Building Climate Resilience through Virtual Water and Nexus thinking in SADC – A think 'peace'

Edited by: Gavin Quibell and Anna Entholzner

CRIDF

Sovereign Security with a Cherry on Top:

Building Climate Resilience through Virtual Water and Nexus thinking in SADC – A think 'peace'

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Acronyms and Jargon Buster

ADB	African Development Bank
ASR	Aquifer Storage and Recovery
AECF	African Enterprise Challenge Fund
AMCOW	African Ministers Council on Water
CAADP	Comprehensive Africa Agriculture Development Programme
CAB	Congo Air Boundary
CAP	Common Agricultural Policy of the European Union
Climate Resilience	For the purposes of this think piece: The ability to cope with climate variability as well as a possible trajectory of change, whether human induced or not.
CRIDF	Climate Resilient Infrastructure Development Facility
DDT	Chemical pesticide used to control malaria
DfID	Department for International Development
EU	European Union
EUWF	European Union Water Facility
ENSO	El Niño Southern Oscillation
FAO	Food and Agriculture Organisation
FLS	Front Line States
GCM	Global Climate Model
GDP	Gross Domestic Product
HDI	Human Development Index
HPI	Happy Planet Index
Hydro centric	Approaches that place water at the centre of development, seeking to convene stakeholders to participate in water-focused processes on a river basin scale..
Hydro supporting	Processes seek to work with user sectors at the scale of political units and focus on demand centres and supply systems. They develop responses to strategies emerging from user sectors and integrate these into multi-purpose rather than single purpose responses.
IBT	Inter Basin Transfer of water
IGWAC	International Ground Water Assessment Centre

ISIC	International Standard Industrial Classification
ITCZ	Inter-Tropical Convergence Zone
IWMI	International Water Management Institute
JWC	Joint Water Commission – Mozambique and Zimbabwe (on waters of common concern)
LIMCOM	Limpopo Watercourse Commission
LUSIP	Lower Usuthu Smallholder Irrigation Project
MAP:MAR	Mean Annual Precipitation to Mean Annual Runoff
NEXAS	**N**atural **E**cosystems e**X**pect **A**ccountable **S**tewardship
OECD	Organisation for Economic Cooperation and Development
OMVS	Organisation pour la Mise en Valeur du fleuve Sénégal – Senegal River Authority
OKACOM	Okavango River Commission
ORASECOM	Orange-Senqu River Commission
Peace Dividends	For the purposes of this think piece does not mean an absence of conflict, but rather an absence of unilateral action and / or hegemony.
PNA	Parallel National Action, a Scandinavian approach to nation growth with regional benefits.
RBO	River Basin Organisations
RISDP	Regional Indicative Strategic Development Plan
RSAP 3	Regional Strategic Action Plan for water 2010-2015
SADC	Southern African Development Community
SADCC	Southern African Development Coordinating Conference
SAHPC	Southern African Hydropolitical Complex
SAPP	Southern African Power Pool
SEEA	System of Environmental-Economic Accounting
SEEAW	System of Environmental-Economic accounts for water
SEFA	Sustainable Energy For All
SPI	Social Progress Index
UNEP	United National Environment Program
VW	Virtual Water

Virtual Water and Nexus thinking	For the purposes of this think piece: A process that considers the additional trade-offs, regional climate resilience, economic and environmental benefits that may be gained from considering the water footprint and virtual water contained in agricultural products and electricity traded when pursuing water, food and energy security through infrastructure.
WBCSD	World Business Council for Sustainable Development
WCI	Water Crowding Index (number of people per unit of water or hydraulic density of population)
WEF	World Economic Forum
WEF Nexus	Water-Energy-Food Nexus
WFD	European Union – Water Framework Directive
ZAMCOM	Zambezi Watercourse Commission

Chapter 1: Introduction

By

Gavin Quibell and Anna Entholzner

1.1 Background

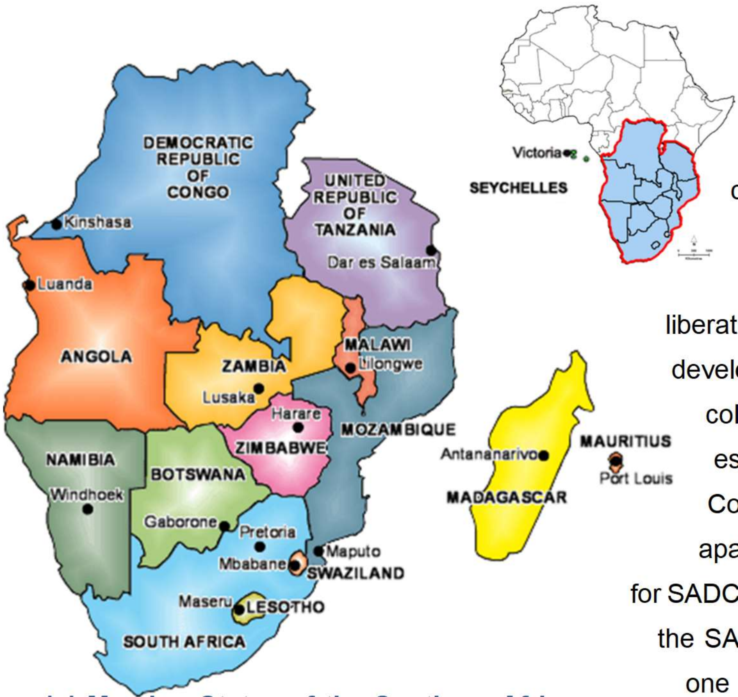

Figure 1.1 Member States of the Southern African Development Community

The Southern African Development Community (SADC) comprises a 15 Member State block covering most of southern Africa (Figure 1.1), three of which are island States. It was born out of the Cold War when a number of localized wars of liberation and independence needed the alignment of development aid, and a coordinated struggle against colonialism, capitalism and racism lead to the establishment of the Southern African Development Coordinating Conference (SADCC). After the fall of apartheid in South Africa there was no longer a need for SADCC, which was then transformed into SADC through the SADC Treaty of 1992, and which entered into force one year later on 30 September 1993.

The Development Community's main objectives are;

> *"To achieve development, peace and security, and economic growth, to alleviate poverty, enhance the standard and quality of life of the peoples of Southern Africa, and support the socially disadvantaged through regional integration, built on democratic principles and equitable and sustainable development"*[1].

This objective is to be achieved largely through the Regional Indicative Strategic Development Plan (RISDP) which is outlined as a comprehensive development and implementation framework for regional integration over a period of fifteen years (2005-2020). It is designed to provide clear strategic direction with respect to SADC programmes, projects and activities. One of the key pillars of the RISDP lies in the activities of the Infrastructure and Services Directorate.

[1] See: http://www.sadc.int/about-sadc/overview/

This Directorate's responsibilities cover;

- Energy;
- Transport;
- Tourism;
- Water resources management and sanitation;
- Meteorology; and
- Communication.

THE SADC VISION

The vision of SADC is one of a Common Future, a future within a regional community that will ensure economic well-being, improvement of the standards of living and quality of life, freedom and social justice and peace and security for the people of Southern Africa.

These sectors are not only all critical to SADC's overarching vision, but are also a nexus of interlinked sectors. One of the main objectives of the Infrastructure and Services Directorate is consequently to harmonise development programmes and strategies across these sectors, with a key focus on establishing an enabling environment for investments in infrastructure to build regional integration, secure peace dividends and secure economic growth.

It was into this milieu that the United Kingdom introduced its Climate Resilient Infrastructure Development Facility (CRIDF). CRIDF's Impact Statement is presented as;

> *"Peaceful and climate resilient management of shared water resources in SADC for the benefit of the poor."*

The Facility's focus on transboundary water resources limit's the geographical scope of its activities in mainland SADC.

The series of papers captured here represents one of CRIDF's strategic think pieces in support of its mandate and legacy. It aims at assessing the extent to which virtual water, water footprint, and the water, food and energy nexus concepts could contribute to the Infrastructure and Services Directorate's goals, and SADCs overarching integration, poverty reduction, peace dividends and economic growth objectives.

CRIDF's raison d'etre and mandate

The Climate Resilient Infrastructure Development Facility (CRIDF) is the United Kingdom's, Department for International Development's (DFID's) new water infrastructure programme for southern Africa. The Facility promotes the delivery of small to medium-scale infrastructure across SADC through technical assistance aimed at developing sustainable pro-poor Projects, and then facilitating access to finance to deliver that infrastructure. CRIDF focuses on water services, water for livelihoods and cross border flood warning infrastructure, aligning with national and regional water resource management goals and basin plans, and building climate resilience for the beneficiary communities. CRIDF's geographical scope of activities is limited to the transboundary basins on the mainland (Figure 1.2).

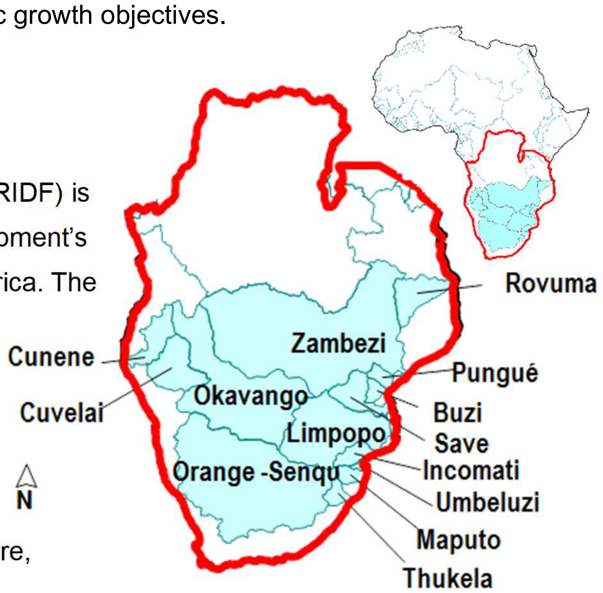

Figure 1.2 The shared watercourses (Transboundary Basins) that form CRIDF's geographical scope.

However, CRIDF also recognises that small to medium-scale infrastructure has limited transboundary impact, and the Facility's small infrastructure Projects will not be large enough to drive regional integration. Moreover, the small-scale infrastructure focus will primarily benefit the rural poor. While currently some 60% of SADC's population is rural, this is down from 66% in 2000, and migration to larger cities and a burgeoning urban poor population is a regional phenomenon[2]. CRIDF's small infrastructure Projects will not be large or numerous enough to drive regional integration, or make a substantial impact on the overall shortfall. The sum total of beneficiaries expected to benefit from CRIDF infrastructure projects is expected to be in the region of 4.5 million people, against a total poor population in excess of 150 million[3]. CRIDF is expected to mobilise some U$ 816 million for financing infrastructure, against an estimated deficit of U$ 100 billion[4].

CRIDF's legacy must, therefore, lie in creating an enabling environment for large scale replication, while recognising the potential risks of cumulative effects, as well as in exploring options to influence larger infrastructure Projects and national planning dialogues. This must be underpinned by examining the role infrastructure, and for CRIDF particularly water infrastructure, plays in the regional and national economies. However, recognising that blue water represents only a fraction of the water in the economy, virtual water, water footprint and nexus thinking could play a role in optimising the development, positioning and operation of large hydraulic infrastructure, and may provide an alternative to the larger regional north-south water transfers that have been mooted to address the regions special water availability challenges.

Infrastructure & Services and 'peace dividends'

"rival"

late 16th cent.: from Latin rivalis, originally in the sense 'person using the same stream as another', from rivus 'stream'.

http://www.etymonline.com/

The concept of 'water wars' as the inevitable consequence of increasing global water stress gained some traction in international circles in the early 1990's. While acknowledging that 'water wars' would be unlikely in the next decade, a 2012 recent report by the US - Office of the Director of National Intelligence highlighted that by 2040 water demand will exceed availability by 40%, noting that this would be a source of regional tension and would be a 'destabilising factor'[5].

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[2] Data from: http://www.sadc.int/information-services/sadc-statistics/sadc-statiyearbook/
[3] Estimated against some 50% of the population that lie below the national poverty line.
[4] CRIDF's M&E system.
[5] Available at: http://www.dni.gov/index.php/newsroom/press-releases/96-press-releases-2012/529-odni-releases-global-water-security-ica.

However, Wolf, Kramer, Carius and Dabelko (2009)[6] argue that, because of the vital nature of water to human development, that water is more likely to fuel greater inter-dependence. Avraham Tamir (an ex-Major-General in the Israeli army), notes;

> “Why go to war over water? For the price of one week’s fighting, you could build five desalination plants. No loss of life, no international pressure, and a reliable supply you don’t have to defend in hostile territory”.[7]

The underlying principle being that water infrastructure solutions would always offer cheaper solutions than armed conflict. Certainly in SADC, with a strong political commitment to regional integration and peaceful cooperation, it seems unthinkable that water wars would ever be contemplated. This is reflected in SADC Water’s objective to;

> “..ensure that water in Southern Africa becomes a sustainable resource through the coordinated management, protection, and equitable use of its shared watercourses”.

Nonetheless, Palmerstone’s[8] caution that;

> “Nations have no permanent friends or allies, they only have permanent interests”.

… underpins a key reality; nation States must act in the interests of their own people. Indeed, the democracy demanded by western donors requires this. The trick is of course to demonstrate that regional integration and cooperation over water is in the national interest, and of the SADC region as a whole. Ultimately, however, this may mean countries foregoing immediate and obvious benefits in favour of a regional optimum. In a rapidly developing region like SADC, still to some extent prone to internal instability, this is a big ask. While, there are certainly excellent examples of significant cooperation over water in SADC, we are still some way from the ideal of joint regional optimal benefits.

Arezki and Brückner (2011)[9] note that in low income countries increases in the international food prices lead to a significant deterioration of democratic institutions and a significant increase in the incidence of anti-government demonstrations, riots, and civil conflict. In southern Africa this may be compounded by extreme inequality, the region has some of the highest Gini Coefficients in the world. An increasingly unreliable electricity supply not only affects the ability to irrigate crops, but also slows economic growth. A lack of transport infrastructure tends to limit growth to the larger urban centres and the existing growth points.

Yet the expectations of the SADC population are high. An increasingly connected population (Africa now has more mobile phones that Europe or the USA[10]) wants to benefit from the wealth and resources of the region.

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[6] Wolf AT, Kramer A, Carius A and Dabelko G (2009) Navigating Peace; Available at; http://www.wilsoncenter.org/sites/default/files/NavigatingPeaceIssue1.pdf;

[7] Quoted in: Wolf, A.T. (1995), *Hydropolitics along the Jordan River: scarce water and its impact on the Arab-Israeli conflict*, United Nations University Press: Tokyo, p. 76

[8] Lord Palmerstone (1784-1865), Minister of Foreign Affairs United Kingdom

[9] Arezki R and Brückner M (2011) Food prices and political instability; IMF Working Paper WP 11/62; available at: www.imf.org/external/pubs/ft/wp/2011/wp1162.pdf

[10] www.smartplanet.com

Tom Magliozzi's 'happiness equation';

"Happiness = Reality - Expectations."

… offers a useful if simplified perspective. SADC's population has growing expectations, driven by rapid growth in some countries, and significant inequality in others. However, the ability of the region to turn these expectations into reality through infrastructure is limited. All SADC's mainland States suffer from significant services backlogs, and understandably SADC States are likely to focus their resources primarily on the interests (or happiness) of their people, seeking more immediate returns for local infrastructure investments. Development in the region is therefore likely to maintain a largely sovereign focus, albeit sometimes through shared infrastructure addressing broader strategic requirements – like water supply to South Africa's Gauteng region, or hydropower for regional use.

CRIDF's approach to securing peace dividends therefore does not necessarily mean avoiding disagreement over water or planned infrastructure, indeed the Facility may assist inter-State notification processes aimed at addressing potential concerns around the transboundary impacts of large infrastructure. CRIDF will rather focus on reducing the chances of this rising to the level of serious dispute, which may affect cooperation in the River Basin Organisations (RBOs), or may spill over to other sectors. In this context;

WHAT ARE PEACE DIVIDENDS

Peace dividends for the purposes of this think piece does not mean an absence of conflict, but rather an absence of unilateral action and / or hegemony.

> "*Peace dividends for CRIDF does not mean an absence of conflict, it is an absence of unilateral action and / or hegemony*."

Peace dividends in SADC, at least in the medium term is likely to be about identifying the value added by cooperation around infrastructure once sovereign security has been secured.

Peaceful water management also means addressing potential conflict around infrastructure at a local scale; ensuring that climate resilience is not conferred on upstream communities at the expense of their downstream neighbours.

Virtual Water and the Nexus in CRIDF

Virtual Water represents water that is 'embedded' in crops, livestock, and industrial items and services, it reflects the total amount of water used to produce the goods. The basic concept of Virtual Water was developed in the early 1990s[11], but has only been adopted relatively recently by the international community as a component of the analysis of water security. The transfers of Virtual Water in traded products can play a critical role in

[11] See, for example, Allan, J.A. (1998) Virtual water: A strategic resource. Global solutions to regional deficits. *Groundwater*, **36** (4), 545-546; also Allan, J.A. (2011). *Virtual Water: Tackling the Threat to our Planet's Most Precious Resource.* London: I.B. Tauris.

determining water security, especially where regions (or trading partners) display a range in water resource stress or water scarcity.

Virtual water has blue, green and grey water components. Blue water is that water abstracted from surface or groundwater resources used to produce the goods; green water the water derived from rainfall (or crop evapo-transpiration); whereas grey water is the volume of water that would be required to restore the water quality impact of any blue abstracted to produce the goods, or dilute any return flows. The water footprint is the total volume as well as the proportions of blue, green and grey water embedded in the product. Different water use sectors compete for blue water resources, however green water use is largely a product of the land use and its position relative to the rainfall available.

The nexus derives from the interaction, competition and trade-offs required between food and energy production both as water users. A regional perspective on the nexus would be to produce the food and energy in places where competition for dwindling water resources would be lowest, or to consider the full water footprint available for production when assessing potential trade-offs. Trading in goods with embedded water, or making better use of the full water footprint may offer alternatives to physical transfers, diversions or storage of water, at lower costs and environmental impacts, as well as reduced potential for disputes over transboundary waters.

The hypothesis lead by CRIDF is that virtual water and nexus perspectives may offer a different view for national and regional infrastructure planners. Alternatives to large scale regional north to south water *transfer* infrastructure so identified, could make better use of the *total water footprint* and *virtual water trades* in food and electricity across the region, promoting regional integration and net benefits for the whole region, without threatening sovereign security. These concepts may also highlight regional benefits to be gained from infrastructure primarily aimed at satisfying national needs, and an alternative take on negotiating the reasonable and equitable use of water.

CRIDF's engagement of this started with an initial assessment to determine whether virtual water flows in agricultural products and electricity were substantial enough to hold potential for building peace dividends. This work showed that there were large transfers of virtual water in both agricultural products and electricity within the SADC region. The blue, green and grey water content of these trades differed across the region, and not necessarily intuitive from the rainfall distribution. A large portion of the region's internal trading for food security came from rain-fed maize from the drier countries. Trading of electricity through the Southern African Power Pool (SAPP) provided the opportunity to reduce water consumption and carbon emissions. This initial analysis highlighted that conjunctive and regional management of water, food and energy may contribute to regional integration. Importantly, the work suggested that sovereign security could be underpinned by regional water, food and energy security; reducing the impacts of local water shortages.

However, noting the sensitivities around shifting entrenched trade patterns, sovereign security and potential hegemony, the Facility set out to both build a strong evidence base of the potential regional benefits to be gained, and to develop politically savvy approaches to introducing these concepts to key decision makers. CRIDF also recognised that to make a real difference it had to go beyond just a water focus, aiming at the 'nexus' of all the sectors relevant to SADC's Infrastructure and Services Directorate mandate. To do this, the Facility had to build an understanding of the role water, and hydraulic infrastructure plays in regional and national development, and its ties to energy, transport, communications and tourism infrastructure.

Shifting thinking from sovereign water, food and energy self-sufficiency to sovereign security through regional strategic planning and trades is challenging. Changing water use patterns in different economic sectors and shifting trade patterns is likely to be politically, legally and economically contentious. While there appeared to be considerable potential for virtual water and nexus concepts to contribute to regional climate resilience and peace dividends, it was recognised that this is a cutting edge concept, largely without precedent. There are clearly considerable political, social and economic challenges to introducing these concepts at both national and regional levels. The Facility, consequently, established a Panel of Experts with considerable experience in regional and global development, water and virtual water concepts. This think 'peace' represents the opinions of this panel in 9 Position Papers aimed at highlighting key considerations for taking these concepts further in meaningful engagements with national and regional planners.

This think 'peace'

This book is aimed at equipping the reader with a better understanding of the SADC context with respect to water, the economy, hydro-politics, development, energy and virtual water. It has the following Chapters;

Chapter 1: This chapter, which highlights the CRIDF context and reasoning behind this think piece.

Chapter 2: Provides background information on SADC's water, social, economic and climate change context.

Chapter 3: Provides a summary of the development of CRIDF's Virtual Water Database, and summarises some key results around virtual water trade in agricultural products and electricity. It also provides a brief background into water accounting in SADC.

Chapter 4: Postulates the future of SADC under the pressures of climate change and shifting water scarcity. It examines the non-political drivers and change and regional integration, and the role that virtual water can play.

Chapter 5: Examines virtual water and the nexus concepts in the context of national and regional development planning, highlighting the key drivers of development.

Chapter 6: Poses options to include virtual water, water footprinting and nexus thinking into water allocation processes both on a national and transboundary scale.

Chapter 7: Outlines electrical power planning in SADC, and the role of the SAPP. It outlines the potential benefits of reduced water stress, costs of generation, and carbon emissions in electricity trades.

Chapter 8: Examines the role of private sector stewardship, and water footprinting in managing water in the economy.

Chapter 9: Provides the international perspective of virtual water and the economy.

Chapter 10: Outlines the challenges of introducing the concepts to the right people in the right way.

Chapter 11: Draws together some of the common threads and key messages from the Panel of Experts, making recommendations for taking the process forward.

These chapters were authored by members of the panel, and peer reviewed by selected other members of the panel. However, the Chapters reflect the individual opinions of their authors, and do not necessarily reflect CRIDF's position.

Chapter 2: Water, Food and Energy; the Economy and climate change in SADC.

By

Gavin Quibell [12]

Introduction

This chapter is intended to be scene-setting in nature. It provides a broad overview of water, agricultural production, social and development indexes and the economy in SADC; and the potential impacts of climate change on water availability. Much of the rest of this think piece outlines the impacts of this on the SADC region, and the opportunities this holds for introducing virtual water and nexus thinking into regional development planning.

Water in SADC

Overview

SADC WATER AT A GLANCE

One of the most defining characteristics of water and the economy in SADC is the north-south conundrum. Water resources are unevenly distributed, both in time and space - with greater water availability in the northern and significant water stress in the southern basins. However, the largest economies and largest water, food and energy demands lie in the south, while the relative water abundance in the north does not as yet support strong economies.

- *Some 67% of SADC's economy is driven by some 5% of its water resources.*
- *70% of surface water resources are found in 15 shared watercourses.*
- *Large storage infrastructure is mostly confined to Namibia, South Africa and Zimbabwe, and less than 5% of annual renewable flows across the region stored.*
- *Groundwater is the main source of water for 70% of the rural population.*
- *Some 35% of the population does not have access to safe drinking water.*
- *Close to 55% do not have access to improved sanitation facilities.*
- *Most basins are prone to floods, droughts and water-related diseases.*
- *Climate change is expected to have significant impacts on the sub-continent, with greater than average increases in temperatures across the interior.*
- *SADC north of the ITCZ, is expected to receive more rain, while that to the south is likely to receive less, exacerbating the regional variability. The impact of this on runoff is difficult to assess.*
- *The heavily water dependent and developing nature of the region's economies, together with large poor rural populations make SADC countries vulnerable to climate change.*

(Modified from SADC's RSAP 3)

[12] This Chapter has been drawn together from contributions from several of the Chapter Authors.

Rainfall and runoff

Rainfall in SADC varies considerably over both time and space. The region is characterised by a wetter north and drier south, demarcated by the 860mm/a isohyet (the red line in Figure 2.1). This is roughly defined by the summer position of the Inter-Tropical Convergence Zone (ITCZ), as well as the wetter east coast associated with the warm Mozambique current. Areas on the 'right side' of this line could support rain-fed agriculture with a higher green water content, whereas areas on the 'wrong side' of this line would be more reliant on irrigation and many crops would have a higher blue water content.

However, areas on the 'wrong side' may be reliant on run off generated on the 'right side', for example some 60% of the runoff in the Zambezi Basin is generated to the north of the 860mm/a isohyet, but most of the use in the basin occurs south of this line. However, the overwhelming majority of agricultural production occurs on the wrong side of this line, predominantly in South Africa.

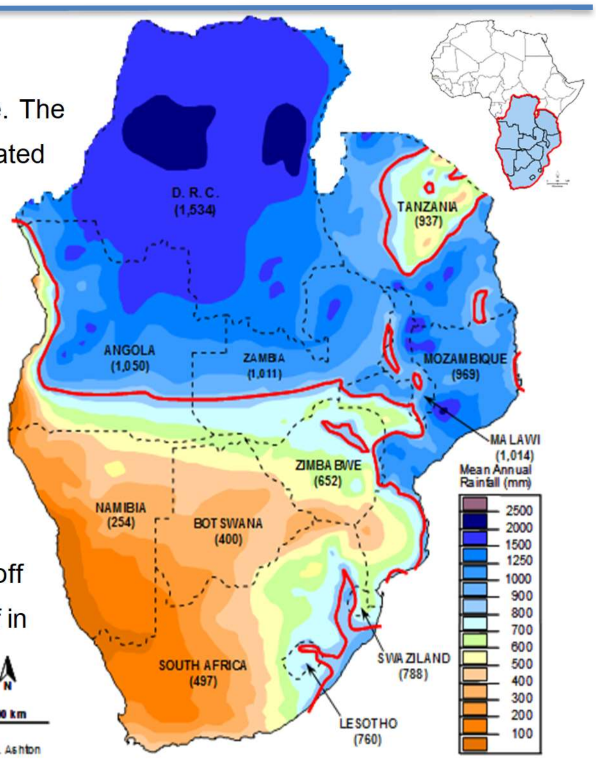

Figure 2.1 Rainfall across mainland SADC, showing the 860mm/a isohyet. The figure in brackets is the Country average rainfall in mm. Modified from Ashton (2005)

SADC's rainfall / runoff characteristices are also somewhat unique. The Mean Annual Precipitation to Mean Annual Runoff (MAP:MAR) conversion ratio for transboundary river basins, with all or some of the basin in the SADC region, clusters around 10% (Figure 2.2), whereas the continental average is some 20% (UNEP, 2002a)[13]. MAP:MAR for European rivers is closer to 50%, while many US rivers are around 25% (Figure 2.2). This low MAP:MAR is driven in part by the higher evaporation off the basin areas, and is a significant development challenge. It can also have a significant impact on the effective use of both blue and green water to drive the economy.

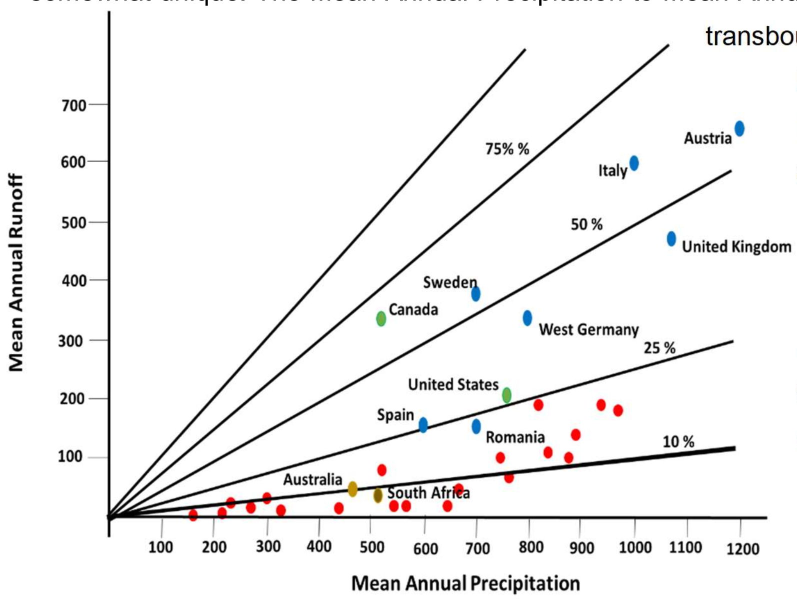

Figure 2.2 The MAP:MAR ratios for selected countries and basins. The red dots represent SADC Transboundary Basins. (re-drawn from O'Keeffe, *et al* 1992).

