Socio-Economic Futures of the Zambezi River Basin

OneWorld Sustainable Investments

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1. The Project Workshop of 15-16th August agreed that, based on the attached presentations and discussion document, the Base Case scenario of IFs was selected as one scenario and the UN projection the other. The IFs method of projection is acceptable from the basis of feedbacks in the model to population growth and to other demand sectors, which is viewed to be "realistic". The potential for unlimited growth on the basis of the probabilistic model is unrealistic;

2. It turns out that at 2070 which is the time horizon, the forecast populations between the two methods are substantially different. The two forecasts are produced by two very different methods. At long ranges, the UN trajectories seem implausible (giving Zambia a population of 140 million people at 2100). These issues are discussed in the accompanying report;

3. IFs is also being used to forecast GDP, potential agricultural production growth (based on population and economic projections) and using this to estimate possible water demand as a percentage of the renewable water resource;

4. A comparison of two scenarios by IFs is described in the text – the Base Case and one called African Renaissance. Some of the changes in parameters that went into making the second scenario prediction are explained in the text and the two different scenarios compared (this is not the same as comparing IFs and UN scenarios). At present, we are unsure as to what other scenarios have been prepared by the UN, nor is it clear that the UN has projections on GDP growth , demand for water, agricultural production and so-on;

5. Future water demands in the Zambezi River basin need to be estimated in preparation for the hydrology model. Water demand is predicated on that abstracted for agriculture (irrigation), urban and industrial demands;

6. Irrigation demands will be taken from estimates contained in the MSIOA studies. The timed implementation of these irrigation demands will be based on assumptions by the hydrological scenario modelling team;

7. Water demands by the growing population are based on two different trajectories. The first is to use the statistics and projections from the United Nations (UN) Population Division. The second is to use those projections produced by IFs;

8. A forecast by IFs of the proportion of the population urbanised forecasts a move of people back to rural areas. The reason for this is not yet understood but it is work thinking about why this may happen;

9. Following the the Project Workshop of 15-16th August, a new list of tasks based on this modelling effort and the questions it raises was developed and distributed. This document is attached. Of additional concern to the team is the prospect of water abstractions to countries in the south – Botswana, possibly South Africa and Zimbabwe. These will have additional impacts and will be factored into the modelling effort.

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1. Introduction

Anticipation of possible future events could and should lead to better decision making, more robust adaption and superior outcomes. This is just as important in the water resources sector as it is in any other socio-economic setting. Determining the future demand for water in a river basin implies an understanding of socio-economic trajectories in that basin and requires a focus on the likely future urban, industrial and agricultural demands for water.

Some authors take the size of the renewable water resource in the Zambezi River basin relative to consumption to be so large that there are few possibilities for water scarcity. We have however seen that major droughts have caused very significant low flows in the basin, such that Kariba Dam was at the point of ceasing power generation in 1999 . Clearly, natural climate variation already results in periodic water scarcity. Further increases of water consumption within the basin will have the effect of increasing the frequency of shortages. On top of that, climate changes which increase rainfall and hence runoff variability will also result in increasing the frequency and intensity of periodic water scarcity. This situation should be of concern to the hydropower producers which require stable flows that allow them to forecast their production requirements and to manage production and clients accordingly.

In this paper, we show two methods for estimating future water demands in the Zambezi River basin that are driven by population end economic growth. We compare the future population sizes estimated by these methods, as well as their potential effects on water demand. These are the UN population estimates and those forecast by the International Futures modelling system. The potential differences between the methods are of concern because, depending on which view is taken, substantial differences in investment could result, with potentially large different socio-economic outcomes. The methods of estimation are spelt out in a little more detail below and the essential differences between the methods are discussed.

2. Methods

Understanding population growth of the river basin requires firstly a projections of population growth and secondly apportioning population from each of the riparian countries into a single value according to their relative contributions. It is not possible to collect population data within in each country according to river basin boundaries. Therefore, we must estimate from national statistics and apportion according to 1) the relative fraction that each country contributes to the total basin area, and 2) make some adjustments for the different features in each country. An example given here is that the two largest Zimbabwean cities – Harare and Bulawayo, are located within the basin. This fact makes it likely that Zimbabwe contributes a higher proportion of its population to the basin than would be estimated by the fraction of the basin within Zimbabwean borders.

