations of the existing data. Specifically, there are differences between the way data on water supply and use is presented by the different water offices for planning purposes from the different data sources. This is different from how economic activity data is structured in the SNA. Therefore, in order to establish a direct link between the water databases and the SNA, the following adjustments were made while constructing the water resource accounts for Uganda:

Water users are aggregated in the water statistics in order to correspond to particular categories according to how water is supplied to these users. In this case, the categorization from the different data sources was followed with the necessary adjustments being made to make the data suit the SNA framework as follows:

- The agricultural sector has its water as used by the relevant subsectors;

- Industry receives bulk water supply from NWSC or under the STWP;
- The energy sector abstracts surface water for 'own-use' which goes back to the environment;
- Households include all urban and rural domestic users;
- Transfers of water outside the accounting boundary area.

Currently, the available water statics do not explicitly provide data on abstraction for own use by self-providers. These data challenges notwithstanding, the classification was further disaggregated by key economic activities following the ISIC of the SNA. From our flow matrix, the main source of irrigation water to agriculture is from surface water while water supply to households, crops and fisheries is from the distribution agencies as well as other ground water and surface water. The industrial sector is taken to be mainly supplied by the distribution agencies since there is no official data on abstraction for own use.

Key indicators and the Water Accounts Balance

From our data sources we obtain the key indicators such as Water abstraction, Total water use, water supply and the general flows in the economy. These key indicators follow the rules of the SEEAW. For the economy, the balance between water flows is expressed as:

Total abstraction **(4,511)** +Use of water received from other economic units **(83.4)** = Supply of water to other economic units (**83.4)** + Total returns **(336)** + Water consumption **(4,175).**

Since total water supply to other economic units equals the total water use received from other economic units, the identity can be rewritten as:

Total abstraction **(4,511)** = Total returns **(336)** + Water consumption **(4,175).**

5 Summary of findings

Flows from the environment to the economy are estimated at 43.2 billion m^3. Agriculture accounts for 63 percent of total water use with 21.2 percent going to livestock, 18.4 percent to irrigation; 47.5 percent for crops, 13 percent to fisheries. Industry accounts for 4 percent of total water use in the economy while households consume 20.4 percent. The results show an estimated 38.6 billion m^3 in water supply surplus. This implies that there are available water resources that can be exploited for productive use. Subject to availability of more detailed data, future analysis will provide for a more accurate picture of the exact amount of surplus water resources in the economy. This is because there is the need to net out the threshold requirements for water that cannot be withdrawn from the environment as it is required for the ecosystems to function. Specifically, subject to the water requirements for say, riverine habitat [in-stream-flow requirements (IFR)][8] which vary from one country to another, depending on the technical

[8] In their study of the South African economy, King and Crawford (2001) cite an estimate of 30 percent of the Mean Annual Run-off (MAR) as the in-stream-flow requirement.

hydrological assessments and recommendations; the existing water resources can be harnessed and utilized. In addition, it is necessary to account for other possible losses of water into the environment through deep seepage, river losses and evapotranspiration.

Flows within the economy consist of supply water to other economic units via distribution (approximately 83.4 million m^3) which accounts for a small part of total use water (6.5 percent). This is evidence of the limited distribution of water in the country through the piped network. For instance, the NWSC and Small Towns Water and Sanitation Programme distribution network is only limited to a few districts in the country and is confined largely to urban areas. Consequently, a big proportion of water use by economic agents is obtained from other sources like springs, deep wells and boreholes among others. Data on total returns from the economy to the environment is still sketchy. In this case, we can only account for the irrigation return which is 151 million m^3, water used for generation of hydro electricity amounting to 80 million m^3 and fisheries with 105 million m^3.

6 Conclusions

The study assesses the water supply and use situation in Uganda in the process of building a water resource accounting framework for the country. The data shows evidence of under utilization of the available water resources. The level of under utilization is prevalent across all productive sectors of the economy. Therefore, a concerted effort towards improving water utilization could yield positive results on the economy. For instance, expansion of reliable water supply to the agricultural sector through improved irrigation can mitigate the adverse effects of the increasingly variable rainfall on which the sector is so heavily dependent. Despite the importance of the sector to the economy, approximately 14,420 ha of the country's farming areas is said to be equipped for formal irrigation with another 53,000 ha of managed wetlands. However, this limited coverage of the area under irrigated agriculture is amidst the fact that the country is endowed with vast water resources. In fact, estimates of Uganda's spatial potential for improved irrigation vary between 170,000 ha and 560,000, whereas the total potential arable area for irrigation is approximately 4,400,000 ha [MWE, (2011)]. The agricultural sector whose productivity and sustainability is partly being threatened by the volatile climate employs over 60 percent of the population in the country [MFPED, (2011)]. In addition, the sector generates export revenue through its exports as well as supply of inputs to other sectors of the economy. The industrial sector as well as household consumption water use is equally constrained by the limited coverage of the water supply infrastructure. This limited and under developed infrastructure presents costs and constrains the scope for productivity improvement, economic growth and other development outcomes. Improving the volume and reliability of water resource flows within the economy is necessary to accelerate economic growth. There is the need to increase the capacity for sustainable water distribution within the economy. The increase in reliable water supply in the economy through the development of an expanded water distribution network to industry and irrigation infrastructure to the agricultural sector will be a vital step in stemming the susceptibility of the economy to these increasingly variable climatic conditions. This could ultimately lead to stable and accelerated growth, employment and poverty reduction.