[13] UNEP. 2002(a). *Vital Water Graphics: An Overview of the State of the World's Fresh and Marine Waters.* United Nations Environment Program (UNEP): Nairobi.

Water use and availability

Blue water availability varies significantly across SADC from over 8000 m^3/cap/yr in the DRC to 869 m^3/cap/yr in South Africa (Table 2.1), a result both of the amount of runoff as well as the population dependent on the resource. Counter-intuitively the most stressed countries are not those with the lowest rainfall. Swaziland with very high water withdrawals primarily to irrigate sugarcane (97% of total), and South Africa with larger total withdrawals stand out as the most water stressed, and in many respects these countries are also the most vulnerable to climate change.

Table 2.1 Blue Water withdrawals, availability and use in SADC (Source CRIDF database, derived from several sources).

	Blue Water Withdrawals					Blue Water Availability and Use				
	Agric	Indust	Munic	Total (Mill m^3)	Withdraw (m^3/cap)	Water footprint m^3/p/yr[2]	% Imported[2]	Water Stress	Renew Water (m^3/cap)	Storage (m^3/cap)[1]
Angola	21%	34%	45%	705.8	34	1004	11.68	1.54	7334	468
Botswana	41%	20%	45%	194	97	623	45.39	1.36	1208	221
Congo, DRC	11%	21%	68%	683.6	10	734	1.27	0.01	> 8000	1
Lesotho	9%	46%	46%	43.8	21			3.97	2577	1272
Malawi	86%	4%	11%	1357	85	1277	1.28	0.11	1044	3
Mozambique	78%	4%	29%	884.2	35	1113	0.28	0.82	4080	1507
Namibia	70%	5%	25%	288	127	683	11.33	1.88	2778	300
South Africa	63%	8%	39%	12500	239	931	21.78	3.04	869	602
Swaziland	97%	2%	4%	1042	846	1225	17.69	3.11	2178	480
Tanzania	89%	0%	10%	5184	108	1127	2.63	1.5	1812	2187
Zambia	73%	8%	18%	1572	112	754	3.32	0.08	5882	786
Zimbabwe	79%	7%	14%	4205	306	952	1.02	0.64	918	936
SADC	**71%**	**7%**	**27%**	**2388**	**169**	**948**	**10.70**	**1.5**	**2789**	**730**

1 – Excluding the large hydropower reservoirs of Kariba and Cahora Bassa which do not act as storage for downstream use *per se*.
2 – From Mekonnen and Hoekstra (2011) [14]

South Africa stands out with respect to total withdrawals at nearly 6 times the SADC average, which is largely made possible by its greater storage. However, Swaziland, Malawi and Tanzania stand out in terms of the proportion irrigation withdrawals, (97%, 86%, and 89% respectively). Angola, the DRC, Lesotho and Mozambique stand out in terms of very low per capita withdrawal.

As may be expected, Botswana because of its relative wealth and low rainfall, and South Africa because of its relative wealth are considerable importers of virtual water, importing 45% and 21% of their water footprints. Another large virtual water importer is Angola, despite having the second highest renewable water per capita.

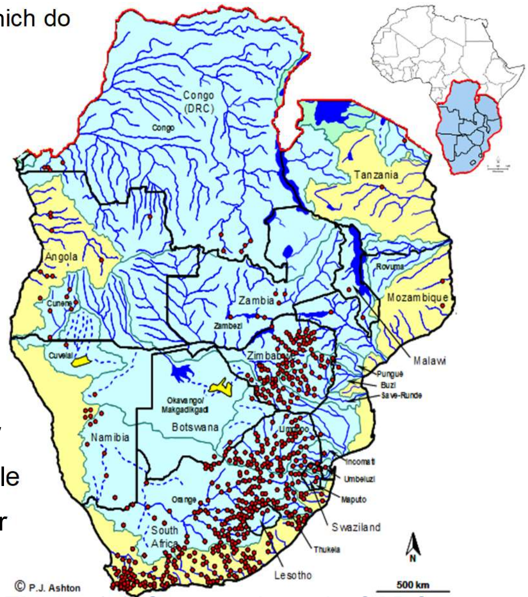

Figure 2.3 Storage dams in SADC over 10m in height.

[14] Mekonnen, M.M. and A.Y. Hoekstra (2011). *National Water Footprint Accounts: The Green, Blue and Grey Water Footprint of Production and Consumption. Volumes 1 and 2.* Value of Water Research Report Series No. 50, UNESCO-IHE, Delft, the Netherlands.

Climate change and water availability

Rainfall across the SADC region is highly variable (Figure 2.1) and driven by a complex interaction of a range of distinct climatic systems, including the:

- ITCZ (Inter-tropical convergence zone)
- Congo Air Boundary
- Mid-latitude cyclones
- Botswana High Pressure
- Cyclones
- Temperate troughs

Low rainfall over most of southern Africa during winter is caused by anti-cyclonic circulation situated over Botswana (Botswana High Pressure). This system weakens during summer when a heat driven low pressure system helps to suppress the circulation pattern. The subsequent regional expression of the global atmospheric circulation causes rainfall in southern Africa, summarised in very broad detail, as follows:

- The Inter-tropical Convergence Zone (ITCZ) and the Congo Air Boundary (CAB) creates a zone of convergence and rainfall;
- Anticyclones (travelling and blocking) suppress the ITCZ circulation;
- A thermal low pressure system over Botswana and Namibia, extending at times into Zambia and Congo DRC, breaks up anticyclone circulation;
- El Niño Southern Oscillation (ENSO) distorts the position of the ITCZ and creates conditions for enhanced or restricted rainfalls, and
- Tropical cyclones make landfall along the Mozambican and South African coastlines, bring very intense rainfalls and flooding to coastal regions.

Other rainfall-producing systems include the Indian Ocean monsoon which affects only the extreme north-east of the Zambezi basin in the upper reaches of the Luangwa basin. It is therefore critical to flows in the lower Zambezi, and consequently the production of hydropower at Cahora Bassa Dam.

Inter-annual variability in SADC is also linked to a number of larger southern hemisphere climatic systems, of which the El Nino event has some of the largest impacts; resulting in warm and dry conditions in summer rainfall regions. The ENSO event is driven by ocean-atmospheric interactions due to warming in the Pacific Ocean, causing an El Nino event every three to seven years. La Nina is the cold phase of the cycle which results in cooler and wetter conditions.

Projecting the impacts of global warming on these events is complex, and Global Climate Models (GCMs) tend to show different projections rainfall patterns for southern Africa. There are nonetheless some points of conversion; all GCMs show increased temperatures of the SADC interior. The IPCC Fourth Assessment Report (IPCC, 2007)[15] indicates that land surface warming in SADC is likely to exceed the global mean land surface temperature increase in all seasons. Changes in rainfall patterns are more difficult to predict as a result of the different climatic forces controlling the weather patterns. Climatically there are distinct regions within SADC with particular expected impacts. The northern regions of SADC, which include the Congo Basin

[15] IPCC (2007) IPCC Fourth Assessment Report; available at: http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm

and Zambezi Valley, are impacted by the position of the ITCZ. A more southerly position of the ITCZ means more rainfall over northern Angola and Zambia, while a more northern position reduces This can make profound differences to runoff in the Zambezi River. Drought-prone areas of Namibia, Botswana, and Zimbabwe are likely to be more vulnerable than the more humid areas of Tanzania or Zambia, and there is a 90 percent probability that the extent of drought-affected areas will increase (IPCC, 2007). Rainfall projections are typified in Figure 2.4.

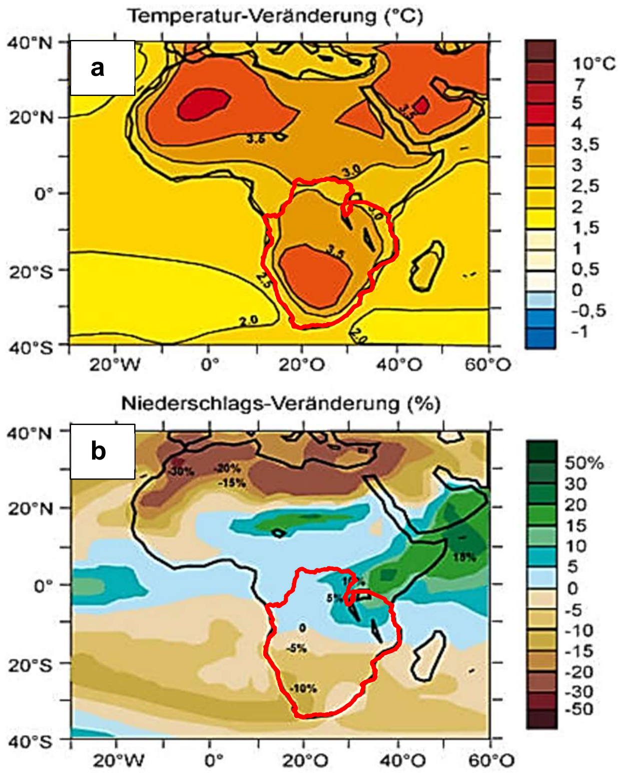

Figure 2.4 Projected temperature (a) and rainfall changes (b) over Africa for 2050.

The effects of both changes in rainfall and higher temperatures are difficult to predict. However the already low MAP:MAR ratios (Figure 2.2) and areas even areas which get more rain ***may*** suffer less runoff. Those that get drier may suffer a multiplier effect of reduced rainfall, and increased evaporative losses.

SADC countries and basins are therefore likely to experience climate change quite differently, and the current wet north / dry south split is likely to get more pronounced. Critical to this will be those basins lying across the ITCZ, which may experience increased variability in runoff depending on the impact of El Nino and the position of the ITCZ. This will particularly affect the southern flowing rivers, the Cunene, Cuvelai, Okavango and Zambezi Basins.

Water availability in the southern Basins, which are currently close to closure; the Orange-Senqu, Limpopo and InKomati, can be expected to reduce even further. Currently these basins support some 67% of the regional economy, with only 5% of the region's renewable water resources.

SADC's Economy

GDP, social progress and climate vulnerability

SADC's economy is also characterised by a north / south split, and by South Africa's regional dominance. South Africa accounts for some 61% of SADC's economy, and the drier southern Countries; Botswana, Namibia and South Africa account for 2/3rds of the regional GDP (Table 2.2). Regionally, the DRC, Malawi, Mozambique, Zambia and Zimbabwe stand out as having a significant portion of their economy and labour linked to agriculture. These countries are also typified as being the most vulnerable to climate change. Importantly, 4 of SADC's Member States are expected to be in top few world's fastest growing economies; Angola, Mozambique, Tanzania and Zambia. While these countries are coming off a lower base, they may still exert growing demands on water, food and energy in the region.

SADC States are also typified by being some of the most unequal in the world, with all of SADC (with the exception of Tanzania) having a Gini Coefficient higher than the global average (Table 2.2). Three countries, Namibia, Botswana and South Africa, are the top three countries in terms of income inequality (not accounting for social grants). All of SADC has a Human Development Index below the global average of 0.66 (Table 2.2).

Table 2.2 Economic and Social indexes for SADC States (Source CRIDF database, various sources).

	GDP				Social Progress				
	GDP U$ Billion	Agriculture, GDP (%)	Industry, GDP (%)	Services, GDP (%)	Gini[1]	HDI[2]	Climate Vulner Index[3]	Happy Planet Index[4]	Well Being[5]
Angola	114.15	9.29		32	50.65	0.51	0.52	33.2	4.21
Botswana	14.50	2.96	54	61	60.96	0.63	0.42	22.59	3.55
Congo, DRC	17.20	45.6	27	40		0.3	0.57	30.55	3.98
Lesotho	2.45	7.4	24	56	57.87	0.46	0.48		
Malawi	4.26	30.17	21	51	44.41	0.42	0.49	42.46	5.15
Mozambique	14.24	30.29	27	47	45.75	0.33	0.51	35.75	4.65
Namibia	13.07	7.32	36	63	69.12	0.61	0.43	38.88	4.89
South Africa	384.31	2.56	45	70	60.85	0.63	0.37	28.19	4.65
Swaziland	3.74	7.48	28	45	54.27	0.54	0.41		
Tanzania	28.24	27.68		48	35.34	0.48	0.54		
Zambia	20.59	19.51	47	45	51.54	0.45	0.50	37.73	5.26
Zimbabwe	9.80	15.66	29	56	50.1	0.4	0.47	35.32	4.85

[1] Gini Coefficient: 100 = absolute inequality (one person has everything), 0 = absolute equality (everyone has the same)

[2] Human Development Index: Measure of the extent to which vital human needs are being met (UN recommends 0.8)

[3] Climate Vulnerability Index: Measure of the vulnerability of the country to climate change. Made up of exposure, sensitivity, and ability to cope.

[4] Happy Planet Index: Measure of the extent to which human needs are being met (HDI) relative to the environmental impact.

[5] Wellbeing: Measure of the extent to which the population feels their needs are met. Arithmetic mean of individual responses to the Ladder of Life question in the Gallup World Poll. Latest data for each country as at February 2012.

SADC's economy is therefore characterised by significant inequality, both between and within countries. There is clearly some way to go with meeting the population's basic needs with HDIs below the world average. The low income status of most of the countries also means that they are particularly vulnerable to climate change. The heavy reliance of several economies on agriculture, and the lack of diversified economies (outside of South Africa) increases this vulnerability.

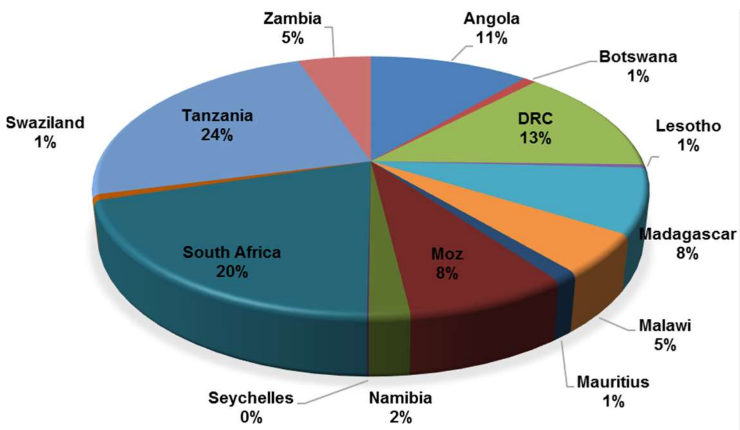

Figure 2.5 The share of Agricultural GDP per country in SADC

Agricultural production is divided between large-scale commercial production and small-scale/subsistence farming. The agricultural sector contributes between 4% and 27% to the GDP of the different countries. Some 13% of overall export earnings are from agriculture, while 70% of the population in SADC depends on agriculture for food, income and employment. Tanzania makes up the largest share of SADC's agricultural GDP, followed by South Africa, the Democratic Republic of the Congo, and Angola. Seychelles makes up the smallest share of SADC's agricultural GDP, followed by Lesotho and Swaziland (Figure 2.5). Although the GDP contribution of agriculture to the region as a whole is low (7%), it rises to 23% if the middle income countries of Botswana, Namibia and South Africa are excluded.

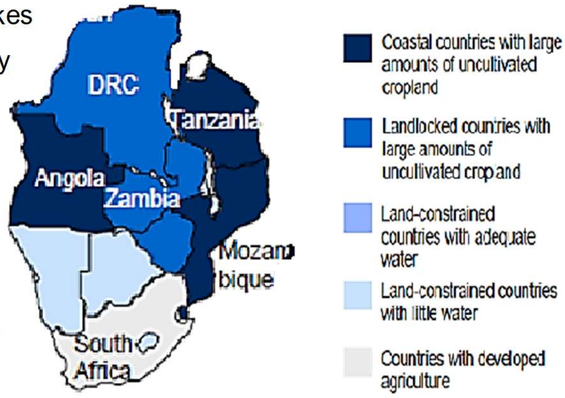

Figure 2.6 Agricultural potential in SADC

There are some 3.45 million hectares under irrigation in SADC as a whole, with some 43% of that in South Africa and a further 31% in Madagascar. The mainland States with the greatest proportion of their land under irrigation are Swaziland (26%), South Africa (9.7%), Zambia (6.5%) and Zimbabwe (4.5%). There is considerable room for expanding agricultural production in the north of SADC (Figure 2.6). Notably, Angola, Mozambique and Tanzania have significant opportunities, with some potential in DRC, Zambia and Zimbabwe (although the latter is likely to suffer the effects of climate change).

Trade in SADC

Total trade is estimated to increase going forward in SADC. The SADC Transport Plan (2012) outlined in Figure 2.6 provides outlines trade flows between SADC countries in 2009, and projected trade flows for 2027.

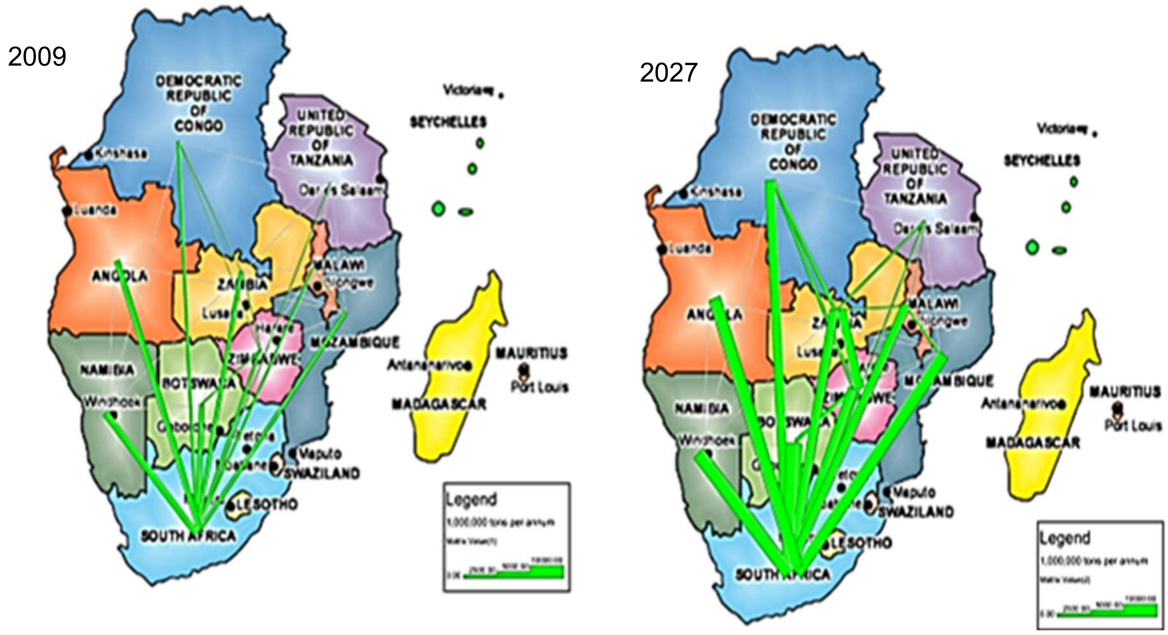

Figure 2.7 Current and expected trade flows between SADC Member States (from SADC Transport Plan, 2012)

This shows that while trades from and to South Africa are expected to dominate intra-SADC trades, there will be increasing trades between other SADC countries, particularly as transport infrastructure is further developed.

SADC's exports are currently dominated by the extractive mining industries which make up by far the bulk of the regions total exports. The regions total exports are also dominated by South Africa, which makes up close to 80% of the total exports. However, Angola rivals South Africa in terms of total value of the exports.

Electricity in SADC

SADC ELECTRICITY AT A GLANCE

SADC's electricity production is dominated by a thermal south and a hydropower north. However, given the dominance of South Africa's economy some 75% of the region's electrical energy comes from coal-fired thermal power stations in South Africa, and only 20% from hydropower, the remainder largely from nuclear and diesel. The following summarises the region's power challenges

- *Only 5% of rural areas in the region have any access to electricity;*
- *SADC falls behind other Regional Economic Communities in Africa regarding access to electricity. While 24 % of the region's residents have access, 36% of the Eastern Africa Power Pool area's residents are connected, as are 44 % of the Western African Power Pool's residents;*
- *An electricity shortage has strained the region since 2007. Although this shortage is expected to be corrected by 2014, projects intended to address the shortage lag behind deadline due to lack of funding;*
- *Low tariffs, poor project preparation, issues with Power Purchase Agreements, and absent regulatory frameworks stunt investment and financing in the energy sector;*
- *Coal supplies 75 % of power generation in Southern Africa, but is considered a contributing factor to global warming;*
- *Weak infrastructure and foreign commitments inhibit use of the region's abundant petroleum and natural gas resources; and*
- *Pricing and infrastructure hurdles such as grid connections, manufacturing, and quality testing impede development of the region's renewable energy potential.*

From: SADC Regional Infrastructure Development Master Plan

In light of these challenges, SADC's - Protocol on Energy supports the cooperation in energy development, harmonising policies, strategies and procedures throughout the region. In 2012 a Regional Infrastructure Development Master Plan with an associated Energy Sector Plan was developed to set out objectives for SADC and its Member States in infrastructure development in energy. However, as is addressed in Chapter 7, there have been considerable challenges with implementation.

The Southern African Power Pool (SAPP) was established in August 1995 in an attempt to address these challenges. Current membership of SAPP comprises the national electricity utilities of the 12 continental members of SADC, an independent power producer (IPP) and independent transmission company (ITC) from Zambia. The SAPP mandate is guided by the SADC Protocol on Energy signed in Maseru on 24 August 1996 which is the principal policy document governing the SADC energy sector. The protocol defines the guidelines for co-operation in the electricity sector, which include the development and updating of a regional electricity Master-plan, development and utilisation of electricity in an environmentally sound manner, and emphasising the need for universal access to affordable and quality services.

Conclusions

One of the most pervasive characteristics of the analysis presented here is the dual nature of SADC, both within and between its Member States. This dual nature is expressed in water availability, the economy and the expected impacts of climate change. The well watered north does not support strong economies, the drier south drives most of the regional economy from a fraction of its total water resources. Climate change is expected to increase this north/south water availability split even further, with the wetter north getting wetter (and perhaps more variable) and the drier south, drier. However, the region's food security is still dominated by rain-fed agricultural crops produced in the south. Outside of the middle income countries, SADC economies are dominated by mining and agriculture – reflecting different climate vulnerability across the region.

SADC States are also characterised by significant internal inequality. The region has some of the world's highest Gini Coefficients, and agricultural production is split between an often informal small grower sector, and the larger commercial operations. Large commercial operations are often supported by irrigation and storage infrastructure, providing some climate resilience, but the smaller enterprises and community food gardens are often rain-fed or bucket watered. The SADC population is clustered in the areas expected to suffer the most from droughts. Small scale rural infrastructure will be required, and on a widespread scale, to make a substantial contribution to climate resilience for these people.

Yet the region is rapidly changing. The proportion of the population that is urban is growing, and there is a growing urban poor problem. The region has some of the world's fastest growing economies, economies that will increasing provide for urban jobs and a shift towards the services industries – which provide more income and jobs per drop. These shifts will have to be underpinned by large scale water, transport and communications infrastructure.

It stands to reason therefore that infrastructure delivery will also have to be dual in nature. Providing climate resilience for small rural and remote communities, but also providing climate resilience for the regional economies as a whole. CRIDF's thesis is that virtual water, and nexus thinking; addressing water, food and energy, and the full water footprint of crops produced across the region might place provide an alternative view for regional and development planners.

The following Chapters address the complex set of metrics behind implementing this challenge.

Chapter 3: Quantifying Virtual Water Flows in the 12 Continental Countries of SADC

By

David Phillips and Steven Boyall

Abstract

CRIDF has developed a data platform for Virtual Water transfers amongst the 12 continental countries of the Southern African Development Community (SADC) and with the rest of the world, embedded in agricultural products and in electricity supplies. This, together with a Global Social and Development Index database, has formed the basis for many of the analyses in other Chapters of this book. This Chapter provides a summary of the processes and source data used in developing develop the databases, as well as some examples of the potential use of the data platform.

The final section of this Paper provides a brief summary of the techniques involved in economic accounting of water, and the current position of the continental SADC countries in that regard. Notably, economic accounting of water relates to Blue Water in isolation, but the technique nevertheless provides useful complementary information to that obtained through considerations of the rest of the water footprint and the economy behind Virtual Water transfers.

Introduction

The Climate Resilient Infrastructure Development Facility (CRIDF) is an initiative of the Department for International Development (DfID) of the United Kingdom Government. CRIDF seeks to develop climate resilience in poor communities through the construction of infrastructure in the continental countries of the Southern African Development Community (SADC), thereby promoting the peaceful management of shared waters. However, CRIDF has recognised that in the longer term, peaceful cooperation in the increasingly water-stressed SADC region also requires attention to larger strategic infrastructure investment and planning. This wider focus is inherently pro-poor, protecting access to water for community-based small-scale infrastructure, but also supporting shared economic growth by planning water-related investments which recognise the potential for Virtual Water trading as a means of addressing regional water, food and energy security.

Virtual Water represents water that is 'embedded' in crops, livestock, and industrial items and services, having been used to produce these. The basic concept of Virtual Water was developed in the early 1990s[16], but has only been adopted relatively recently by the international community as a component of the analysis of water security. The transfers of Virtual Water in traded products can play a critical role in determining water security, especially where regions (or trading partners) display a range in water resource stress or water scarcity. The continental SADC countries exhibit a wide range in water resource availability, the southern portions of the African continent being much more water-stressed than the northern SADC States. Changes to international trading patterns could help to alleviate such stress, and can sometimes be mutually beneficial to partner countries – in certain instances, reducing the expenditure and infrastructure required to develop additional Blue Water resources[17], and building regional climate resilience. From one perspective, agricultural production and international trade patterns are driven by a wide range of factors, many of which are intractable and not easily changed or influenced. However, large multi-national companies present in most or all of the SADC countries may minimise their climate change risk by considering Virtual Water in their supply chains. In any event, sound and politically aware arguments will be needed to underpin any shifts in attitudes towards regional rather than sovereign water and energy security, and climate resilience.

These factors underpin the basic rationale for the 'Virtual Water and Nexus Project' within the CRIDF programme. This chapter outlines the data assembled on Virtual Water transfers in agricultural products and in electrical supplies traded by the continental SADC countries (with each other and in some cases with the rest of the world), and has been created to act as a partial basis for further work

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[16] See, for example, Allan, J.A. (1998) Virtual water: A strategic resource. Global solutions to regional deficits. *Groundwater*, **36** (4), 545-546; also Allan, J.A. (2011). *Virtual Water: Tackling the Threat to our Planet's Most Precious Resource*. London: I.B. Tauris.

[17] Blue Water is present in surface waters and aquifers, and is the classical focus of studies on the hydrosphere. However, Green Water (known sometimes as soil moisture) is also of great importance in the agricultural sector in particular, and Grey Water (volumes required to account for polluting effects) can also be of significance.

under the CRIDF as a whole, with the intention to help the development of sound arguments and an evidence base grounded in improved resource management and shared economic benefits.

Data Sources; Quality Assurance/Quality Control

Data Relating to Agricultural Products

As noted in greater detail in the following section of this Chapter, CRIDF's identifies the Virtual Water components and transfers relating to all internationally traded agricultural products (crops and livestock) for all of the 12 continental countries within SADC.

In most cases, the resources available to the study team precluded the collation of primary data from specific agricultural sectors, or the data available from SADC States which are not accessible through the internet. The primary databases employed were therefore mainly of a global nature, and included:

- Chapagain and Hoekstra (2004) for bulk Virtual Water transfers[18];
- Mekonnen and Hoekstra (2011) for water footprints[19];
- statistics from the Water Footprint Network (http://www.waterfootprint.org);
- import and export data from Trade Map (http://www.trademap.org/), which rely on statistics from UN Comtrade (http://comtrade.un.org/); and
- national and regional data for South Africa from the Department of Agriculture, Forestry and Fisheries (http://www.daff.gov.za/), supplemented in particular scenarios by other national/ regional data.

The first four sources cited above are those utilised by most or all researchers on Virtual Water internationally, and are widely recognised as offering state-of-the-art information that has been comprehensively quality-assured by the respective authors. There is nevertheless some controversy concerning detailed levels of Water Footprint data, and it is cautioned that some authorities suggest that such detailed Water Footprint estimates should be treated with caution. The current authors have noted that such caution is merited, on occasion.

The Trade Map and UN Comtrade data include some inconsistencies which have been noted by the project team. These involve occasional mismatches between the export statistics for a specific product involving a particular country of destination and time period, and the mirror-image import statistics of

[18] Chapagain, A.K. and A.Y. Hoekstra (2004). *Water Footprints of Nations. Volume 1: Main Report. Volume 2: Appendices.* Value of Water Research Report Series No. 16, UNESCO-IHE Institute for Water Education, the Netherlands.

