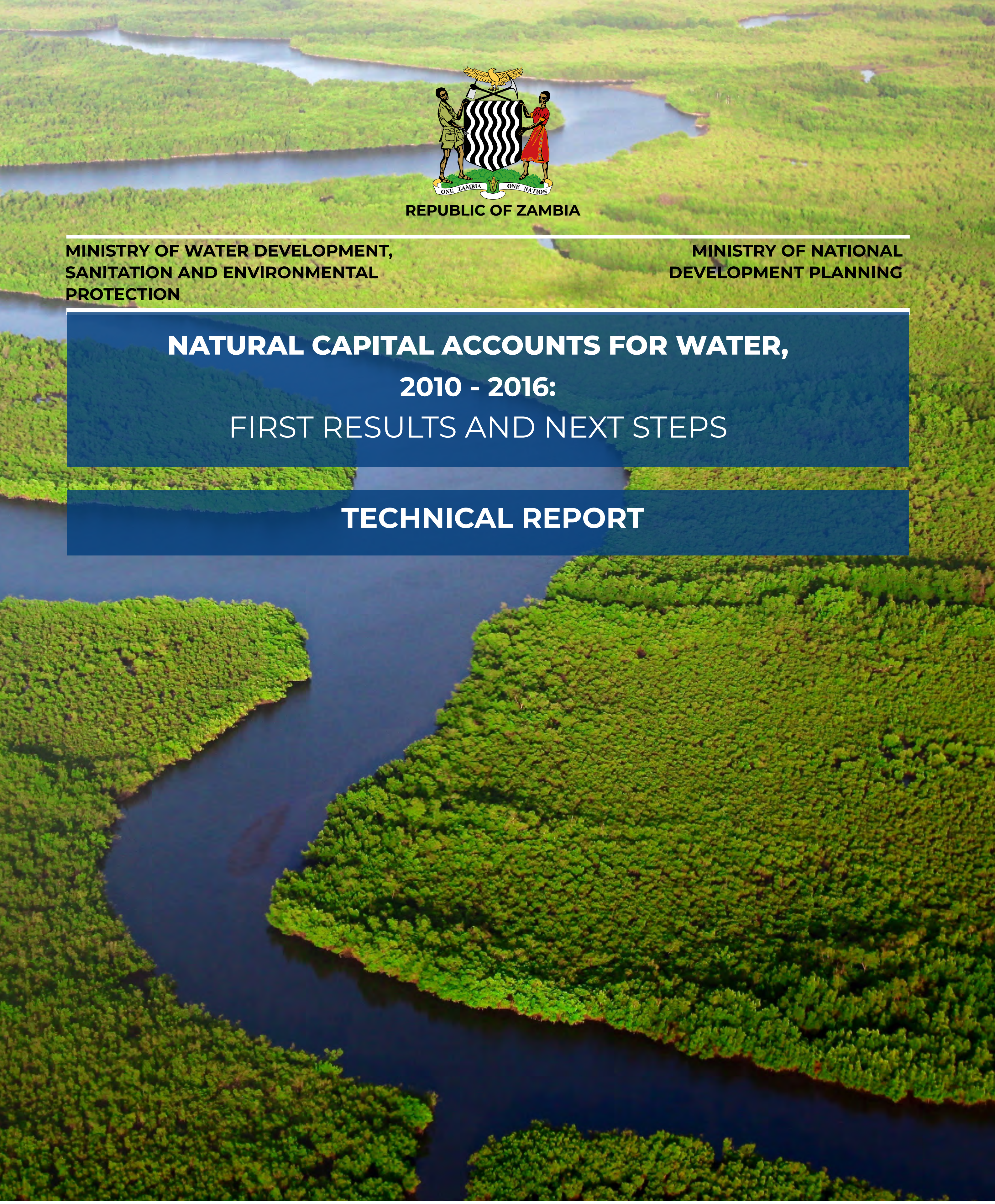

REPUBLIC OF ZAMBIA

MINISTRY OF WATER DEVELOPMENT, SANITATION AND ENVIRONMENTAL PROTECTION

MINISTRY OF NATIONAL DEVELOPMENT PLANNING

NATURAL CAPITAL ACCOUNTS FOR WATER, 2010 - 2016: FIRST RESULTS AND NEXT STEPS

TECHNICAL REPORT

WORLD BANK GROUP

WAVES

The Zambia Natural Capital Accounts for Water, covering the period 2010 – 2016 were produced by the Ministry of Water Development, Sanitation & Environmental Protection (MWDSEP) in collaboration with the Zambia Statistical Agency and the Ministry of National Development Planning (MNDP) with financial and technical assistance from the World Bank and the WAVES Global Partnership. Further information on the Water Accounts may be obtained from the addresses below:

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1 *Zambia Statistical Agency (ZamStats) formerly known as Central Statistical Office*

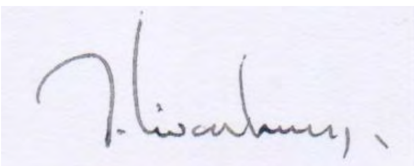
Foreword

The Water Sector is increasingly being called upon to rise to the occasion of the many developmental opportunities and challenges that are presented before Zambia in her quest to become a prosperous middle-income country by 2030. This is arising from recognition of water as a key enabler of socio-economic development through direct job creation and other economic opportunities in water resources development sectors such as agriculture, hydropower generation, tourism, construction and manufacturing, etc.; and improving human wellbeing through access to adequate water supply and sanitation.

Therefore, the importance to sustainably manage, develop and utilize water as a finite resource cannot be over-emphasized. This is particularly important given the impacts of climate change and other development-induced pressures on the resource in Zambia.

It is gratifying to note that Zambia joined the global coalition on Natural Capital accounting viz-a-viz the Wealth Accounting and Valuation of Ecosystem Services global programme (WAVES) led by the World Bank. This effort has resulted in the development of the first ever water accounts for Zambia following the System of Economic Environmental Accounting (SEEA) for Water. The water accounts are a step in the right direction of sustainable water resource development and utilization for Zambia. This is because the accounts help to highlight the interaction between water resources and the economy and how effectively and efficiently water resources are utilized within the economy. In this way, it is possible to formulate policy interventions that seek to maximize the benefits from water resources development and utilization for the Zambian economic and social development agenda whilst ensuring water resource sustainability, preservation and protection.

The focus of this report is on the supply and use of water resources from the environment into and within the Zambian economy and back to the environment for the period 2010 to 2016. The main policy issues highlighted include: the sensitivity of water dependent economic sectors such as agriculture and hydro power production to the effects of climate change; the under development of irrigated agriculture; the problem of non-revenue water; and the trend of increasing own water supply as opposed to dependence on service from the water utilities. These are issues which will attract policy focus in the foreseeable future until they are adequately dealt with; and the water accounts will expand and be institutionalized to form an important policy tool for the country.



Dr. Dennis M. Wanchinga, MP.
Minister of Water Development, Sanitation and Environmental Protection

Hon Alexander Chiteme, M.P.
Minister National Development Planning

We cannot emphasize enough the relevance of Natural Capital Accounts (NCA) for the Republic of Zambia. Natural capital forms a large share of Zambia's wealth and is integral to its national development. The sustainable management of these natural resources is vital and keeping track of changes over time is imperative.

Zambia's Vision 2030 and Seventh National Development Plan (7NDP) express both an aspiration to live in a prosperous, sustainable middle-income economy with opportunities for all. This cannot be achieved without the use of NCA which provides detailed statistics on to inform and improve the management of the resources.

Prioritizing Natural Capital Accounting to contribute to economic development is not an easy task. Zambia has selected forest, land and water as priority sectors in the initial stages of development and management of its NCA with the Forest and Water Accounts ready to be launched. We commend the Government of the Republic of Zambia for the substantial progress made.

These three accounts have played and continue to play a key role in providing the data needed for informed decision-making in key sectors of Zambia's economy.

Since its inception in 2017, the WAVES program has provided technical support to the Government through its Ministry of National Development Planning (MNDP). This support focused on mainstreaming NCA into national development and extended to training and capacity building for focal points in key ministries.

Once the first three initial NCA are successfully completed, the WAVES program will build on the results and develop new accounts that will further inform policy and decision-making.

Various studies have shown that Zambia has an abundance of natural resources, but their potential remains underutilized, and in some cases unsustainably used. The continuous development of NCA will give impetus to Zambia to drive and promote sustainable development and shared prosperity.

The World Bank continues to be committed to working with the Government of Zambia to ensure that the information from these accounts provides a strong basis for an optimal management of the natural resources.

We recognize the tremendous efforts of the Ministry of Lands and Natural Resources, Ministry of Water Development, Sanitation and Environmental Protection (MWDSEP) in collaboration with the Zambia Statistical Agency (ZamStats) and the Ministry of National Development Planning (MNDP) and their focal points who continue to build and manage NCA for sustained growth but also for resilient ecosystems and livelihoods.

Iain G. Shuker

Practice Manager for Environment & Natural Resources

The World Bank Group

Acknowledgments

The work presented in this report would not have been possible without the dedicated effort of the Zambia WAVES Water Technical Working group led by Eng.Dr. Mkhuzo Chongo, and the following members: Stanley Hantambo; Buchizya Soko; Nkandu Kabibwa; Mwenya Mulindwa; Melvin Sikazwe, and Winford Sikapula. In addition, the support rendered to the Technical Working Group by the Director of Water Resources Development Eng. Kenneth Nyundu and the Director of Planning and Information, Mr. Tobias Musonda is also acknowledged.

Special mention is made of the Ministry of National Development Planning, led by Permanent Secretary-Mr Chola Chabala, Director of Development Planning, Mr Maketo Mulele, and Richard Lungu (Zambia WAVES National Focal Person) from the Ministry of National Development Planning for their strategic oversight and coordination of the various activities that made it possible to develop the Water account, produce and launch this report.

Appreciation is also given to the Zambia WAVES (ZWAVES) project task team at the World Bank who supported the water account activities. The ZWAVES team includes: Iretomiwa Olatunji; Sofia Ahlroth; Michael Verdon; Juan - Pablo Castaneda; Prof. Lloyd Chinga'mbo; Rebbeca Naomi Munsanda Ngulube; Mercy Mwanje Soko; and Raffaello Cervigni. Others were Sonu Jain, Rosina Mbewe, Christabel Mutale and Ben Makayi from the Ministry of Higher Education.

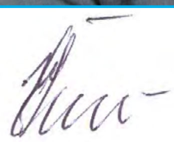
We acknowledge the following stakeholder institutions for the data that they provided to inform this report: These comprised the National Water Supply and Sanitation Council (NWASCO); The Water Resources Management Authority (WARMA); The Zambia Electricity Supply Corporation (ZESCO); Lunsemfwa Hydro Power Company; The Ministry of Agriculture; The Ministry of Livestock and Fisheries, The Zambia Statistical Agency and the Zambezi River Authority to mention but a few.

The team greatly acknowledges the reviewers from the World Bank; Sofia Ahlroth, Michael Vardon, Juan-Pablo Castaneda, and the international reviewers, Steve May (Australian Bureau of Statistics), François Soulard (Statistics Canada) and Cor Graveland (Statistics Netherlands) and feedback received from various local experts and stakeholder institutions that helped to shape the report.

We would also like to acknowledge the European Commission, the Netherlands Ministry of Foreign Affairs and United Kingdom Department for International Development, as donors to the project.

Mr Mabvuto Sakala

Permanent Secretary Water Development, Sanitation and Environmental Protection



Mr Chola Chabala

Permanent Secretary - Ministry of National Development Planning

Executive summary

This report represents the first ever attempt at producing water accounts for the Republic of Zambia, following the System of Environmental Economic Accounting. Water accounts consisting of physical and monetary supply and use tables covering the period 2010 to 2016 were produced. The Water Accounts produced came as the result of the World Bank supporting Zambia via the Wealth Accounting and Valuation of Ecosystem Services (WAVES). The report is a culmination of efforts by many people and agencies, and also took into account stakeholder reviews.

The first results for the Water Accounts for Zambia reveal that significant amounts of water are unaccounted for, given the amount of water that was withdrawn from rivers and aquifers by water utility companies. The first results suggest that a very high portion of water supply in Zambia is going to waste without being accounted for. Also, the results show that households consumed more water obtained from their own private sources, such as boreholes and shallow wells, than from water utility companies. Nevertheless, the amount of water supplied to households by water utility companies was still greater than the supply of water to industry by the water utility companies. However, the revenue from water supply was greater from industry than from households.

Commercial farmers used very little water from the water utility companies and instead relied upon their own abstractions from surface water and groundwater. The highest use of water was found to be hydropower generation, followed by rain fed agriculture. However, the use of water by the energy industry was almost all for hydro power, and hence non-consumptive. This means that the water was available for use by others immediately after use for hydro power.

There are several potential action points arising from the findings of the Water Accounts. In particular, findings have highlighted the need for enhancing water management and development aimed at balancing socio-economic development, improving livelihoods and protecting the environment, as outlined in the Seventh National Development Plan. Improving water related information sources would thus be needed so that decisions about the development of water resource infrastructure (e.g. constructing dams, inter basin water transfer schemes and well field development) can be fully assessed from economic, environmental and social perspectives. In the long run, this will ensure water security and availability for all in Zambia through increased national water availability. Finally, the Water Accounts can also help to more effectively utilize water policy instruments such as water pricing, polluter pays-based taxes or fees, or subsidies for those investing in infrastructure that would reduce water consumption or lead to sustainable utilization of the water resources in Zambia.