One of the most important issues is how to project population growth. We used two methods:

1. UN population projections; and
2. Projections by International Futures.

No credible study on population projections could fail to mention the UN projections, which are standard references. Therefore we use these projections as one standard reference. However, because of inherent methodological issues which need to be addressed, we used another method projection population – International Futures.

2.1. What is International Futures (IFs)

IFs is "a large-scale, long-term, integrated global modelling system. It represents demographic, economic, energy, agricultural, socio-political, and environmental subsystems for 183 countries interacting in the global system" (Hughes, 2006). IFs uses a general equilibrium structure for its 6-sector economic module (Hughes, 2006). IFs is useful for modelling stocks and flows of elements such as goods and services, money, human well-being, environmental conditions, materials status, and knowledge. IFs also has functions for many non-market socio-economic interactions (Hughes et al., 2004).

We use two embedded scenarios in IFs model called the Base Case to simulate the "plodding along" and the "African Renaissance" to simulate the high economic growth scenarios. An accelerated economy could result in the tripling of GDP per capita by 2050, if accelerated investments into economic infrastructure take place. Increases in GDP per capita only make a difference accumulatively after 2025 if such increases in infrastructural change are implemented in 2005.

2.2. Scenario Construction

The construction of a scenario in IFs can be relatively simple, with only a few variables in the model changed, or it can be rather sophisticated, reflecting changes in the world as well as within a region or country. In the example of the "African Renaissance", many variables were altered. The knowledge of what to change remains an art more than a science and is a product of the users view of the world. The changes initiated in this scenario were implemented by Dr Barry Hughes, who has a very deep experience of this type of integrated modelling. His annotated changes are summarised here, but the different durations over which these changes were implemented is not discussed for the sake of brevity.

International migration increases by 25%. A global carbon tax is initiated. Foreign aid donations from OECD nearly double in less than a decade. Foreign aid donations (from the donating countries) increases by 25% and remains at that level (note that cyclicity in the Base Case is induced by having some variables increase and decrease on a regular cycle). The proportion of foreign loans decreases (repayment of debt is reduced). Protectionism in trade import prices for the globe are reduced, except for Africa (African produce is somewhat protected from fierce global competition, allowing establishment and sustainability of regional production capacity). Multifactor productivities for agriculture, energy, materials, manufactures , services, and ICT (components of the six-sectory model) increase by varying amounts. Multifactor productivity of the economically emerging regions also increases – China, South America and South Asia. Import tariffs in Africa reduce by 25%, reflecting perhaps an increasing competitiveness and lower import prices (especially capital goods). Foreign direct investment into Africa increases by 60% over a few years. Economic freedom increases somewhat.