[19] Mekonnen, M.M. and A.Y. Hoekstra (2011). *National Water Footprint Accounts: The Green, Blue and Grey Water Footprint of Production and Consumption. Volumes 1 and 2.* Value of Water Research Report Series No. 50, UNESCO-IHE, Delft, the Netherlands. Base data include those from Mekonnen, M.M. and Hoekstra, A.Y. (2010) The green, blue and grey water footprint of farm animals and animal products, Value of Water Research Report Series No. 48, UNESCO-IHE, Delft, the Netherlands; and Mekonnen, M.M. and Hoekstra, A.Y. (2010) The green, blue and grey water footprint of crops and derived crop products, Value of Water Research Report Series No. 47, UNESCO-IHE, Delft, the Netherlands.

the country of importation for the same product and time period. In order to complete a comprehensive Quality Assurance check in line with best practice, the following advice from UN Comtrade has been followed:

> *UN Comtrade disclaimer: http://comtrade.un.org/db/help/uReadMeFirst.aspx. (Point 5) "Imports reported by one country do not coincide with exports reported by its trading partner".*

In such circumstances, UN Comtrade recommends the use of data for imports when evaluating trade patterns, as such data are independently verified through the Customs protocol of a receiving country. The Virtual Water trade database for agricultural products has therefore been constructed in this way to ensure that the most accurate and verifiable data sets have been used.[20]

The national statistics for South Africa were derived directly from the primary governmental source of such information, and this is also the case for other specific State-centric data used in the examples quoted in the present report. Trade-related data for various countries have been compared in general terms to information in the FAOSTAT database of the Food and Agricultural Organisation (http://faostat.fao.org/), and this acted as a further quality assurance check.

Specific Studies

The data used to compile the agriculturally-related database for the 12 continental SADC States are of a country-specific nature and are hence broad in scope. While the specific treatment of these data adds considerable value and creates a data platform to support the development of regional water and food scenarios, scope remains for more detailed analyses within specific sectors. The authors of the other Chapters were invited to raise specific queries, where these were considered likely to provide useful insights or lead to potential interventions of importance.

Data Relating to Trade in Electricity

At the present stage of the work, data for the trade in electricity amongst the SADC countries have been provided primarily by Eskom and by the staff of the SAPP offices in Harare, Zimbabwe.[21] Further information of relevance (and to support the primary sources) was accessed from on-line sources of the US Energy Information Administration (http://www.eia.gov/countries/), which is an entity under the United States Department of Energy based in Washington D.C. Various published sources were

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[20] See http://unstats.un.org/unsd/trade/methodology%20IMTS.htm

[21] Data from Eskom were provided by Dr. Dave Lucas (dave.lucas@eskom.co.za), and those from SAPP were provided by Dr. Lawrence Musaba (musaba@sapp.co.zw).

employed to check the general patterns of trade in electricity (which are subject to a degree of change over time).[22]

Data reported here on the consumptive use of water in the generation of electricity and on the renewable water resources of specific countries were abstracted primarily from three sources:

- national statistics for South Africa, compiled by Eskom (see footnote [6] above);
- the report of Beilfuss (2012) for hydroelectric facilities[23]; and
- the FAOSTAT database of the Food and Agricultural Organisation.[24]

Cross-checks on these data were completed using published information for the consumptive use of water by electricity generating facilities elsewhere in the world.[25] As noted in the relevant later section of this report, there is considerable variation in the methodologies used internationally to calculate consumptive water use in the generation of electricity. The current study was constrained by the availability of time and financial resources, and does not seek to provide highly precise full life-cycle estimates of consumptive water use at each specific facility of relevance in the 12 continental countries of SADC. Such precise estimates are in any event not of utility in the context of this work, which relates to the introduction of virtual water and nexus-based thinking into the regional debate on water resource management and development. Hence, the estimates of consumptive water use in the generation of electricity as shown here are of an indicative nature, and it is argued that this is more than sufficient to act as the backdrop for future discussions of preferred approaches to electricity generation in the future in the region.

Data on economic accounting of water were amassed from a number of sources internationally and within SADC, as noted in the final section of this Chapter.

Virtual Water Transfers in Agricultural Products

The Development and General Structure of the Database

The data platform that has been established provides information at three distinct tiers of detail which are inter-related, as shown in Figure 3.1. These are described below, with examples of their use also being provided.

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[22] The sources used included Economic Consulting Associates (2009): *The Potential of Regional Power sector Integration. South African Power Pool (SAPP) Transmission and Trading Case Study.* Economic Consulting Associates Limited, London, October 2009; and the *Southern Africa Regional Integration Strategy Paper 2011-2015* of the African Development Bank (2011).

[23] Beilfuss, R. (2012). *A Risky Climate for Southern African Hydro: Assessing Hydrological Risks and Consequences for Zambezi River Basin Dams.* International Rivers, September 2012.

[24] The FAOSTAT database is available at http://www.fao.org/statistics/en/

[25] Examples include Torcellini, P., N. Long and R. Judkoff (2003), *Consumptive Water Use for U.S. Power Production*. National Renewable Energy Laboratory, Colorado; and World Bank (2010), *The Zambezi River Basin: A Multi-Sector Investment Opportunities Analysis.* The World Bank, Washington D.C., June 2010.

- The top-tier data are of a generic nature, involving net and gross estimates at country level of all internationally traded crops and livestock (separately in those two categories). External trading parties are identified specifically within the continental SADC group of 12 States, while trade with the rest of the world is cited as a single entity in the main platform. These data characterise international trade patterns in a broad manner, showing whether specific countries are net importers or exporters of Virtual Water. With more detailed interrogation, the data platform can reveal 'water savings' either for particular countries or globally, given the existing trade pattern or following pre-supposed changes to the existing pattern. Trade with the rest of the world can also be broken down into imports/exports involving specific individual countries or groups of countries, where this is of interest.

- The middle tier of detail provides data on specific traded items (including all crops and livestock subject to international trade involving SADC countries), as either single products or small groups of products according to the citations in the available trade data (as 4-digit categories of the Harmonised System, these numbering 117 products in total in the present context[26]). The specific traded products included in the data platform are those listed in Annex 1 to this Position Paper. Data are available in this tier of detail as country-wide exports and imports, with tonnages and total Virtual Water equivalents being provided. Regional data (within countries) can also sometimes be accessed.

- The lower tier of detail superimposes Water Footprints onto each product and country pairing, with Blue, Green and Grey Water all being identified in full. While this averages the footprint information across single countries, it provides a useful starting point for more detailed analysis, which can again involve regional differences where these are of interest.

The tiers of the data platform inter-relate, in the sense that information derived from one tier can be related to that in any other tier. Figure 3.2 shows an example of this, and also provides an overview of the trade in agricultural products between the continental SADC countries and the rest of the world. It is notable that the overview shown in Figure 3.2 suggests that the trade pattern as a whole is generally coherent in relation to the continental SADC States, at least in terms of the water-stressed countries.

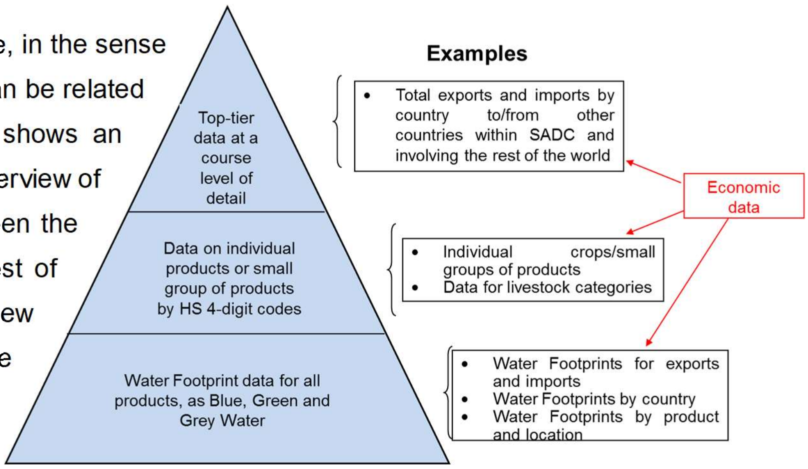

Figure 3.1 The levels of data provided in the CRIDF database for agricultural products traded around SADC

[26] The Harmonised System – also known as the Harmonised Commodity Description and Coding System – was introduced in 1988 and is used by most countries in the world to characterise trade. It is run and maintained by the World Customs Organisation based in Brussels, which has over 170 members.

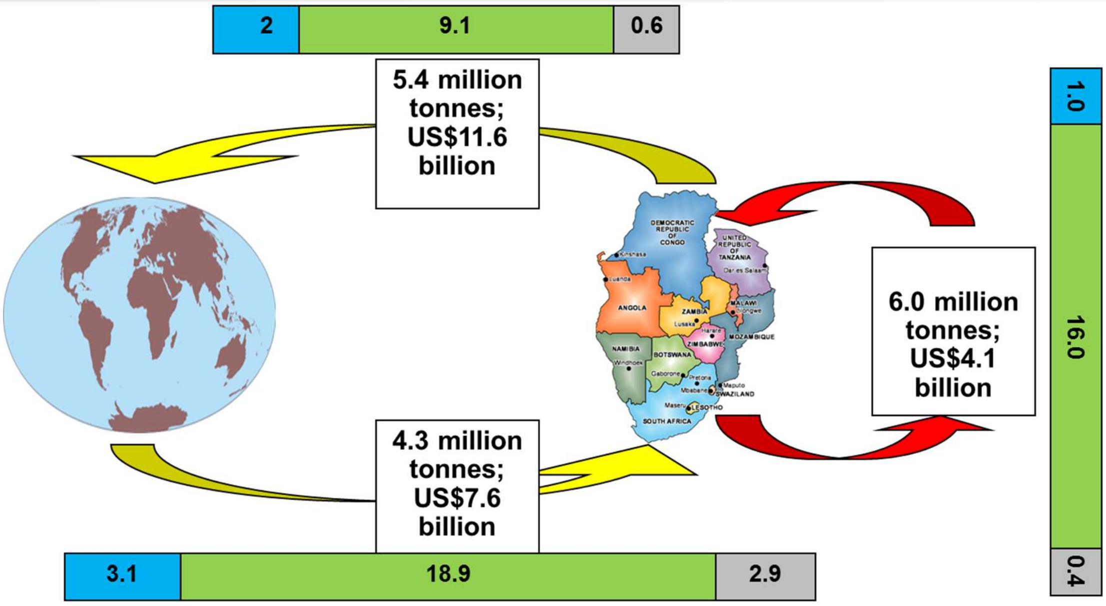

Figure 3.2 The imports and exports of agricultural products (in total) in 2012 amongst the continental SADC countries, and between these and the rest of the world. Tonnages and values are shown in text boxes; the accompanying blue, green and grey virtual water transfers are shown by 'colour' in cubic kilometres

Thus, the 12 continental SADC countries import agricultural products of lower tonnage and lower value from the rest of the world than they export thereto, but the imported products have about twice the virtual water content compared to the exports. The trade in agricultural products amongst the continental SADC countries is of a generally similar order of magnitude to the external trade, but of lower total value – and this is also accompanied by significant virtual water transfers. Greater levels of detail within the data platform reveal more nuanced patterns, however, not all of which appear so strategically coherent. Thus, for example, the exports from the continental SADC countries to the rest of the world have a higher percentage of Blue Water, compared to the imports (see Figure 3.3) – and this would appear at first sight to be contrary to the interests of the water-stressed countries within the SADC group of States.

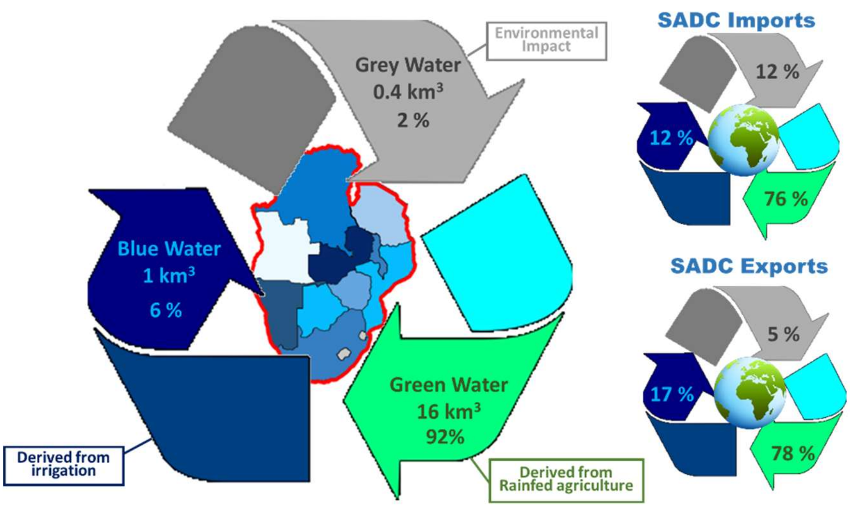

Figure 3.3
The Virtual Water components of imports and exports of agricultural products (in total) in 2012 amongst the continental SADC countries, and between these and the rest of the world. Virtual Water transfers are shown by 'colour' in cubic kilometres and also in percentage terms in relation to trade with the rest of the world.

It is also notable that agricultural products imported into SADC from the rest of the world tend to have a proportionally larger Grey Water content than those derived from and traded internally within SADC. The Water Footprint of agricultural products in the SADC countries contains only a minor Grey Water component, although the proportions of the Water Footprint taken up by Blue Water and Green Water vary considerably for some products, from country to country and also from place to place within a single country. Certain examples which follow here have ignored the Grey Water component of the overall Water Footprint for commodities traded within SADC, for simplicity.

As shown in Figure 3.1, the economic values of agricultural products have also been captured in the creation of the data platform, these being abstracted from the Trade Map and UN Comtrade statistics. The economic data can be utilised in a variety of different fashions, e.g. to calculate standard 'water productivity' values (US dollars generated per unit of Blue Water). A reliance on Green Water or Grey Water has a significant effect on the standard 'water productivity' values, and 'virtual water productivity' is proposed as a more useful indicator. It is also notable that the Virtual Water productivity of specific crops has been found to vary widely from one location to another within southern Africa, this being ascribed to a combination of the efficiency of irrigation, the yields achieved in crop production, and the prices paid for the exported crops. Such variations are of obvious significance in terms of the potential for poverty reduction in specific circumstances, but the caveats noted previously in terms of the robustness of water footprint data at high levels of detail should be kept in mind during such analyses. These regional differences notwithstanding, the virtual water productivity of SADC imports from the rest of the world is approximately U$ 0.3/m^3, while that of SADC exports to the rest of the world is U$ 1.00/m^3 (see Figure 3.2 above).

The complete agricultural dataset is very substantial, the file size in Excel being almost 18 megabytes. The data are made available for each of the 12 SADC countries addressed by the work as a whole, as well as individually. This assists users of the database to access information relating to their own specific interest. The units employed have been chosen to create sufficient precision, while avoiding the use of decimal points (i.e. a rounding up/down method has been utilised). This rounding up/down technique occasionally results in minor differences between information synthesised from the data platform, and that published by Mekonnen and Hoekstra (see footnote [4] above), but such distinctions are not of any significance.

Examples of the Use of the Agricultural Data Platform

Given the very considerable breadth of the data platform and its inherent detail, many examples could be provided of its use relating to traded agricultural commodities. However, in the interests of simplicity and brevity, this Chapter is restricted to only a few of these.

Examples of Top-Tier Data

Table 1 shows data for the net transfers of Virtual Water in the imports and exports of crops, livestock and industrial products amongst the 12 continental SADC countries.

Table 1. Net Virtual Water imports/exports internationally for the 12 continental countries of SADC. (Data from Chapagain and Hoekstra, 2004; see footnote [3] above). ND: No data.

Country	Net Virtual Water Imports [MCM/year]			
	Crop Products	Livestock Products	Industrial Products	Total Trade
Angola	206	447	140	793
Botswana	376	minus 62	54	369
DRC	136	107	59	302
Lesotho	ND	ND	ND	ND
Malawi	minus 646	8	32	minus 607
Mozambique	minus 1,112	minus 6	54	minus 1,064
Namibia	45	minus 96	88	37
South Africa	1,426	minus 293	1,011	2,145
Swaziland	134	41	41	216
Tanzania	minus 2,203	minus 41	83	minus 2,161
Zambia	minus 271	minus 14	minus 38	minus 323
Zimbabwe	minus 3,032	minus 319	103	minus 3,247

Five of the 12 countries are net exporters of Virtual Water in traded products (Malawi, Mozambique, Tanzania, Zambia and Zimbabwe). However, it is cautioned that these high-level data are derived from Chapagain and Hoekstra (2004) and refer to the late 1990s and early 2000s. Trade patterns for agricultural products change somewhat over time, and more recent data reveal subtle differences to the pattern shown in Table 1, these being explained below.

To break the net data down and add a layer of detail (albeit still at the top tier of the pyramid as presented in Figure 3.1), Figures 3.4 and 3.5 show country data for imports and exports of agricultural products (crops and livestock together) during the year 2012 by the individual SADC countries, and the respective values of those traded products (as thousands of US dollars).

South Africa dominates the overall profile for traded agricultural products in SADC, with high volumes for both imports and exports. The tonnages of imports outstrip those of exports (as is the case for the Virtual Water transfers shown in Table 3.1 above), but the economic values show a reverse trend, with exports being of greater total value than imports. In general terms (and as would be expected), the Virtual Water transfers shown in Table 3.1 align well with the data on traded tonnages and values in Figures 3.4 and 3.5.

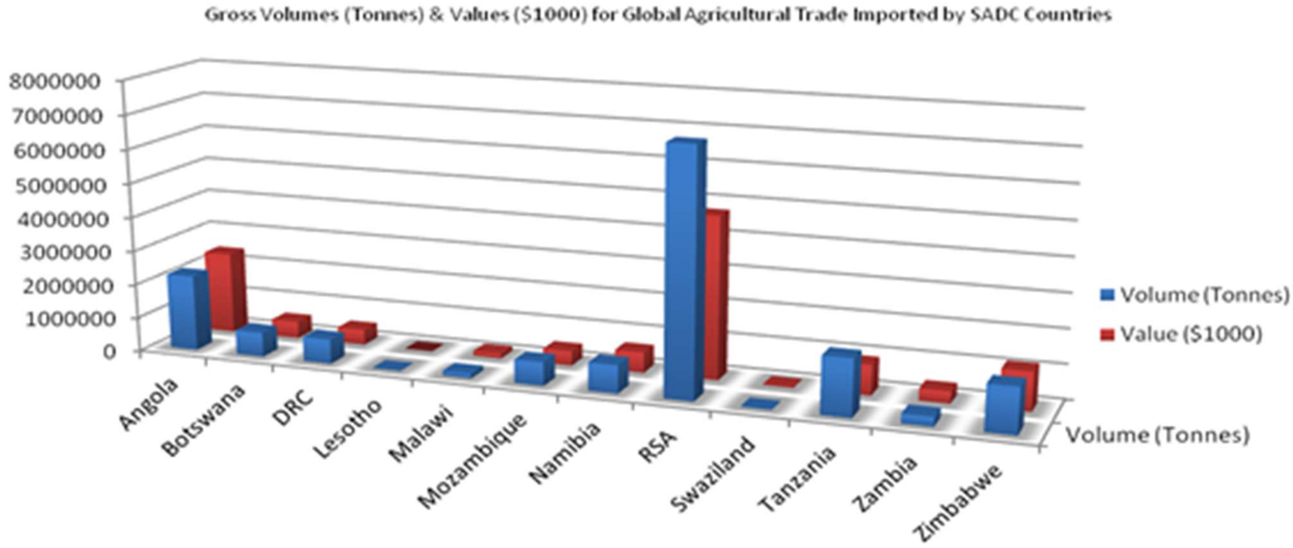

Figure 3.4 Imports of agricultural products by the continental SADC countries, and their total values.

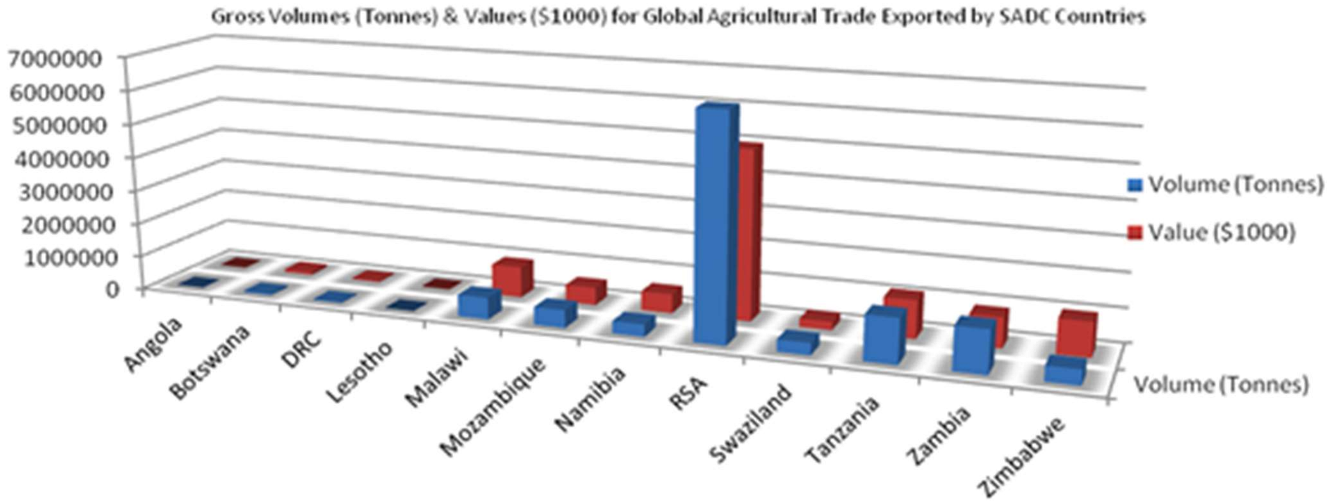

Figure 3.5 Exports of agricultural products by the continental SADC countries, and their total values.

A number of the continental SADC countries are presently significant net importers of agricultural products (and Virtual Water), these including Angola, Botswana, the DRC, Tanzania, and Zimbabwe. Mismatches appear between the gross virtual water data shown in Table 3.1 and the data in Figures 3.4 and 3.5, for both Tanzania and Zimbabwe. These relate to the distinct ages of the datasets, the annually averaged data in Table 3.1 referring to a five-year period in the late 1990s and the early 2000s, whilst the information in Figures 3.4 and 3.5 pertains to the year 2012.

Notably, Malawi, Swaziland and Zambia are presently net exporters of virtual water, and are also substantial net earners of foreign exchange in agricultural products. While South Africa is a net foreign exchange earner in agricultural products, it remains a net importer of Virtual Water. However, when data are contextualised against the size of the economy, Malawi, Swaziland and Zambia stand out as substantial exporters of agricultural products in terms of both Virtual Water transfers and value –

perhaps making these countries particularly vulnerable to reduced rainfall and run-off due to climate change.

Examples of Middle-Tier Data

As noted in Figure 3.1 of this Chapter, the 'middle tier' of the data platform is populated by product-related data. Certain products stand out amongst the internationally-traded commodities in SADC, and maize is one of these – and is also of course important as a staple foodstuff, being produced in all of the SADC countries to assist in feeding their respective national populations.[27]

Figure 3.6 shows the tonnages and values of maize imports and exports amongst the SADC countries only. It is noted that data involving trade with the rest of the world are not shown, and are minor by comparison in any event. The trade pattern within SADC is complex, and maize represents a product of significant interest to the present studies due to its importance in regional food security (see also the data on water footprints for traded maize, in the following sub-section).

The detailed trade patterns for ground nuts and sugar provide examples of three very different agricultural products. The tonnages and values of ground nuts and sugar traded within SADC are shown at Figures 3.7 and 3.8, respectively. Information of this type can be provided from the data platform for any of the single products or groups of products.

Examples of Lower-Tier Data

Lower-tier data relate to Water Footprints, which can be generated for trade patterns as a whole as shown in Figure 3.2 above, or for individual products (or groups thereof). Figures 3.9 - 3.11 show data on the Blue Water and Green Water transfers between the SADC countries allied to the trade in maize, ground nuts and sugar. These graphics provide the key Virtual Water components to complement the data on tonnages and values shown in Figures 3.6 - 3.8.

[27] It is notable in passing here that the data platform created concentrates on internationally traded items, as possible changes to the Virtual Water transfers internationally are the primary issue of interest. However, countries can also free up Blue Water resources by altering their patterns of crop and livestock production to feed their own national population, and this represents an area which could well be of major interest to the Virtual Water studies in southern Africa in the future.

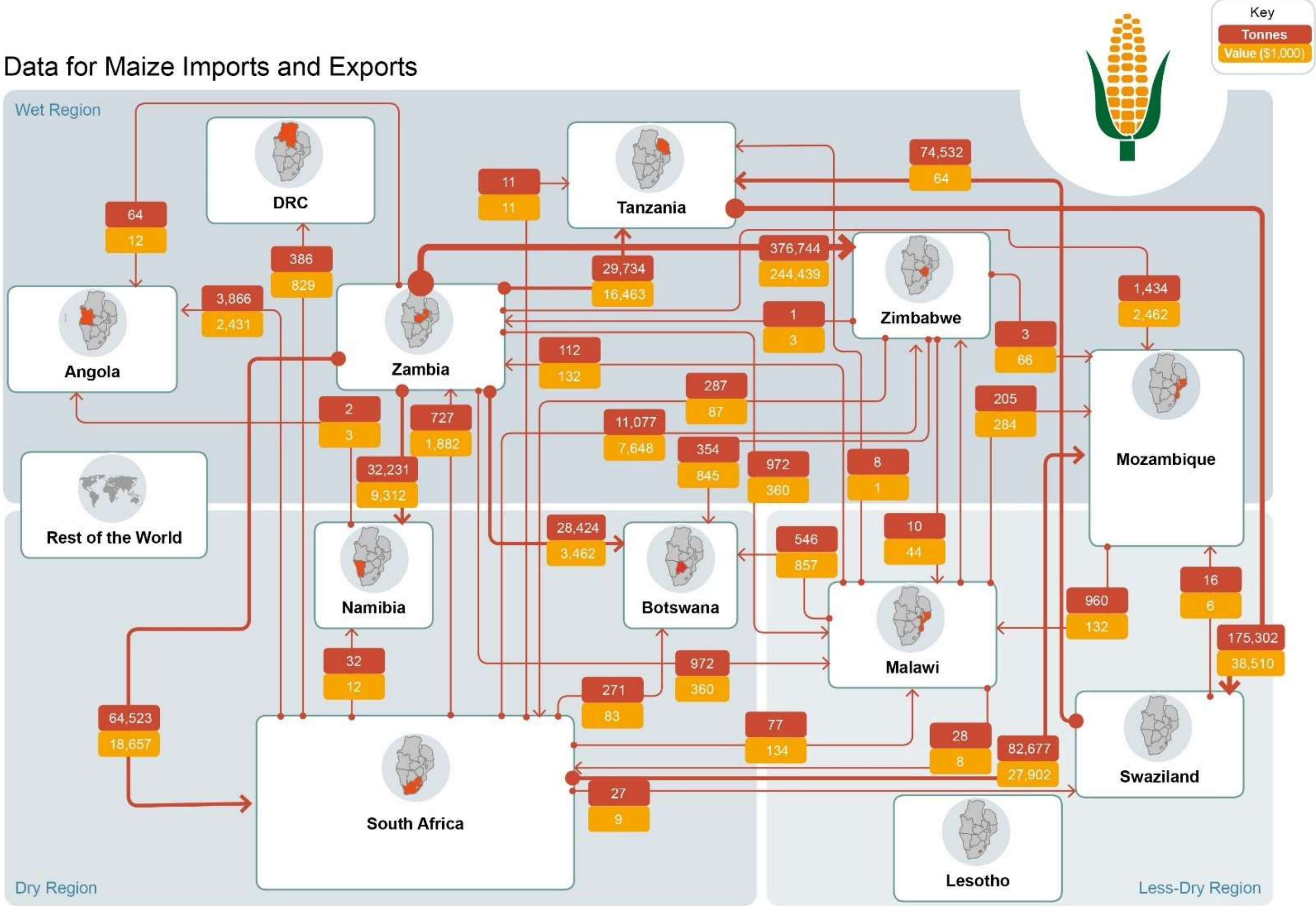

Figure 3.6 The import and export of maize within SADC, in terms of tonnages and respective values. Trade data with the rest of the world are not shown.