Limitations of the study

The study set out to assess the water resources in Uganda with the view to developing the water resource accounts for the Ugandan economy. The process requires a detailed break down of sectoral water supply and use, the minimum water requirements for the ecosystem as well as returns of waste water to the environment. The data bases utilised didnot have most of the breakdown which makes the analysis more interesting and insightful when investigating the impact of water resources supply and use on the different sectors of the economy. To mitigate this challenge, necessary adjustments we made in order to achieve the objective. Since the study is the first of its kind on the Ugandan economy, these accounts can be updated and adjusted in future, subject to availability of more detailed and updated data.

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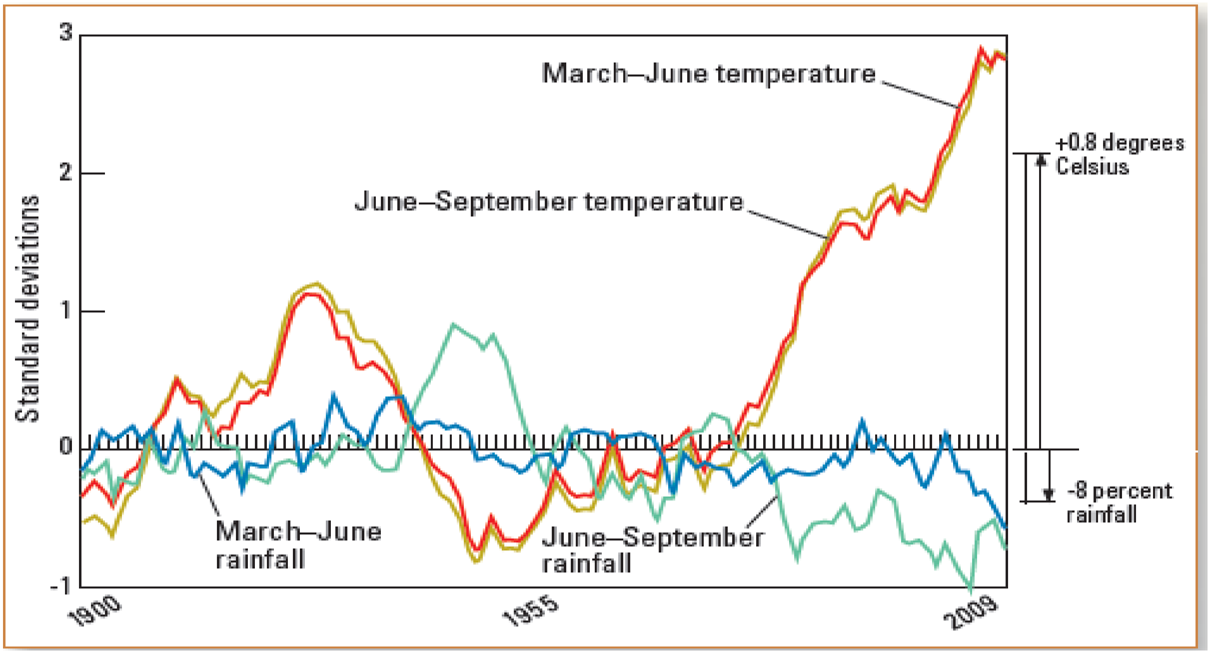
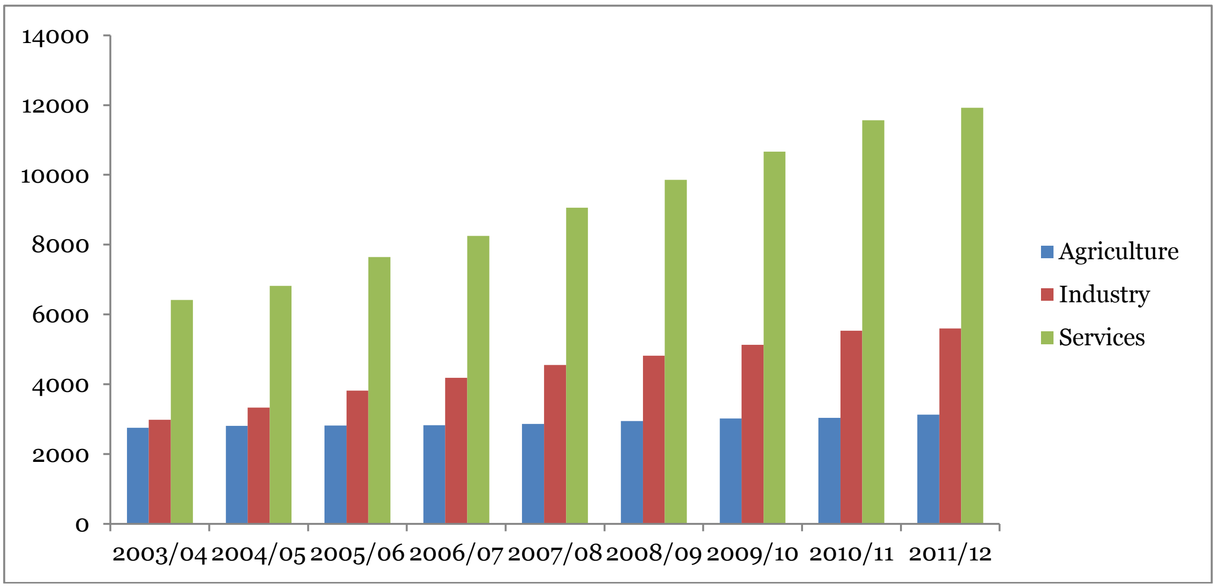
Figure 1: *Smoothed 1900-2009, March–June and June–September Rainfall and Air temperature time series for the crop-growing regions.*