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1 Introduction

1 Introduction

Wealth Accounting and Valuation of Ecosystem Services (WAVES) is a global partnership that uses natural capital accounting to mainstream natural capital considerations into economic policy. Natural capital accounting helps to underscore the contribution of natural resources to the environment as well as highlight the impact of the economy on the environment. It is for this reason that the Government of the Republic of Zambia became part of the global WAVES program supported by the World Bank.

This document is a technical report for the Water Accounts for Zambia covering the period 2010 to 2016, and follows extensive work by the Technical Working Group (TWG) on Water Accounts, the World Bank Task Team and consultants on natural capital accounting. This report is the first official Water Accounts for Zambia. It serves as a starting point, proving that water accounts can be produced for the nation but also recognizing that NCA water accounts can be improved, expanded and institutionalized to address key policy issues in Zambia. The report has taken into account, to the extent possible, stakeholder reviews.

It is hoped that the Water Accounts will prompt discussion and action leading to improved coverage, data sources and methods and also lead to applications of the accounts within government. The full spectrum of water accounting is very broad, covering physical supply and use, water pollution accounts, water asset accounts and a range of monetary accounts. However, this report focuses on the flow accounts, including physical and monetary supply and use accounts for 2010 to 2016. The development of water pollution accounts and water asset accounts has been scheduled for the next iteration of the Water Accounts in Zambia.

Basic economic, environmental and social information about Zambia is found in Box 1. This information is to place the report into a national context. Some of this information is also important for the derivation of indicators, for example, per capita water use and productivity of water use as measured by GDP per m^3 of water used.

Box 1. Information on Zambia

The Republic of Zambia is located in southern Africa. The country has an area of 752, 610 km^2, with 32% of this agricultural land and 65% forested area (FAO country databases). In 2017 Zambia had a population of 17.1 million (ZamStats 2018) and approximately 57% of the population lived below the poverty line (World Bank 2019). Gross Domestic Product (GDP) was USD$25.868 billion (current price) in 2017, with an average annual growth rate of 3.4% (World Bank database) while GDP per capita was USD$3,652 in 2016 (FAO country database). Mining contributes 14.8% to GDP while agriculture contributes 7.2% (ZamStats national accounts). The development aspirations, opportunities and challenges of the country are outlined in 7th National Development Plan 2017-2021 (Ministry of National Development and Planning 2017).

This report has six sections: the Introduction (Section 1); Main findings (Section 2); Concepts, data sources and methods (Section 3); Next steps (Section 4), and References (Section 5). The report also has an Annex containing the diagrams and tables showing the physical and monetary supply and use of water in Zambia for 2010 to 2016. Section 2 outlines the main findings which mostly outline the impressions and policy issues derived from the Water Accounts. The sources of data that were used to compile the Water Accounts, approaches, and assumptions used to make estimates for missing data are elaborated in Section 3. A brief narrative on the concepts for compiling the water accounts following the System of Environmental Economic Accounting (SEEA) Central Framework (UN, 2014) and SEEA Water (UN, 2014) are also in the 3rd section. Section 4 outlines the next steps for the continued development and application of Water Accounts in Zambia.

1.1 Process

The Water Accounts were developed between May 2017 and March 2019. The process included the following steps:

i. Establishment of the Technical Working Group on Water Accounts under Zambia WAVES;
ii. Draft accounts were produced and circulated within government for comments; and
iii. Reviewed by international water accounting experts.

The ongoing development of Water Accounts and their relationship to other accounts being developed in Zambia is discussed in Section 4.

> **This report is the first official Water Accounts for Zambia. It serves as a starting point, proving that water accounts can be produced for the nation but also recognizing that they can be improved, expanded and institutionalized to address key policy issues in Zambia.**

2 Main findings

2.1 Trends in data and basic analysis

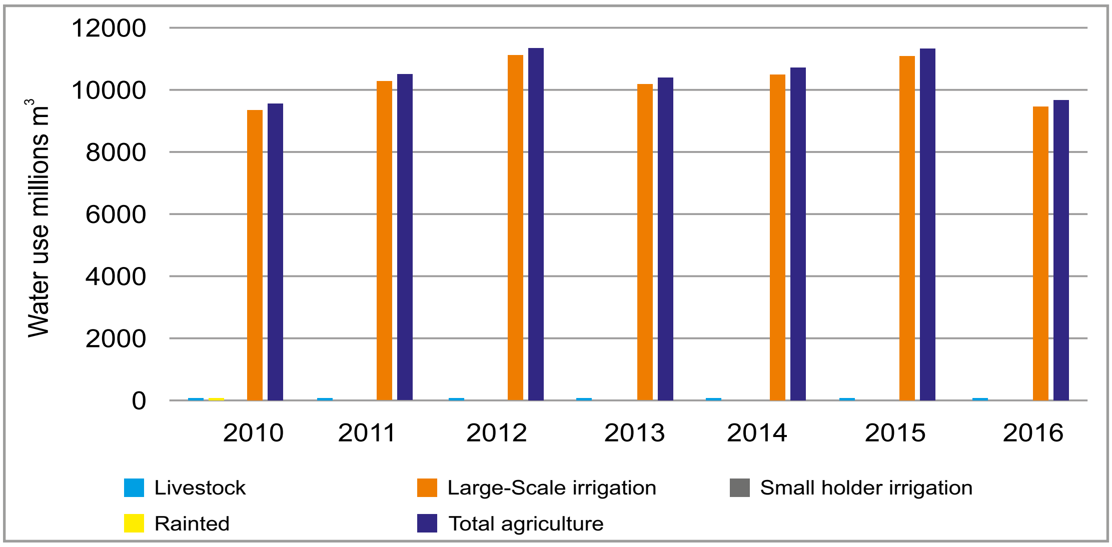
This section outlines the main trends identified in the accounts. This is done by industry and sector, beginning with agriculture followed by other industries (e.g. mining, energy, manufacturing) and the household sector. The information is drawn from the physical and monetary supply and use tables shown in the Annex (Tables 1-to 14).

2.1.1 Agricultural water use

Total agricultural water use comprised three main components, that is, large scale irrigation of agriculture, livestock watering and rain-fed agriculture. Rain-fed agriculture used by far the largest amount of water in the order of around 10,000 Mm^3/annum. Livestock uses around 120 Mm^3/ annum, and irrigation agriculture 50 Mm^3/ annum. The variation in water use by agriculture is shown in Figure 1.

Figure 1 shows a difference of about two orders of magnitude between rain-fed agriculture and irrigated agriculture, which highlights a policy issue that needs to be dealt with if government development objectives are to be met. The objectives include; diversification of the economy, job creating, poverty reduction and value addition for agricultural produce. The link to poverty is the fact that rain-fed agriculture is mostly associated with subsistence farming and low value crops, whereas irrigation is often tied to high value crops and commercial agriculture. The accounts clearly highlight the underdevelopment of irrigated agriculture, a situation which denotes loss of potential economic productivity and contribution to GDP from the agricultural sector. Therefore, an appropriate policy intervention would be to implement measures that promote irrigation development as a means to increase agricultural production and productivity in terms of area under cultivation for high value crops. Much of the drive for irrigation development will have to focus on development of water resources infrastructure to support irrigation; organizing and capacitating rural and urban communities into viable cooperatives capable of operating as commercial entities; developing and guaranteeing markets for agricultural produce from rural areas; and value chain addition for excess agricultural produce.

> **"The link to poverty is the fact that rain-fed agriculture is mostly associated with subsistence farming and low value crops, whereas irrigation is often tied to high value crops and commercial agriculture.**

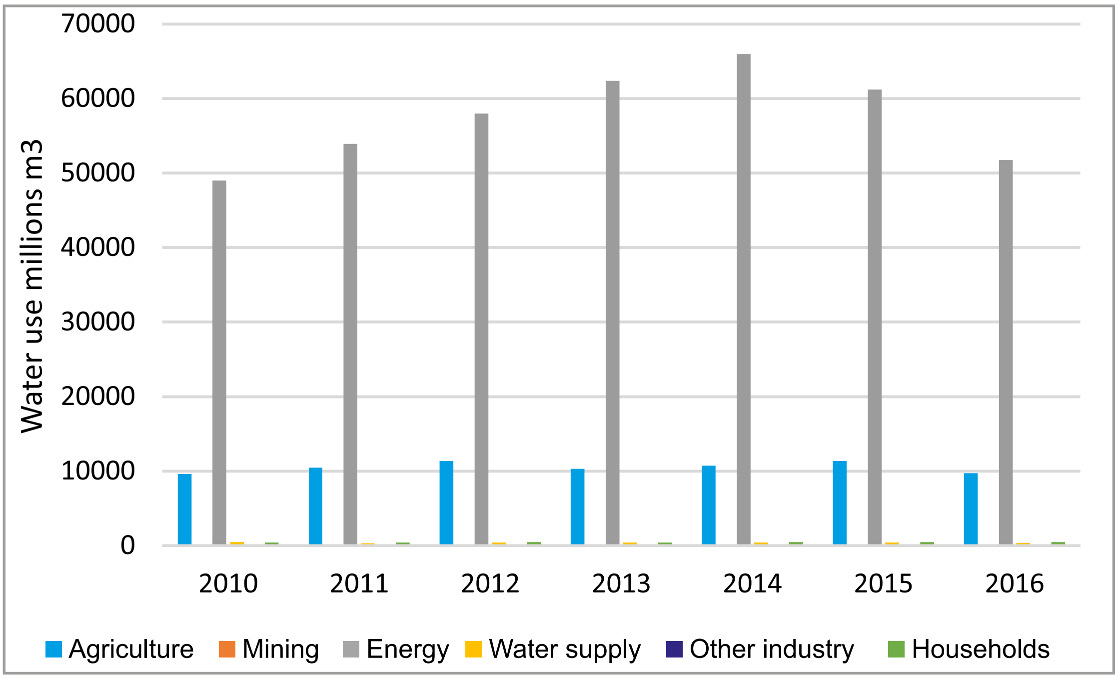


Source: *Physical supply and use tables, see Annex*

Figure 1: *Agricultural water use histogram.*

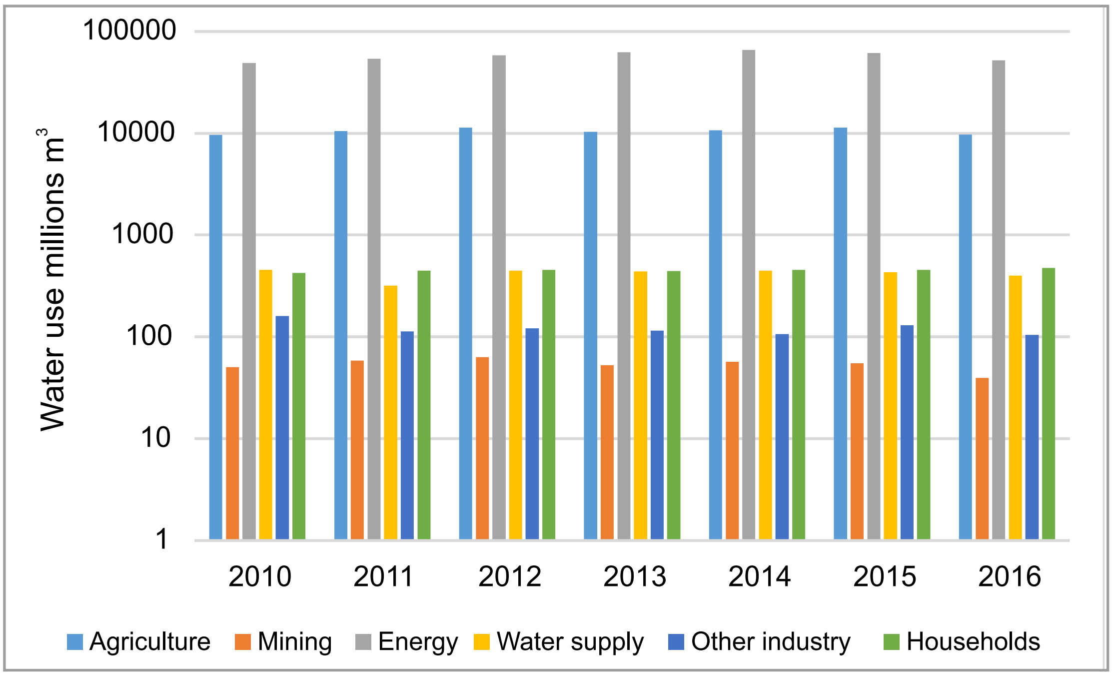
2.1.2 Industry and sector water use

From an industry perspective, the largest user of water is energy (for hydropower generation), followed by agriculture. The water use in the energy industry is non-consumptive and thus the water is available for further use after the generation of hydropower. The third largest use of water is the household sector, followed by all other industries, and mining the smallest user. Figure 2 below shows the industry and sector water use on a linear scale, whereas Figure 3 shows industry and sector water use on a logarithmic scale.