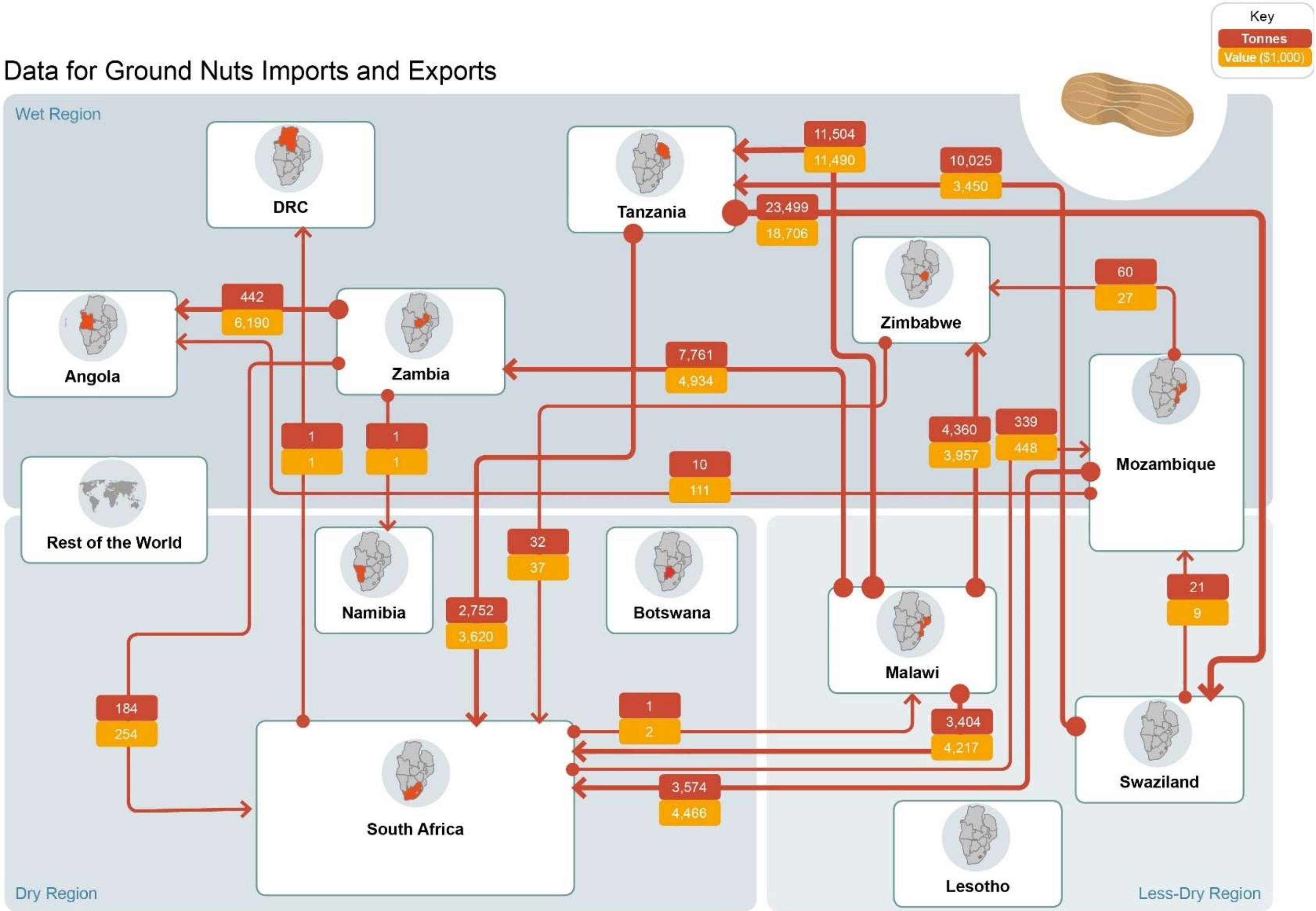

Figure 3.7 The import and export of ground nuts within SADC, in terms of tonnages and respective values. Trade data with the rest of the world are not shown.

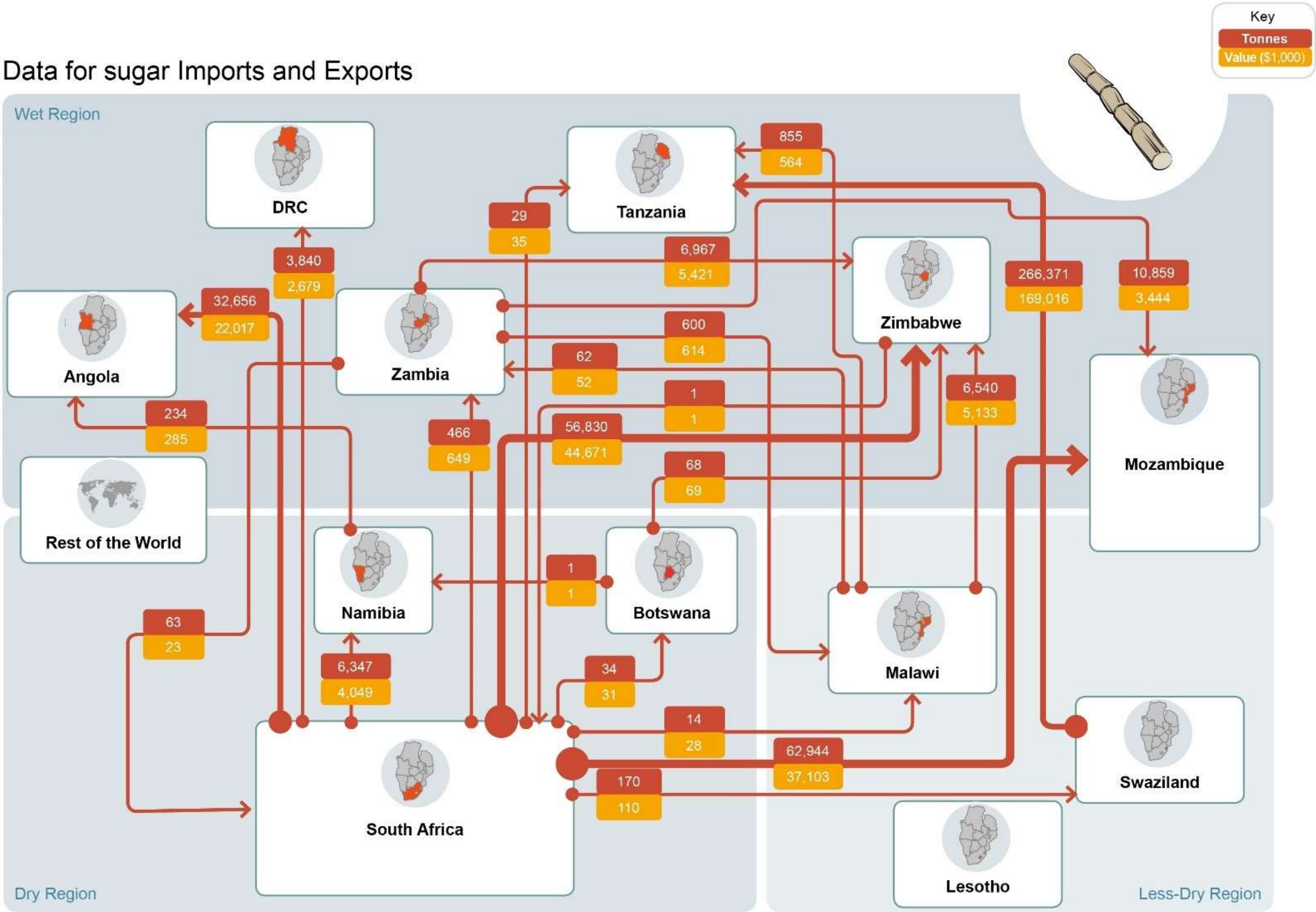

Figure 3.8 The import and export of sugar within SADC, in terms of tonnages and respective values. Trade data with the rest of the world are not shown

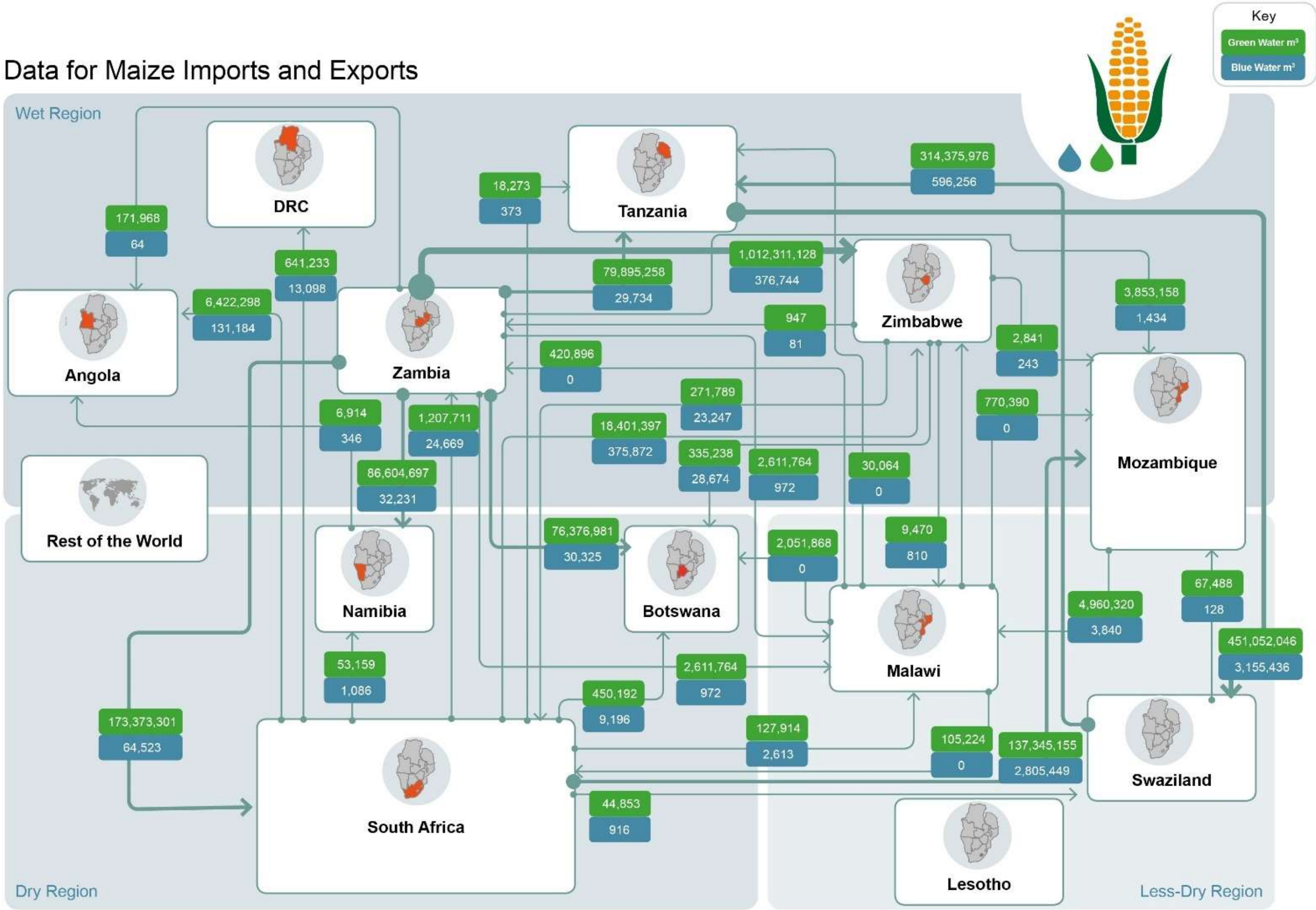

Figure 3.9 The import and export of Green Water and Blue Water in maize traded within SADC. Data for trade with the rest of the world are not shown.

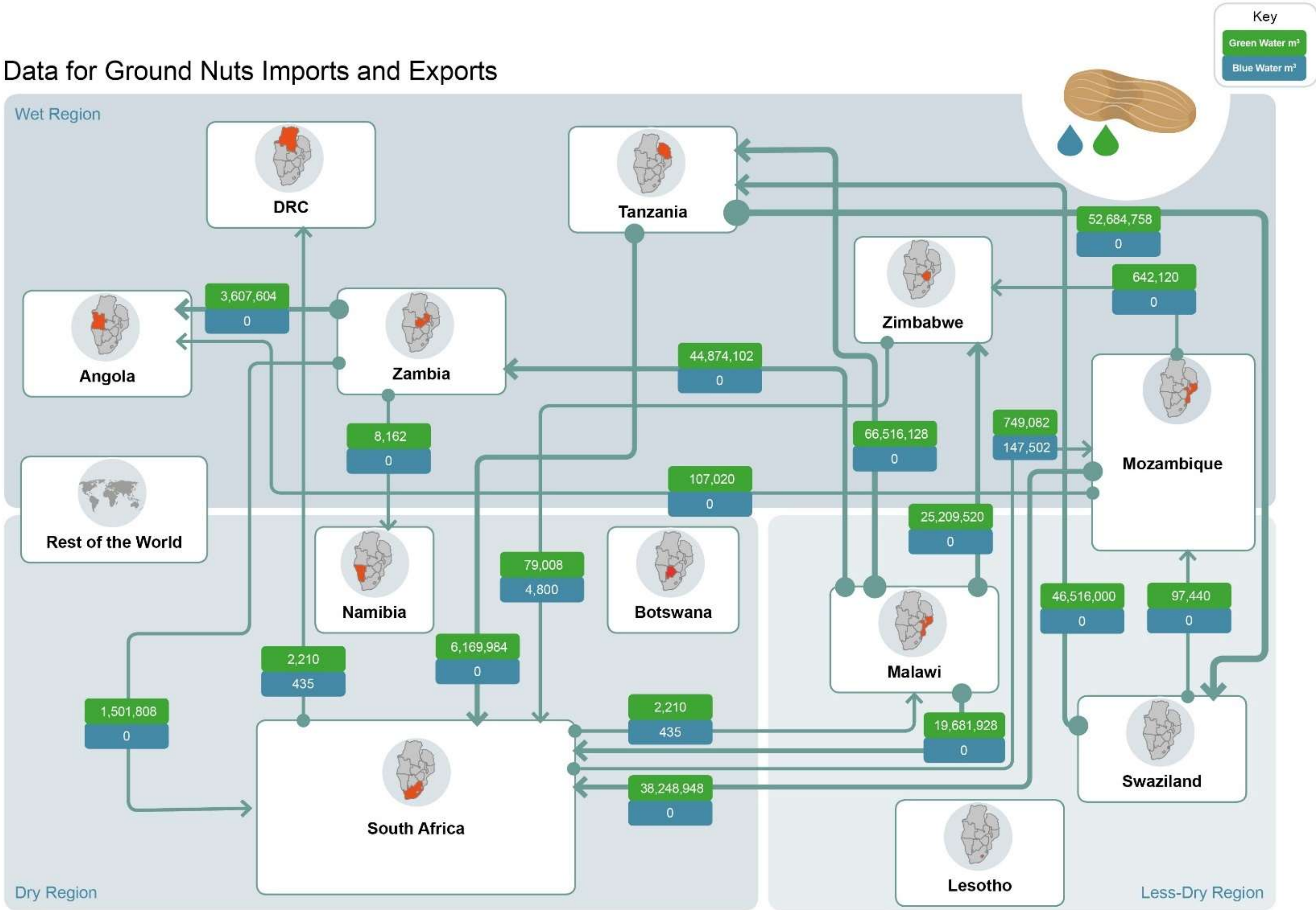

Figure 3.10 The import and export of Green Water and Blue Water in ground nuts traded within SADC. Data for trade with the rest of the world are not shown.

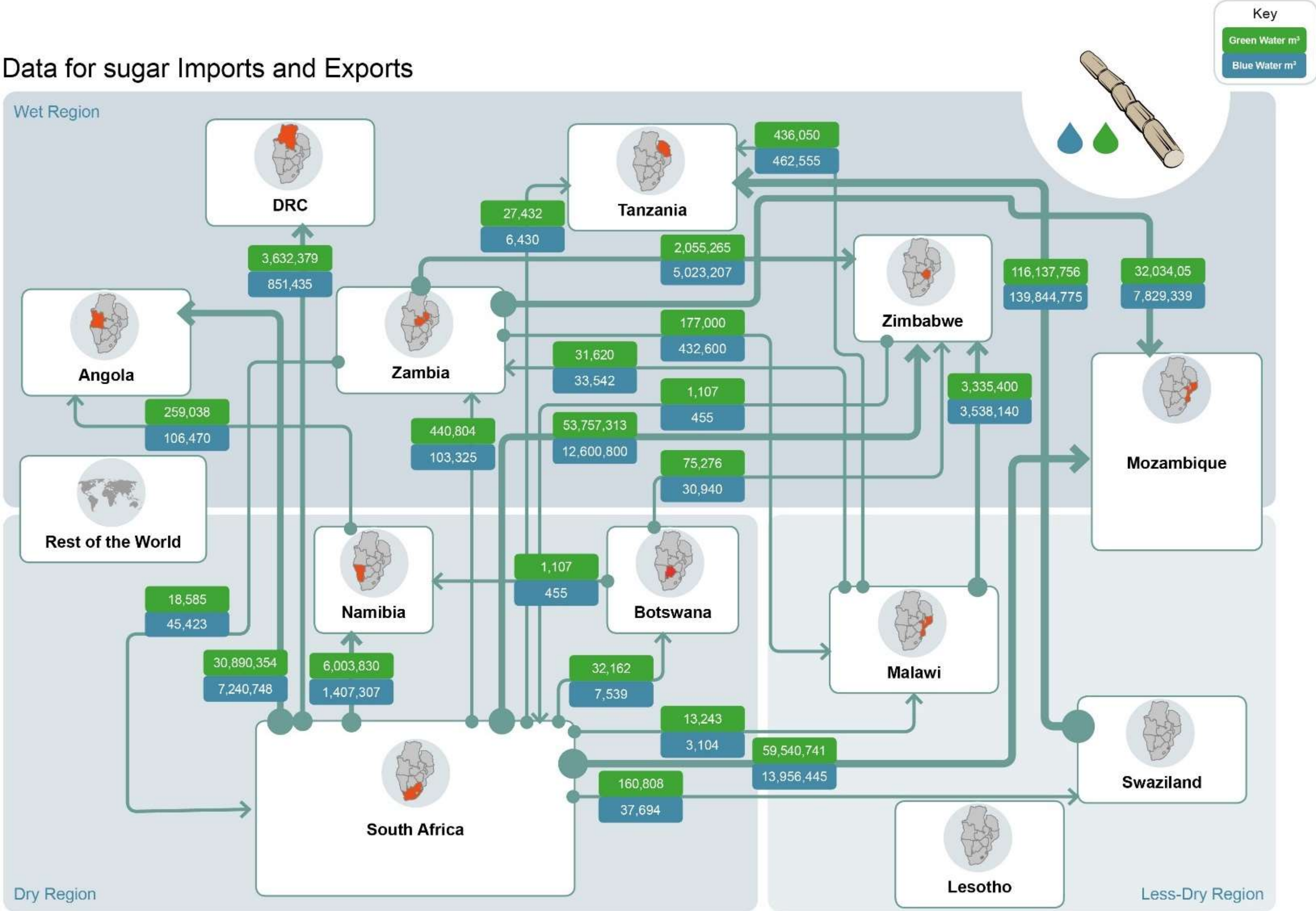

Figure 3.11 The import and export of Green Water and Blue Water in sugar traded within SADC. Data for trade with the rest of the world are not shown.

Interesting patterns are revealed when the Water Footprint data are interrogated in detail. Examples of these are shown in Text Boxes 3.1 and 3.2, which address water productivity values of various types, and crop yields. As noted in Text Box 3.1, Blue water productivity is generally quite low for sugar production in southern Africa, averaging US$2.78/m^3. Higher blue water productivity is noted for groundnuts (mean of US$4.41/m^3), with very much higher values for maize (averaging US$177/m^3). These figures reflect the reliance on blue water (and irrigation) for the crops involved. It is noted that while the data on water productivity are to some extent dependent on exactly where the crop is grown (and may be susceptible to the issues described previously in terms of the robustness of detailed water footprint information), average data have been used here.

When analysed on the basis of the full virtual water footprint, productivities average only US$0.38/m^3 for groundnuts, but somewhat higher for sugar (US$0.69/m^3) and considerably greater for maize (US$1.28/m^3). The most striking facet of the data relates to the very large differences between the water productivities calculated for specific sources/destinations of traded crops. Chapter 9 reflects on the implications of international food prices and subsidies as a key driver in this context. These reflect a combination of the efficiency of crop production, and the prices assigned to traded crops. It is clear from the relatively simple analysis completed to date that further focus on the patterns of crop production would materially affect both agricultural efficiency and economic returns, with potentially large effects on poverty in certain rural areas.

The second example provided here involves the production of sugar on a regional basis in both South Africa and Zimbabwe. In South Africa, sugar is grown primarily in KwaZulu Natal and Mpumalanga Provinces. Very considerable differences exist between these two locations in terms of the extent of irrigation of the crop, this being far greater in KwaZulu Natal than in Mpumalanga. As expected, crop yields are lower for the non-irrigated product (56 tonnes/hectare as an average in KwaZulu Natal), and rise considerably when irrigation is made available (89 tonnes/hectare in Mpumalanga). In Zimbabwe, all of the sugar crop is grown in the Save River Basin, and this is all irrigated. The primary distinction relating to sugar production in this instance involves the average yields attained by subsistence farmers on small-holdings (34 tonnes/hectare) and those achieved by commercial operations (76 tonnes/hectare). Text Box 3.2 includes some initial analysis in this regard.

The Use and Possible Extension of the Data Platform

The examples cited above show that the data platform is of exceptional utility, and is capable of providing information at many levels of detail and specificity. It is important to note that the tool that has been created by the current work is not simply a cut-down version of the dataset published by Mekonnen and Hoekstra (see footnote [4] above), but has been designed specifically for use in southern Africa to assist SADC in moving towards regional water and food security, creating a vision of water as a regional public good.

Text Box 3.2: The production of sugar in southern Africa.

Yields for the production of sugar in South Africa and Zimbabwe are shown below:

Location	*Type of Production*	*Yield (Tonnes/ha)*
KwaZulu Natal (RSA)	Dry land (not irrigated)	56.0
	Irrigated	70.7
Mpumalanga (RSA)	Dry land (not irrigated)	63.6
	Irrigated	89.5
Zimbabwe	Subsistence (small-holdings)	34.0
Zimbabwe	Commercial	76.0

As would be anticipated, the yields increase perceptibly when irrigation is made available (in South Africa), although the uplift in yield provided by irrigation is not particularly great (26% in KwaZulu Natal, and 41% in Mpumalanga). In Zimbabwe, the key determinant of yields of sugar involves the distinction between those attained by subsistence farmers on small-holdings, and the much higher yields achieved by commercial operations.

What level of Government intervention may be countenanced, to attempt to improve crop yields in such scenarios?

Is the irrigation of sugar (which has low water productivity in general) a rational use of Blue Water supplies in the water-stressed areas of southern Africa? Should Blue Water be allocated to higher-value crops in such water-stressed areas, and how might this be achieved?

What forms of intervention may be promoted to increase subsistence-level yields of crops? Should subsistence farmers be encouraged to grow crops with higher water productivities, and how might this be achieved?

Text Box 3.2: An example concerning Virtual Water transfers in agricultural products traded internationally in southern Africa.

'Water productivity' is considered by many commentators to be an important measure of the efficiency of agricultural activities. Generally measured as the financial return per volume of water used (US$/m^3), water productivity values as reported to date in the literature refer to a basis of Blue Water only. Where crops are grown with a heavy reliance on Green Water (and only limited Blue Water use), this increases the apparent water productivity.

The data platform was used to derive the standard water productivity values (based on Blue Water alone) and also for a new parameter, which could be termed the 'Virtual Water productivity'. The latter values are based on all forms of water used to grow a primary crop: Blue, Green and Grey Water, in combination.

Three distinct types of crops were selected to create this example, and the resulting data are summarised as follows:

- Average (Blue) water productivity values were US$2.78/m^3 for sugar; US$4.41/m^3 for groundnuts; and US$177/m^3 for maize.
- Mean values for the Virtual Water productivity were US$0.38/m^3 for groundnuts; US$0.69/m^3 for sugar; and US$1.28/m^3 for maize.

The water productivity data show the influence of the Blue Water/Green Water mix used for each crop, in a very clear fashion. Virtual Water productivity figures provide a much more coherent base to compare the financial output from each crop, but effectively value each form of water equally.

The data for these three crops traded in various fashions between the SADC countries show great differences from place to place (trade to trade) in both water productivity and Virtual Water productivity – the averages cited above masking very large variations. Such information is not usually used by farmers or by governmental authorities in reaching decisions on preferred crops to be produced in specific locations.

Should public or private entities incorporate considerations of Virtual Water (or at least, the distinct types of water) into their planning in terms of which crop to grow, where?

Are governmental bodies the most appropriate to lead in any such an intervention, or would private sector farming interests be better engaged?

How likely is it that the SADC countries would agree to grow 'thirsty crops' in the north of SADC, and 'less thirsty crops' in the more arid southern regions, with trade between these addressing local demand for all the various types of crops?

In the course of the construction of the data platform, the team noted that certain types of data could be added to the data platform. These include the following:

- Data on the national production and consumption of agricultural products (as opposed to internationally traded products), which would be of interest when parties wish to interrogate the efficiency of the sector in particular countries and provinces. The production data can be associated with areas farmed, yields, and economic values.
- Detailed data on the specific trade patterns of the SADC nations with individual countries in the 'Rest of the World' category, on a product-by-product basis or more generic platform, as may be desired.

In terms of high levels of detail, a few products do not have assigned water footprints, as no data are available internationally in this regard. Further work could also be completed to superimpose more detailed estimates of animal size on the data platform, to better assess the Virtual Water component of livestock products. However, given that this type of additional work is likely to require substantial resources, it should only be pursued on an as-needed basis.

Virtual Water Transfers in Traded Electricity

Consumptive Water Use in the Generation of Electricity

The Methodology: Detailed and Indicative Analyses

As noted in a previous section, there is considerable variation in the methodologies used internationally to measure the consumptive use of water in the generation of electricity. Some authors cite data based simply on the evaporative losses involved in the generation process, as this is generally by far the largest and most important component of overall net water use. By contrast, other authors attempt 'life cycle analyses' which extend to the source of the energy (and the process making this available), the equipment used, downstream transmission, etc. Such details are captured particularly clearly in a recent literature review by Meldrum *et al.* (2013).[28]

The resources available to the current authors did not permit full life-cycle analyses of consumptive water use in the generation of electricity amongst all of the facilities in the continental SADC countries, and in any event these were not deemed to be required. Thus, CRIDF seeks to introduce the concepts of virtual water and the nexus into the general policy-related planning process within the region as a whole. While it is recognised that highly specific data on life cycle water use in particular scenarios

[28] Meldrum, J., S. Nettles-Anderson, G. Heath and J. Macknick (2013). Life cycle water use for electricity generation: A review and harmonization of literature estimates. *Environmental Research Letters*, **8 (1),** doi:10.1088/1748-9326/8/1/015031.

might be of relevance in particular circumstances at a later time, the present report employs indicative data only, based on estimates of the evaporative losses of water in particular electricity generating technologies. Similarly, no attempt has been made to address the relatively minor sources of electricity within the continental SADC countries (wind, solar, etc.), and the focus here is on thermoelectric plants which dominate in the south of SADC, and hydropower facilities that are primarily located in the north of the region.

Comparative Estimates of Consumptive Water Use

In thermoelectric power generation, the level of consumptive water use depends primarily on the selected method of cooling, with a significant difference being observed between once-through and recycling systems. By contrast, the consumptive use of water in the generation of electricity using hydropower varies greatly amongst distinct types of facilities, and also between specific plants of any one type.[29] Run-of-the-river systems which do not involve large impoundments have low consumptive water use, while facilities including large dams and reservoirs exhibit a much higher consumptive use of water. This is due to a number of factors, including in particular the surface area of any impoundment; the rate of evaporative loss from the reservoir; and the efficiency of the turbines. In the USA, Torcellini *et al.* (2003) cited a range for hydropower plants from close to zero consumptive use for run-of-the-river systems, to more than 208 litres/kWh – very much greater at the higher end of the range than the consumptive water use in thermoelectric plants (see below).[30] The consumptive use of water by hydropower facilities in Africa can be far higher than that of similar plants in the USA, due to the higher evaporative loss in many locations in Africa (although these also vary considerably from site to site). Importantly, increased evaporative loss due to climate change induced higher temperatures could increase net water use in hydropower. Given the higher than average temperature increases expected in the SADC region, climate change could play an increasingly important role in SADC's energy future.