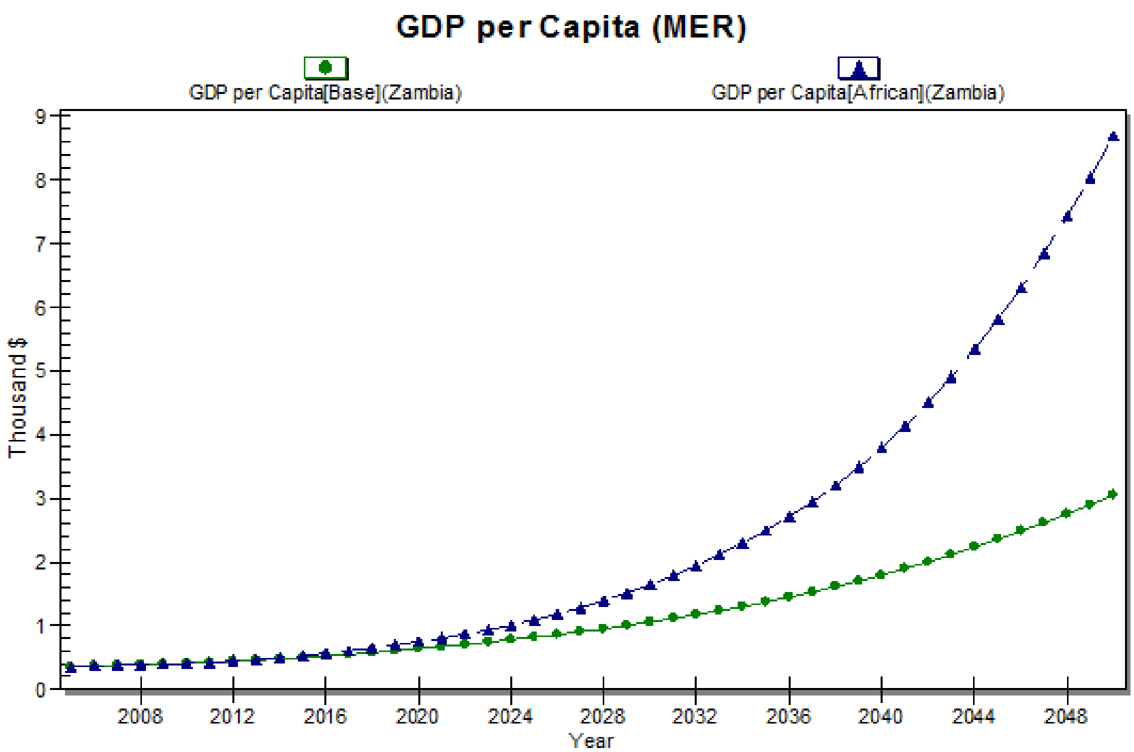

Figure 1 GDP per capita (MER) modelled for Zambia using the Base Case and the African Renaissance scenarios, with the origin of increased investment implemented in 2005. MER is the market exchange rate unit of GDP

Government expenditures were changed in the scenario. Military spending decreased by 20%, Spending on health increased by 20%. Education and R&D increased by 20%. Agricultural productivity increased by 20%. Infrastructure electricity use increased by 10%, reflecting a more intense infrastructure that aids the economy – pumps, load haulage being key examples. The percentage of people with access to safe water increased by 25% (note – the proportion, not the absolute number).

3. Population Projections and Distributions

The relative proportions of each riparian country within the Zambezi River basin is represented in Table 1 below.

Table 1 Proportions of each riparian country located within the Zambezi River Basin

Zambezi River Basin	Total area of country (km^2)	Area of country within basin (km^2)	As % total area of the basin (%)	As % of total area of the country (%)
Angola	1,246,700	235,423	17.4	18.9
Namibia	824,900	17,426	1.3	2.1
Botswana	581,730	12,401	0.9	2.1
Zimbabwe	390,760	213,036	15.8	54.5
Zambia	752,610	574,875	42.5	76.4
Tanzania	945,090	27,840	2.1	2.9
Malawi	118,480	108,360	8.0	91.5
Mozambique	801,590	162,004	12.0	20.2
		1,351,365		

Source:
http://www.fao.org/docrep/W4347E/w4347e0o.htm

The population projections of the UN (2010) and IF (V 6.38) are compared in Figure 2 below. At the 2010 mark they are the same because they are modelled off the same data. Projecting out to 2070, the projections diverge dramatically, such that the UN system exceeds the IFs forecast by 100%. The discrepancy is driven by the way the projections are estimated. The UN projections are probabilistic expressions based on historical data. The IFs projections are based on the interactions of socio-economic development in a large-scale integrated model and contain significant feedbacks. Both are models and attempting to predict the future. By definition, both are projections and we cannot predict the future, therefore by definition neither are correct but one is more likely to represent the truth than the other. In this case, we favour the IFs projections. It seems scarcely credible that by 2100 Zambia may have a population of 140+ million people. How would they obtain sufficient food, energy and otherwise sustain their livelihoods? The IFs system models population growth with significant feedbacks from such effects as growing wealth and educational standards, especially for women, which usually means a faster reducing Total Fertility Rate (TFR).

In the IFs model, based on the researches of others, population growth is predicated on mortality (life expectancy) and total fertility rate as well as to a lesser extent, migration (Hughes et al, 2009). Life expectancy in turn is driven by the health spending of the country, measures of technology in use and GDP per capita. Total fertility rates are driven also by GDP per capita, measures of population policies and education (especially of females) (Hughes et al., 2009).