Source: *Physical supply and use tables, see Annex*

Figure 2: *Industry and sector water use histogram (Linear scale).*

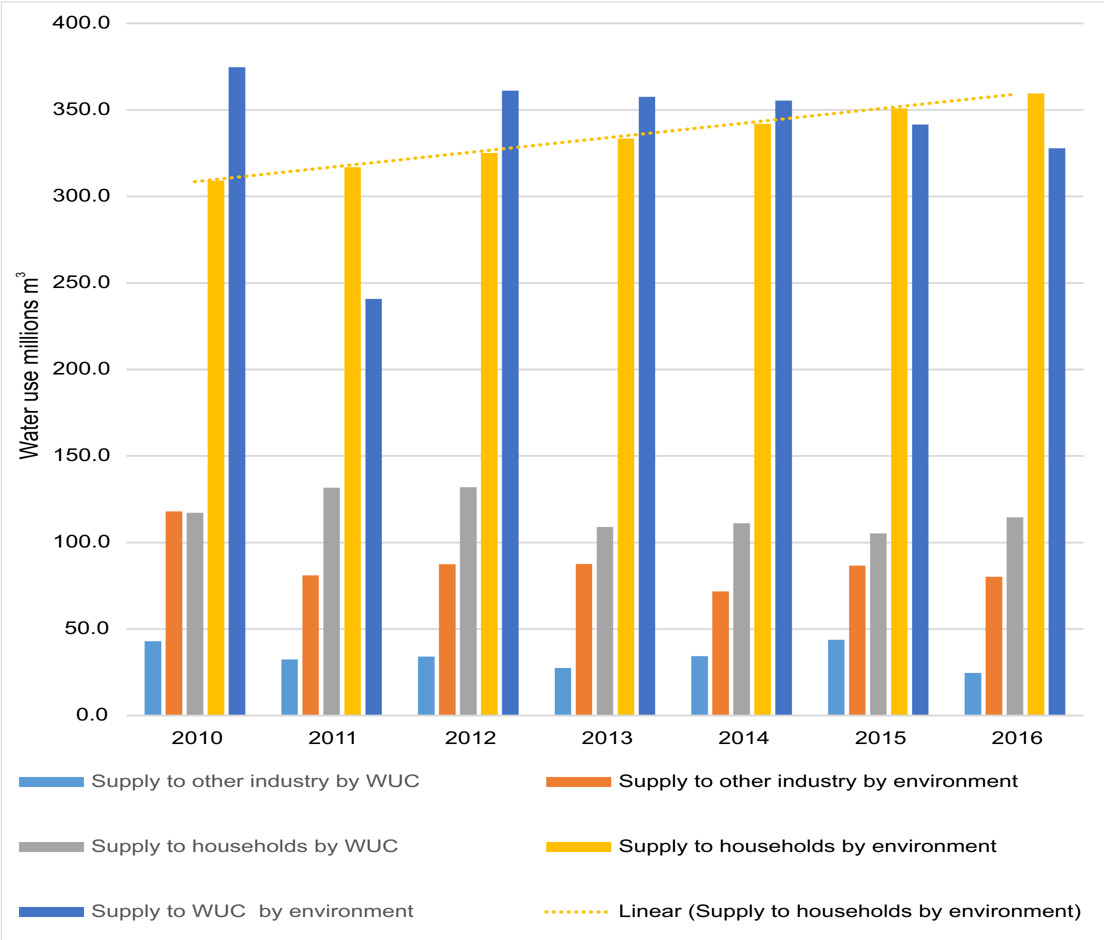


Source: *Physical supply and use tables, see Annex*

Figure 3: Industry and sector water use (Log scale).

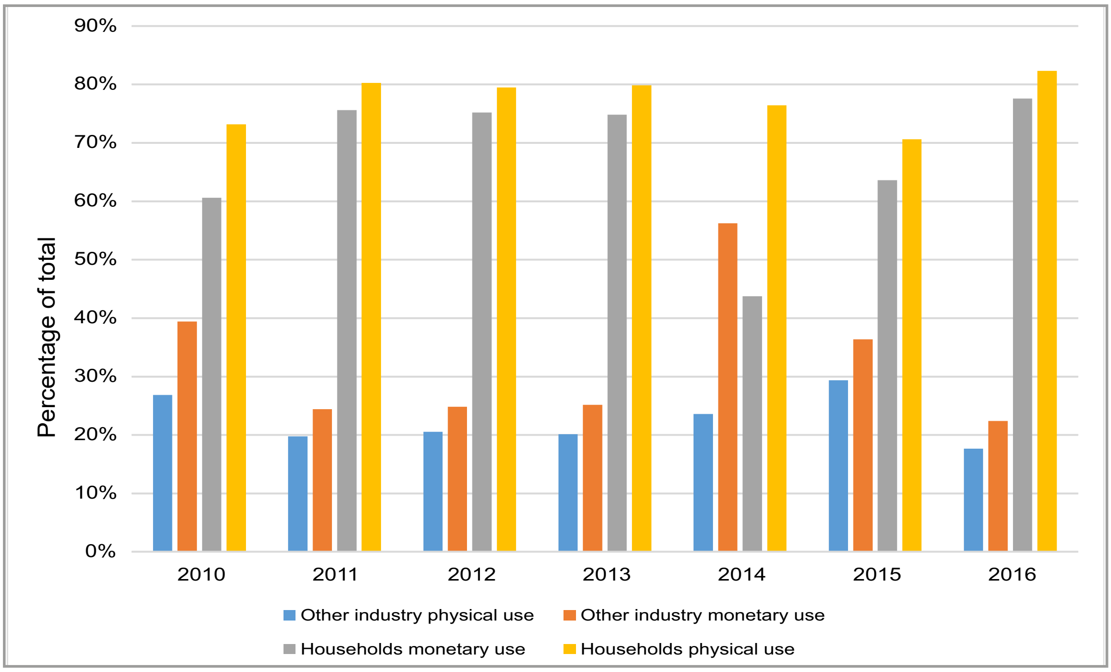
2.1.3 Household and other industry water use

Data on water use by households, other industry and water utility companies indicates that abstractions from the environment by water utility companies (WUC) have been declining, whereas abstractions from the environment by households have been increasing, as depicted by the trend line in Figure 4. The reasons for these changes are not known with certainty but are related to surface water availability (drought) and increases in population not connected to the water supply network. These households are increasingly depending more on their own sources of water supply which include boreholes and shallow wells as opposed to the supply from the water utility companies. This is an important policy issue because the Government needs to consider whether to encourage this trend to continue or not, considering the impacts on the environment, sustainability of the water utility companies and social aspects, including human health.



Source: *Physical and Monitory supply and use tables, see Annex*

Figure 4: *Household and other industry water use: supply by water utilities and environment*



Source: *Physical and monetary supply and use tables, see Annex*

Figure 5: *Comparison of physical and monetary water use, for water supplied by the water utilities corporations (WUC)*

Figure 5 compares the monetary and physical use of water supplied by the WUC. It shows a number of interesting features, including that other industries pay more for water than households. For example, in 2016, other industries used 18% of physical water supplied by WUCs while they paid 22% of money to WUCs for the use of this water. Between the period 2010 to 2016 the price difference for water supplied by WUCs to households and other industries has declined, with households now paying more than other industries in relative terms. It should also be noted that there is an anomaly in the 2014 monetary supply and use accounts that was unable to be resolved. In this the amount paid for water by households in 2014 apparently much less than in either the previous (2013) or subsequent years (2015 and 2016). As noted in, Section 3, the monetary data is indicative and should be interpreted with caution.

2.2 Possible applications of accounts

The global push for economic development, and its effects on climate change and variability, has brought with it increased pressure on water resources. Zambia has not been spared from these issues and is particularly disadvantaged due to an inadequate provision of basic services, largely as a result of limited infrastructure. There are also non-climate related issues such as the loss and degradation of freshwater ecosystems; pollution leading to contamination; and increased occurrence of waterborne diseases. Water management under such circumstances is very challenging and frequently risks being ineffective. This is because the traditional approach to handling data about water has exclusively focused on hydrology and water quality aspects without due regard to the economic and social aspects of water. The Water Accounts are particularly suited for dealing with the challenges of water management because of their ability to integrate both environmental and economic data with respect to water supply and use. The water accounts can be an effective tool for water management at various levels including national, catchment and basin levels. In this regard, some of the possible applications amenable to the water accounts include:

i. Determining water demand for livelihood, economic growth, patterns of domestic consumption, and international trade of water resources;
ii. Understanding the social and economic implications of water policy instruments like water pricing, abstraction permits, property rights and regulation. One example for Zambia in this regard would be evaluation of the impact of the recently introduced statutory instruments for groundwater regulations on agriculture and industry;
iii. Determining the specific contributions of economic activities to the various needs and pressures on water resources, such as pollution and over-abstraction, as well as the opportunities for reducing these pressures;
iv. Determining the impact from changes in the natural environment, including climate change on water resource availability in time and space and subsequently the uses in and impact on particular economic sectors;
v. Providing key input in evaluating the possible future water demands under alternative economic development scenarios and determining their sustainability;
vi. Understanding how changes in sector policies such as agricultural, energy, forestry, land, etc. can affect water resource utilization;
vii. Linking and enhancing with already existing initiatives such as the Integrated Water Resource Management Information System (IWRMIS) under the Water Resources Management Agency (WARMA) required for capturing and storing integrated information on environment, water and economic sectors.

   The database for this would need to be configured along the lines of the International Recommendations for Water Statistics (IRWS) (UN, 012a); and

viii. Visualizing the possible social and economic impacts of pricing reforms for water among others.

The main power of the water accounts lies in the furnishing of information on:

i. Indicators and descriptive statistics at the *macro* level that enable monitoring and evaluation. These indicators can serve the purpose of warning signs with respect to unsustainable and socially undesirable trends in water resource utilization and status at national level;
ii. Indicators and descriptive statistics at the *meso* level, i.e. by industry, such as agriculture, mining, energy, manufacturing industry, allowing cross-sectoral comparison. The same industry comparison for benchmark studies across countries;
iii. Detailed statistics for policy analysis which enable determination of the sources of pressure on water resources as well as the opportunities for mitigating against these pressures. Furthermore, the detailed statistics allow for the determination of the effect of economic instruments such as pricing to address the problem and associated possibility of solutions (UN, 2012b);
iv. The linkage of physical water resource use by sectors (in a PSUT), with the economic information from the National Accounts and the natural water resources available for the country in Water Asset tables. This allows us to derive integrated indicators, either from integrating physical flows, stocks and assets, or from integrating physical water flows with economic flows or transactions in the economy;
v. The range of flow and asset accounts allow us to inform investments and finance & funding on priorities for the country;
vi. Linkage between water accounts and other physical accounts (e.g. Forest and Land Accounts) and key water related ecosystem services that could possibly be monitored by ecosystem accounts;
vii. Input to setting water permit fees for groundwater abstraction.

Consideration for further analysis and application to policy of the water accounts would be most appropriate in the following areas:

i. Evaluating the current and future water demands for the country and determining the appropriate interventions or investments with respect to water security such as the required water storage or water transport;
ii. Evaluating the current and potential impact of current and projected economic growth on the water resources;
iii. Determining development options that maximize economic benefits while ensuring sustainable water resource utilization;
iv. Monitoring and evaluation of the impact of water pricing and regulatory instruments in the water supply and sanitation, and water resources subsectors.

> **"The Water Accounts is particularly suited for dealing with the challenges of water management because of their ability to integrate both environmental and economic data with respect to water supply and use.**

3 Concepts, data sources and methods

3.1 Concepts for the Zambia Water Accounts

As mentioned above, the water accounts presented in the publication were compiled based on the SEEA (UN, 2014, 2012b). The tables presented are for the supply and use of water in both physical (m^3) and monetary terms (ZMW). The data used to populate the tables were drawn from a variety of sources to produce a consolidated water data set that can be linked to the System of National Accounts, which among other things produces the metric GDP (Gross Domestic Product).

The first version of the SEEA was published in 1993 and was made an international statistical standard in 2012. Environmental accounts extend the boundaries of the System of National Accounts to more fully include environmental resources and the economic activities that degrade the environment (e.g. pollution). The water supply and use tables also provide the means to link water information to other environmental data presented according to the SEEA (e.g. forest, land and energy accounts).

The physical and monetary water supply and use tables for Zambia have aggregated all available data on surface water, groundwater and rainwater collected in tanks for the years 2010 to 2016. The main data sources are listed in the references and additional detail is mentioned in the sub-sections that follow. Soil water use by agriculture is presented separately as there are no financial transactions associated with its abstraction. Supply may be by the environment to the economy, by one economic unit to another, and by the economy to the environment. In the accounts, supply and use are always balanced, and any gaps in the data will be captured in a balancing item. This helps to identify gaps in the underlying data and, in some cases, gaps in the recording of transactions in the economy.

The tables are intended to show the use of water by all industry and households located in Zambia. The data in the tables includes information on:

i. Individuals and companies that directly abstract water from surface water and groundwater sources for their own use (e.g. domestic, industrial, agricultural or other uses);
ii. Households, government and businesses that use water supplied by water and sewerage companies for domestic, industrial, agricultural or other uses;
iii. Water companies that abstract water from surface water or groundwater and supplies it to customers for use (e.g. domestic, industrial, agricultural or other uses);
iv. Companies that treat water (i.e. sewerage water); and
v. Other large abstracting and/or discharging water directly to the environment (e.g. hydropower stations, mines).

Calculating water use by industries is complex and involves a number of data sources and modelling that is described in more detail below. These accounts have been the first ever efforts made at this and feedback that would lead to improvement of this report would still be welcome and appreciated.