Table 3.2 provides a brief summary of the energy sector in each of the 12 SADC countries addressed in this Position Paper, and this highlights two key points of relevance to Virtual Water transfers. South Africa generates about 80% of the electricity produced in southern Africa as a whole, and this equates to approximately 40% of the generation of electricity in the entire continent. Amongst the CRIDF

[29] For generic data, see for example *Energy Demands on Water Resources. Report to Congress on the Interdependency of Energy and Water.* US Department of Energy, December 2006.

[30] See Torcellini, P., N. Long and R. Judkoff (2003). *Consumptive Water Use for U.S. Power Generation.* Technical Report, National Renewable Energy Laboratory, Golden, Colorado. It is notable that some of the water sources used to support thermoelectric power generation also involve impoundments, in some instances to increase assurance of supply. However, these are generally much smaller than those employed to generate hydropower, with minor evaporative losses – and they are also usually multi-use facilities, being employed in support of agricultural irrigation in particular. It is also arguable that the evaporation off the large hydropower-related impoundments such as Kariba and Cahora Bassa might not all be allocated to hydropower generation in isolation (where multiple use occurs), but in those cases the hydropower generation was the primary *raison d'etre* for the construction of the dams. The analysis provided here is thus considered to be generically robust, and in any event the very large distinction between consumptive water use in the two forms of electricity generation would persist, even where additional (minor) factors are taken into account.

countries addressed here, the northern States rely heavily on hydropower for the generation of electricity (see Table 3.3), while South Africa presently utilises coal-fired thermoelectric generation for the great majority of its electrical supplies, as shown in Table 3.4.

Recent data from Eskom reveal a consumptive use of water of 1.37 litres/kWh in the generation of South African electricity, as a nation-wide average. This nation-wide average for the consumptive use of water in electricity generation in South Africa is competitive by comparison to performance elsewhere, e.g. Torcellini *et al.* (2003) reported an average consumptive use of 1.4-1.9 litres/kWh for thermoelectric power generation by a large range of such facilities in the USA.[31] It is notable that the newer thermal plants in South Africa are more water-efficient, and the gradual introduction of dry cooling will reduce water consumption even further.

Amongst the major hydropower plants in SADC (see Table 3.3), certain facilities in the Zambezi River basin are of particular significance due to their reliance on large dams which impound reservoirs of very considerable surface area – with highly significant evaporative losses. Data from Beilfuss (2012) were used by the CRIDF project team to determine the consumptive uses of water (as evaporation) at the three major hydropower sites in the Zambezi River basin.[32]

These revealed the lowest use at Itezhi-Tezhi/Kafue Gorge (64 litres/kWh); intermediate values at Cahora Bassa (296 litres/kWh); and by far the highest consumptive use of water at Kariba (1,040 litres/kWh). The particularly high losses at Kariba reflect the relatively shallow reservoir with a large surface area, and this is also demonstrated by data for electricity generation per reservoir surface area (0.3 MW/km^2 at Kariba, as opposed to 1.4 MW/km^2 for Cahora Bassa). The total evaporative losses at the hydropower facilities in the Zambezi River basin equate to a consumptive use of about 11% of the mean annual flow of the system as a whole, and this creates major changes not only to the total water flow in the basin but also to the seasonal pattern of flows.[33]

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[31] See footnote [15] above for this reference.

[32] See footnote [8] above for this reference. It has been assumed that the difference between inflow and outflows of these reservoirs reflects the net use of water used to produce the electricity. None of this water is apportioned to other water users, and the potential reduced downstream evaporation has not been considered.

[33] It could be argued that the construction of major dams for generating hydropower has effects not only on evaporation rates upstream, but also those downstream, due to the resulting changes in river flow dynamics/cross-section, etc. Such effects are certainly relevant in terms of basin-level water management, but they have not been taken into account here (and are believed in most cases to be minor, compared to evaporative losses at the reservoir sites).

Table 3.2 Brief overview of the energy resources and electricity supplies in each of the continental SADC countries. (Page 1 of 2).

Country	Energy Resources	Electricity Supplies
Angola	Very considerable oil and gas resources (global #18 in reserves) in ongoing development, these entirely dominating the national economy. Primary energy use still dominated by biomass, followed by oil, hydropower and natural gas.	Approximately 70% of internal generation from hydropower (Cuanza, Catumbela, Cunene Rivers). Gas-fired production likely to increase. Only 30% coverage of the population currently. Not yet fully integrated into the SAPP, but a connection to Namibia is being established currently.
Botswana	No oil or gas reserves. Moderate coal resource, essentially all utilized within the country.	Significant importer of electricity, mostly from South Africa.
DRC	Significant oil reserves, with more likely to be discovered. A minor oil exporter currently. Some coal, and significant hydropower at Inga in particular. The development of Grand Inga could completely alter the African balance of power generation.	Only a moderate net exporter of electricity, mostly from the Inga projects. New Power Purchase Agreement with South Africa relating to Inga III. Massive future potential as an exporter of hydropower from Grand Inga.
Lesotho	No oil, gas or coal reserves; reliant on national biomass and imported fossil fuels.	Minor generation through hydropower, including the Lesotho Highlands Water Project. Minor net importer of electricity, from South Africa.
Malawi	Very minor oil production at present. No gas currently exploited, but attempts are ongoing to develop oil and gas under Lake Malawi/Nyasa (involving a dispute with Tanzania).	Essentially all electrical power generated in-country mostly through hydropower – with significant new hydropower plans, and no significant imports or exports.
Mozambique	No significant oil reserves. Natural gas exploited from the onshore Pande and Temane fields mainly (80%) used by South Africa, *via* the Sasol pipeline. Massive natural gas reserves found recently in the Rovuma basin offshore in the north. Significant coal reserves.	Poor internal access to electricity (25% of population). National grid backbone to be constructed. Cahora Bassa and other hydropower sources of key importance, but coal and gas also used increasingly for generation. Significant exporter of electricity, likely to increase considerably over time. Imports energy from the RSA to support an aluminium smelter.

Table 2. Brief overview of the energy resources and electricity supplies in each of the continental SADC countries. (Page 2 of 2).

Country	Energy Resources	Electricity Supplies
Namibia	No oil or gas reserves exploited currently, but Kudu gas field offshore (shared with South Africa) under early development. Ruacana hydropower facility operating in the north, and hydropower at Baynes on the Cunene River is planned (shared with Angola). Coal imported to supply ageing Van Eck facility in Windhoek. Plans for 500MW coal-fired facility at Walvis Bay.	Significant importer of electricity, mainly from South Africa and historically also from Zimbabwe (Hwange thermal station). New agreement with Aggreko for importation from Mozambique (Ressano Garcia), sourced from natural gas.
South Africa	By far the most dominant country in southern Africa in terms of energy development to date. Small internal reserves of oil and gas, but some imports from Mozambique, and Kudu/shale gas in the Karoo may change this in the future. Heavily reliant on coal currently (global #9 in coal reserves) but poor quality leads to very high *per capita* greenhouse gas emissions. Major synthetic fuels sector. Minor hydropower, mostly already constructed.	Strong coverage of the population, being enhanced over time. By far the largest electricity generator in southern Africa, about 90% from coal (minor nuclear, hydropower and gas). Plans to increase nuclear generation to diversify the energy mix remain under review. Recent exports have decreased as domestic demand has increased and growth of generation capacity slowed.
Swaziland	No oil or gas reserves, but moderate coal resources. Biomass dominates the energy use in-country.	Minor net importer of electricity, mostly from South Africa.
Tanzania	No proven oil reserves, but significant gas, some of this shared with Malawi (under dispute) and also with Mozambique in the Rovuma Basin. Likely to export natural gas in the future. Moderate coal reserves, supplemented by importation. Heavy reliance on biomass for fuel.	Low population coverage (15%). Most electricity from hydropower (60%), with the remainder from fossil fuels. Essentially self-sufficient for electricity. Recent link to the SAPP; Tanzania represents a link between the SAPP and the Eastern Africa Power Pool.
Zambia	Minor oil production, and no gas. Significant hydropower, Kariba being dominant. New hydropower being planned.	Net minor exporter of electricity from hydropower sources. This may change given the rapid growth in national demand.
Zimbabwe	Minor oil reserves and no gas, but moderate coal resources. Thermal power plants are present, with some hydropower. Marked reliance on biomass in rural areas.	Net importer of electricity, mainly from South Africa. Previous Power Purchase Agreement for export to Namibia has apparently lapsed.

Table 3.3 Examples of major existing hydropower facilities in the northern countries of SADC.

Country	Hydropower Site	Installed Capacity (MW)	Date of Construction	Comments
DRC	Inga I and II	351 and 1,424	1972 and 1982	Major refurbishment needed
DRC	Inga III	4,800	2015 on?	Being developed currently
Lesotho	Lesotho Highlands Water	110	1998	Phase II being considered at present
Mozambique	Cahora Bassa	2,075	1974	Operation delayed until 1997
Namibia	Ruacana	330	1978	Fourth turbine added in mid-2012
Zambia/Zimbabwe	Kariba	1,470	1959	Two separate power stations exist
Zambia	Kafue Gorge	990	1973	The Itezhi-Tezhi Dam regulates flows

Table 3.4 The generation of electricity by South Africa for the year 2012/2013. [After data from Eskom].

Source	GWh (net)	Percentage of Total
Coal-fired stations	232,749	90.5
Nuclear power station	11,954	4.6
Purchase from IPP[34]s	3,516	1.4
Pumped storage stations	3,006	1.2
Wheeling (transmission)	2,948	1.1
Gas turbine stations	1,904	0.7
Hydroelectric stations	1,077	0.4
Wind energy	1	<0.1
Totals	**257,155**	**100**

[34] IPPs = Independent Power Producers

Trade in Electricity, and Virtual Water Transfers

It is important to note that the international trade of electrical power in southern Africa varies substantially over time. This reflects short-term changes in the capabilities of utilities to generate power, coupled to fluctuations in power demand. Some such variations are challenging to predict, e.g. unexpected problems at generating stations can reduce the electrical power available in a broader geography and can have knock-on effects elsewhere, sometimes with major consequences involving wide-scale load-shedding. This is a particular problem in circumstances where the reserve margin is low, as has been noted throughout almost all of SADC since late 2007 – in large part because of the difficulties experienced in South Africa over recent years (reflecting the high proportion of SADC electricity that is generated in South Africa; see above).

These time-related variations in the international trade in electricity in southern Africa imply that any analysis of Virtual Water transfers in electrical supplies that are traded between the various countries should be considered as a general ***pattern***, rather than in terms of absolute values which are in fact of relevance only to one particular time period. This is not especially problematic, however, as the key issue relating to Virtual Water transfers in the regional electricity network involves the very large difference in the consumptive use of water by facilities involving thermoelectric technology, *versus* the larger hydropower plants (primarily in the north; see Table 3.3 above).

Table 3.5 and Figure 3.12 show an example of virtual water transfers in electricity traded internationally within southern Africa for the year 2012-2013, data on the trading pattern being derived from Eskom and from the SAPP offices in Harare. Exports from South Africa to other countries occur in general through the SAPP transmission network, and Eskom does not assign a specific source to any such trading, all electricity generated in-country being considered as a 'common pool'. In this circumstance, the national estimate of consumptive use of water in South Africa for the generation of electricity (in 2012/2013) was utilised to calculate the volumes of virtual water transferred in each trade. Relatively small volumes of virtual water were involved, as South Africa exhibits a low consumptive use of water in its overall electricity generation portfolio (and most of the power generated is in any event used nationally, rather than being traded). The total transfer of virtual water in electricity traded externally by South Africa in 2012-2013 was 19.34 MCM, as compared to 331 MCM of water used consumptively for all of the power generation in-country (5.8% traded; the remainder used nationally).

Table 5 The transfers of Virtual Water in internationally traded electricity in the year 2012/2013. [After data from Eskom and SAPP]. VW: Virtual Water.

From	To	GWh/year [Net]	Litres/kWh	MCM/year VW	Comments
South Africa	Mozambique	8,280	1.42	11.76	No specific source identified; generic consumptive use figure employed.
	Botswana	2,570	1.42	3.65	
	Namibia	1,780	1.42	2.53	
	Swaziland	600	1.42	0.85	
	Zambia	250	1.42	0.35	
	Lesotho	140	1.42	0.20	
Mozambique	South Africa	6,540	296	1,936	From Cahora Bassa

The cross-trade in electricity between South Africa and Mozambique involves a considerable differential in Virtual Water transfers. As shown in Table 5 and Figure 12, the 8,280 GWh traded from South Africa to Mozambique in 2012-2013 involved a transfer of 11.76 MCM of virtual water, whilst the 6,540 GWh of electricity derived from Cahora Bassa and traded to South Africa in the same time period implied a virtual water transfer of 1,936 MCM.

This very large differential holds true, whether more sophisticated life-cycle analyses (or estimates of downstream effects of hydropower dams) are included, or otherwise. The distinction reflects the very great differences in the consumptive use of water by the two power generation systems, but these need also to be considered against the background of the annually renewable water resources in each country, as a whole. Thus, the degree of constraint on the water supplies is of importance in determining preferred regional patterns of electricity generation in the future. It is possible that these types of details will be addressed in later work by the project team.

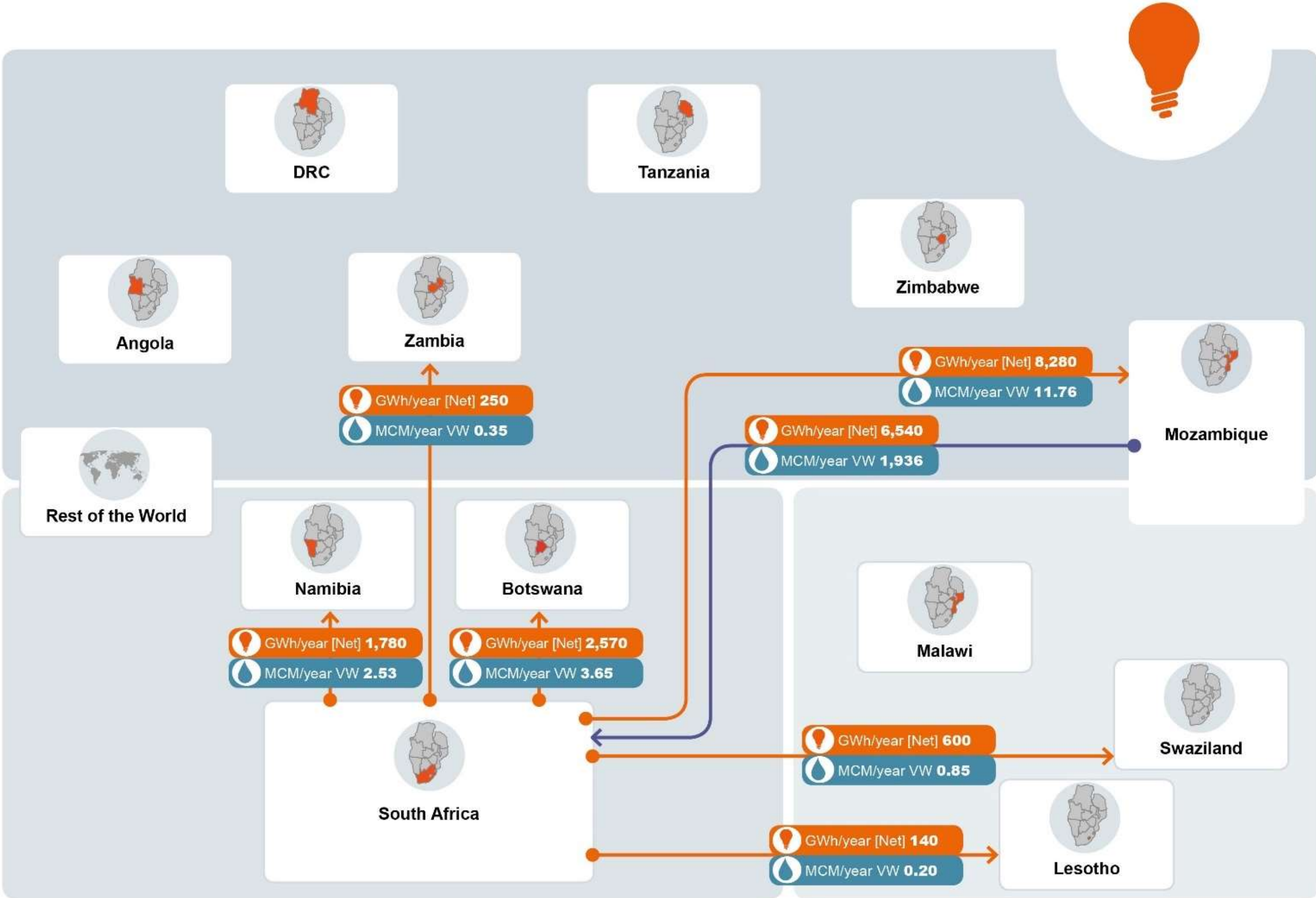

Figure 3.12 The trade in electricity in 2012-2013 amongst the SADC countries. [After data from Eskom and SAPP].

Initial Reflections on the Top-Level Data

Effects on River Systems

The total volume of water utilised in generating electricity in South Africa is not insignificant, at 331 MCM/year in total in 2012/2013 (2.65% of the total annual renewable water resource nationally, making Eskom the single largest user of water in the country). However, this is altogether dwarfed by the water volumes used in the large hydropower schemes in the northern SADC countries. As noted by Beilfuss (2012; see footnote [8] above), the three biggest hydropower facilities in the Zambezi River basin have fundamentally altered the total mean annual flow of the river system, and have very significantly changed the seasonal flow patterns. Thus, the evaporative losses at Kariba amount to 16% of inflows at that point, on average; those at Itezhi-Tezhi/Kafue Gorge account for 3% of inflows; and the evaporative loss at Cahora Bassa equates to 6% of inflows at that point in the system. In overall terms, some 11% of the flow of the Zambezi River system is lost by evaporation at the various hydropower facilities along its length – amounting to more than 12 km^3 of water annually, as an average. This represents by far the single largest use of water in the Zambezi River system, and rivals the Blue Water component of the Virtual Water volumes traded in the agricultural sector (see the previous section of this report). Indeed, the Zambezi Basin IWRM Strategy recognises hydropower as the single largest water user in the Basin. (Mott Macdonald, 2008[35]).

It is important to understand that this does not necessarily imply a preference for thermoelectric power over hydroelectric power (or *vice versa*) at any one part of the overall system within the continental SADC States. Thus, national preferences (relating to self-sufficiency/security of supply, costs, and other factors) are viewed differently by each country, and the existing pattern of supply reflects this, at least to some degree. The 12 Sovereign States thus face individual and collective decisions on their preferred future pattern of electricity generation and trading internationally. However, as is argued in Chapter 7, there are substantial water carbon and cost savings to be had in the conjunctive management of hydro and thermal-power.

Electricity Generation in SADC

Representatives of the SAPP have stated that electricity demand in southern Africa is increasing by more than 5% annually (faster than the GDP growth in most of the countries), and this implies a doubling in the total demand for electricity every 14 years, amongst the continental SADC countries as a whole. In particular, very rapid increases in industrial demand for electricity between 2003 and 2007 caught ESKOM off guard. Major challenges exist in terms of satisfying the increasing demand:

[35] Mott-Macdonald (2008) Integrated Water Resources Management Strategy and Implementation Plan for the Zambezi River Basin; available at; http://www.zambezicommission.org/index.php?option=com_content&view=category&layout=blog&id=16&Itemid=178

- Large numbers of new generating facilities will be required. Some of these are already in construction (e.g. Inga III) or are planned (e.g. Batoka Gorge, Mphanda Nkuwa), with hydropower facilities again dominating in the northern SADC countries.[36]

- South Africa is continuing to consider its preferred energy mix, with possible increases in nuclear energy but the certainty of new coal-fired stations also being involved (the Kusile thermoelectric station having been selected to follow the finalisation of the Medupi facility), and the potential use of shale gas (although the latter remains highly controversial).[37]

- Major new transmission systems are required, both to satisfy existing demand and to create a robust network for international trade in electricity. This is a particular focus of the SAPP, and some of the challenges that will be faced are highlighted in Chapter 7.

For South Africa, the future is especially challenging due to tightening restrictions on water availability; the inexorable increase in demand for electricity; and the current reliance of some of the neighbouring countries on exports of electricity from South Africa. The high assurance of supply that is required for electricity generation implies that this end use of blue water exerts particularly severe effects on other types of water utilisation or allocation in times of drought. Inter-sectoral competition for water already exists in many of South Africa's basins (and in some of the neighbouring countries also), and the high and increasing domestic/municipal demand for water is especially notable on a country-wide basis in South Africa. In addition, the atmospheric emissions from power generating facilities in South Africa are considerable, and concerns exist over greenhouse gases and effects on climate change. The possibility of the development of shale gas resources in the Karoo – estimated by the US Energy Information Administration to amount to up to 485 trillion cubic feet – remains controversial, in large part due to concerns over the environmental impacts of hydraulic fracturing ('fracking').

Other countries in southern Africa exhibit varying responses to the energy sector, and the satisfaction of their own national demand (see Table 3.2 above). For example, Namibia has long been reliant on imports of electricity from South Africa, but it is predicted that this will change in the future as major new supplies are developed within Namibia (a coal-fired power station near Walvis Bay; the Kudu gas reserve in Namibian waters offshore; and the Baynes hydropower site on the Kunene River). Botswana depends heavily on its national coal resources, and also on imports of electricity from South Africa. Tanzania, having suffered load-shedding due to low water levels serving its hydropower plants (which produce almost 40% of the country's electricity needs) is focusing on expanding thermal energy production – and the newly discovered gas supplies in the Rovuma basin offshore offer considerable future potential in this regard. Nonetheless, there

[36] It is notable that when these new facilities come on-line, some will affect the data for consumptive water use as shown here. This will occur as new plants are constructed downstream of existing facilities which already enjoy regulated flows from upstream reservoirs, and also when some of the existing facilities are expanded in relation to their electrical output. CRIDF has suggested that the dataset being developed through the use of Annex 2 shown in the present report could be taken over by the SAPP offices in Harare in due course, so that it may continue to be updated over time.

[37] See *Report on Investigation of Hydraulic Fracturing in the Karoo Basin of South Africa*. Department of Mineral Resources, Republic of South Africa, July 2012.

are still opportunities to develop hydropower in the wetter regions of Tanzania – some of which are being explored through CRIDF.

Other SADC countries have limited hydrocarbon reserves and continue to rely heavily on hydropower, with major facilities planned or under development at sites such as Batoka Gorge (Zambia/ Zimbabwe), Lower Kafue Gorge (Zambia), Mphanda Nkuwa (Mozambique), and Inga III (the DRC). Extensions to existing hydropower stations are also envisaged, substantially increasing the present electricity generation portfolio of SADC as a whole.

The Grand Inga development in the DRC would fundamentally alter the pattern of electricity production in Africa, given its massive potential (variously estimated as 39,000 to 42,000 MW). Several types of scheme have been considered, including run-of-the-river facilities and impoundments of various forms. Although the latter would be likely to imply a higher consumptive use of water, the Congo River flow is so massive, and the use of water in the DRC is so small at the present time (the Congo's low flows tend to equate with the Zambezi's peak flows) that Virtual Water transfers should not raise problems in that instance.

A second factor that could substantially change the future pattern of electricity production in southern Africa involves the very large gas reserves discovered recently in the offshore Rovuma Basin in northern Mozambique/south-eastern Tanzania, referred to briefly in the text above. Current estimates suggest that this will exceed 100 trillion cubic feet, and the world class resource offers very significant opportunities for electricity production (with relatively low consumptive water use and atmospheric emissions). No decisions have been made as yet as to the preferred use of the gas – although the export of liquefied natural gas to the Far East appears to be almost certain for a significant proportion of the resource.

It is also possible that South Africa will proceed with the exploitation of shale gas in the Karoo. However, this option involves the use of hydraulic fracturing ('fracking'), which remains highly controversial; potentially contaminative; and relatively water intensive. No analysis of the possible use of water in fracking procedures has been made during the current work, although this could be addressed at a later stage to provide important new information of relevance to eventual policy considerations.[38] It is anticipated that these types of 'mega-projects' will be amongst the issues to be discussed under CRIDF Activity 1807 and later studies within the Virtual Water project.

Impacts of Potential Climate Change

As outlined in Chapter 2, the impacts of climate change on water availability are difficult to estimate. The Word Bank estimated that climate change in the Zambezi River basin may reduce mean annual river flows predicted by 16% in the upper section; 24-34% in the middle reaches; and 13-14% in the lower Zambezi.[39] While most scientists now acknowledge that the precise changes to hydrological parameters that would

[38] The report cited at footnote [21] above cites some limited information on the use of water resources in hydraulic fracturing, but notes that further data are needed in this regard.
[39] World Bank (2010). *The Zambezi River Basin: A Multi-Sector Investment Opportunities Analysis.* The World Bank, Washington D.C., June 2010.

accompany climate change are challenging to predict, any such alterations in flow patterns would be little short of catastrophic in relation to hydropower generation in the Zambezi basin.

Various alternatives are being considered in this regard, including the operation of hydropower plants as effective run-of-the-river facilities (at full reservoir levels), coordinated hydropower management (as opposed to unilateral management), and other possibilities.

Regional Planning *Versus* Securitisation

Such considerations bring the importance of regional planning into the forefront of the debate. The rationale for the creation of the SAPP is instructive in this regard.[40] Prior to the SAPP being established, the early development of transmission systems between Botswana, Zambia and Zimbabwe was intended to reduce the reliance of the 'Frontline States' on imports of electricity from South Africa during apartheid. The dismantling of apartheid in the early 1990s brought new opportunities, and in response to the 1991-92 drought which imposed severe limitations on hydropower production in the Zambezi River basin, South Africa was able to fill the gap through the existing transmission network. Other facilities brought into operation at a later time (e.g. Cahora Bassa) assisted in creating greater robustness within the regional electricity network. Nonetheless, the regional transmission network requires upgrading for the SAPP to reach its full capacity, and currently only a small portion of the demands for trades through the SAPP can be met (see Chapter 7).

South Africa possessed two goals through this and the later period: initially to act as the power-house of southern Africa (and maybe even the continent as a whole); and later to be in a position to import relatively cheap hydropower from the northern SADC countries. For some 8 years, a regional option of importing energy from the north at peak times, and reversing that process off peak allowed for the optimisation of hydropower and thermal power – effectively storing energy behind the hydropower dams in the Zambezi for use at peak times. However, the long term operation has been compromised, primarily due to the rapid growth in electricity demands in the region, making little available for export. The bilateral trade in electricity that pre-dated the establishment of the SAPP continues to represent the great majority of the electricity trade in the region, the initial short-term electricity market (STEM) and the more recent day-ahead market (DAM) created under the SAPP representing only very small proportions of the electricity traded internationally.

In the present context, the southern countries within SADC face a complex challenge – the need to meet sovereign demands, while also receiving benefits from regional cooperation in electricity trading (and the water-related benefits that may accompany this). Thus:

- The demand for electricity is growing more rapidly that GDP in all of the countries involved, and commonly at a faster pace than the electricity generation/transmission infrastructure can be delivered.

[40] Economic Consulting Associates (2009): *The Potential of Regional Power sector Integration. South African Power Pool (SAPP) Transmission and Trading Case Study.* Economic Consulting Associates Limited, London, October 2009.

- There is little scope for further hydropower generation in the southern countries, with the exception of the 600 MW Baynes facility to be shared by Namibia and Angola on the Kunene River, and the expansion of hydropower production through the Lesotho Highlands scheme.[41]
- A continued reliance on coal-fired power stations in SADC as a whole will exacerbate the emissions of greenhouse gases, which are already high on a *per capita* basis, in South Africa in particular.
- Concerns raised by the Fukushima event of 2011 and by previous incidents in the nuclear power industry have cast doubt on plans for enhanced nuclear power generation in South Africa.
- Only minor scope exists for the expansion of renewable electricity generation, e.g. from wind and solar sources, and the lead times for these systems may be longer than is typical in more developed economies.

The southern countries in SADC – which experience much greater water stress than those further north – need to finalise strategic decisions on their preferred approach to electricity generation in the future. The fundamental components of this decision relate to a choice between additional thermoelectric facilities which will maintain national supplies in South Africa at least, *versus* the importation of the relatively cheaper mix of hydropower and thermally-derived electricity from the northern SADC countries (the latter, accompanied by a concomitant reduction in national energy security for the southern States). The preferred degree of regional integration represents a significant issue in this regard, and some commentators have placed this goal to the forefront of the debate.[42] South Africa has therefore largely pursued its own power plan, rather than the optimised regional plan (see Chapter 7).

Despite this, the water-related implications of regional integration in energy production have received little attention in SADC, to date. However, the connections within the water, food and energy Nexus are coming into greater focus in the international arena.[43] The data reported here on the distinctions in consumptive water use between thermoelectric and hydropower facilities in southern Africa augment this debate, and support the CRIDF focus on the Nexus (as opposed to simply addressing water availability in isolation).