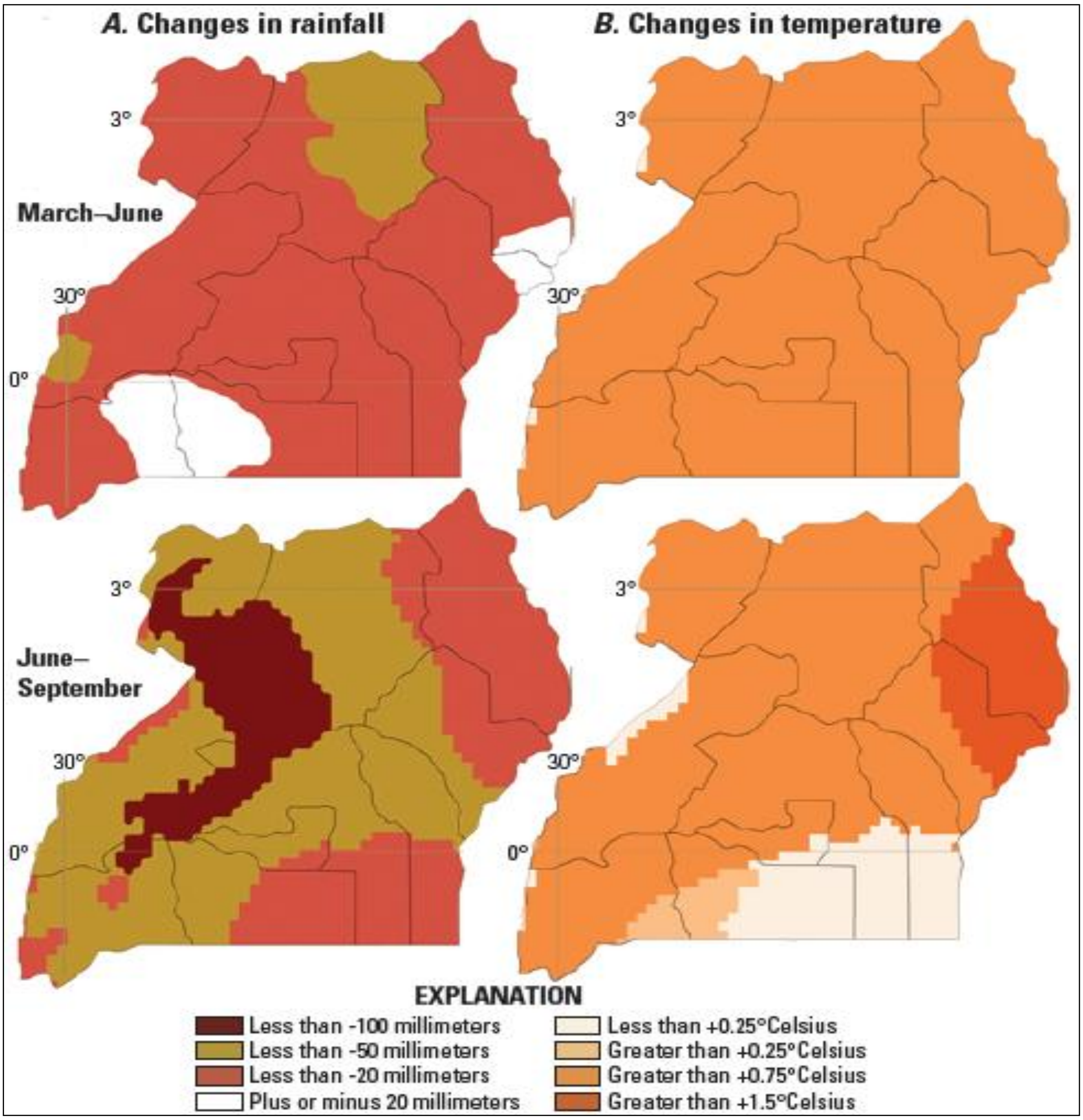
Source: FEWSNET (2012).

Figure 2: GDP *by Economic Activity at constant (2002) Prices (UGX Billions)*



Source: Bank of Uganda (2011).