Water use is shown as water supplied directly from the environment (i.e. abstraction of surface and groundwater) and water supplied by economic units (i.e. water supply companies). Thus, total water use is the sum of the two. In some cases, and in particular for hydroelectric power generation, the water is not consumed and is available for use by others immediately after it is used.

3.2 Data Sources and Methods

3.2.1 Water Supply and Sanitation

Data on water supply and sanitation was obtained from the National Water Supply and Sanitation Council (NWASCO) through a questionnaire that was designed to capture the data in a format that was relevant to the Water Accounts. The data covers mostly urban areas serviced by the Water Utility Companies and does not include water supply and use in the rural areas. Estimates of water supply and use for rural areas are covered under Section 3.2.5.

3.2.2 Agriculture

Data on irrigation in terms of crops and area cultivated were obtained from the Ministry of Agriculture for the year 2013 only. Data for the other years was not available. Therefore, using the Food and Agricultural Organization (FAO) CropWat software (Clarke, 1998), water requirements for irrigation for 2013 were estimated for the driest growing period. The 2013 estimate was then used to estimate the crop water use for successive years based on the ratio of total water requirements to total agricultural production. It is acknowledged that 2013 may not adequately represent subsequent years. Data on agricultural production in terms of crops grown, yields and land area under cultivation are readily available on the Zambia Data Portal (http://zambia.opendataforafrica.org).

Similarly, water utilization by rainfed agriculture was estimated using the FAO CropWat Software and applied to the area under cultivation for each crop in the different provinces. Data on crops grown and area under cultivation were obtained from the Zambia Data Portal as mentioned above. The reference climatic conditions were for the Kabwe station and soils were assumed to be red loamy soils except for rice where the soils were assumed to be black clayey soils. Going forward, other sources of information on soil can be investigated (e.g. international soil databases)

3.2.3 Energy

The Zambezi River Authority (ZRA) provided data on the flows of water into and out of the Kariba dam complex on the Zambezi River covering the period 2010 to 2016. This was correlated with the power produced from the Kariba North Bank to derive a unit rate of water consumption per Gigawatt-hour (GWh) of energy produced. This was then applied to all the power produced in Zambia from all power stations to derive an average estimate indicative of national water use for energy production. It is acknowledged that this coefficient may not be appropriate for all hydro electricity producers, especially the newer hydro power stations. This is an area for future research. Data on energy production for the period 2010 – 2016 was derived from the respective Energy Sector reports produced by the Energy Regulation Board (ERB, 2016, 2015).

This method only gives an order of magnitude estimate of the water use for hydropower generation. A more accurate approach would have been to make a similar estimate for each power station and then aggregate for the national estimate. This is important as hydro power was the single biggest user of water in Zambia. However, there were challenges in acquiring water use data for each and every hydro power station in Zambia. Going forward, it is hoped that a water statistics database for Zambia can be developed with the associated data collection and input provisions to maintain up to date. These data considerations and the need for a water statistics database hold true for the data requirements of the other sectors as well.

3.2.4 Mining

Water abstraction from the environment by the mining industry was estimated by assuming that 20 % of the bulk volume of total rock extracted was void space. The total rock volume comprised the volume of waste rock plus the volume of the mineral ores. The 20 % of bulk volume is the rule of thumb for porosity of earth materials in the absence of actual physical measurement and can generally be satisfactorily used for modelling or estimation processes, as in the present case. In order to estimate the amount of water use by the mining industry, the upper limit of what is physically possible was assumed. In simplified terms, groundwater can only occupy the space available as porosity or void space, such that the maximum possible amount of groundwater that needs to be removed for mining purposes is typically less than or equal to the volume of water contained in the pore spaces.

Data on ore volumes mined for the largest mines in Zambia was obtained from the Zambia Statistical Agency (ZamStats) and the website for the Extractive Industry Transparency Initiative (https://eiti.org). Again as with the data estimates for the energy sector, this approach only provide an order of magnitude estimate of the water use by the mining sector. Challenges in data collection from the mines made it difficult to determine water use on a mine by mine basis.

3.2.5 Households and Other Industry

Water supply and use for households from sources other than the Water Utility Companies was estimated based on data in the ZamStats Living Conditions Monitoring Survey (LCMS) report for 2015 (ZamStats, 2016) and projected or discounted for the other years from 2010 to 2016 based on the rate of population growth (ZamStats, 2012, 2003). Furthermore, water supply and use for Other Industry (which excludes agriculture, mining and energy) was estimated by applying the ratio between household supply and industry supply from water utility companies to the water use by households from other sources for each of the respective years.

3.2.6 Monetary Estimates

The monetary estimates were based on the application of a tariff to the physical quantities of flows between the various sectors. The applicable tariffs were broadly split in two categories: raw water tariffs, and water supply & sewerage tariffs. There are separate tariffs for water supply and sewerage services. The raw water tariff was a flat rate tariff based on the old regime of water uses charges which was pegged at ZMW 0.55/m^3 of raw water usage for the review period. However, it is important to note that there is currently new regulations on pricing of raw water which were developed by WARMA (GRZ, 2018). These new regulations became effective on 7th March 2018 and were thus not applicable to the period under review. The water supply and sewerage tariff was a national average tariff for each year based on the approved tariffs by NWASCO covering the review period (NWASCO, 2012; 2014; 2016; 2017). As such, the monetary estimates are indicative and should be interpreted with caution.

3.3 Data quality and data gaps

The water accounts presented in this report were based on available data, which are unfortunately incomplete with respect to the requirement for building a full set of Water Accounts. The ideal situation would have been to obtain direct water usage data from each sector; better still, there should have had been a system in place that compelled entities from all sectors to report their water sources and uses into a central repository configured along the lines of the International Recommendations for Water Statistics (UN, 2012a). However, the kind of data required was only available from the water utility companies through NWASCO. Therefore, estimates of water supply and use for the other sectors were mostly based on estimates derived from secondary data such as national patterns on water use as derived from the ZamStats and other sources. In addition, modelling approaches such as the estimation of soil water use using the FAO irrigation modelling tool CropWat were also utilized. These approaches of data estimation were considered the best option available at the time of compiling the water accounts, given the general lack of water statistics for Zambia.

4 Next steps

4 Next steps

Going forward the need for an integrated database on water statistics for Zambia must be emphasized. This means that additional work on water statistics needs to be undertaken to look specifically into the data requirements for the regular production of Water Accounts for Zambia. This could be based on the International Recommendations on Water Statistics. Additional work would include:

i. Developing a data collection strategy encompassing determination of needs, stakeholder and institutional arrangements, review of existing water statistics, prioritization of data elements, and definition of roles and responsibilities;

ii. Designing survey methods and collecting data on household, agricultural and industrial water use. Further disaggregation of industrial water use would be a very useful aspect of this. Other data that would also need to be collected includes administrative data from government and non-governmental organizations, hydrological and meteorological data, and any other useful data as determined in the data collection strategy;

iii. Setting up measures for data quality control and systematic documentation of information about the data; and

iv. Development of an approach to data dissemination focusing on information products, monitoring of the use of water statistics, and national and international data reporting (UN, 2012a).

Additional work envisaged for improving and institutionalizing water accounting in Zambia includes:

i. Producing physical supply and use tables for 2017;

ii. Producing monetary supply and use tables for 2017. The ability to produce this depends on the information available and the development of suitable methodologies;

iii. Developing a physical water asset account;

iv. Investigating the production of subnational water accounts;

v. Applying the Water Accounts to policy issues and decision-making processes in Zambia. This would include using the information from the Water Accounts for:

- Economic modelling to inform decisions such as what would be the economic costs and benefits of extending the water supply and sewerage networks.
- Understanding the links between water and tourism activity and in particular iconic sites such as the World Heritage listed site of Victoria Falls, Ramsar Wetlands and wildlife tourism (noting that 8% of water in Botswana was used by wildlife. See Vardon et al. 2018); and

vi. Sharing the experience of accounts development and use in Zambia with the international community and working to the establishment of a regional community of practice with other nations working towards or producing water accounts (e.g. Botswana, Madagascar, Rwanda, and Uganda).

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ANNEX: DIAGRAMS OF PHYSICAL FLOWS AND PHYSICAL AND MONETARY SUPPLY AND USE TABLES