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[41] The second phase of the Lesotho Highlands Water Project was officially commenced in late March 2014. This is reported to involve a total cost of R15.5 billion, and will involve the construction of the Polihali Dam and the Kopong pumped storage supplying a further 1,200MW of hydroelectric power to Lesotho.

[42] For example, see the *Southern Africa Regional Integration Strategy Paper 2011-2015* of the African Development Bank (2011).

[43] See, for example, *Thirsty Energy*: Water Paper 78923, June 2013, the World Bank, Washington D.C.; also the report on shale gas as cited in footnote [21] above.

Text Box 3.3: Virtual Water transfers in electrical supplies in southern Africa.

South Africa faces specific problems in relation to electricity generation in the future:

- The national demand for electricity continues to grow rapidly, with no reduction forecast.
- The capacity for additional hydroelectric supplies within the RSA is minor.
- Other renewable sources (wind, solar) are very unlikely to contribute significantly to RSA demand, especially peak demand, in the shorter term.
- Concerns exist in relation to the development of further nuclear energy.
- A continued reliance by South Africa on coal-fired facilities will increase atmospheric emissions yet further, which is not preferred. Carbon capture technologies are not yet sufficiently developed to reduce effects on climate change.
- There are concerns regarding the availability of sufficiently high grade coal, and the reliance on open cast mining which affects the suitability of coal in wet weather.
- The South African Government is currently exploring shale gas and fracking, but this will occur in one of the drier regions of the country, and remains highly controversial.
- Fresh water demand will also rise if electricity generation within South Africa is to increase in the future. The water demand of Eskom is already significant, at 331 MCM/year.

In such a scenario, a case can be made for a regional approach to electricity generation and use, with South Africa importing some of its electricity from countries to the north, most of whom rely heavily on hydropower (and have very significant water resources). The development of Grand Inga in the DRC is one obvious option. An alternative possibility (which is not mutually exclusive) would involve an agreement with Mozambique for electricity supplies from natural gas reserves, to be developed off northern Mozambique/southern Tanzania. However, this will increase South Africa's reliance on external electricity, and hence requires a shift in thinking from sovereign to regional security. This can, however, reduce the demand for water in South Africa.

What strategy appears most appropriate for South Africa, and is this an issue that should be addressed in the near future in strategic terms, including a recognition of Virtual Water transfers in the scenario?

Should South Africa seek bilateral talks on future electricity generation and use, with the DRC and/or Mozambique? What role can be envisaged for SADC and SAPP in this scenario?

Developing a Strategic Plan

The key issue in relation to Virtual Water transfers in electricity involves the massive distinction between the Virtual Water content of electrical supplies derived from thermoelectric facilities, and those from hydropower stations relying on large impoundments. This matter is addressed in brief in Text Box 3.3, which raises questions as to the preferred mix of regional electrical supplies in the future.

Notwithstanding the complexity of comparing the precise water footprints of various sources of electricity, for the purposes of the current study, certain broad inferences can be made specifically with respect to building regional climate resilience, improving regional integration, and building regional energy security:

- Given the strategic nature of electricity and its role in sustaining and building national economies, the SADC States are unlikely to significantly erode their sovereign security in terms of their national supplies of electricity.

- There is considerable scope for increased hydropower production in the Zambezi River basin, and this may be the only viable source to create greater sovereign security for electricity supplies to Zambia and Zimbabwe.
- There are substantial opportunities for increased thermal generation based on supplies from offshore gas fields in Mozambique and Tanzania.
- Hydropower production in the hotter northern States, while generally supported by higher flows and water availability, is highly vulnerable to increased temperatures and evaporation, and hence to climate change.
- Thermal power production in the generally dry south, while gradually becoming more water-efficient, remains a significant user of water especially in drought periods, and makes South Africa a substantial source of carbon emissions.
- The conjunctive and coordinated trading of electricity supplies through the SAPP can bring greater regional water/energy security and economic benefits for the SADC States, and can also reduce the carbon footprint of the region as a whole.

Economic Accounting of Water

Background

Economic accounts for water were developed initially as a specific component of the overall System of Environmental-Economic Accounting (SEEA), with the United Nations Statistics Division taking a leading role.[44] The parent system was described in the handbook on integrated environmental and economic accounting, which is commonly referred to as SEEA-2003.[45] The accounting system as a whole is aligned with the System of National Accounts used by most nations to generate statistics of relevance to their economies.[46]

Economic accounts for water (the SEEAW) are one of five sub-components of the SEEA, the others addressing energy, fisheries, land and ecosystems, and agriculture. The key documents of specific relevance to water are those from 2006 and 2012, the later version having been aligned to a revision of the System of National Accounts released in 2008.[47]

[44] See *System of Environmental-Economic Accounting (SEEA)*, at http://unstats.un.org/unsd/envaccounting/seea.asp

[45] *Handbook of National Accounting on Integrated Environmental and Economic Accounting 2003.* United Nations, Commission of the European Communities, International Monetary Fund, Organisation for Economic Co-operation and Development, and World Bank, 2003.

[46] *System of National Accounts 1993.* Commission of the European Communities, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations, and World Bank, 2003.

[47] *System of Environmental-Economic Accounting for Water: Final Draft.* United Nations Statistics Division, available at http://www.semide.net/media_server/files/semide/thematicdirs/glossaries/system-environmental-economic-accounting-water-/SEEAWDraftManual.pdf. *SEEA-Water: System of Environmental-Economic Accounting for Water.* United Nations Statistics Division, available at file:///C:/Documents%20and%20Settings/user/My%20Documents/dpu8744cridfSEEAW2012.pdf

The SEEAW includes the following water-related parameters as components of its standard format:

- stocks and flows of water resources within the environment;
- pressures of the economy on the environment in terms of water abstraction, and emissions added to wastewater and released to the environment, or removed from wastewater;
- the supply of water, and the use of water as input in a production process and by households;
- the re-use of water within the economy;
- the costs of collection, purification, distribution and treatment of water, as well as the service charges paid by the users;
- the financing of these costs, that is, who is paying for the water supply and sanitation services;
- the payments of permits for access to abstract water, or to use it as sink for the discharge of wastewater; and
- the hydraulic stock in place, as well as investments in hydraulic infrastructure during the accounting period.

Quality accounts and the economic valuation of water represent additional components of the SEEAW which remain experimental in nature at the present time, and are subject to further development.

Relevant Studies to Date in SADC

The SADC Economic Accounting of Water Use Project was completed in late 2010.[48] Pilot Water Account Reports were produced for four countries (Malawi, Mauritius, Namibia and Zambia), and also for two river basins (the Maputo and the Orange-Senqu). The standard approach embodied by the SEEAW was utilised, hence aligning the data with the System of National Accounts.

In general terms, economic accounting for water provides a conceptual framework to analyse the contribution of water to the economy of a country, and also the impact of the economy on water resources. This allows conclusions to be reached on whether water is utilised in efficient, equitable and sustainable fashions within countries (or in other distinct geographical units). Importantly, only blue water is addressed (in all its forms, including groundwater) in the present economic accounting systems, and green water, grey water and virtual water are not taken into account by the current techniques. However, the linkage between the water-related data and the national accounting system provides a powerful indicator of the uses of blue water in support of the economy, and the effects of the economy on blue water resources. The accounting system can be used at various levels, from individual enterprises and establishments (defined by their International Standard Industrial Classification [ISIC] denoters), to industry types; and also at the household level and higher levels of domestic use. ISIC components of specific relevance to water use within SADC include the following:

- ISIC 1-3 Agriculture, forestry and fishing;
- ISIC 5-33, Mining and quarrying;

48 *Southern African Development Community (SADC) Economic Accounting of Water Use Project*. Available at http://www.sadcwateraccounting.org/1.0EconomicAccountingForWater/1.4SADCEconomicAccountingProject.aspx

- ISIC 41-43 Manufacturing and construction;
- ISIC 35 Electricity, gas steam and air conditioning supply;
- ISIC 36 Water collection, treatment and supply;
- ISIC 37 Sewerage; and
- ISIC 38, 39, and 45-99 Service industries.

Within these rather broad categories, economic accounting of water can be utilised to demonstrate the contribution of Blue Water to various components of a national or regional economy. This represents a tool of some utility in relation to Blue Water (and Integrated Water Resource Management) in the specific, and complements considerations of the other forms of water that are the key focus of the present report. Key indicators that are derived by economic accounting of water include:

- water use intensity;
- water pollution intensity;
- water productivity (relating to Blue Water only; see elsewhere in this report);
- water losses in distribution;
- the per capita water storage; and
- the average water price and supply cost.

Examples of the results of the SADC project on economic accounting of water include the following:

- All of the SADC countries allocate the majority of the Blue Water in use to their agricultural sector, even though this sector provides low returns to the economy by comparison to the industrial or services sectors. The agricultural sector is, however, of particular importance for employment (e.g. 83% of the total workforce in Malawi).
- In some countries, the sectoral comparison on returns to the economy is particularly marked. Thus, for example, a cubic metre of Blue Water in Mauritius provides US$0.38 as a return from the agricultural sector, but US$237 from the industrial sector. Such a pattern has been noted in other studies also, as shown in Figure 3.13.
- Certain countries suffer a major lost opportunity cost relating to Blue Water, due to poor levels of water supply and sanitation. The data for Malawi reveal that this equates to an astonishing 17% of Gross Domestic Product (US$456 million annually), compared to a SADC-wide average of 3.2% annually.

- Namibia performs quite well by comparison to some of the other SADC countries, in part because it has been utilising water accounting techniques since the mid-1990s (and its legislation and Vision 2030 documentation recognise the value of this approach). However, returns to the economy from the agricultural sector in Namibia are low, reflecting the highly arid nature of the country.

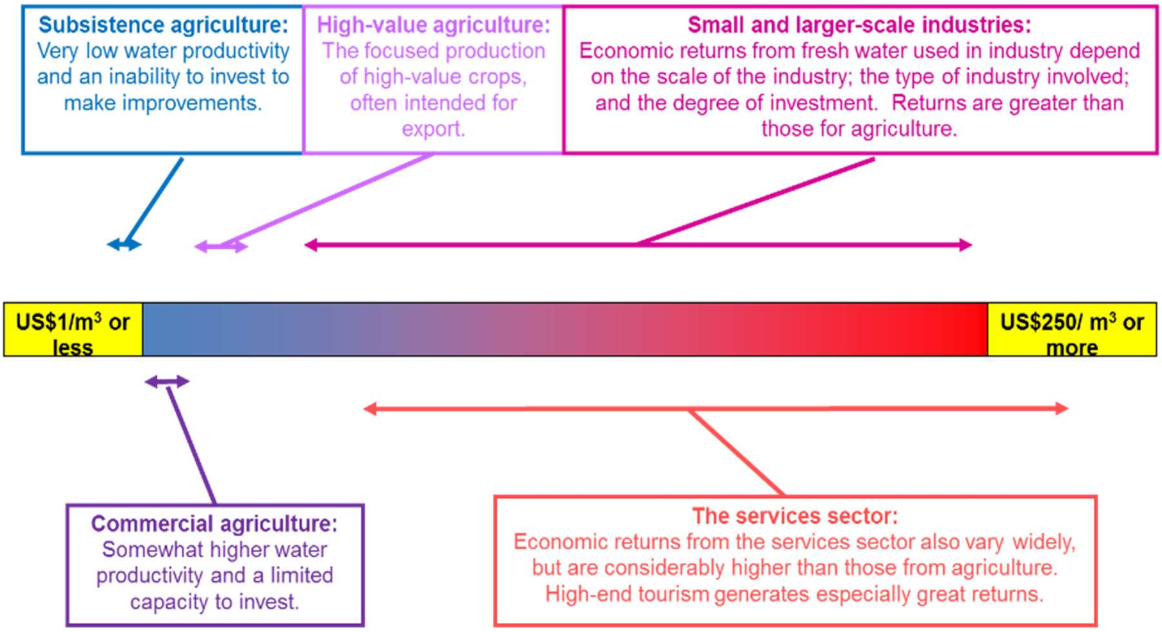


Figure 13 The water productivity continuum, with comments on the three major sectors. [After Phillips, 2012; see footnote 33].

- Zambia is relatively water-rich, but suffers from under-development of its Blue Water resources (and its industrial sector, which provides high returns from Blue Water use). Tourism is also a notable sub-sector in Zambia, and provides very high returns for Blue Water allocations.
- River basin-based studies are of considerable utility in revealing the economic effects of distinct Blue Water allocation strategies. Issues relating to benefit sharing and to the appropriate pricing of Blue Water resources are also highlighted in these investigations.
- While the fact that the current techniques are restricted entirely to Blue Water erodes the utility of economic accounting of water approaches, the data arising from such studies are nevertheless of importance. The SADC investigation concluded that:
- The technique can be used with pertinent results at both national and river basin level, although certain indicators are somewhat challenging to derive at the river basin level.
- A variety of indicators can be generated during the process involved in economic accounting of water use (see below), and these are of importance for decision making and policy formulation at the national and regional levels.
- The capacity to compile water accounts represents a challenge to many SADC countries, but certain States (Botswana, Namibia, and South Africa) have experience in the techniques involved and have already recognised the policy relevance of the approach.
- The compilation of economic accounts for water is best approached through the establishment of national task teams, these involving a range of governmental entities and skill bases.
- The harmonisation of certain types of data collection within SADC would assist in the compilation of economic accounts of Blue Water use – including a reliance on the ISIC categories in terms of industrial groupings. In some instances, hydrological data are also inadequate, and groundwater remains especially poorly characterised to date in SADC.

- Wastewater-related data are inadequate, and the water quality aspects of the approach remain under-developed as a result.
- The SEEAW approach does not address livestock as an economic unit, but Blue Water allocations to livestock are important in SADC.
- Economic accounting of water also fails to address the demand for Blue Water allocation as an ‘environmental reserve’ or to provide base flow in river systems.

A combination of approaches involving economic accounting of water and the techniques relating to other forms of water shows particular promise for the future. The complementary nature of the various approaches addressed in the present report is of very considerable importance, and the use of all of the forms of analysis in combination will offer a highly nuanced view of water resource management in the future. This is especially important in water-stressed systems, where allocations account for most or all of the available Blue Water. However, in other circumstances – exemplified especially well by Malawi within SADC, but also by Zambia and perhaps Angola – it is clear that relatively minor changes to water policy could have far-reaching implications for food security, poverty alleviation, and climate resilience. These topics may be taken up by later stages of the CRIDF work, reflecting the conclusions of other inputs under Activity 1807, which should reveal the most promising areas for future activities.

Chapter 4: The future of SADC: An investigation into the non-Political drivers of change and regional integration.

By

Antony Turton

Abstract

The present day SADC region is characterized by the spatial misalignment between water and economic development. The countries to the south generally have more diversified economies, but are also water constrained; whereas the countries to the north have less economic diversification, but are water abundant. The skewed nature of regional development is an artefact of history dating back to trading patterns that arose during the period of colonial rule. Subsequent to the independence of the various countries, a regional integration model is being followed by SADC, based essentially on the European Union approach.

However, the colonial-era dependency relationships have persisted, with the region being characterized by limited intra-regional trade. Global climate change is likely to pressurize these historic trading patterns, specifically because the dry portions of the region are likely to reach the hydrological limits to their internal economic growth in the near future. This disruption has the potential to reset the trade dynamics within the SADC region, specifically as each of the more economically diverse but water-constrained member states realize that food security will have to be secured at regional rather than at national level. The same is likely to occur with water and energy security, all of which can best be optimized at regional level.

The question is opened about the role that virtual water trade can play in such a scenario. The existence of an entity known as the Southern African Hydropolitical Complex (SAHPC) becomes relevant in this regard, because conceptually it enables the current power base of each SADC member state to be analysed. The four most economically diverse member states – Botswana, Namibia, South Africa and Zimbabwe – are also water scarce, with an increasing probability that their future economic growth will be constrained by the decreasing availability of water. These are called Pivotal States in the SAHPC and they are highly dependent on the water resources found in transboundary river basins. The global climate change scenario is likely to drive a fundamental shift in hegemonic status, with an erosion of power from these four countries as a new set of interstate dynamics play themselves out.

The new potential hegemonic states are those that will monopolize access to water, energy and food at regional level. Angola has the potential to become a regional hegemon, given its abundance of energy, water and its latent potential to become a significant food producer. However it remains essentially outward looking with limited internal connection with the regional economy by virtue of poor infrastructure. The Democratic Republic of Congo (DRC) has similar potential, but the vast size and absence of basic infrastructure will inhibit its potential to emerge as a regional power at least in the medium term. Zambia is better served with infrastructure and is likely to become the first example of economic growth driven by diversification as it becomes a regional bread-basket. Northern Mozambique is also a likely candidate to emerge as a regional power, with potential to produce food and energy on a significant scale.

The change in the biophysical environment is thus likely to drive a significant shift in the relative power of all SADC member states, with the potential big gainers being Angola, the DRC, Mozambique and Zambia; but countries like Namibia and Botswana are likely to increasingly leverage this fundamental change in interstate relationships to their advantage by virtue of their strategic location on two of the three infrastructure corridors that are likely to emerge, and the fact that they are riparian to the Zambezi, Cuvelai and Okavango Rivers. The three infrastructure corridors are: Western linking South Africa to the Grand Inga project in the DRC via

Namibia and Angola; Central linking Botswana to Zambia via Kasane with a rear link to South Africa bypassing Zimbabwe; Eastern linking South Africa to northern Mozambique. A shift in hegemony towards the northern SADC States will also make it increasingly difficult for the south to prosecute long term plans to physically transfer (blue) water from the Zambezi towards the south. It is important that CRIDF takes note of this strategic shift, in order to play a role in influencing future regional infrastructure development; further building climate resilience and deepen poverty eradication opportunities through stronger regional growth.

Introduction

The Southern African Development Community (SADC) region covers fifteen sovereign states, three of which are islands. The twelve mainland African states are linked by twenty-one river basins that cross international political borders, fifteen of which are considered to be the most important in terms of socio-economic development, 12 of which are CRIDF focus basins. SADC is based on the notion of integrating national economies, along lines similar to the European Union (EU). SADC was born out of the Cold War when a number of localized wars of liberation and independence were fought across the sub-continent of Africa (Turton, 2004). One of the responses to that process was the founding of the Southern African Development Coordinating Conference (SADCC) as a means of coordinating development aid in what was then known as the Front Line States (FLS) in their struggle against colonialism, capitalism and racism (Baynham, 1989). The EU was also born of conflict after two wars in Europe engulfed the entire world (Nye, 1971). Both of these organizations are thus based on the logic of a peace dividend that would be capable of effectively containing any localized conflict with regional integration based on trade and infrastructure as a key element. When peace broke out in the Southern African region, there was no longer the need for SADCC, so it transformed itself into SADC, with one of the first protocols being agreed by all member states focussing on the peaceful development of the many shared river basins in the region (Ramoeli, 2002). The development of water resources is thus a fundamental aspect of SADC with strategic ramifications (Basson, 1995; Heyns, 2002; Snaddon *et al*., 1999; Turton, 2003). This paper will explore the non-political drivers of change in the SADC region, by focussing on water as a manifestation of the development potential and aspirations of the various member states. The linkage to energy (World Bank, 1992) and food production (Africa, 1984) will also be developed, within the broader context of the Water-Energy-Food-Nexus (WEF Nexus) as manifest in the concept of virtual water trading (Allan, 2011; Earle & Turton, 2003; Hoekstra & Hung, 2002; Turton *et al*., 2000). Inherent to this is the inescapable fact that water resources are unevenly distributed within the SADC region (Mott McDonald & Partners, 1990), so in the face of global climate change (Scholes & Biggs, 2004), a growing population base (Turton & Warner, 2002) and the current absence of significant intra-regional trade, a series of biophysical drivers are at work. This paper seeks to map out some of those non-political drivers by exploring possible future development scenarios that are likely to arise.

Assumptions

Given that this paper attempts to look into the future, there is obviously a degree of uncertainty involved. In order to meet the objective of the paper in a meaningful way, it is necessary to base the contents on three key assumptions. These will be taken as given, merely because this set of assumptions then allows a viable set of future scenarios to be developed. The purpose is thus not to interrogate whether these three assumptions are valid or not, but rather to use them to develop a plausible argument.

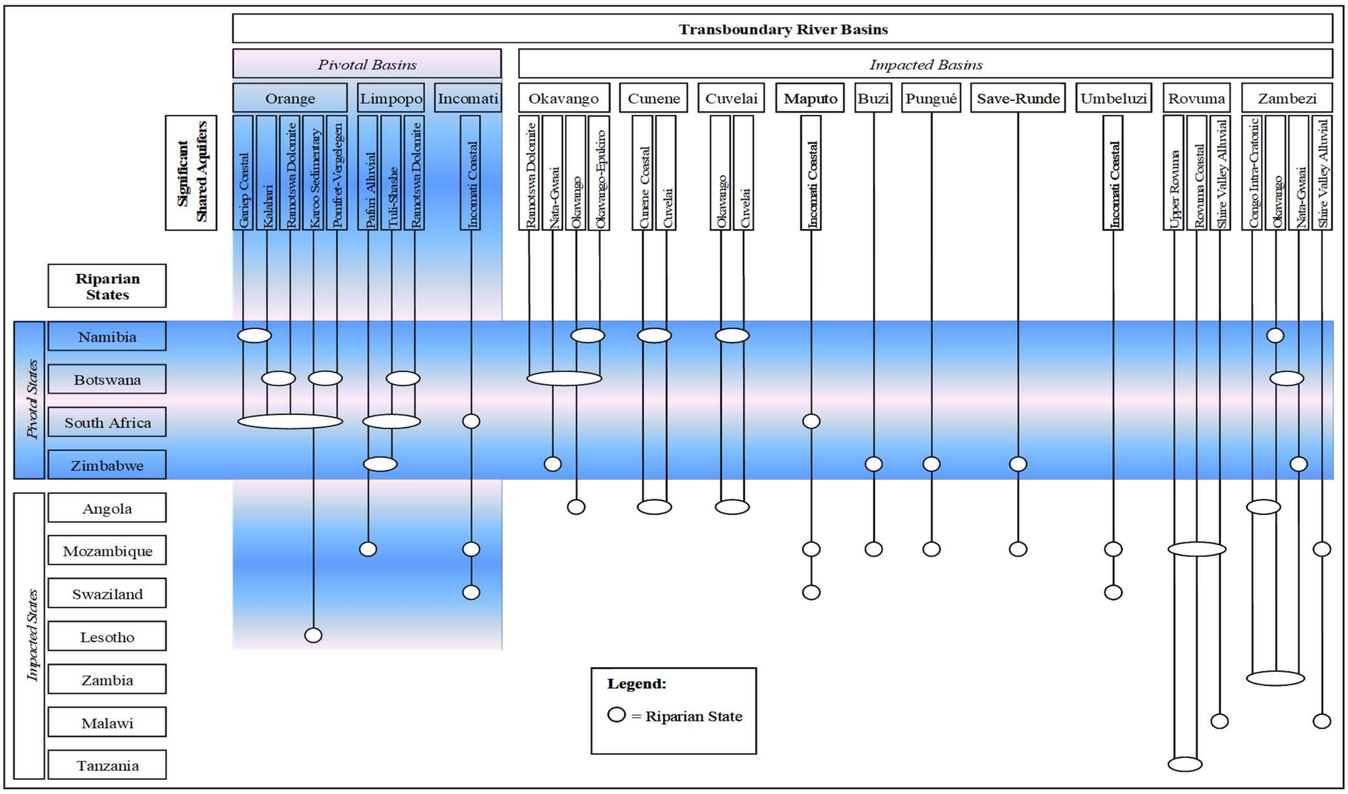
The first significant assumption is that climate change is happening so the author is not going to argue the science. The foundation of the scenarios presented in this paper is based on the assumption that the SADC region is likely to impact in a mosaic, as outlined in Chapter 2. The assumption is that in essence the SADC region as a whole is likely to become hotter, while the areas to the south of the ITCZ will get and drier, and those above the ITCZ wetter.

The second assumption is that a hydropolitical complex exists (Turton, 2001a; 2001b). The implication is that there is already a set of inter-state relationships that exist, and are partially shaped by, the strategic need of each SADC Member State to find security of water supply. A hydropolitical complex exists when patterns of inter-state amity (cooperation) and enmity (conflict) converge around the co-dependence on a specific shared water resource, with the overall pattern of convergence tending towards co-operation rather than conflict (Ashton & Turton, 2008; Maupin, 2010; Turton, 2008; Turton & Ashton, 2008). This is the pattern in the SADC region, so it is prudent to call the SADC region the Southern African Hydropolitical Complex (SAHPC) when referring to interstate relations over water, specifically because of the convergence around cooperation rather than conflict[49] (Turton, 2007; Turton *et al.,* 2006b). Within the SAHPC there are two distinct classifications of riparian state and transboundary river basin. Pivotal States are those that are the most economically diversified, with water resources likely to constrain future economic growth and development. Pivotal States have a natural tendency to play a hydro-hegemonic role in a given riparian relationship, by virtue of the fact that their greater diversification often translates into a political, military and economic power asymmetry in their favour. Impacted States are those that are least economically diverse, typically locked into a relationship with a Pivotal State by virtue of co-dependence on a transboundary water resource, in which the power asymmetry between the various riparian states does not favour them. In the SAHPC there are four Pivotal States – Botswana, Namibia, South Africa and Zimbabwe – all of which have water constrained national economies. An Impacted State often has significant water resources available on which future growth can be based, but is typically lacking the investment and physical infrastructure to develop the economy (referred to as economic water scarcity in Schreiner and Quibell). Pivotal Basins are those on which a Pivotal State has a high level of dependence, and are thus regarded as a strategic issue in those countries, and which have already been fully, or almost fully, allocated. There are three Pivotal Basins in the SAHPC – the Incomati, Limpopo and Orange/Senqu – which can be considered as closed resources (Ashton & Turton, 2008) (see **Figure 8**). The other basins are known as Impacted Basins, because while they have water available, this cannot necessarily be developed because of the absence of investment, infrastructure and economic diversification to support a robust tax base. Groundwater resources have not yet been fully classified, but current work being done by the International Groundwater Assessment Centre (IGRAC) is showing that a large number of aquifers are in fact transboundary in nature, so their relevance is likely to be better understood in terms of the SAHPC as soon as more information is known about them. This unique pattern of distribution has a number of ramifications that are absent from the current literature. The SAHPC is presented schematically in Figure 4.1 that names the water resources – both surface and groundwater – on the top horizontal

[49] CRIDF sees peaceful cooperation not as an absence of conflict, but as an absence of hegemony and or unilateral action.

axis; while the left hand vertical axis shows the riparian states. The matrix gives an indication of the hydrological foundation of the SADC region, most notably by identifying areas of convergence in the management of any specific resource.

Figure 4.1 Schematic representation of the relationship between significant water resources and various units of management in the SADC region structured within the SAHPC (Turton et al., 2008).



The third assumption is that while sovereignty is known to be a challenge in any regional integration scenario, it can be managed, so it need not necessarily become a stumbling block (Turton, 2002). The significance in the context of this paper is based on the core argument that global climate change will increasingly challenge state sovereignty in terms of water, energy and national food supplies, by forcing regional cooperation to the point where these three forms of security will be sourced at regional rather than national level, with the SAHPC as a key defining feature of future interstate dynamics. This might trigger a desire by SADC member states to cooperate in a way that does not erode their sovereign authority, such as *via* a Parallel National Action (PNA) model (Nielson, 1990; Turton, 2008) (a discussion of which is beyond the scope of this paper).

The Current Situation

The SADC region is characterized by a specific hydrological regime, made more complex by the fact that the majority of the area lies between the Inter-Tropical Convergence Zone (ITCZ) and the Southern Ocean, both of which drive different patterns of weather and precipitation (see Chapter 2).

This biophysical characteristic is superimposed onto a set of countries, each with different developmental trajectories, different political histories, differing legal systems that reflect previous colonial legacies and diverse natural resource endowments. Critical linkages arise from the interplay between these complex levels of scale, each driving different perceptions of national sovereign risk arising from attempts by different stakeholders (both state and non-state actors) to meet their legitimate developmental aspirations.

The economic development potential of the SADC region is defined by the availability of water. The primary source of water is precipitation, which is highly skewed across the region (See Chapter 2). The precipitation patterns are characterized by steep gradients from north to south and from east to west, with the most currently economically diverse countries being on the "wrong side" of the global average of 860 mm/yr^{-1}. Because of the low MAR:MAP ratios (Chapter 2), SADC region is particularly poorly endowed with water in rivers. This makes the transboundary river basins extremely important for the future economic integration of the SADC region.