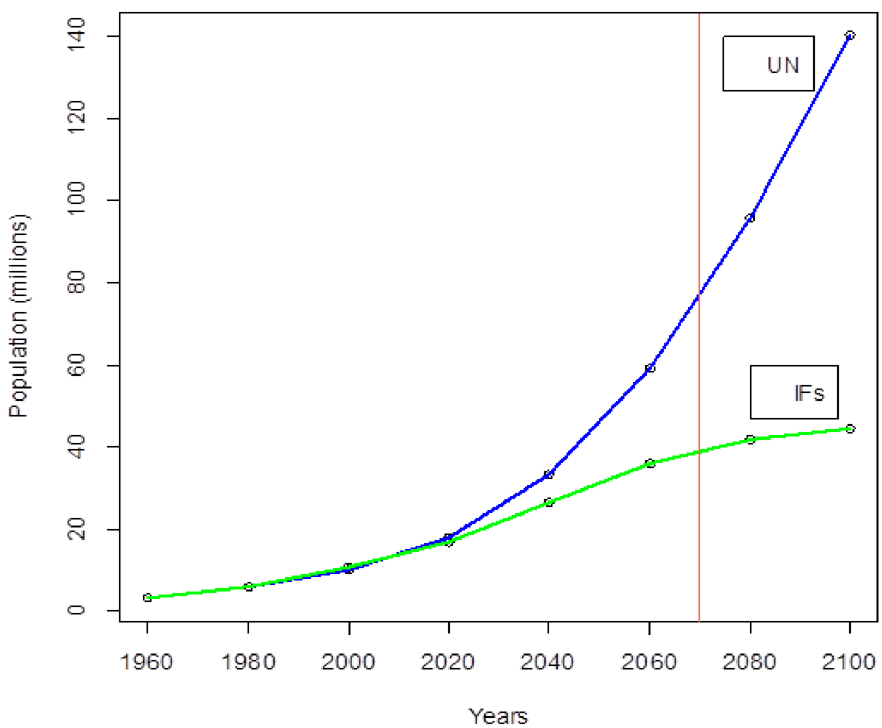

Figure 2 A comparison between the UN and IFs projections on population growth within Zambia (UN – blue line, IFs – green line). The red line represents 2070 – the projection horizon for the analysis.

4. Alternative population projections driven by other IFs scenarios

Population growth is primarily a function of the Total Fertility Rate (TFR), and in the IFs model, is modified by the influence that rising personal income and education levels lowers the fertility rate. Higher GDP growth developed in the AR scenario feeds through to the population growth rate by modifying the TFR. This effect is widely acknowledged in the literature (see Hughes et al., 2009). An accelerating growth in GDP leads to rising individual wealth which people use to invest more strongly into health and education of offspring. Therefore, increased GDP has the effect of lowering regional population growth rates, pointing to the effects of a population dividend.

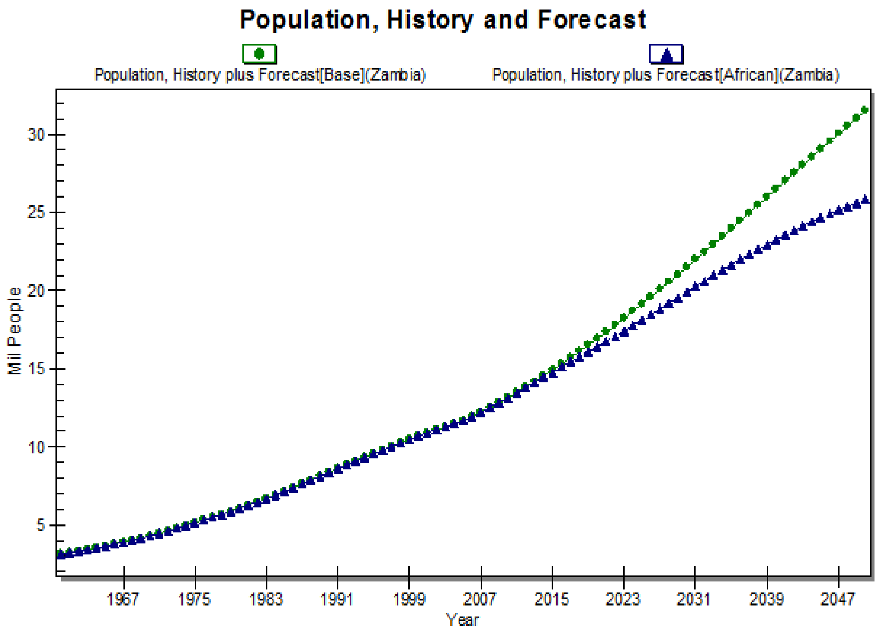

Figure 3 Population projections, based on historical record and IFs forecasts for the Base Case and African Renaissance scenarios (IFs V. 3.68)