Figure 3: *Observed (1960–2009) and projected (2010–2039) changes in March–June and June–September rainfall and temperature.*

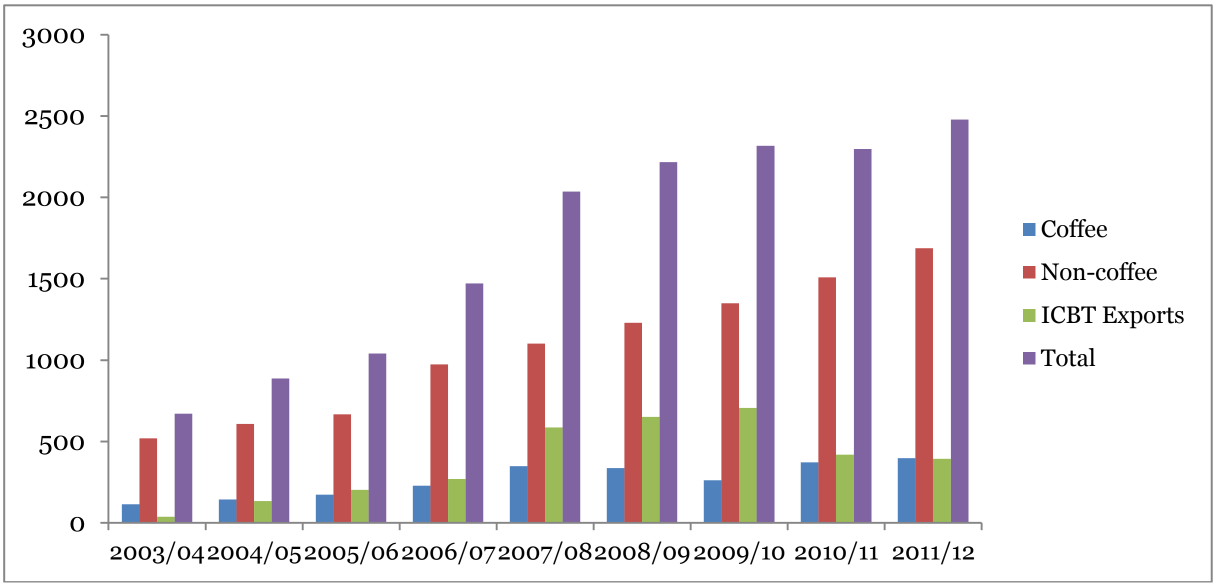


Source: FEWSNET (2012).

Figure 4: *Coffee Growing Areas in Uganda*

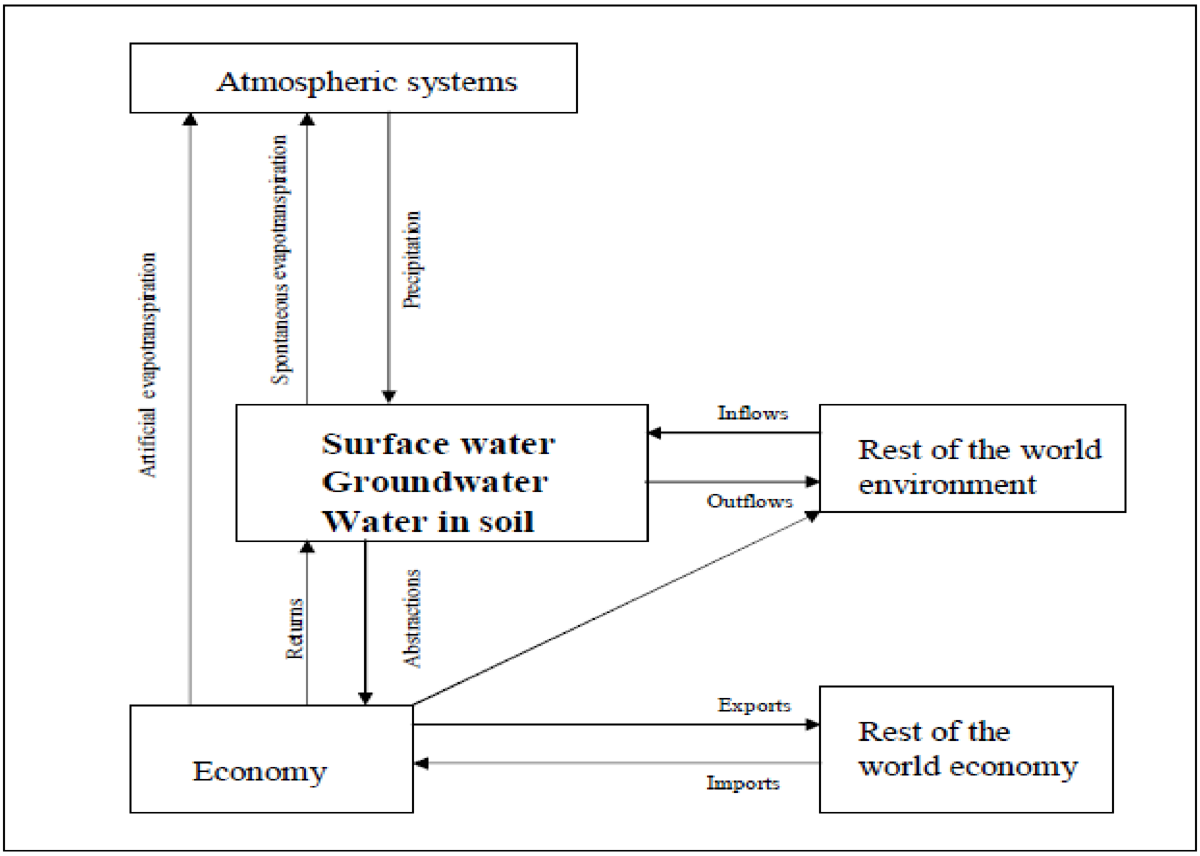
Source: Volcafe (2012).