Table 4.1: There are twenty-two known transboundary aquifer systems in the SADC region, but their geographic extent and hydrogeological characteristics are poorly described (Maupin, 2010; Turton *et al.,* 2006b).

Aquifer **Ripar. State**	**Cunene Coastal**	**Cuvelai**	**Congo Coastal**	**Congo Intra-Cratonic**	**Gariep Coastal**	**Incomati Coastal**	**Kagera**	**Kalahari**	**Karoo Sedimentary**	**Kenya-Tanzania Coastal**	**Kilimanjaro**	**Limpopo Granulite-Gneiss Belt**	**Nata-Gwaai**	**Okavango**	**Okavango-Epukiro**	**Pafuri Alluvial**	**Pomfret-Vergelegen Dolomitic**	**Ramotswa Dolomite**	**Rovuma Coastal**	**Shire Valley Alluvial**	**Tuli-Shashe**	**Upper Rovuma**	*Shared aquifers*
Angola	X	X	X	X										X									5
Botswan								X				X	X	X	X		X	X			X		8
DRC			X	X																			2
Lesotho									X														1
Madag.																							0
Malawi																				X			1
Mauritiu																							0
Moz.						X										X			X	X		X	5
Namibia	X	X			X			X						X	X								6
South					X	X		X	X			X				X	X	X			X		9
Swazilan						X																	1
Tanzani							X			X	X								X			X	5
Zambia				X									X	X									3
Zimbab												X	X			X					X		4
States	2	2	2	3	2	3	1	3	2	1	1	3	3	4	2	3	2	2	2	2	3	2	

While surface water is important, the significance of groundwater should not be forgotten. Groundwater in the SADC region is a vital resource, often used by rural communities as their only reliable source of drinking water. The livelihood flows derived from groundwater are thus extremely important, specifically in terms of poverty eradication, so these should not be forgotten. Table 4.1 lists the twenty-two known transboundary aquifer systems within the SADC region along with their respective riparian states (Maupin, 2010; Turton *et al.,* 2006a). The column on the right shows how many shared aquifers are in each country and the bottom row shows how many riparian's exist within each shared aquifer system.

If one superimposes the surface and groundwater resources available across the SADC region, then an interesting pattern of distribution occurs. Figure 4.1 shows a schematic representation of the distribution of water resources, both surface and groundwater, across the SAHPC. It is significant to note that the four most water constrained countries that are on the "wrong side" of the global average isohyet of 860 mm/yr^{-1} (see Figure 2.1) – Botswana (400 mm/yr^{-1}), Namibia (254 mm/yr^{-1}), South Africa (497 mm/yr^{-1}) and Zimbabwe (652 mm/yr^{-1}); are also the countries that share the largest number of transboundary aquifers (see Table 4.1) – Botswana (8), Namibia (6), South Africa (9) and Zimbabwe (4). These four countries are Pivotal States in the SAHPC, and the three transboundary surface water basins that they depend on for strategic supplies of water, and which have already been fully – or almost fully – allocated (Incomati, Limpopo, Orange/Senqu), are called Pivotal Basins.

It becomes instructive to see where the main transboundary aquifers are. Maps to this effect are scarce and where they are found are extremely inaccurate by virtue of the paucity of knowledge about the full geographic extent of the aquifer systems. Recent work by Cobbing *et al.,* (2008) generated a map that was further developed by Maupin (2010:60). Maupin's map represents the most accurate available at the time of writing and is presented as Figure 4.2. From this it is evident to what extent water is shared by the various SADC Member States, both surface and groundwater.

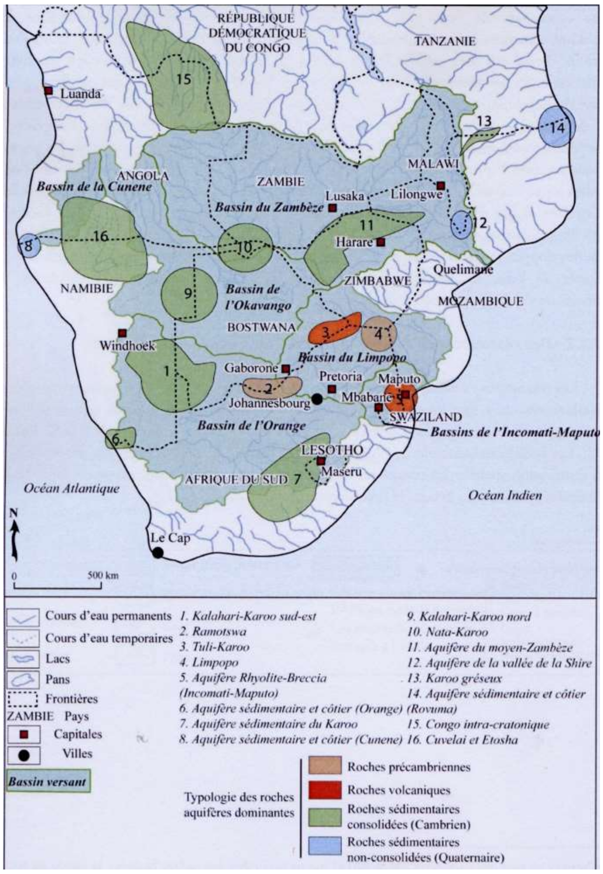


Figure 4.2 The location of transboundary groundwater aquifers in the SADC region as depicted by Maupin (2010:60) using Turton *et al.,* (2006b), Cobbing *et al.,* (2008); and IGRAC, (2009) as primary sources.

With these facts having been presented, it now becomes possible to examine each of the transboundary rivers in the SADC region with a view to determining what national sovereign risk each manifests for sustaining national economic development and regional integration. The SADC region has twenty-one transboundary river basins to which one or more SADC Member States are riparian, 15 of these are the focus of CRIDF's work. The 21 basins are shown in Table 4.2, which also indicates the existence of an inter-state agreement, the names of the respective riparian states and the classification in terms of being either perennial (a river that flows permanently) or ephemeral (a river that flows intermittently, mostly driven by specific episodic events giving such systems a unique hydrology and risk profile).

Table 4.2 Transboundary River Basins to which one or more SADC Member State is a Riparian (Turton et al., 2008).

Basin Name	Agreement	Type	Riparian States
Buzi	No	Perennial	Mozambique, Zimbabwe
Chiloango	No	Perennial	Angola, DRC
Congo	Yes	Perennial	Angola, Tanzania, Zambia
Cunene	Yes	Perennial	Angola, Namibia
Cuvelai	Yes – no RBO	Endorheic & Ephemeral	Angola, Namibia
Incomati	Yes	Perennial	Mozambique, South Africa, Swaziland
Lake Chilwa	No	Endorheic	Malawi, Mozambique
Lake Natron	No	Endorheic	Kenya, Tanzania
Limpopo	Yes	Perennial	Botswana, Mozambique, South Africa, Zimbabwe
Maputo	Yes	Perennial	Mozambique, South Africa, Swaziland
Nile	Yes	Perennial	DRC, Kenya, Tanzania
Okavango / Makgadikgadi	Yes	Endorheic	Angola, Botswana, Namibia
Orange / Senqu	Yes	Perennial	Botswana, Lesotho, Namibia, South Africa
Pagani	No	Perennial	Kenya, Tanzania
Pungué	No	Perennial	Mozambique, Zimbabwe
Rovuma	Yes – no RBO	Perennial	Mozambique, Tanzania
Savé / Runde	No	Perennial	Mozambique, Zimbabwe
Thukela	No	Perennial	Lesotho, South Africa
Umba	No	Perennial	Kenya, Tanzania
Umbeluzi	Yes	Perennial	Mozambique, South Africa, Swaziland
Zambezi	Yes	Perennial	Angola, Botswana, Malawi, Mozambique, Namibia, Zambia, Zimbabwe

The twenty-one transboundary river basins to which a SADC member state is riparian are shown on Figure 4.1. From this map it is evident that there are three broad categories of transboundary rivers. Category 1 consists of those transboundary rivers where not all of the riparian's are members of SADC. This means that the SADC

Protocol is not necessarily applicable to the management of that specific river basin, but it could become the foundation for management in the future[50]. Included in this category are the: Chiloango, Congo, Lake Natron, Nile, Pagani and Umba basins. Category 2 consists of those transboundary rivers where all riparian's are members of SADC, so the management of those systems is subject to the SADC Protocol. This consists of two distinct subsets. Category 2a consists of rivers that have significant portions of their basin in each riparian state so joint management is vital; this sub-set consists of the: Cunene, Incomati, Limpopo, Maputo, Okavango/Makgadikgadi, Orange/Senqu, Rovuma, Savé-Runde, Umbeluzi and the Zambezi basins. Category 2b consists of rivers that are fully within SADC territory and thus under the jurisdiction of the SADC Protocol, but are characterized by basins where the largest proportion of the resource lies in one country. As a result, joint management is not critical and might even be impractical. This sub-set includes the: Buzi, Pungué and the Thukela basins. Category 3 consists of rivers that have specific hydrological regimes, which are not conducive to the construction of large dams, mostly being endorheic in nature, but sometimes also ephemeral typically being linked closely to groundwater systems. This means that a disproportionately large number of livelihoods are dependent on a water supply that is often highly irregular and erratic, and where the management of these systems is very complex, often linked to endemic poverty, and mostly under-funded. Included in this category are the: Cuvelai and Lake Chilwa basins.

Of these transboundary river basins, a number are closed out, meaning that more rights have been allocated to these systems than actual water available at a high assurance of supply. Basin closure thus poses a unique set of sovereign risks, so it is important that these specific systems be distinguished from the rest. The closed river basins in the SADC region are shown on Figure 4.3.

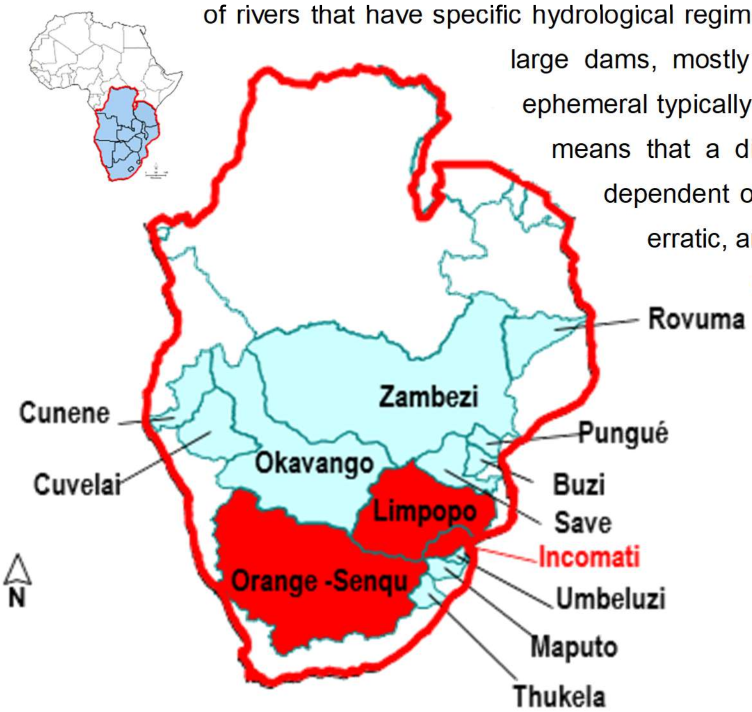


Figure 4.3 Three Closed Basins exist in the SADC region, shown here in red (Ashton & Turton, 2008; Turton & Ashton, 2008). These are called Pivotal Basins in the Southern African Hydropolitical Complex based on two criteria - being fully allocated but also being strategically important to the Pivotal States that depend on them for economic development.

The hydrological data for the major transboundary river basins in the SADC area is shown in Table 4.3. In this regard it must be noted that most sovereign states consider hydrological data to be sensitive and it is thus

[50] Some international customary law principles contained in the protocol could nevertheless be applied even under the present context

classified in many cases, which means that accurate data is not in the public domain. The data in Table 4.3 is thus the best available public domain data, used for illustrative purposes only in the context of this paper.

Table 4.3 Physical Description of the Major Transboundary Rivers in the SADC Region

Basin Name	Total Basin Area (km²)			River Length (km)	Mean Annual Runoff (Mm³/yr⁻¹)
	Pallett	**UNEP**	**Wolf**		
Buzi	31,000	-	-	250	2,500
Congo / Zaire	3,800,000	3,669,100	3,669,100	4,700	1,260,000
Cunene	106,500	110,000	-	1,050	5,500
Cuvelai	100,000	-	-	430	Ephemeral
Incomati	50,000	46,000	46,000	480	3,500
Limpopo	415,000	414,800	414,800	1,750	5,500
Maputo	32,000	30,700	30,700	380	2,500
Nile	2,800,000	3,038,100	3,038,100	6,700	86,000
Okavango / Makgadikgadi	570,000	706,900	706,900	1,100	11,000
Orange / Senqu	850,000	945,500	945,500	2,300	11,500
Pungué	32,500	-	-	300	3,000
Rovuma	155,500	151,700	151,700	800	15,000
Savé - Runde	92,500	-	-	740	7,000
Umbeluzi	5,500	10,900	10,900	200	600
Zambezi	1,400,000	1,385,300	1,385,300	2,650	94,000
Data Source: Columns 2, 5 & 6 – Pallett *et al.*, (1997); Column 3 – UNEP (2002b); Column 4 – Wolf (2006).					

Hydraulic Infrastructure Development

Cognizant of the fact that the logic underpinning this paper suggests that water is one of the foundations of the economic development potential of the state, it becomes instructive to assess the level of hydraulic infrastructure in the region. Figure 2.3 shows the number and location of major dams across the SADC region, outlining a stark misdistribution of hydraulic infrastructure in the SADC region, with a dense clustering of dams in two of the Pivotal States of the SAHPC – South Africa and Zimbabwe. When this data is superimposed onto the precipitation data shown on Figure 2.1, then it is obvious that these economies are capturing the resource from the better-watered eastern portion of the subcontinent (Homer-Dixon, 1994; 1996).

The notion of resource capture by the Pivotal States is even more apparent when one examines the location of current and future inter-basin transfer (IBT) infrastructure shown on Figure 4.4 (Snaddon *et al.*, 1999).

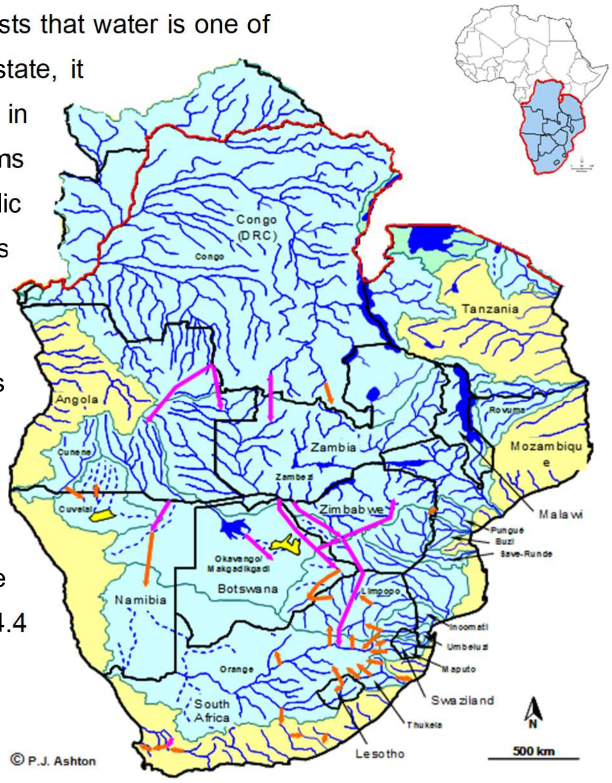


Figure 4.4 The distribution of current (orange) and future (purple) IBT's in the SADC region demonstrates the desire by the four Pivotal States in the SAHPC (Botswana, Namibia, South Africa and Zimbabwe) to secure future economic development by capturing the water resources of the north (Ashton in Turton *et al.*, 2008).

The data shown on Figure 4.4 demonstrates a harsh reality in the SADC region, namely that while the economic development is in the dry south, the water in the wetter north will increasingly be sought as hydrological constraints to development become apparent. This is a critical piece of evidence in the logic of the SAHPC, because in essence the four Pivotal States will increasingly be confronted by a sovereign security choice: either create water, energy and food security at national level by capturing the (blue) water resources of the north; or seek water, energy and food security at regional level by means of a shared vision of future infrastructural development based on VW trade using both blue and green water resources.

This is the essence of the biophysical facts that will increasingly become evident as climate change introduces a new level of risk that can only be managed by means of cooperation within the SAHPC *via* the institutions of SADC.

Broader Socio-Economic Factors

Given the hydrological dilemma within the SADC region noted above, it is now necessary to analyse some of the socio-economic factors that are currently at play. Figure 4.5 shows the relationship between GDP *per capita* expressed as a function of the percentage of water imported.

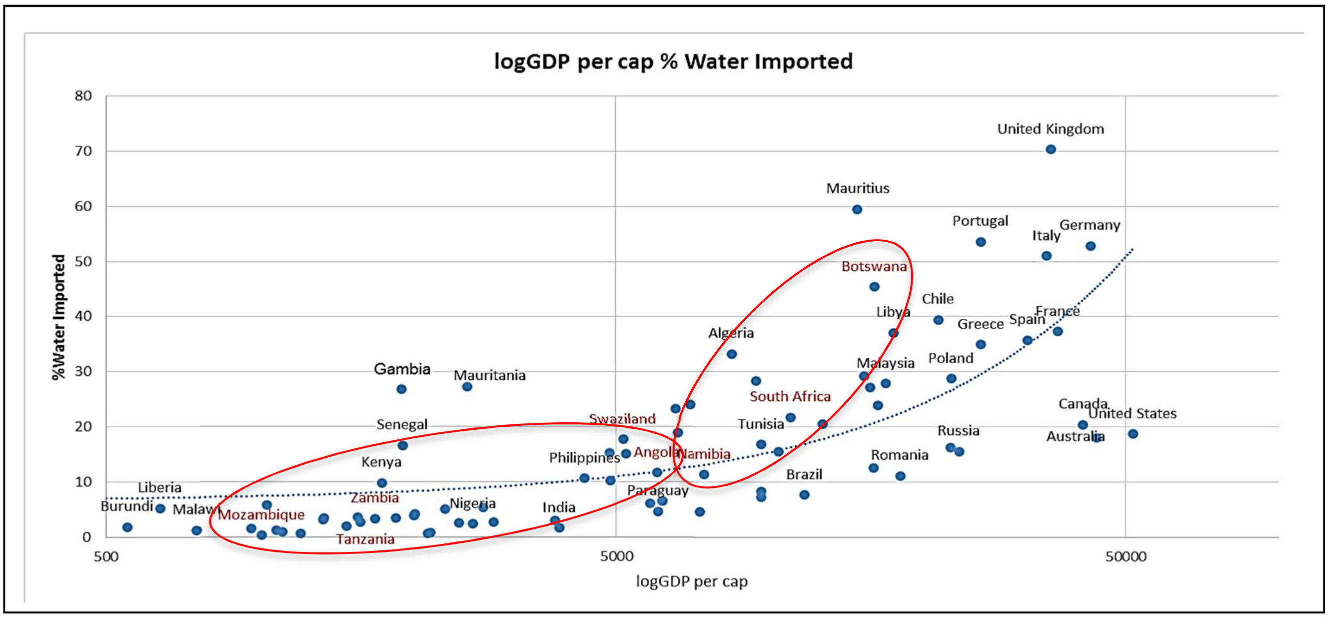


Figure 4.5 Relationship between GDP *per capita* expressed as a function of the percentage of water imported (CRIDF Dataset).

Three of the Pivotal States in the SAHPC are at the upper range of GDP *per capita* in the region, and are generally above the trend line for the scatter plot[51]. Significantly the Impacted States that are also generally water abundant (Mozambique, Zambia and Angola) are lower down the GDP scale, with a significant spread between them. Angola is significant in this regard, because the annual average precipitation is 1,050 mm/ yr^{-1} (Turton *et al*., 2008), making it the second wettest country in the mainland SADC region, beaten only by the DRC (with 1,534 mm/ yr^{-1}). More importantly the GDP *per capita* in that country has the potential to grow in terms of the future scenario suggested in this paper, raising the question of whether Angola would choose to import its food, or grow its own.

Mozambique is also important because it is a relatively water-abundant country, located on the eastern seaboard and thus in intimate contact with the warm Mozambique current. The annual average precipitation is 969 mm (Turton *et al*., 2008), making it the fifth wettest country in the mainland SADC region. It is riparian to the largest number of transboundary rivers in the SADC region, but it is a classic “downstreamer” in terms of geographic location, with a long history of being dominated by the Pivotal States upstream (South Africa and Zimbabwe). It

[51] While the trend line will be heavily influenced by the few outliers there is a general relationship between GDP and VW water imported, with the exceptions being richer territorially large States (US, Canada and Australia) which are below, rich small States (UK, Mauritius) which are above and the desert countries which can't grow their own food.

also has the potential to benefit greatly from regional integration in terms of the future scenario suggested in this paper, potentially to the point where it can break out of its relatively weaker riparian position. Zambia is also significant because the annual average precipitation is 1,011 mm/ yr^{-1}, on a par with Angola and only slightly less than the DRC. The southern portion of Zambia where most of the agricultural productivity lies is drought-prone however, and it is here that internal problems lie for the country – making it relatively blue water dependent. When analysed in terms of global climate change scenarios (Chapter 2), it is evident that northern Zambia is likely to become hotter and wetter by 2050 (Scholes & Biggs, 2004), which is somewhat of a better situation than most of South Africa (Scholes, 1998).

When the regional data is shown as a relationship between GDP *per capita* and wellness (Figure 4.6), then a more nuanced dimension emerges.

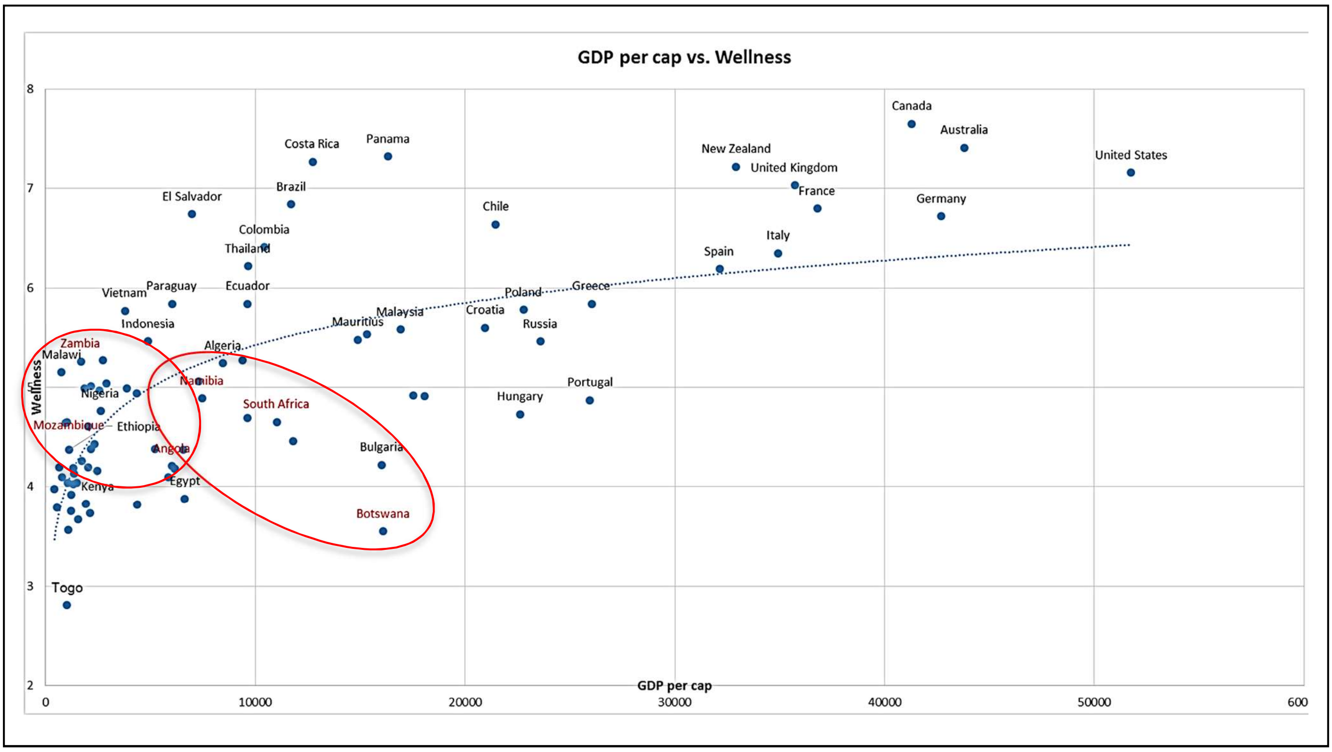


Figure 4.6 Relationship between wellness and GDP *per capita* (CRIDF Dataset).

Three of the Pivotal States in the SAHPC (Botswana, Namibia and South Africa) are once again on the upper range for the region, but are all below the global trend line for wellness. This is due to lower life expectancy due to HIV, but also high expectations among the population in part due to the high Gini (see Chapter 2). More significantly, three of the most water abundant of the Impacted States (Angola, Zambia and Mozambique) are low on the GDP scale for the region, but straddle the global trend line on the wellness scale, suggesting that life expectancy and satisfaction with life is higher than expected for the GDP.

Figure 4.7 shows the relationship between wellness and social progress in the region.

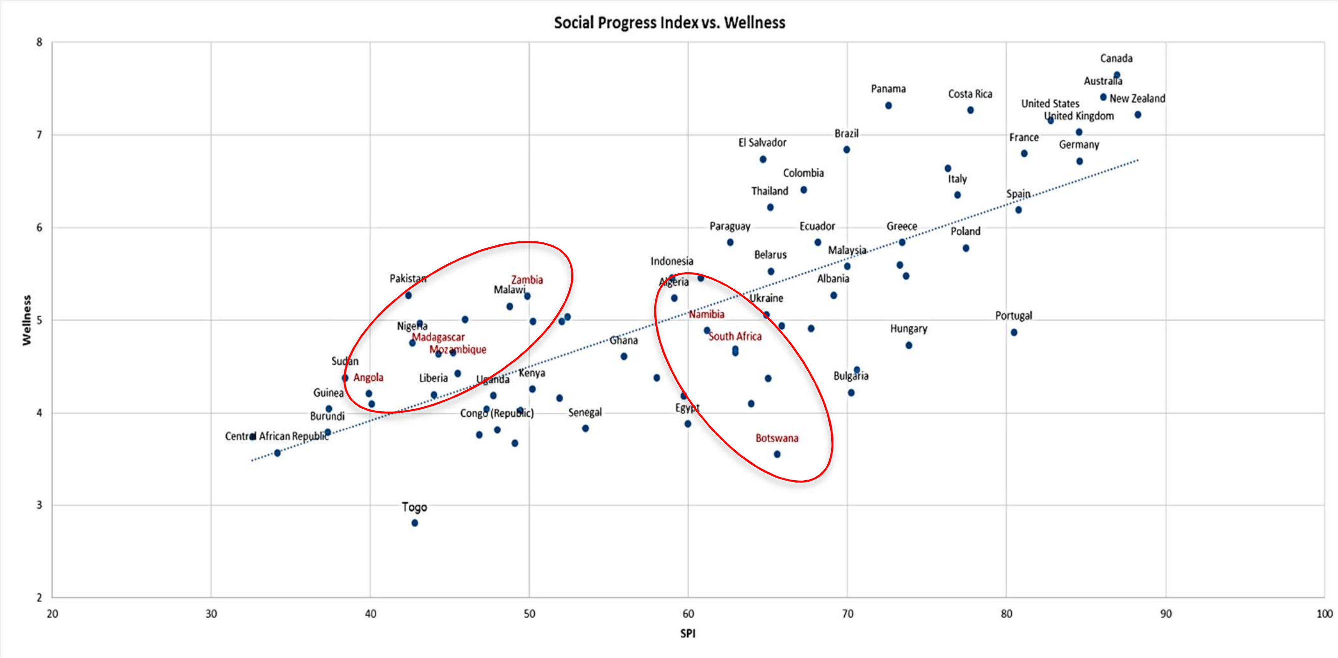


Figure 4.7 Relationship between wellness and social progress (CRIDF Dataset).