5. Urban-rural transitions

The rate of rural migration to urban areas is a subject of concern because it will affect the demand for water in the system. Modelling using IFs suggests that while urbanization proceeded rapidly from the 1960s and since independence in Zambia resulted in the lifting of migration laws, by the 1980s the rate of influx suddenly reversed. This had much to do with the economic crises that Zambia experienced and people left the cities to find livelihoods on the land.

there will be some urban to rural migration within Zambia (Fig 4). The reasons for this are not clear at present and this needs further investigation. It does suggest that the population growth within the cities and other major urban centres is drivern mostly internally through high fertility rates

Urban population growth for key towns

Population projections for the following urban centres have been modelled and time series for each city is provided in a separate spreadsheet. A logistic model is used for these projections. One of the most important aspects is to provide an upper limit to which each city could expand. The rationale for this that for less than optimal developmental status, the higher the population becomes, the more likely there is an outmigration back to rural areas. This is reflected in the forecasts by IFs of the Zambian population in Figure 4. Upper limits for population numbers in an urban centre are suggested by its current commercial importance and are listed in Table 2 below. They are also loosely based on estimates contained in Demographia (2010), which were use to set rough limit to absolute size. As with all estimates, caution in using these numbers is urged.

Table 1 Major urban centres within the Zambezi River basin and their likely population limits by 2070

Urban centre	Population limits (millions)
Kitwe	1.5
Ndola	1.0
Lusaka	2.5
Harare	3.0
Bulawayo	2.0
Lilongwe	3.0
Blantyre	2.0

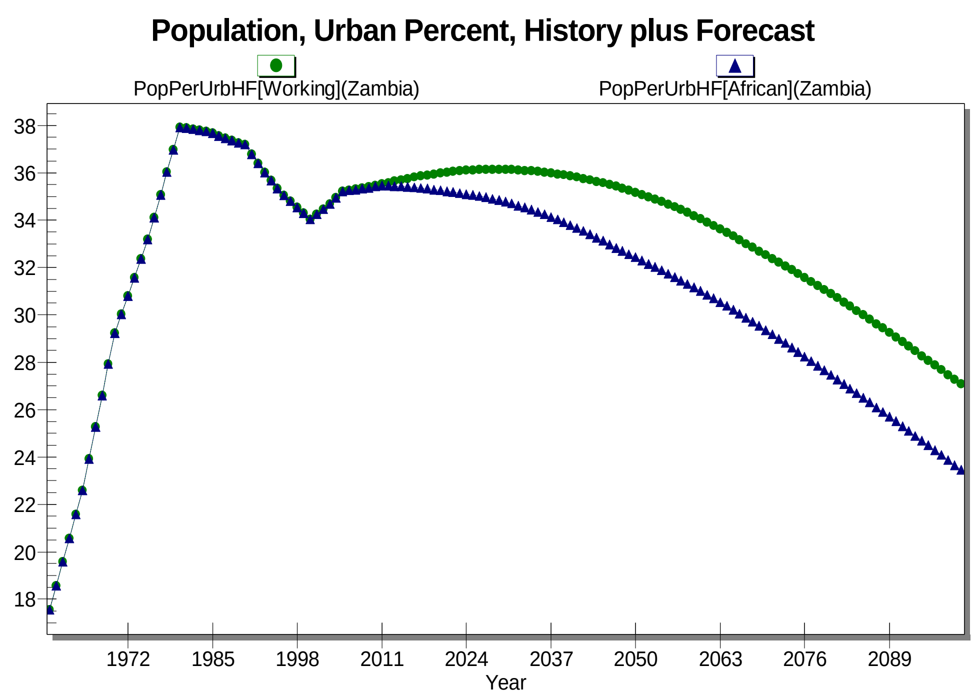

Figure 4 Projections of the percentage of urban population, as a fraction of the total population in Zambia (IFs V6.38)

6. Projections on Agriculture

The rising population numbers of necessity require increased investment in agricultural production. This can come through increases i both irrigated and rainfed production. Rising agricultural production is reflected in Figure 3 and its effects on the water resources in the IFs model in Figure 5.