Figure 5: *Composition of Exports (US$ Millions)*[1]



Source: Bank of Uganda (2011).

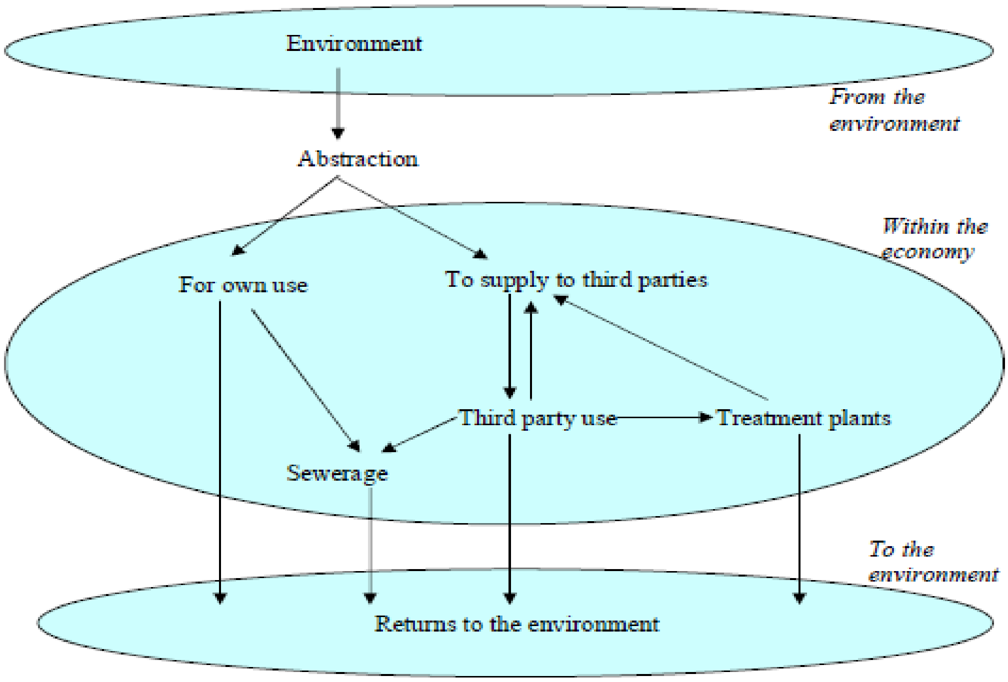
Figure 6: *Link between the Hydrological system and the Economy*



Source: Adapted from Tafi and Weber (2000).

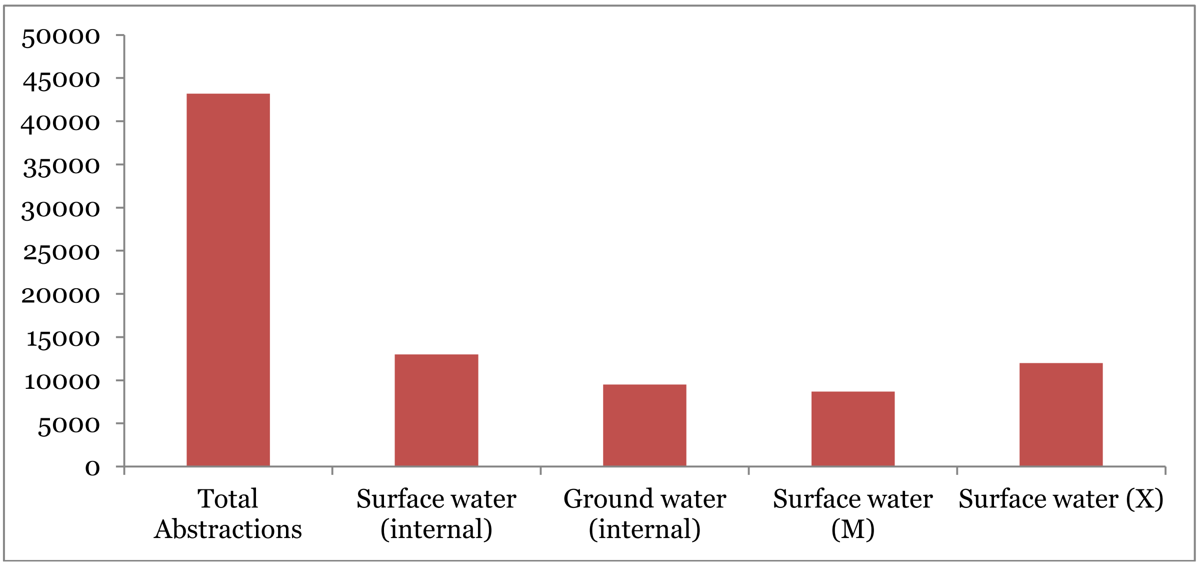
[1]ICBT refers to Informal Cross Boarder Exports.