Figure 6: PSUT diagram for 2010

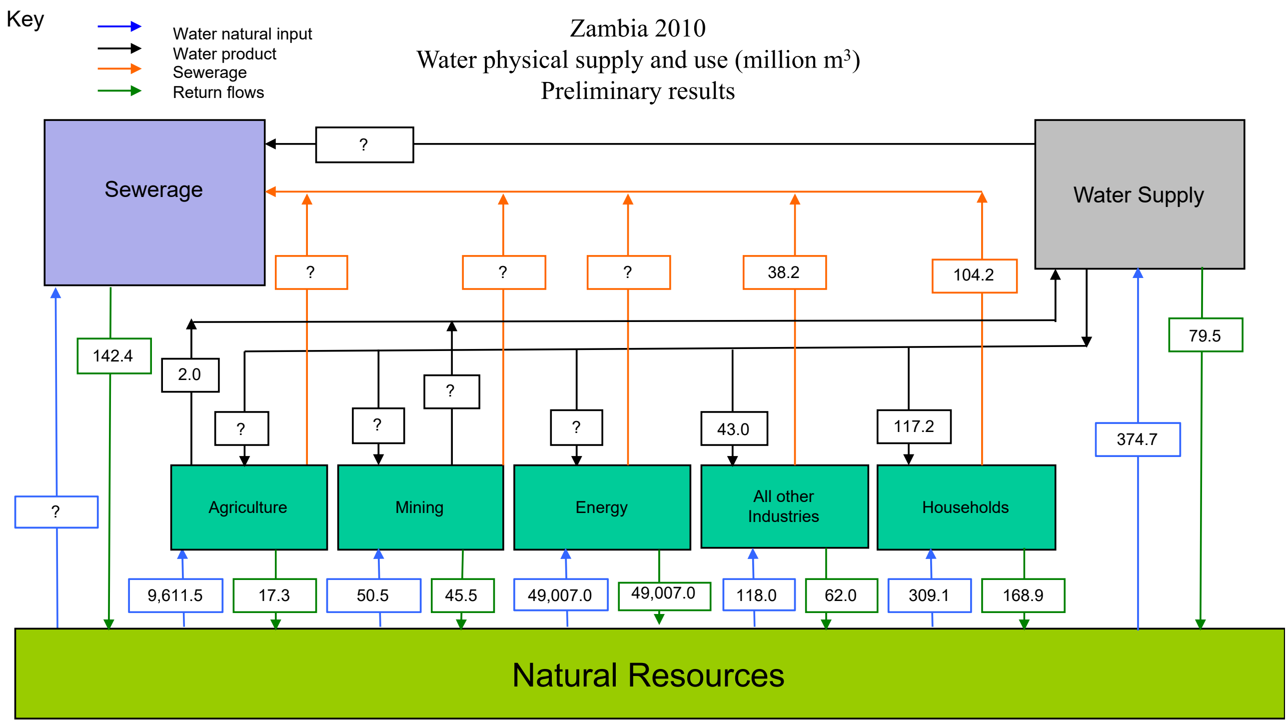

Figure 7: PSUT diagram for 2011

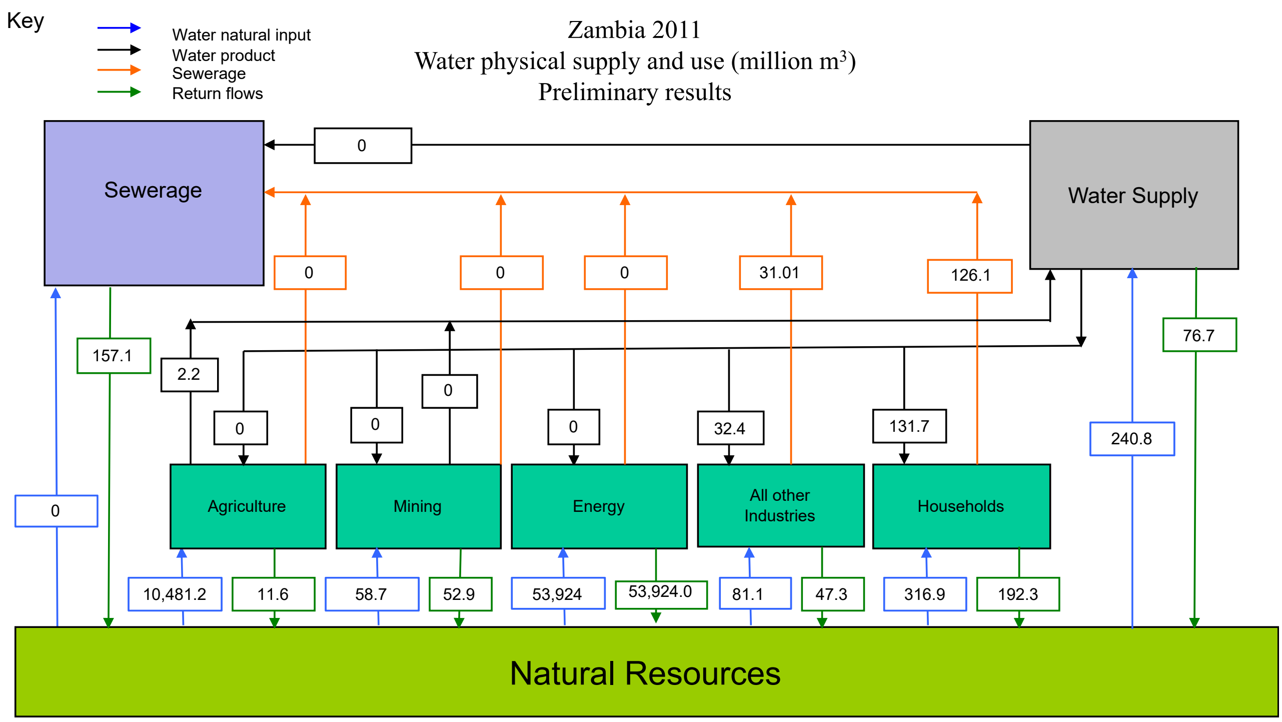

Figure 8: PSUT diagram for 2012

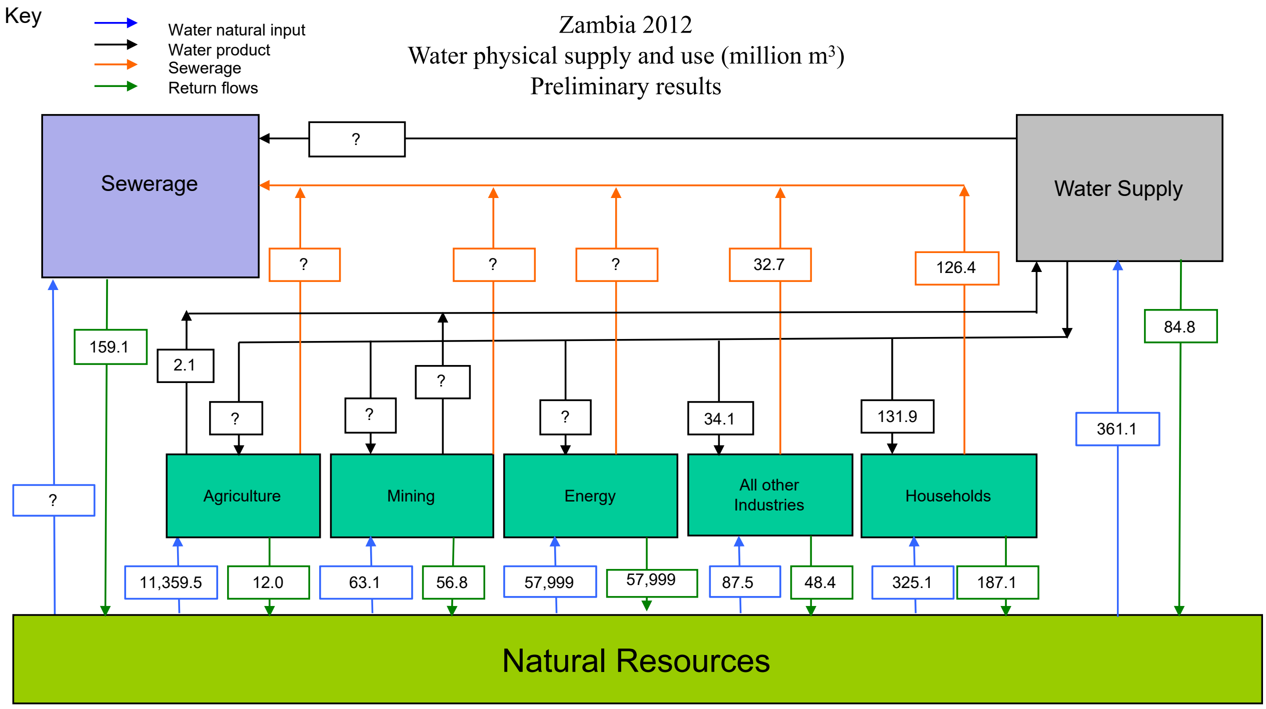

Figure 9: PSUT diagram for 2013

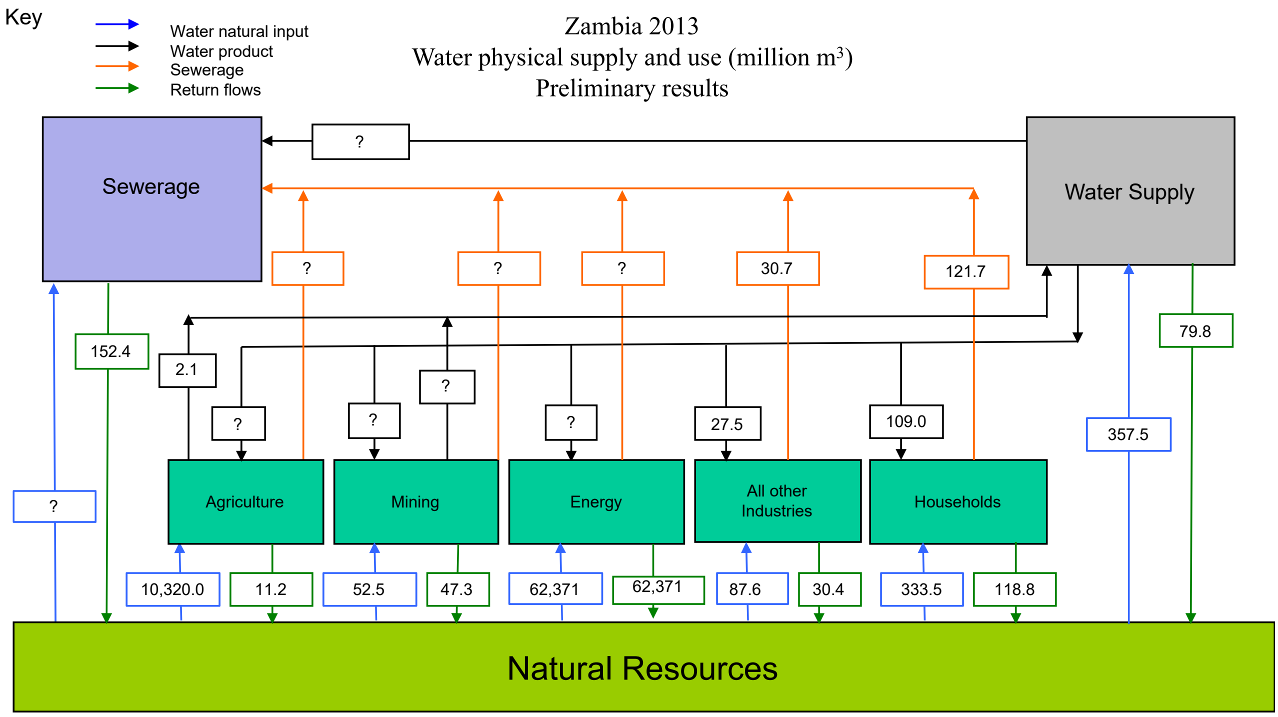

Figure 10: PSUT diagram for 2014

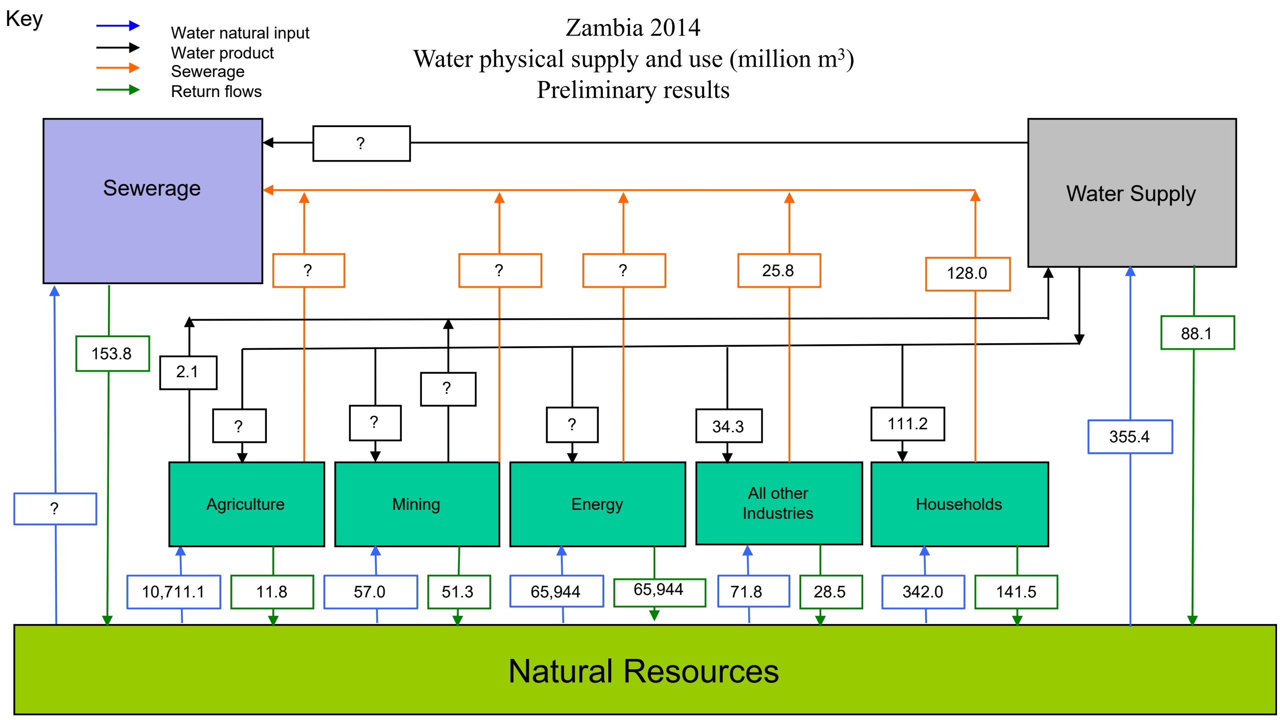

Figure 11: PSUT diagram for 2015

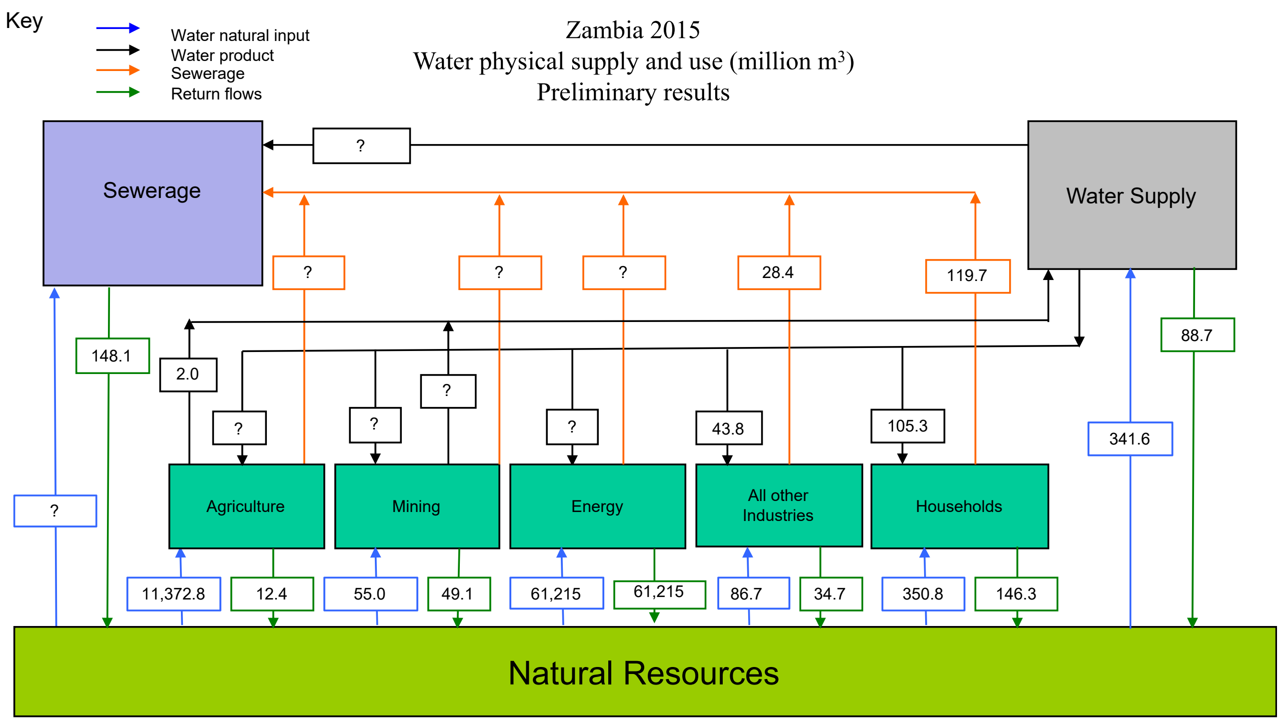

Figure 12: PSUT diagram for 2016

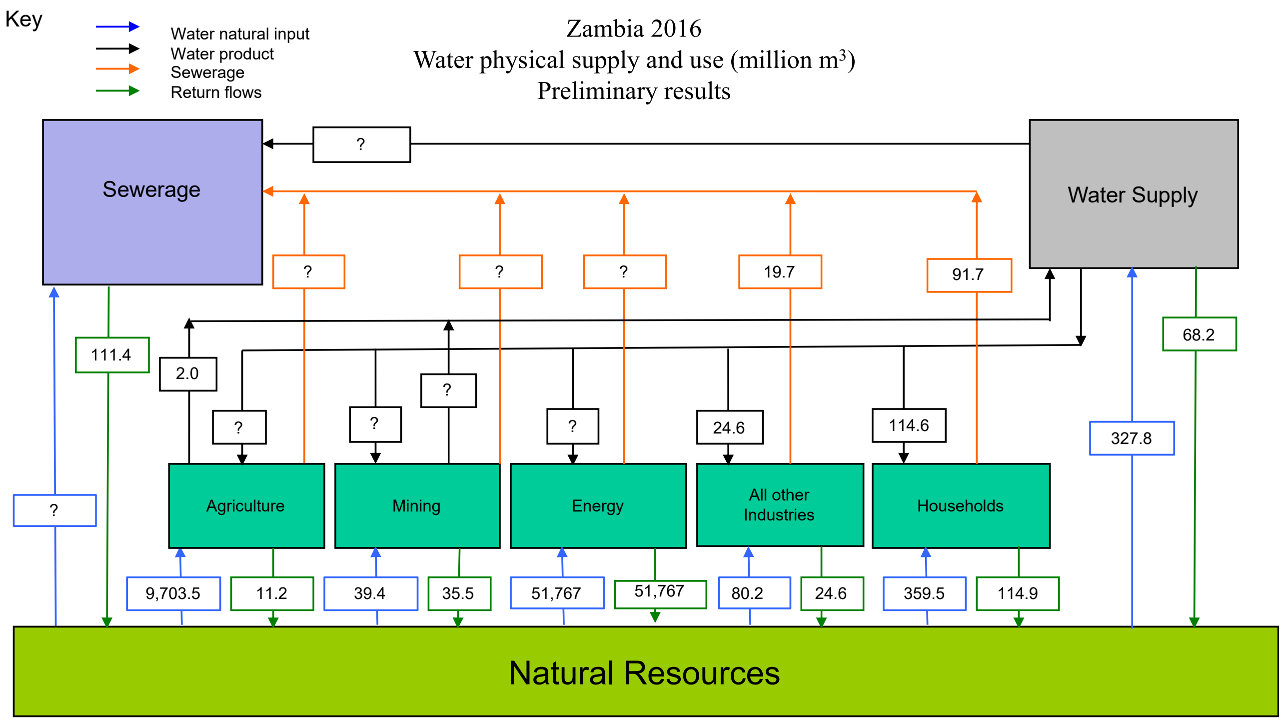

Table 1 (a): Water accounts physical supply tables for Zambia, 2010 (Mm³)

Table 1.	Preliminary water physical supply and use tables for Zambia, 2010 (Mm3)																
Physical supply table		Industry													House-holds	Environ-ment	TOTAL
		Agriculture (rainfed)	Agriculture (large-scale irrigation)	Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agriculture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry			
Natural resources																	
	Surface water															49,414.6	49,414.6
	Ground-water															585.5	585.5
	Soil water															9,470.7	9,470.7
	Total natural resources															59,470.8	59,470.8
Products																	
	Natural water			2.0		2.0			239.7		239.7			241.7	-		241.7
	Sewerage					-							38.2	38.2	104.2		142.4
	Total water and sewerage products	-	-	2.0	-	2.0	-	-	239.7	-	239.7	-	38.2	279.9	104.2		384.1
Return flows																	
	To surface water		17.3			17.3	45.5	49,007.0				142.4		49,212.2			49,212.2
	To ground-water*					-			79.5		79.5		62.0	141.5	168.9		310.4
	Total re-turn flows	-	17.3	-	-	17.3	45.5	49,007.0	79.5		79.5	142.4	62.0	49,353.7	168.9		49,522.6
TOTAL SUPPLY			17.3	2.0		19.3	45.5	49,007.0	319.2	-	319.2	142.4	100.2	49,633.6	273.1	59,470.8	109,377.5

Table 1 (b): Water accounts physical use tables for Zambia, 2010 (Mm³)

Physical use table		Industry													House-holds	Environ-ment	TOTAL
		Agriculture (rainfed)	Agriculture (large-scale irrigation)	Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agriculture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry			
Natural resources																	
	Surface water		57.7	2.0	81.1	140.8		49,007.0	161.3		161.3		68.5	49,377.6	37.0		49,414.6
	Ground-water					-	50.5		213.4		213.4	-	49.5	313.4	272.1		585.5
	Soil water	9,470.7				9,470.7			-			-	-	9,470.7			9,470.7
	Total natural resources	9,470.7	57.7	2.0	81.1	9,611.5	50.5	49,007.0	374.7		374.7	-	118.0	59,161.7	309.1		59,470.8
Products																	
	Natural water			-		-			81.5		81.5		43.0	124.5	117.2		241.7
	Sewerage					-						142.4		142.4	-		142.4
	Total water and sewerage products	-	-	-	-	-	-	-	81.5	-	81.5	142.4	43.0	266.9	117.2		384.1
Return flows																	
	To surface water															49,212.2	49,212.2
	To ground-water*															310.4	310.4
	Total re-turn flows															49,522.6	49,522.6
TOTAL USE		9,470.7	57.7	2.0	81.1	9,611.5	50.5	49,007.0	456.2	-	456.2	142.4	161.0	59,428.6	426.3	49,522.6	109,377.5

*Losses in distribution plus unaccounted for water (e.g. from leaky pipes)

Table 2 (a): Water accounts physical supply tables for Zambia, 2011 (Mm^3)

Table 1.	Preliminary water physical supply and use tables for Zambia, 2011 (Mm3)																
Physical supply table		Industry													House-holds	Envi-ron-ment	TOTAL
		Agriculture (rainfed)	Agriculture (large-scale irrigation)	Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agriculture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry			
Natural resources																	
	Surface water															417.00	417.0
	Ground-water															54,342.80	54,342.8
	Soil water															10,342.90	10,342.9
	Total natural resources															65,102.70	65,102.7
Products																	
	Natural water			2.2		2.2			240.8		240.8			243.0	-		243.0
	Sewerage					-							31.0	31.0	126.1		157.1
	Total water and sewerage products			2.2		2.2			240.8	-	240.8	-	31.0	274.0	126.1		400.1
Return flows																	
	To surface water		11.6			11.6	52.9	53,924.0	76.7		76.7	157.1		54,222.3			54,222.3
	To ground-water*					-					-		47.3	47.3	192.3		239.6
	Total return flows	-	11.6	-	-	11.6	52.9	53,924.0	76.7		76.7	157.1	47.3	54,269.6	192.3		54,461.9
TOTAL SUPPLY			11.6	2.2		13.8	52.9	53,924.0	317.5	-	317.5	157.1	78.3	54,543.6	318.4	65,102.7	119,964.7

Table 2 (b): Water accounts physical use tables for Zambia, 2011 (Mm^3)

Physical use table	Industry														House-holds	Environ-ment	TOTAL
		Agriculture (rainfed)	Agriculture (large-scale irrigation)	Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agriculture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry			
Natural resources																	
	Surface water		38.5		99.8	138.3			240.8		240.8			379.1	37.9		417.0
	Ground-water					-	58.7	53,924.0			-	-	81.1	54,063.8	279.0		54,342.8
	Soil water	10,342.9				10,342.9			-			-	-	10,342.9			10,342.9
	Total natural resources	10,342.9	38.5	-	99.8	10,481.2	58.7	53,924.0	240.8	-	240.8	-	81.1	64,785.8	316.9		65,102.7
Products																	
	Natural water			-		-			78.9		78.9		32.4	111.3	131.7		243.0
	Sewerage					-						157.1		157.1	-		157.1
	Total water and sewerage products			-		-			78.9		78.9	157.1	32.4	268.4	131.7		400.1
Return flows																	
	To surface water															54,222.3	54,222.3
	To ground-water*															239.6	239.6
	Total return flows															54,461.9	54,461.9