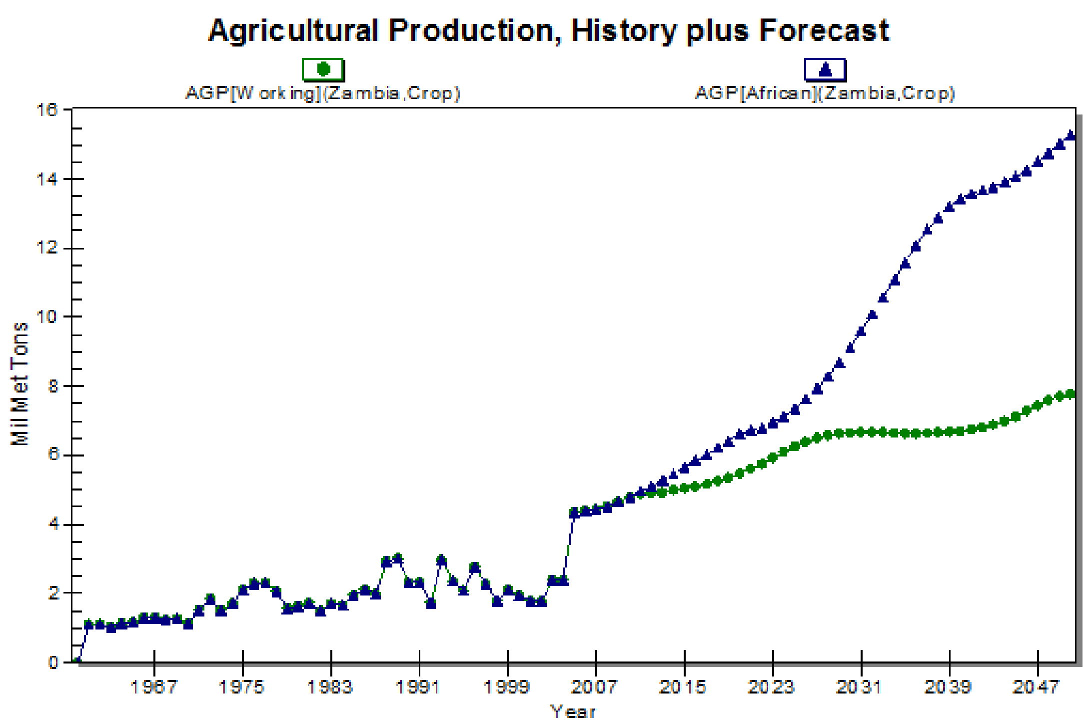

Figure 5 Forecasts for agricultural production for the Base Case and African Renaissance scenarios (IFS, V6.38).

The agricultural impact on water is only simulated in this case as the agricultural production in terms of crop yield. "The dominant relationships of agricultural yield are is an aggregation of food demand, feed demand (for animal production) and industrial demand. The primary determinants of food demand are the size of the population and consumption level per capita" (IFs V 6.38). Once demand has been calculated, agricultural production is then a product of land available and crop yield (IFs V6.38). Shortfalls are met through a model of imports and suppressed production.

7. Projections on Water Demand

Based on the above changes to GDP and the flow through to agricultural production, water demand in the Zambezi River basin rises (Fig 6) Increasing wealth means greater individual demand for water in the major urban centres. Increasing GDP therefore feeds through to greater water demand across all sectors of society. Improved technology also means greater ability to exploit available water resources. The figure below is presented for illustrative purposes. The main study is likely to use those figures prepared by the World Bank.