Figure 7: *Schematic flow of Water resources*



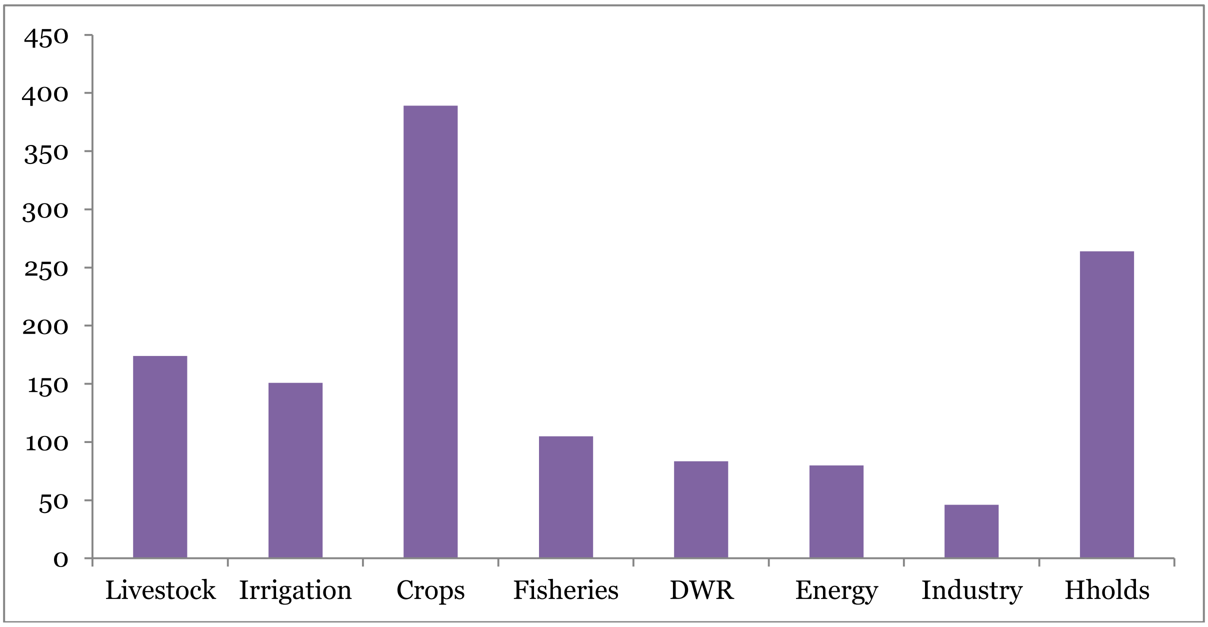
Source: Adopted from UN, IMF, IBRD and OECD (2003).

Figure 8: *Water supply by source (Millions of cubic meters)*



Source: DWRM (2011) and own calculations.

Figure 9: *Water use within the economy (Millions of cubic meters)*



Source: DWRM (2011) and own calculations.

Table 1: *The SEEAW Asset Classification*

Code	*Asset*
EA.13	Water Resources
EA.131	Surface water
EA.1311	Artificial reservoirs
EA.1312	Lakes
EA.1313	Rivers
EA.132	Groundwater

Source: UN, IMF, IBRD and OECD (2003).

Table 2: Water Supply Table (Millions of Cubic Meters)[2]

			Agriculture				Energy[l]	Industry	DWR (Total)			Govt	Hholds	RoW		Total Supply
			Livestock	Irrigation[l]	Crops[l]	Fisheries				**NWSC**	**STWSP**					
	Total Abstractions														**43,201**	**43,201**[a]
From the environment	From Surface water (internal)														13,000	13,000
	From Ground water (internal)														9,500	9,500
S1	RoW (in Transfers)	From Surface water (M)													8,700	8,700
		From Surface water (X)													12,001	12,001
		From Ground water (M)														
		From Ground water (X)														
		For Own use					80									
		For Delivery							83.4	79.7	3.7					
Within the Economy	**Total Supply of Water**		**174.1**[l]	**151**[k]	**389**[j]	**105**[i]	**80**[h]	**46**[g]	83.4[f]	**79.7**[e]	**3.7**[d]		**264.1**[c]	**3,301**[b]		**4,594**
	Water Supplied to users								83.4	79.7	3.7		264.1			348
S2	Recycled Water															
	Waste water to Sewerage															
To the Environment																
S3	Total residuals															
	Waste water															
	Returns from Irrigation			151												
	Water supply for HEP Generation						80									
	Leakages															
	Other returns to the environment					105										
	To the Sea															
Consumption																**4,174**
Total Supply			**174.1**	**151**	**389**	**105**	**80**	**46**	**83.4**	**79.7**	**3.7**		**264.1**	**3,301**	**43,201**	**43,201**

[2] See Appendix 1 for explanatory notes on the data sources and table presentation.