TOTAL USE			38.5	-	99.8	10,481.2	58.7	53,924.0	319.7	-	319.7	157.1	113.5	65,054.2	448.6	54,461.9	119,964.7

*Losses in distribution plus unaccounted for water (e.g. from leaky pipes)

Table 3 (a): Water accounts physical supply tables for Zambia, 2012 (Mm^3)

Table 1.	Preliminary water physical supply and use tables for Zambia, 2012 (Mm3)																
Physical supply table		Industry													House-holds	Environ-ment	TOTAL
		Agriculture (rainfed)	Agriculture (large-scale irrigation)	Agriculture (small holder irrigation)	Agriculture (live-stock)	Subtotal agri-culture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry			
Natural resources																	
	Surface water															58,337.00	58,337.0
	Groundwater															639.10	639.1
	Soil water															11,219.20	11,219.2
	Total natural resources															70,195.30	70,195.3
Products																	
	Natural water		2.1			2.1			250.8		250.8			252.9	-		339.80
	Sewerage												32.7	32.7	126.4		159.10
	Total water and sewer-age products			-		2.1			250.8	-	250.8	-	32.7	285.6	126.4		412.00
Return flows																	
	To surface water		12.0			12.0	56.8	57,999.0				159.1		58,226.9			58,226.9
	To ground-water*								84.8		84.8		48.4	133.2	187.1		320.3
	Total return flows		12.0	-	-	12.0	56.8	57,999.0	84.8		84.8	159.1	48.4	58,360.1	187.1		58,547.2
TOTAL SUPPLY			12.0	-		14.1	56.8	57,999.0	335.6	-	335.6	159.1	81.1	58,645.7	313.5	70,195.3	129,154.5

Table 3 (b): Water accounts physical use tables for Zambia, 2012 (Mm^3)

Physical use table		Industry													House-holds	Environ-ment	TOTAL
		Agriculture (rainfed)	Agriculture (large-scale irrigation)	Agriculture (small holder irrigation)	Agriculture (live-stock)	Subtotal agri-culture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry			
Natural resources																	
	Surface water		39.9		100.4	140.3		57,999.0	158.8		158.8			58,298.1	38.9		58,337.0
	Groundwater					-	63.1		202.3		202.3	-	87.5	352.9	286.2		639.1
	Soil water	11,219.2				11,219.2			-			-	-	11,219.2			11,219.2
	Total natural resources	11,219.2	39.9	-	100.4	11,359.5	63.1	57,999.0	361.1	-	361.1	-	87.5	69,870.2	325.1		70,195.3
Products																	
	Natural water			-		-			86.9		86.9		34.1	207.9	131.9		339.8
	Sewerage					-						159.1		159.1	-		159.1
	Total water and sewer-age products			-		-			86.9		86.9	159.1	34.1	280.1	131.9		412.0
Return flows																	
	To surface water															58,226.9	58,226.9
	To ground-water*															320.3	320.3
	Total return flows															58,547.2	58,547.2
TOTAL USE		11,219.2	39.9	-	100.4	11,359.5	63.1	57,999.0	448.0	-	448.0	159.1	121.6	70,150.3	457.0	58,547.2	129,154.5
*Losses in distribution plus unaccounted for water (e.g. from leaky pipes)																	

Table 4 (a): Water accounts physical supply tables for Zambia, 2013 (Mm^3)

Table 1.	Preliminary water physical supply and use tables for Zambia, 2013 (Mm3)																
Physical supply table		Industry													House-holds	Environ-ment	TOTAL
		Agriculture (large-scale irrigation)	Agriculture (small holder irrigation)	Agriculture (rainfed)	Agriculture (livestock)	Subtotal agri-culture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other indus-tries	Subtotal industry			
Natural resources																	
	Surface water															62,717.20	62,717.2
	Groundwater															634.10	634.1
	Soil water															10,170.70	10,170.7
	Total natural resources															73,522.00	73,522.0
Products																	
	Natural water		2.1			2.1			216.3		216.3			218.4	-		218.4
	Sewerage												30.7	30.7	121.7		152.4
	Total water and sewerage products		2.1			2.1			216.3	-	216.3	-	30.7	249.1	121.7		370.8
Return flows																	
	To surface water		11.2			11.2	47.3					152.4		210.9			210.9
	To ground-water*							62,371.0	79.8		79.8		30.4	62,481.2	118.8		62,600.0
	Total return flows	-	11.2		-	11.2	47.3	62,371.0	79.8		79.8	152.4	30.4	62,692.1	118.8		62,810.9
TOTAL SUPPLY		-	13.3			13.3	47.3	62,371.0	296.1	-	296.1	152.4	61.1	62,941.2	240.5	73,522.0	136,703.7

Table 4 (b): Water accounts physical use tables for Zambia, 2013 (Mm^3)

Physical use table		Industry													House-holds	Environ-ment	TOTAL
		Agriculture (large-scale irrigation)	Agriculture (small holder irrigation)	Agriculture (rainfed)	Agriculture (live-stock)	Subtotal agriculture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry			0.0
Natural resources																	
	Surface water	37.3			112.0	149.3		62,371.0	157.0		157.0			62,677.3	39.9		62,717.2
	Groundwater					-	52.5		200.5		200.5	-	87.6	340.6	293.5		634.1
	Soil water			10,170.7		10,170.7			-			-	-	10,170.7			10,170.7
	Total natural resources	37.3	-	10,170.7	112.0	10,320.0	52.5	62,371.0	357.5	-	357.5	-	87.6	73,188.6	333.4		73,522.0
Products																	
	Natural water		-			-			81.9		81.9		27.5	109.4	109.0		218.4
	Sewerage					-						152.4		152.4	-		152.4
	Total water and sewerage products		-			-			81.9		81.9	152.4	27.5	261.8	109.0		370.8
Return flows																	
	To surface water															210.9	210.9
	To ground-water*															62,600.0	62,600.0
	Total return flows															62,810.9	62,810.9
TOTAL USE		37.3	-		112.0	10,320.0	52.5	62,371.0	439.4	-	439.4	152.4	115.1	73,450.4	442.4	62,810.9	136,703.7
*Losses in distribution plus unaccounted for water (e.g. from leaky pipes)																	