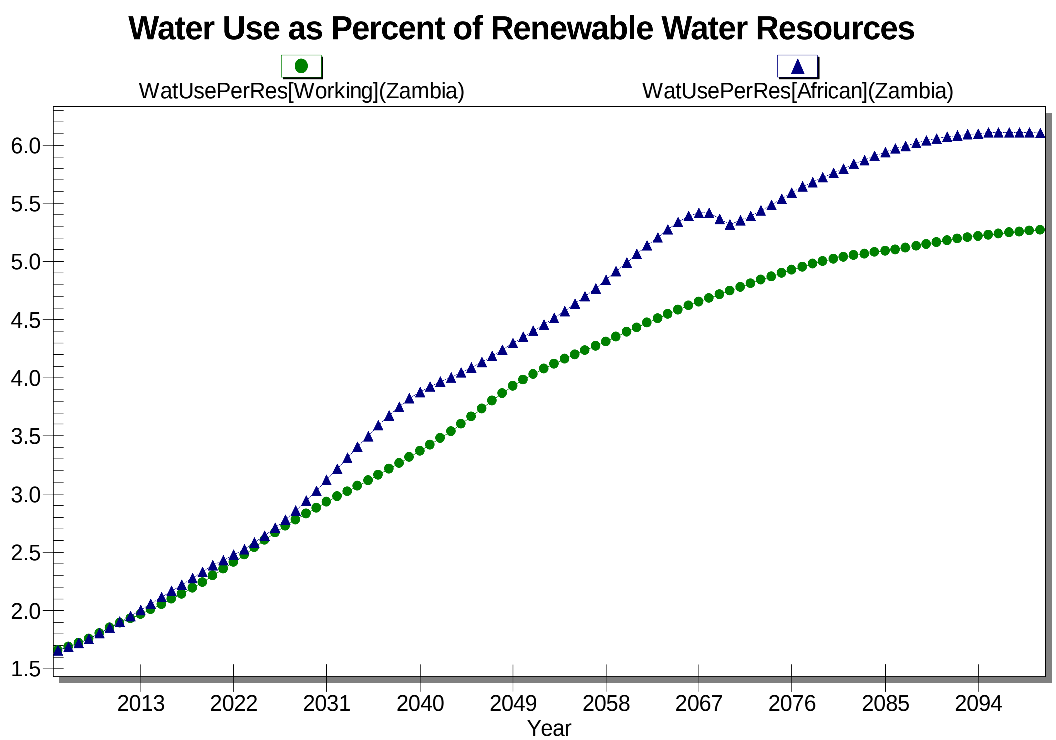

Figure 6 Forecasts for water use as a percentage of the total renewal water resource for the Base Case and African Renaissance scenarios (IFS, V6.38).

8. Potential Inter-basin Transfer Schemes (IBTS) out of the Zambezi River Basin

Several IBTS have been proposed for the Zambezi River basin.

Botswana

A feasibility design study was released in August 2010 by Ministry of Minerals, Energy and Water Resources, Department of Water Affairs, Republic of Botswana – undertaken by a consortium of consultants (WRC, 2010). The Botswana National

Water Master Plan commissioned a study to investigate the feasibility of transferring 495 x 106 m3.yr-1 from the Chobe-Zambezi for use mostly in an agricultural scheme at Pandamatenga, an amount which could be increased at later stages to accommodate forseen water deficits in urban centres in Botswana.

The scheme would link up to the existing North-South Carriers Water Pipeline and implementation would begin in this decade 2011-2020. Botswana has submitted a formal request to the Zambezi Member States to the SADC Ministers of Water Meeting at Maputo, Mozambique, 6-9 July 2009.

Zimbabwe

The National Matabeleland Zambezi Water Project is a proposal to withdraw water from the Zambezi River and pipe it as far as Bulawayo, which has a chronic water problem. To date, it has proved prohibitively expensive and there is still discussion around the legality of the potential development. The Chinese government are potential funders. The scheme layout includes pipeline from the Zambezi River to the Gwayi-Tshangani Dam and then from there to Bulawayo's Cowdry Park reservoir. The total length of such a pipeline would be about 450 km.

Initial estimates are for about 4,500 x 106 m3.yr-1 (or at 2 m3.s-1 this works out at 63 x x 106 m3.yr-1 – Nakayama, 2003) There is much ongoing discussion and even some initial construction, which appears stalled as the necessary agreements between the riparian countries has not been initiated.

South Africa

A concept proposal has been put forward for a water transfer of ~ 100 m3.s-1 (or 3154 x 106 m3.yr-1 from the Zambezi River basin to the South African Highveld/Gauteng region (Heyns, 2003).

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