Table 3: Water Use Table (Millions of Cubic Meters)[3]

			Agriculture				Energy	Industry	DWR (Total)			Govt	Hholds	RoW	Total Use
			Livestock	Irrigation	Crops	Fisheries				NWSC	STWSP				
	Total Abstractions														
From the environment	**From Surface water (internal)**		**174**	**151**		**105**	**80**	46	83.4	79.7	3.7		181.9		**821**
U1	From Ground water (internal)				**389**								82.10[b]		82.1
	RoW (X-M)													**3,301**	**3,301**
		From Surface water (M)												8,700	8,700
		From Surface water (X)												12,001	12,001
		From Ground water (M)													
		From Ground water (X)													
		For Own use					80								
		For Delivery													
Within Economy	**Total Use of Water**		**174**	**151**	**389**	**105**	**80**	**46**	**83.4**	**79.7**	**3.7**		**264.1[a]**	**3,301**	**4,594**
	Water Supplied to users									79.7	3.7		264.1		348
U2	Recycled Water														
	Waste water to Sewerage														
To the Environment															
U3	Total residuals														
	Waste water														
	Returns from Irrigation														
	Water used for HEP Generation														
	Leakages														
	Other returns to the environment														
	To the Sea														
Consumption															**4,174**
Total Use			**174**	**151**	**389**	**105**	**80**	**46**	**83.4**	**79.7**	**3.7**		**264.1**	**3,301**	**4,594**

3 See Appendix 1 for explanatory notes on the data sources and table presentation.

Table 4: Water Flow Matrix within the Economy (Millions of Cubic Meters)

Origin	Destination	From Surface water (internal)	From Ground water (internal)	From Other water(Rain Harvesting)	RoW (in Transfers)	From Surface water (X)	From Ground water (M)	From Ground water (X)	For Own use	For Delivery	Agriculture				**Energy**	**Industry**	**DWR (Total)**			**Govt**	**Hholds**	**RoW**	**Consumption**	**Total supply**
					From Surface water (M)						Livestock	Irrigation	Crops	Fisheries		Industry	DWR (total)	**NWSC**	**STWSP**					
From Surface water (internal)											174	151		105	80		83.4	79.7			144.5			13,000
From Ground water (internal)													389						3.7		82			9,500
	RoW (X-M)																					3301		3,301
RoW (in Transfers)	From Surface water (M)																							8,700
	From Surface water (X)																							12,001
	From Ground water (M)																							
	From Ground water (X)																							
	For Own use														80									
	For Delivery																							
Agriculture	Livestock																							
	Irrigation																							
	Crops																							
	Fisheries																							
Energy																								
Industrial																								
DWR																								
	NWSC															46					33.70			80
	STWSP																				3.7			3.7
Govt																								
Hholds																								
RoW																						3,301		
Consumption																							**4,174**	**4,174**
Total Supply																								**43,201**
Total Use of Water		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**174**	**151**	**389**	**105**	**80**	**46**	**83.4**	**79.7**	**3.7**	**0**	**264**	**3,301**		**4,594**
Surplus																								**38,524**