Table 5 (a): Water accounts physical supply tables for Zambia, 2014 (Mm³)

Table 1.	Preliminary water physical supply and use tables for Zambia, 2014 (Mm3)																
Physical supply table		Industry													Households	Environ-ment	TOTAL
		Agriculture (rainfed)	Agriculture (large-scale irrigation)	Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agriculture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry			
Natural resources																	
	Surface water															66,296.10	66,296.1
	Groundwater															637.60	637.6
	Soil water															10,547.60	10,547.6
	Total natural resources															77,481.30	77,481.3
Products																	
	Natural water			2.1		2.1			233.6		233.6			235.7	-		235.7
	Sewerage					-							25.8	25.8	128.0		153.8
	Total water and sewerage products			2.1		2.1			233.6	-	233.6	-	25.8	261.5	128.0		389.5
Return flows																	
	To surface water		11.8			11.8	51.3	65,944.0	88.1		88.1	153.8		66,249.0			66,249.0
	To ground-water*					-					-		28.5	28.5	141.5		170.0
	Total return flows	-	11.8	-	-	11.8	51.3	65,944.0	88.1		88.1	153.8	28.5	66,277.5	141.5		66,419.0
TOTAL SUPPLY		-	11.8	2.1		13.9	51.3	65,944.0	321.7	-	321.7	153.8	54.3	66,539.0	269.5	77,481.3	144,289.8

Table 5 (b): Water accounts physical use tables for Zambia, 2014 (Mm³)

Physical use table		Industry													House-holds	Environ-ment	TOTAL
		Agriculture (rainfed)	Agriculture (large-scale irrigation)	Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agri-culture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry			
Natural resources																	
	Surface water		39.2		124.3	163.5		65,944.0	147.7		147.7			66,255.2	40.9		66,296.1
	Groundwater					-	57.0		207.7		207.7	-	71.8	336.5	301.1		637.6
	Soil water	10,547.6				10,547.6			-			-	-	10,547.6			10,547.6
	Total natural resources	10,547.6	39.2	-	124.3	10,711.1	57.0	65,944.0	355.4	-	355.4	-	71.8	77,139.3	342.0		77,481.3
Products																	
	Natural water			-		-			90.2		90.2		34.3	124.5	111.2		235.7
	Sewerage					-						153.8		153.8	-		153.8
	Total water and sewerage products			-		-			90.2		90.2	153.8	34.3	278.3	111.2		389.5
Return flows																	
	To surface water															66,249.0	66,249.0
	To ground-water*															170.0	170.0
	Total return flows															66,419.0	66,419.0
TOTAL USE		10,547.6	39.2	-	124.3	10,711.1	57.0	65,944.0	445.6	-	445.6	153.8	106.1	77,417.6	453.2	66,419.0	144,289.8

*Losses in distribution plus unaccounted for water (e.g. from leaky pipes)

Table 6 (a): Water accounts physical supply tables for Zambia, 2015 (Mm^3)

Table 1.	Preliminary water physical supply and use tables for Zambia, 2015 (Mm3)																
Physical supply table		Industry													Households	Environment	TOTAL
		Agriculture (rainfed)	Agriculture (large-scale irrigation)	Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agriculture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry			
Natural resources																	
	Surface water															61,628.30	61,628.3
	Ground-water															600.40	600.4
	Soil water															11,193.20	11,193.2
	Total natural resources															73,421.90	73,421.9
Products																	
	Natural water			2.0		2.0			237.8		237.8			239.8			239.8
	Sewerage					-							28.4	28.4	119.7		148.1
	Total water and sewerage products	-	-	2.0	-	2.0			237.8	-	237.8	-	28.4	268.2	119.7		387.9
Return flows																	
	To surface water		12.4			12.4	49.1	61,215.0	88.7		88.7	148.1		61,513.3			61,513.3
	To ground-water*					-					-		34.7	34.7	146.3		181.0
	Total return flows	-	12.4	-	-	12.4	49.1	61,215.0	88.7		88.7	148.1	34.7	61,548.0	146.3		61,694.3
TOTAL SUPPLY		-	12.4	2.0		14.4	49.1	61,215.0	326.5	-	326.5	148.1	63.1	61,816.2	266.0	73,421.9	135,504.1

Table 6 (b): Water accounts physical use tables for Zambia, 2015 (Mm^3)

Physical use table		Industry													Households	Environment	TOTAL
		Agriculture (rainfed)	Agriculture (large-scale irrigation)	Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agriculture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry			
Natural resources																	
	Surface water		41.3		138.3	179.6		61,215.0	191.7		191.7			61,586.3	42.0		61,628.3
	Ground-water					-	55.0		149.9		149.9	-	86.7	291.6	308.8		600.4
	Soil water	11,193.2				11,193.2			-			-	-	11,193.2			11,193.2
	Total natural resources	11,193.2	41.3	-	138.3	11,372.8	55.0	61,215.0	341.6	-	341.6	-	86.7	73,071.1	350.8		73,421.9
Products																	
	Natural water			-		-			90.7		90.7		43.8	134.5	105.3		239.8
	Sewerage					-						148.1		148.1	-		148.1
	Total water and sewerage products	-	-	-	-	-			90.7		90.7	148.1	43.8	282.6	105.3		387.9
Return flows																	
	To surface water															61,513.3	61,513.3
	To ground-water*															181.0	181.0
	Total return flows															61,694.3	61,694.3
TOTAL USE		11,193.2	41.3	-	138.3	11,372.8	55.0	61,215.0	432.3	-	432.3	148.1	130.5	73,353.7	456.1	61,694.3	135,504.1
*Losses in distribution plus unaccounted for water (e.g. from leaky pipes)																	

Table 7 (a): Water accounts physical supply tables for Zambia, 2016 (Mm^3)

Table 1.	Preliminary water physical supply and use tables for Zambia, 2016 (Mm3)																
Physical supply table		Industry													House-holds	Envi-ron-ment	TOTAL
		Agriculture (rainfed)	Agriculture (large-scale irrigation)	Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agriculture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry			
Natural resources																	
	Surface water															52,152.10	52,152.1
	Groundwater															615.40	615.4
	Soil water															9,509.90	9,509.9
	Total natural resources															62,277.40	62,277.4
Products																	
	Natural water			2.0		2.0			207.4		207.4			209.4	-		209.4
	Sewerage					-							19.7	19.7	91.7		111.4
	Total water and sewerage products	-	-	2.0	-	2.0			207.4	-	207.4	-	19.7	229.1	91.7		320.8
Return flows																	
	To surface water		11.2			11.2	35.5	51,767.0				111.4		51,925.1			51,925.1
	To ground-water*					-			68.2		68.2		24.6	92.8	114.9		207.7
	Total return flows	-	11.2	-	-	11.2	35.5	51,767.0	68.2		68.2	111.4	24.6	52,017.9	114.9		52,132.8
TOTAL SUPPLY		-	11.2	2.0	-	13.2	35.5	51,767.0	275.6	-	275.6	111.4	44.3	52,247.0	206.6	62,277.4	114,731.0

Table 7 (b): Water accounts physical use tables for Zambia, 2016 (Mm^3)

Physical use table		Industry													House-holds	Environ-ment	TOTAL
		Agriculture (rainfed)	Agriculture (large-scale irrigation)	Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agri-culture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other indus-tries	Subtotal industry			
Natural resources																	
	Surface water		37.3		156.3	193.6		51,767.0	148.5		148.5			52,109.1	43.0		52,152.1
	Groundwater					-	39.4		179.3		179.3	-	80.2	298.9	316.5		615.4
	Soil water	9,509.9				9,509.9			-			-	-	9,509.9			9,509.9
	Total natural resources	9,509.9	37.3	-	156.3	9,703.5	39.4	51,767.0	327.8	-	327.8	-	80.2	61,917.9	359.5		62,277.4
Products																	
	Natural water			-		-			70.2		70.2		24.6	94.8	114.6		209.4
	Sewerage					-						111.4		111.4	-		111.4
	Total water and sewerage products			-		-			70.2		70.2	111.4	24.6	206.2	114.6		320.8
Return flows																	
	To surface water															51,925.1	51,925.1
	To ground-water*															207.7	207.7
	Total return flows															52,132.8	52,132.8
TOTAL USE		9,509.9	37.3	-	156.3	9,703.5	39.4	51,767.0	398.0	-	398.0	111.4	104.8	62,124.1	474.1	52,132.8	114,731.0

*Losses in distribution plus unaccounted for water (e.g. from leaky pipes)

Table 8 (a): Water accounts monetary supply tables for Zambia, 2010 (ZMW 'Million')

Monetary supply table Agriculture (large-scale irrigation)		Agriculture (small holder irrigation)	Agriculture (livestock)	*Subtotal agriculture*	Mining	Energy	Water utilities	Industry Irrigation schemes	*Subtotal water supply industry*	Sewerage	All other industries	*Subtotal industry*		Households	Environment	TOTAL
Natural resources																
	Surface water														27,178.0	27,178.0
	Groundwater														322.0	322.0
	Rainwater tanks															0.0
	Total natural resources														27,500.1	27,500.1
Products																
	Natural water		1.1		1.1			291.2		*291.2*			*292.3*	-		292.3
	Sewerage											27.1	*27.1*	41.6		68.7
	Total water and sewerage products		*1.1*		*1.1*			*291.2*	-	*291.2*	-	*27.1*	*319.4*	*41.6*		361.0
Return flows																
	To surface water	9.5			9.5	25.0	26,953.9				78.3	27.2	*27,093.9*	*74.3*		27,168.2
	To groundwater*							*43.7*		*43.7*			*43.7*			*43.73*
	Total return flows	*9.5*	-	-	*9.5*	*25.0*	*26,953.9*	*43.7*		*43.7*	*78.3*	*27.2*	*27,137.7*	*74.3*		27,211.9
TOTAL SUPPLY		9.5	1.1		*10.6*	25.0	26,953.9	335.0	-	335.0	78.3	54.3	*27,457.1*	115.9	27,500.1	55,073.0

Table 8 (b): Water accounts monetary use tables for Zambia, 2010 (ZMW 'Million')

Monetary use table Agriculture (large-scale irrigation)		Agriculture (small holder irrigation)	Agriculture (livestock)	*Subtotal agriculture*	Mining	Energy	Water utilities	Industry Irrigation schemes	*Subtotal water supply industry*	Sewerage	All other industries	Subtotal industry		Households	Environment	TOTAL
Natural resources																
	Surface water	31.7	1.1	44.6	77.4		6,953.9	88.7		*88.7*		37.7	27,157.7	20.4		27,178.0
	Groundwater					27.8		117.4		*117.4*	-	27.2	172.4	149.7		322.0
	Rainwater tanks				-			-			-	-	-			-
	Total natural resources	*31.7*	*1.1*	44.6	77.4	*27.8*	26,953.9	206.1	-	*206.1*	-	*64.9*	27,330.1	170.0		27,500.1
Products																
	Natural water		-		-			44.8				83.4	128.2	164.1		292.3
	Sewerage				-						68.7		68.7	-		68.7
	Total water and sewerage products		-		-			44.8			68.7	83.4	197.0	164.1		361.0
Return flows																
	To surface water														27,168.2	27,168.2
	To groundwater*														43.7	43.7
	Total return flows														*27,211.9*	27,211.9
TOTAL USE		31.7	1.1	44.6	77.4	27.8	6,953.9	250.9	-	206.1	68.7	148.3	27,527.0	334.1	27,211.9	55,073.0

Table 9 (a): Water accounts monetary supply tables for Zambia, 2011 (ZMW 'Million')

		Agriculture						Industry						Households	Environment	TOTAL
Monetary supply table Agriculture (large-scale irrigation)		Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agriculture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry				
Natural resources																
	Surface water														96.91	96.91
	Groundwater														29,888.54	29,888.54
	Rainwater tanks															-
	Total natural resources														29,985.45	29,985.45
Products																
	Natural water		1.2		1.2			320.9		320.9			322.2	-		322.16
	Sewerage											26.4	26.4	64.0		90.39
	Total water and sewerage products		1.2		1.2			320.9	-	320.9	-	26.4	348.6	64.0		412.54
Return flows																
	To surface water	6.4			6.4	29.1	29,658.2				86.4		29,780.1			29,780.1
	To groundwater*									-		19.6	19.6	79.8		99.4
	Total return flows	6.4	-	-	6.4	29.1	29,658.2	-		-	86.4	19.6	29,799.7	79.8		29,879.5
TOTAL SUPPLY		6.4	1.2		7.6	29.1	29,658.2	320.9	-	320.9	86.4	46.1	30,148.3	143.8	29, 985.5	60, 277.5

Table 9 (b): Water accounts monetary use tables for Zambia, 2011 (ZMW 'Million')

		Agriculture						Industry						Households	Environment	TOTAL
Monetary use table, 2011 Agriculture (large-scale irrigation)		Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agriculture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry				
Natural resources																
	Surface water	21.2		54.9	76.1					-			76.1	20.8		96.9
	Groundwater					32.3	29,658.2			-	-	44.6	29,735.1	153.5		29,888.5
	Rainwater tanks				-			-			-	-	-			-
	Total natural resources	21.2	-	54.9	76.1	32.3	29,658.2	-	-	-	-	44.6	29,811.2	174.3		29,985.5
Products																
	Natural water		-		-			43.4				68.0	111.4	210.7		322.2
	Sewerage				-						90.4		90.4	-		90.4
	Total water and sewerage products		-		-			43.4			90.4	68.0	201.8	210.7		412.5
Return flows																
	To surface water														29,780.1	29,780.1
	To groundwater*														99.4	99.4
	Total return flows														29,879.5	29,879.5
TOTAL USE		21.2	-	54.9	76.1	32.3	29,658.2	43.4	-	-	90.4	112.6	30,013.0	385.0	29,879.5	60,277.5

Table 10 (a): Water accounts monetary supply tables for Zambia, 2012 (ZMW 'Million')

Monetary supply table, 2012 Agriculture (large-scale irrigation)		Agriculture				Industry								Households	Environment	TOTAL
		Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agriculture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry				
Natural resources																
	Surface water														32,085.35	32,085.35
	Groundwater														351.51	351.51
	Rainwater tanks															-
	Total natural resources														32,436.86	32,436.86
Products																
	Natural water	1.2			1.2			362.5		362.5			363.6	-		363.65
	Sewerage											24.4	24.4	55.8		80.19
	Total water and sewerage products		-		1.2			362.5	-	362.5	-	24.4	388.0	55.8		443.84
Return flows																
	To surface water	6.6			6.6	31.2	31,899.5				87.5		32,024.8			32,024.8
	To groundwater*							46.6		46.6		21.3	68.0	82.5		150.5
	Total return flows	6.6	-	-	6.6	31.2	31,899.5	46.6		46.6	87.5	21.3	32,092.8	82.5		32,175.3
TOTAL SUPPLY		6.6	-		7.8	31.2	31,899.5	409.1	-	409.1	87.5	45.7	32,480.8	138.3	32,436.9	65,056.0

Table 10 (b): Water accounts monetary use tables for Zambia, 2012 (ZMW 'Million')

Monetary use table, 2012 Agriculture (large-scale irrigation)		Agriculture				Industry								Households	Environment	TOTAL
		Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agriculture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry				
Natural resources																
	Surface water	21.9		55.2	77.2		31,899.5	87.3		87.3			32,064.0	21.4		32,085.4
	Groundwater					34.7		111.3		111.3	-	48.1	194.1	157.4		351.5
	Rainwater tanks				-			-			-	-	-			-
	Total natural resources	21.9	-	55.2	77.2	34.7	31,899.5	198.6	-	198.6	-	48.1	32,258.1	178.8		32,436.9
Products																
	Natural water		-		-			47.8				78.4	126.2	237.4		363.6
	Sewerage				-						80.2		80.2	-		80.2
	Total water and sewerage products		-		-			47.8			80.2	78.4	206.4	237.4		443.8
Return flows																
	To surface water														32,024.8	32,024.8
	To roundwater*														150.5	150.5
	Total return flows														32,175.3	32,175.3
TOTAL USE		21.9	-	55.2	77.2	34.7	31,899.5	246.4	-	198.6	80.2	126.6	32,464.5	416.2	32,175.3	65,056.0

Table 11 (a): Water accounts monetary supply tables for Zambia, 2013 (ZMW 'Million')

Monetary supply table, 2013 Agriculture (large-scale irrigation)		Agriculture				Industry								Households	Environment	TOTAL
		Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agriculture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry				
Natural resources																
	Surface water														34,494.46	34,494.5
	Groundwater														348.76	348.8
	Rainwater tanks															0.0
	Total natural resources														34,843.22	34,843.2
Products																
	Natural water	1.1			1.1			349.8		349.8			350.9	-		350.9
	Sewerage											23.7	23.7	53.8		77.5
	Total water and sewerage products		-		1.1			349.8	-	349.8	-	23.7	374.6	53.8		428.4
Return flows																
	To surface water				-	26.0					83.8		109.8			109.8
	To groundwater*						34,304.1	43.9		43.9		26.8	34,374.8			34,374.8
	Total return flows	-	-	-	-	26.0	34,304.1	43.9		43.9	83.8	26.8	34,484.6	-		34,484.6
TOTAL SUPPLY		-	-		1.1	26.0	34,304.1	393.7	-	393.7	83.8	50.5	34,859.2	53.8	34,843.2	69,756.3

Table 11 (b): Water accounts monetary use tables for Zambia, 2013 (ZMW 'Million')

Monetary use table, 2013 Agriculture (large-scale irrigation)		Agriculture				Industry								Households	Environment	TOTAL
		Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agriculture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry				
Natural resources																
	Surface water	20.5		61.6	82.1		34,304.1	86.4		86.4			34,472.5	21.9		34,494.5
	Groundwater					28.9		110.3		110.3	-	48.2	187.3	161.4		348.8
	Rainwater tanks				-			-			-	-	-			-
	Total natural resources	20.5	-	61.6	82.1	28.9	34,304.1	196.6	-	196.6	-	48.2	34,659.8	183.4		34,843.2
Products																
	Natural water		-		-			45.0		45.0		77.0	122.0	228.9		350.9
	Sewerage				-						77.5		77.5	-		77.5
	Total water and sewerage products		-		-			45.0			77.5	77.0	199.6	228.9		428.5
Return flows																
	To surface water														109.8	109.8
	To roundwater*														34,374.8	34,374.8
	Total return flows														34,484.6	34,484.6
TOTAL USE		20.5	-	61.6	82.1	28.9	34,304.1	241.7	-	196.6	77.5	125.2	34,859.4	412.3	34,484.6	69,756.3

Table 12 (a): Water accounts monetary supply tables for Zambia, 2014 (ZMW 'Million')

Monetary supply table, 2014 Agriculture (large-scale irrigation)		Agriculture				Industry								Households	Environment	TOTAL
		Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agriculture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry				
Natural resources																
	Surface water														36,462.86	36,462.86
	Groundwater														350.68	350.68
	Rainwater tanks															-
	Total natural resources														36,813.54	36,813.54
Products																
	Natural water		1.2		1.2			375.9		375.9			377.1	-		377.05
	Sewerage											22.2	22.2	60.2		82.41
	Total water and sewerage products		1.2		1.2			375.9	-	375.9	-	22.2	399.3	60.2		459.46
Return flows																
	To surface water	6.5			6.5	28.2	36,269.2				84.6		36,388.5			36,388.5
	To groundwater*									-		20.6	20.6	102.3		122.9
	Total return flows	6.5	-	-	6.5	28.2	36,269.2	-		-	84.6	20.6	36,409.1	102.3		36,511.4
TOTAL SUPPLY		6.5	1.2		7.6	28.2	36,269.2	375.9	-	375.9	84.6	42.8	36,808.4	162.5	36,813.5	73,784.4

Table 12 (b): Water accounts monetary use tables for Zambia, 2014 (ZMW 'Million')

Monetary use table, 2014 Agriculture (large-scale irrigation)		Agriculture				Industry								Households	Environment	TOTAL
		Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agriculture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry				
Natural resources																
	Surface water	21.6		68.4	89.9		36,269.2	81.2		81.2			36,440.4	22.5		36,462.9
	Groundwater					31.4		114.2		114.2	-	39.5	185.1	165.6		350.7
	Rainwater tanks				-			-			-	-	-			-
	Total natural resources	21.6	-	68.4	89.9	31.4	36,269.2	195.5	-	195.5	-	39.5	36,625.4	188.1		36,813.5
Products																
	Natural water		-		-			49.6				71.7	121.3	255.8		377.1
	Sewerage				-						82.4		82.4	-		82.4
	Total water and sewerage products		-		-			49.6			82.4	71.7	203.7	255.8		459.5
Return flows																
	To surface water														36,388.5	36,388.5
	To groundwater*														122.9	122.9
	Total return flows														36,511.4	36,511.4
TOTAL USE		21.6	-	68.4	89.9	31.4	36,269.2	245.1	-	195.5	82.4	111.2	36,829.1	443.9	36,511.4	73,784.4

Table 13 (a): Water accounts monetary supply tables for Zambia, 2015 (ZMW ‘Million’)

Monetary supply table, 2015 Agriculture (large-scale irrigation)		Agriculture				Industry								Households	Environment	TOTAL
		Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agriculture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry				
Natural resources																
	Surface water														33,895.57	33,895.57
	Groundwater														330.22	330.22
	Rainwater tanks															-
	Total natural resources														34,225.79	34,225.79
Products																
	Natural water		1.1		1.1			446.0		446.0			447.1			447.15
	Sewerage											25.6	25.6	59.4		85.02
	Total water and sewerage products		1.1		1.1			446.0	-	446.0	-	25.6	472.8	59.4		532.16
Return flows																
	To surface water	6.8			6.8	27.0	33,668.3				81.5		33,783.5			33,783.5
	To groundwater*									-		23.6	23.6	99.4		123.0
	Total return flows	6.8	-	-	6.8	27.0	33,668.3	-		-	81.5	23.6	33,807.1	99.4		33,906.5
TOTAL SUPPLY		6.8	1.1		7.9	27.0	33,668.3	446.0	-	446.0	81.5	49.2	34,279.9	158.8	34,225.8	68,664.5

Table 13 (b): Water accounts monetary use tables for Zambia, 2015 (ZMW ‘Million’[3])

Monetary use table, 2015 Agriculture (large-scale irrigation)		Agriculture				Industry					Households				Environment	TOTAL
		Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agriculture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry				
Natural resources																
	Surface water	22.7		76.1	98.8		33,668.3	105.4		105.4			33,872.5	23.1		33,895.6
	Groundwater					30.3		82.4		82.4	-	47.7	160.4	169.8		330.2
	Rainwater tanks				-			-			-	-	-			-
	Total natural resources	22.7	-	76.1	98.8	30.3	33,668.3	187.9	-	187.9	-	47.7	34,032.8	192.9		34,225.8
Products																
	Natural water		-		-			49.9				144.5	194.4	252.7		447.1
	Sewerage				-						85.0		85.0	-		85.0
	Total water and sewerage products		-		-			49.9			85.0	144.5	279.4	252.7		532.2
Return flows																
	To surface water														33,783.5	33,783.5
	To groundwater*														123.0	123.0
	Total return flows														33,906.5	33,906.5
TOTAL USE		22.7	-	76.1	98.8	30.3	33,668.3	237.8	-	187.9	85.0	192.2	34,312.3	445.7	33,906.5	68,664.5

Table 14 (a): Water accounts monetary supply tables for Zambia, 2016 (ZMW 'Million')

Monetary supply table, 2016 Agriculture (large-scale irrigation)		Agriculture				Industry								Households	Environment	TOTAL
		Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agri-culture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other indus-tries	Subtotal in-dustry				
Natural resources																
	Surface water														28,683.66	28,683.66
	Ground-water														338.47	338.47
	Rainwater tanks															-
	Total natural resources														29,022.13	29,022.13
Products																
	Natural water		1.1		1.1			421.6		421.6			422.7	-		422.67
	Sewerage											26.8	26.8	70.1		96.85
	Total water and sewer-age prod-ucts		1.1		1.1			421.6	-	421.6	-	26.8	449.4	70.1		519.52
Return flows																
	To surface water	6.2			6.2	19.5	28,471.9				61.3		28,558.8			28,558.8
	To ground-water*							37.5		37.5		21.6	59.1	93.6		152.7
	Total return flows	6.2	-	-	6.2	19.5	28,471.9	37.5		37.5	61.3	21.6	28,617.9	93.6		28,711.5
TOTAL SUPPLY		6.2	1.1		7.3	19.5	28,471.9	459.1	-	459.1	61.3	48.3	29,067.3	163.7	29,022.1	58,253.1

Table 14 (b): Water accounts monetary use tables for Zambia, 2016 (ZMW 'Million')

Monetary use table, 2016 Agriculture (large-scale irrigation)		Agriculture				Industry								Households	Environ-ment	TOTAL
		Agriculture (small holder irrigation)	Agriculture (livestock)	Subtotal agriculture	Mining	Energy	Water utilities	Irrigation schemes	Subtotal water supply industry	Sewerage	All other industries	Subtotal industry				
Natural resources																
	Surface water	20.5		86.0	106.5		28,471.9	81.7		81.7			28,660.0	23.7		28,683.7
	Groundwater					21.7		98.6		98.6	-	44.1	164.4	174.1		338.5
	Rainwater tanks				-			-			-	-	-			-
	Total natural resources	20.5	-	86.0	106.5	21.7	28,471.9	180.3	-	180.3	-	44.1	28,824.4	197.7		29,022.1
Products																
	Natural water		-		-			38.6				86.1	124.7	298.0		422.7
	Sewerage				-						96.8		96.8	-		96.8
	Total water and sewerage products		-		-			38.6			96.8	86.1	221.6	298.0		519.5
Return flows																
	To surface water														28,558.8	28,558.8
	To groundwater*														152.7	152.7
	Total return flows														28,711.5	28,711.5
TOTAL USE		20.5	-	86.0	106.5	21.7	28,471.9	218.9	-	180.3	96.8	130.2	29,046.0	495.7	28,711.5	58,253.1

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