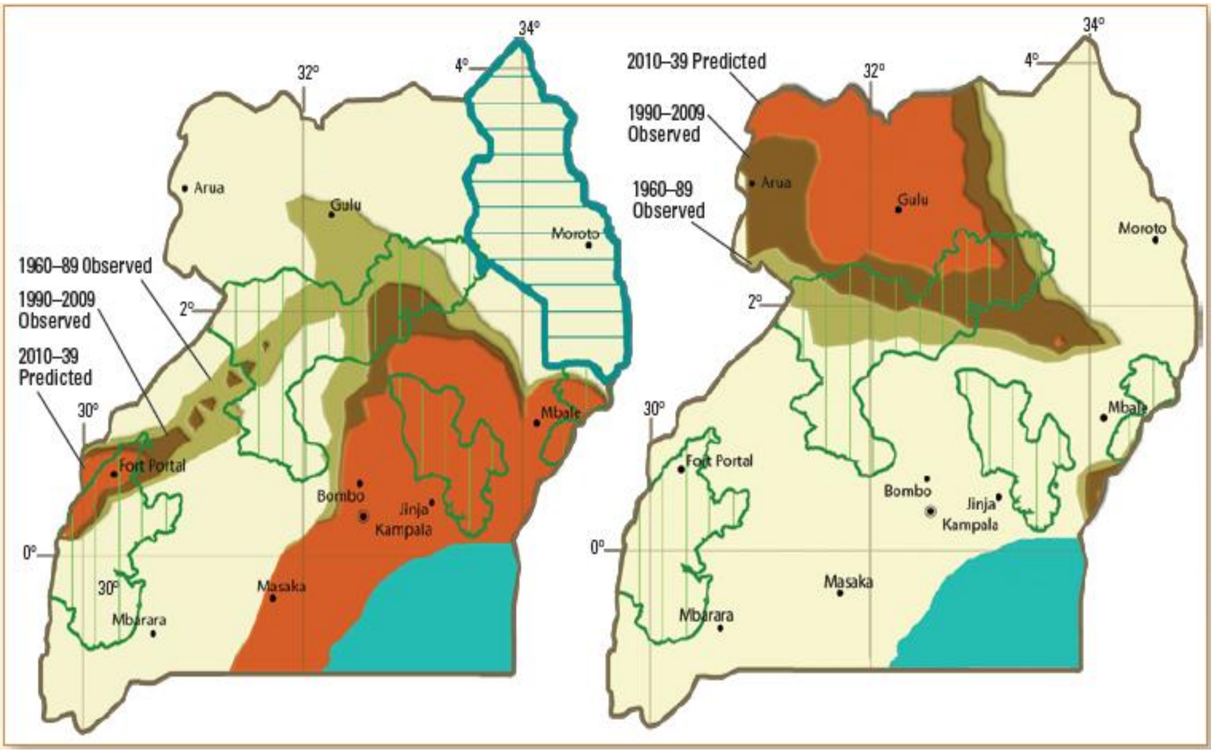
Appendix

Appendix 1: Notes on Table 2: The supply table

From Surface water (M): Imports of surface water.
From Surface water (X): Exports of surface water.
From Ground water (M): Import of ground water.
From Ground water (X): Export of ground water.
RoW (in Transfers): Water supply to and from the rest of the World.
Water supply for HEP Generation: Water supplied to Hydro-electricity generation.
DWR: Water under jurisdiction of the Directorate of Water Resources. Both commercial and non commercial supply.
NWSC (National Water and Sewerage Corporation): This is commercially supplied water by The National Water and Sewerage Corporation.
STWSP (Small Towns Water and Sanitation Programme): This is commercial water supplied in other smaller urban centres in the country outside the NWSC supply territory by the Directorate of Water Development (MWE) .
S1, S2, S3: These are the sources water supply.
a) Source (DWRM, 2011), National Water Resources Assessment Draft Report. This value is given as a lump sum volume. The disaggregating by source was done using the FAO (2013) AQUASTAT Database base. The values by source from FAO (2013) scaled down to yield the lump sum total supply volume provided the MWE (2011) study.
b) RoW is given by (X-M) of Surface water flows.
e) Commercial water supply data from National Water and Sewerage Corporation (2011).
d) Data from the Small Towns Water and Sanitation Programme under the Department of Water Development Ministry of Water and Environment (2011).
c) Source (Government of Uganda. Ministry of Water and Environment, Department of Water Resources Management (2011) Report page 14).
f) This is a sum of commercially distributed water by the NWSC and the SWSP.
g) Food and Agriculture Organization of the United Nations. (2005)Global Information System on Water and Agriculture [Online] Available from: http://www.fao.org/nr/aquastat/ [Accessed: 22nd Feb 2013 at 08:07 CET].
h) Food and Agriculture Organization of the United Nations. (2005)Global Information System on Water and Agriculture [Online] Available from: http://www.fao.org/nr/aquastat/ [Accessed: 22nd Feb 2013 at 08:07 CET].
i) Ministry of Water and Environment (2009): Sector Investment Report -Table 1-1 (2015 projections were taken), Page 3.
j) Ministry of Water and Environment. (2009): Sector Investment Report -Table 1-1 (2015 projections were taken), Page 3.
k) Government of Uganda. (2006) National Water Development Report Table 7.1, Page 118.
l) DWRM (2006) National Water Development Report-Table 7.2 (2015 projections were taken), Page 121
m) Water used for irrigation and, crops as well as one used for electricity generation is taken as water returned to the environment.

Notes on Table 3: The Use table
From Surface water (M): Imports of surface water.
From Surface water (X): Exports of surface water.
From Ground water (M): Import of ground water.
From Ground water (X): Export of ground water.
RoW (in Transfers): Water use by and from the rest of the World.
Water used for HEP Generation: Water used for Hydro-electricity generation.
DWR: Total Distributed water both for NWSC and the Small Towns Water and Sanitation Programme.
NWSC (National Water and Sewerage Corporation): This is commercially supplied water by The National Water and Sewerage Corporation.
STWSP (Small Towns Water and Sanitation Programme): This is commercial water supplied in other smaller urban centres in the country outside the NWSC supply territory.
U1, U2, U3: These are the uses of water supply.
a) Total = surface water (90%) and Ground Water (10%) based on the design consumption rates in Table 4.8 (Government of Uganda. Ministry of Water and Environment, Department of Water Resources Management (2011), National Water Resources Assessment Draft Report-page 96.
b) Government of Uganda. Ministry of Water and Environment, Department of Water Resources Management (2011), National Water Resources Assessment Draft Report-page 98.

Appendix 2: *Climate change in Uganda*



Notes: The left map shows the average location of the March–June 500 mm rainfall isohyets for 1960–1989 (light brown), 1990–2009 (dark brown), and 2010–2039 (predicted, orange). The green polygons in the foreground show the main maize surplus regions; these areas produce most of Uganda's maize. The blue polygon in the upper-right shows the Karamoja region. The right map shows analogous changes for the June–September 500 mm rainfall isohyets.

Source: FEWSNET (2012).