The Social Progress Index (SPI) measures the extent to which countries provide for the social and environmental needs of their citizens. Fifty-two indicators in the areas of basic human needs, foundations of wellbeing, and opportunity show the relative performance of nations. This dataset has a clustering of three Pivotal States in the SAHPC (Botswana, Namibia and South Africa) on the upper end of the regional range of the SPI, but all below the global trend line, again perhaps due to decreased lifespan due to HIV and the higher expectations due to high inequality. Conversely, the three most water abundant of the Impacted States in the SAHPC are low down in the regional range for the SPI, but above the global trend line, possibly because countries with low rainfall may mean more people need to migrate to where the rainfall is or where the cities are, where densely populated areas increase the risk of communicable disease. This is significant in terms of the future scenario presented in this paper.

An interesting picture emerges when one compares GDP *per capita* with the Human Development Index (HDI) non-income component as shown in Figure 4.8. The HDI is a composite statistic of life expectancy, education, and income indices used to rank countries into four tiers of human development.

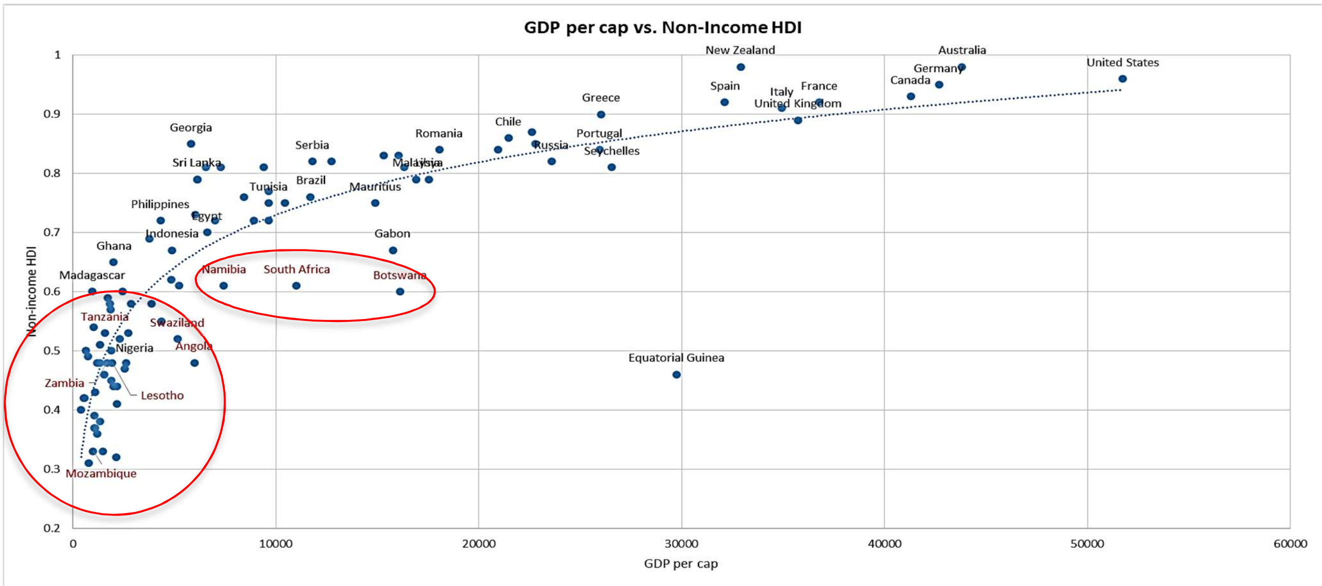


Figure 4.8 Relationship between GDP *per capita* and the non-income aspects of the Human Development Index (CRIDF Dataset).

Yet again the three Pivotal States in the SAHPC are clustered along a similar non-income HDI scale, but more importantly, they are significantly lower than the global trend line, again due to higher HIV rates. This suggests a large potential dividend needs to be unlocked to bring them into the global trend. The rest of the SADC countries are low on both the GDP scale and the non-income HDI scale.

The regional data is presented as a function of both the Happy Planet Index (HPI) and the GDP *per capita* in Figure 4.9. The HPI uses global data on life expectancy, experienced well-being and Ecological Footprint to calculate this. The index is an efficiency measure, ranking countries on how many long and happy lives they produce per unit of environmental input.

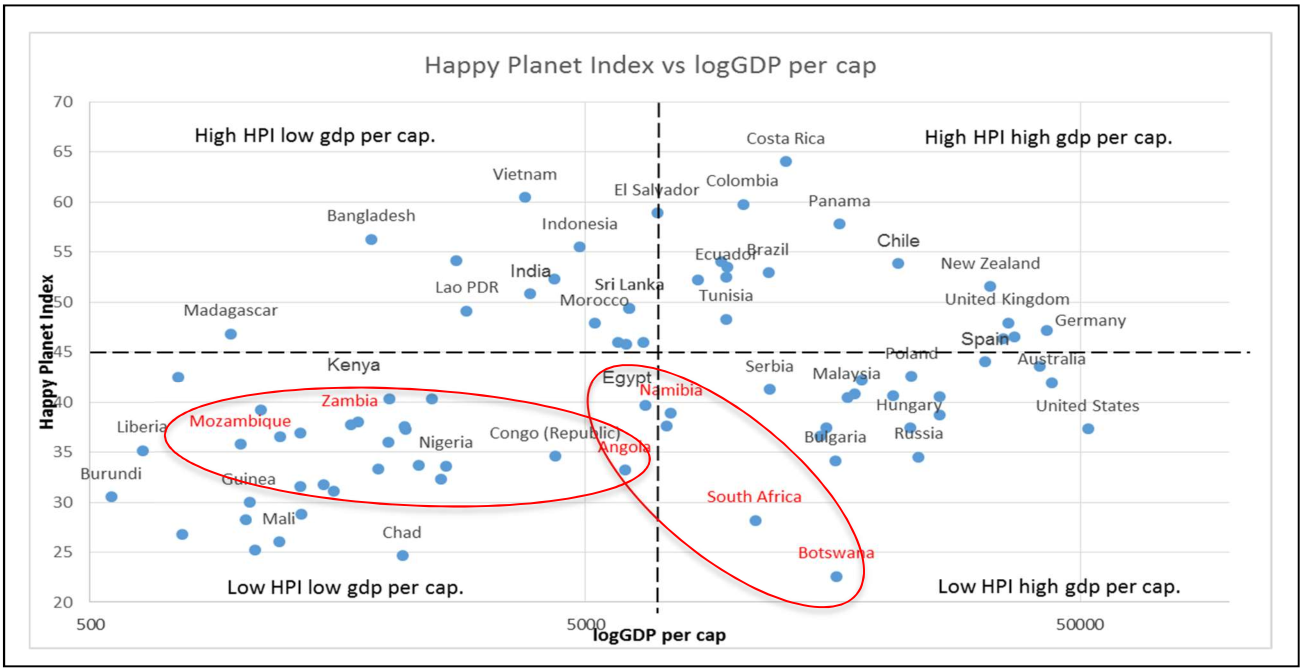


Figure 4.9 Matrix showing the relationship between GDP *per capita* and the Happy Planet Index (CRIDF Dataset).

The stark reality of the SADC region is manifest as all of the member states score below the median in terms of the HPI. Two of the Pivotal States (Botswana and South Africa) score above the median for GDP *per capita*, but are also the lowest in terms of HPI. Namibia, the third Pivotal State, is on the threshold of the GDP *per capita* median, scoring high on the HPI scale, which would suggest that these countries have a higher impact on the Planet that would be suggested by their GDP. The three most water abundant SADC countries in the dataset all occur in the quadrant with low GDP *per capita* and a low HPI.

Data showing renewable water *per capita* expressed as a function of the water footprint of the state is shown in Figure 4.10.

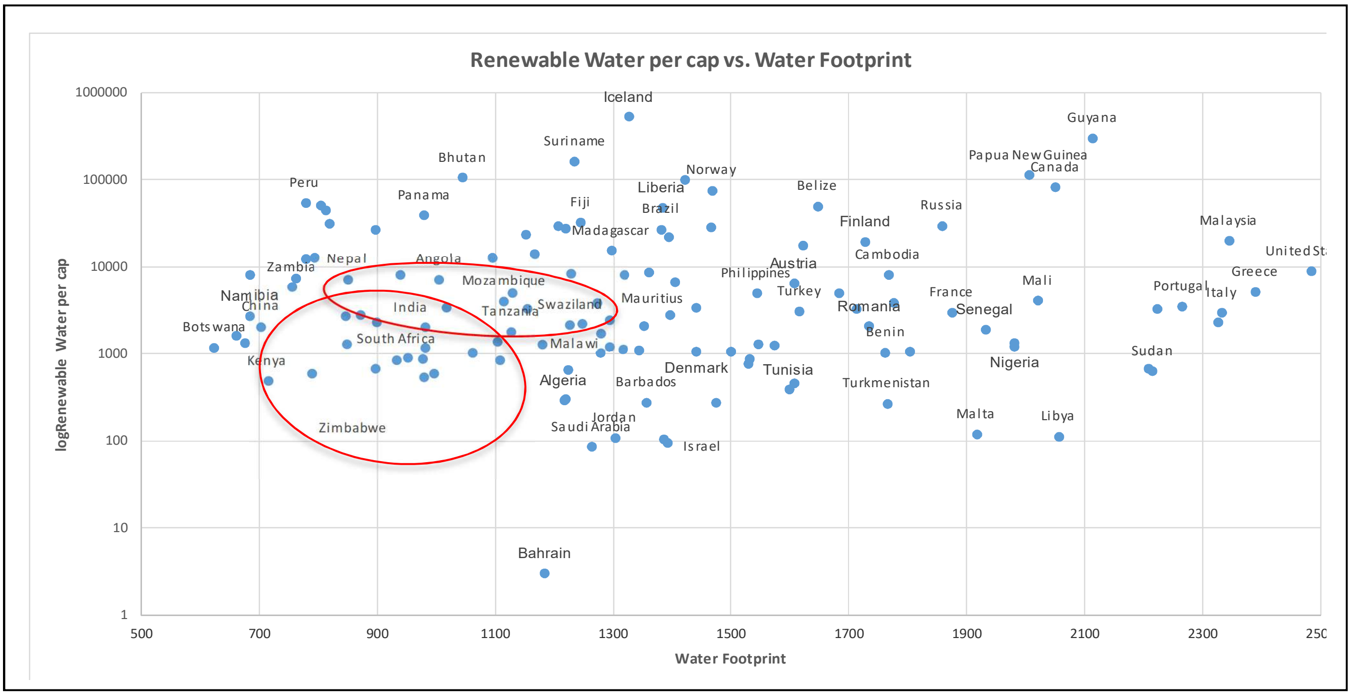


Figure 4.10 Shows the relationship between renewable freshwater per capita and the water footprint of a country (CRIDF Dataset**).**

The renewable internal freshwater resources *per capita* (cubic meters) refers to internal renewable resources (internal river flows and groundwater from rainfall) in the country. Renewable internal freshwater resources *per capita* are calculated using the World Bank's population estimates, while the water footprint is defined as the total blue, green, and grey amount of water consumed per person *per annum* (Mekonnen and Hoekstra, 2011). The three most water-abundant SADC members in this dataset (Angola, Mozambique and Zambia) are all on the upper scale for the region. Namibia presents as an anomaly, because the reason it scores in the upper range is based on the fact that significant volumes of water flow in the rivers that form the northern and southern borders of the country, but these are not necessarily capable of being utilized or developed for a variety of complex reasons. The low population base in Namibia also skews this data significantly. None of the SADC countries score very highly on the water footprint scale when compared globally. Those that do are generally exporters of virtual Water embedded in crops such as sugarcane (Swaziland). Malawi is an interesting case in this context, because it has a high water footprint, while also scoring low in terms of renewable water *per capita*. Both Swaziland and

Malawi stand out in terms of the blue water component of their exports, and are relevant to the scenario presented below.

Potential Future Scenarios

Given the known current situation presented above, in the context of the three assumptions – that climate change is likely to make the SADC region both hotter and drier; that a hydropolitical complex exists in the region that has already structured inter-state relations in the context of water resource management; and that sovereignty need not necessarily be a stumbling block because models that promote cooperation without eroding state independence do exist – we can start to construct a set of scenarios to guide our forward thinking.

As outlined in Chapter 2 the summer position is critical to the impact of climate change on SADC's water resources. The ITCZ funnels warm moist air across the SADC region in the summer months. The ITCZ weather pattern that accounts for much of the rain in the South African Highveld in summer, because it is channelled down south over the Kalahari Desert when an upper atmosphere low pressure trough forms. It is the formation of this upper atmosphere trough that makes South Africa vulnerable to climate change and increased variability, because a small disturbance in this process can alter rainfall patterns over much of the hinterland of the mainland SADC region.

Similarly, the expectations for higher rainfall in Angola and northern Zambia is also of major importance to the economic activity of the SADC region, because rainfall originating from that country sustains the national economies of many countries. In terms of our future scenarios for the SADC, we will therefore assume that climate change will create a disturbance to this specific weather system that will reduce the amount of precipitation entering the atmosphere above the region. While we cannot predict with certainty, this is also likely to reduce the conversion of rainfall to runoff, effectively forcing the MAP: MAR ratio in the larger rivers to converge around the 10^{th} percentile.

The impact of this will be dramatic, because the 860 mm/yr^{-1} isohyet will be forced to shift northwards across Angola and Zambia, and eastwards across southern Mozambique and Zimbabwe. This will change the precipitation pattern as follows:

- The rivers on which two Pivotal States in the SAHPC are totally dependent on (Namibia and Botswana) all rise on the Bié Plateau and include the Cunene, Cuvelai and the Kavango/Okavango. This triggers economic stagnation as the assurance of supply is reduced and localized water shortages start to accompany electricity blackouts. Unemployment grows and social instability starts to take hold. This is particularly evident in northern Namibia where the loss of the Cuvelai impacts a large percentage of the total Namibian population. Major tributaries of the Zambezi are also affected, notably the Luiana, Cuando, Lunge-Bungo and Luena on which Zimbabwe (another Pivotal State) is highly dependent. Of great strategic significance however, is the fact that an IBT from the Congo River, discharging water on the Bié Plateau, can thus be linked to increased water security for all of these rivers, with major benefits accruing to Namibia, Botswana, Zimbabwe and even Mozambique and potentially South Africa. The Proposed IBT's from the Cassai to the Cuito/Okavango, Cassai to the Zambezi and the Lualaba to the Zambezi all show the significance of the Bié Plateau in Angola (Basson, 1995; Heyns, 2002; Snaddon *et al*., 1999). This aspect, when combined with the dormant hegemonic status of Angola, is a significant factor in understanding how the hydropolitical dynamics of SADC will change, with Angola potentially becoming the dormant hydropolitical superpower in the SADC region.

- The eastwards shift of the 860 mm/yr^{-1} isohyet will start to increase ambient air temperatures in the north and east of South Africa (a Pivotal State in the SAHPC). This increases evaporative losses in Limpopo and Mpumalanga, both centres of energy production now and into the mid-term future. This means that South African energy security is placed under increased pressure. Swaziland is placed under increased pressure by South Africa, whose demands upstream leave less water for use by downstream riparian states. Significantly however, Mozambique also experiences an increase in demand for water, most notably from the capital city of Maputo, whose population growth and economic development demand more water than is available at a high assurance of supply level. This means that Swaziland is squeezed by the upstream riparian and regional hegemon – South Africa – and downstream riparian with a growing demand – Mozambique. The heavy dependence of Swaziland's economy on blue water (irrigated sugar) exacerbates this stress. This leaves South Africa increasingly vulnerable, but more importantly, increasingly at risk of meeting its energy needs from Mpumalanga and Limpopo provinces without re-allocating water from the irrigation sector. This means that the Greater Soutpansberg coal mining projects, currently in the exploration phase, will be unable to be realized simply by virtue of the fact that there is insufficient water available to sustain the mining process. In turn this means that nuclear power becomes an increasingly attractive option, but opposition to this grows at the very same time that national food security declines and unemployment increases. This changes South Africa's position in the SAPP, as it increasingly recognises the value of hydropower in the north. Zimbabwe, another Pivotal State, is also affected, because the climatic conditions that give rise to rainfall are similar. This means that the already semi-arid southern portion of Zimbabwe becomes even more arid, with the Kalahari Desert encroaching from the west but reaching deeper into Zimbabwe than at present. Zimbabwe's sugar industry and biofuels in the Save Basin is put under increasing stress, affecting flows into Mozambique. The small pocket of well-watered land around the Mazoe Valley shrinks, with farm production in this specific area of Zimbabwe declining. The firm energy outputs of hydropower projects such as the Batoka Gorge in Zimbabwe, and the Mepando Uncua in Mozambique, need to be reviewed in the context of lower system yields, altering the energy planning in these countries significantly (see Chapter 7). This combines with the collapse of food production in South Africa and Mozambique, giving rise to a localized form of out-migration driven by loss of livelihood in the subsistence farming sector (Homer-Dixon, 1994; 1996; Percival & Homer-Dixon, 2001). Commercial farms, already under pressure from a variety of issues such as indigenization and land restitution, also lose production. The culmination of these two factors is a loss of national food security, which given South Africa's dominance in food exports to the rest of SADC, is cascaded upwards to the SADC region, which if left unmanaged, could start to resemble the type of situation currently occurring in the Horn of Africa centred on Somaliland in Kenya.

- The shifting of the 860 mm/yr^{-1} isohyet has a profound impact on transboundary aquifer systems as recharge is significantly reduced (Cavé *et al*., 2003). This occurs at the same time as these systems are being developed for poverty eradication purposes, so this translates into a localized series of humanitarian crises. The most significant aquifer system to be negatively impacted is the Cuvelai/Etosha (No. 16 on Figure 4.2), which is one of the densest areas of human settlement in Namibia. This becomes the foretaste of things to come as donor agencies become aware of the problem. Other aquifers follow suit, with the Nata/Karoo and Zambezi Aquifers (No's. 10 & 11 respectively on Figure 4.2) the next to manifest as a problem. Other aquifers are also affected, with the Tuli/Karoo and Limpopo Aquifers (No's 3 & 4 on Figure 4.2) affecting planned mining operations and wildlife tourism destinations in a way that reduces employment for local people, further marginalizing these already vulnerable communities. The Rhyolite Breccia Aquifer (No 5 on Figure 4.2) is very significant because the peri-urban population of Maputo is directly impacted. This aquifer becomes saline as it is overdrawn, allowing salt water to intrude at the very same time as the city of Maputo faces a water crisis from the reduced flow of the Incomati, Maputo and Umbeluzi River basins (TPTC, 2008). This places considerable pressure on Swaziland, already in crisis because of increased evaporative losses and eutrophication arising from microcystin contamination of the dams. South Africa is also placed under pressure in the same systems, given their existing reliance on the Incomati and Maputo Rivers for their energy supply in Mpumalanga.
- The increase in ambient air temperature across the SADC region has a major impact on the dams located mostly in South Africa and Zimbabwe (both Pivotal States in the SAHPC). Evaporative losses increase significantly, lowering system yield, but the increase in the temperature of the water in these dams drives an increase in eutrophication (Oberholster & Ashton, 2008). This will cause an increase in cyanobacterial blooms potentially resulting in microcystin toxin being released into the food chain, posing particular risk for vulnerable communities with compromised immune systems (Abe *et al*., 1996; Bradshaw *et al*., 2003; Codd *et al*., 1999; Doyle, 1991; Falconer 1998; 2005; Humpage *et al*., 2000; Oberholster *et al*., 2004; 2008; Ueno *et al*., 1996). This triggers a series of health-related crises in the four Pivotal States, all of which are highly dependent on dams for strategic storage of water. Irrigation farming is placed under pressure, most notably because of the improved research into microcystin deposition onto crops, but also because increased evaporative losses cause salinization of the soils over time, reducing crop yield significantly. Swaziland is also affected, given the high reliance on irrigated agriculture for that country, and GDP is directly affected as exports diminish on the back of media coverage about microcystin contamination of produce.

As the regional hydrology changes, so too does the climate, with the Kalahari and Karoo generally expanding northwards as far as southern Zambia and eastwards as far as Mozambique. This has a direct impact on national food production in the four Pivotal States of the SAHPC. Initially seen as a crisis, realization starts to dawn on decision-makers that Virtual Water trade is a regional solution, so food security is increasingly found at regional rather than national level in these four countries. Regional food production moves to the following countries:

- The DRC is well watered and has vast landscapes that are capable of being tilled. International interest is triggered as multinational agribusiness corporations secure land in order to seize market share for the future. A parallel process occurs with smallholder agriculture being organized into cooperative movements capable of moving produce to the markets of the south before spoiling. South African and Zimbabwean commercial farmers, displaced because of land restitution issues in those two countries, migrate northwards and set up successful operations. The challenge for the DRC is the lack of infrastructure and the relative weakness of the central government, so security remains a constraint and development of the agricultural resource-base is initially slow and patchy.
- Angola is also well watered, so it starts to emerge as a new regional hegemon by virtue of the fact that it controls the Bié Plateau, and with that the headwaters of the Cunene, Cuvelai, Kavango and parts of the Zambezi. IBT's from the Congo into these systems enhances the prestige and power of the country. However, the Angolan economy is generally outward looking, based mostly on mining and energy, with trading partners outside of the SADC region. This inhibits Angola to reach its full potential as a hegemonic state in the SAHPC, but it does not curtail the natural processes at work at regional level. Large commercial farms start to develop in the central and northern portion of Angola as the desert encroaches from the south-west. Small-scale farming co-exists with large commercial farms similar to the DRC. The outward looking nature of the Angolan economy is reflected in the relative absence of transport infrastructure, so while the agricultural potential is good, connectivity to the markets of the south remains a challenge.
- Northern Zambia is also well-watered, with some indications that this might even improve under climate change conditions (Scholes & Biggs, 2004). While the south sees some encroachment of the Kalahari, the rest of the country starts to boom as the agricultural potential is realized, and north – south transport infrastructure is established. The soils are good and the population density is relatively low, giving rise to a rapid expansion of large commercial farming operations. The logistical infrastructure, while not extensive, does exist to the extent that upgrades can rapidly connect the production centres in Zambia with the markets in the south. This transportation corridor is therefore prioritized with the construction of a bridge across the Zambezi at Kasane into Botswana to avoid the bottleneck at Beit Bridge. Zambia therefore becomes one of the first movers in the climate change scenario, because all of the primary drivers are already in place – good soil, abundant water, existing transport infrastructure along the north-south axis. Consequently Zambia starts to emerge as a regional economic power as food processing corporations establish the first significant industrial diversification outside of mining.
- Mozambique also becomes a significant country under the scenario of climate change. While the south becomes more desertified as the Kalahari encroaches eastwards, the northern Rovuma Basin is well watered with good soils. The recent discovery of coal and gas in this area creates an impetus for the development of infrastructure, but this is initially focussed on east-west connections leaving the existing north-south road as the only significant transport corridor to the food markets. Revenues to the fiscus from mining and gas are wisely invested into north-south road, rail and electricity transmission infrastructure, so Mozambique starts to compete with Zambia as a significant food producing area, exporting both to the increasingly water stressed southern SADC countries and world-wide.

The shift in the epicentre of regional food production marginalizes the following countries:

- Malawi, with a heavy reliance on blue water in sugar is unable to translate its relatively favourable geographic position into a regional comparative advantage because of the relatively small size of the country along with the very high hydraulic density of population. Malawi therefore becomes a food importer over time with increasing levels of poverty potentially driving a population migration across the SADC region.
- Swaziland sees a significant change in its regional comparative advantage in this scenario. Climate change causes reduced flows in the rivers that sustain irrigated agriculture, with an increase in the grey water content of its sugar export, and making its exports less attractive on global markets. . The reduction in precipitation also plays a role. Swaziland starts to resemble Malawi with population pressure and job losses in the agricultural sector causing an increase in poverty. As with Malawi, there is out migration pressure over time.
- Lesotho, already under pressure, becomes increasingly marginal in economic terms as the mines in South Africa shed jobs. Precipitation in the highlands is affected by the eastward shift of the 860 mm/yr^{-1} isohyet, but the orographic nature of the rainfall means that system yields are not too badly reduced. Lesotho joins Malawi and Swaziland as a country in trouble as donor aid is ramped up over time. Lesotho reaches out to its ally Botswana, connected culturally and linguistically, as a water transfer is planned for Gaborone to provide an alternative revenue stream for the government.

The shift in epicentre of regional food production is likely to be felt by the four Pivotal States in the SAHPC as follows:

- South Africa retains its status as the largest economy in the region, although the intra-SADC differences are reduced. Nonetheless South Africa remains a significant industrial power. However, the loss of national food security is countered by an increase in the trade of Virtual Water in food products produced in the north. The existing road and railway infrastructure connecting South Africa to Mozambique and Zambia is rapidly upgraded, stimulating the manufacturing sector to produce goods for sale up north. Border crossings are streamlined in order to facilitate the rapid and unhindered flow of produce down south. Infrastructure investment gives Mozambique and Zambia an initial advantage as regional food producers. However, benefit is leveraged by both Zimbabwe and Botswana for the same reason. Zimbabwe is significant by virtue of the existing road and railway line northwards to Zambia. Botswana, on the other hand, is less well connected, but it leverages the growing South African dependence on food production in the north to develop its own infrastructure, most notably by upgrading the road to, and bridge across the Zambezi River at Kasane. South Africa achieves some form of redundancy in its dependence on the goodwill of neighbouring states. As this infrastructure develops, so too does the northward trade of goods manufactured in South Africa. This drives an increase in intra-SADC trade, creating opportunities elsewhere in the region.
- Zimbabwe is increasingly vulnerable for a variety of reasons, but it survives by leveraging its gatekeeping position on the one major north-south transport infrastructure between South Africa and Zambia. The loss of food production in the country is not easily translated into Virtual Water trade because of the absence

of foreign currency arising from reduced industrialization. Given the complexity of this issue the country lurches forward, but slowly starts to lose its hegemonic status as infrastructural development takes place around it rather than through it.

- Botswana is initially highly vulnerable, but strategically positioned to benefit from the changing regional dynamics. On the one hand its benefits by developing transport infrastructure bypassing Zimbabwe. It creates an inland port at Kasane by establishing a bonded warehouse facility. Early infrastructure investment starts to attract traders who increasingly set up businesses in the Kasane area. As the bridge across the Zambezi is developed, a high speed border crossing is introduced to attract logistics companies away from the Zimbabwe route, reducing the number of border crossings needed. Botswana also builds redundancy into its water supply by developing the North-South Carrier to the point where it can connect into the Zambezi at Katombora Rapids. Yet again Zimbabwe is bypassed, giving Botswana control over water delivery to Bulawayo and potentially Pretoria. Botswana also leverages its advantage on the various river basin organizations it is active in, to foster a cooperative approach to solution seeking. In this role it can broker power between various States, and given its existing dependency on imported Virtual Water, it more readily adopts the concepts into water and development policies. The linkage between Botswana and Lesotho is expanded as the possibility of transferring water from the Highlands to Gaborone is taken through a series of feasibility studies.
- Namibia is highly vulnerable because the majority of its water resources are located on either the northern or southern borders. While it has a low population base, the heavy population settlements in the north are severely impacted as the 860 mm/yr^{-1} isohyet moves northwards. The first crisis occurs when the Cuvelai basin dries up for an extended period, placing additional pressure on the IBT from the Kunene back into Ongiva in Angola. However the yield from the Kunene is also affected, placing pressure on this alternative water supply scheme while also reducing the viability of the planned hydro-electric dams downstream of Calueque. The loss of food security is not readily translated into an expanding industrial base, so Namibia is increasingly marginalized in this scenario because of the low tax base to fund infrastructural development.

On the energy side of the equation, this shift in the food production epicentre of the SADC region has profound implications. Growing differences in firm versus average power from the Zambezi, and growing local demands in Zambia also shift the playing field. Broadly speaking these drivers play out as follows in the four Pivotal States in the SAHPC:

- Zimbabwe is directly impacted because the more variable flow of the Zambezi immediately translates into reduced hydropower capacity at Kariba. More importantly, the viability of Batoka Gorge (Knight Piésold & Lahmeyer International, 1993) is likely to be in jeopardy. The thermal energy based on the Hwange coalfields is also impacted, plunging Zimbabwe into a new energy crisis. Zimbabwe starts to look east to Mozambique for gas; and north to the DRC for both geothermal energy along the Great Rift Valley and hydropower from Grand Inga in the west of the country.
- South Africa is hard hit as a result of the reduced yield from the Incomati and Maputo basins, with an immediate negative impact on the Mpumalanga-based Eskom operations. In similar vein the newly developed Eskom thermal energy plant in the Limpopo basin is placed at risk because of deteriorating

water quality arising from return flows out of Gauteng, and Acid Mine Drainage from coal mining operations. South Africa is forced to revaluate the nuclear option, but growing public anger causes the government to look northwards towards the gas fields of Mozambique, and to the periodic surplus power available when the Zambezi is flowing strongly. Investment into north-south transmission infrastructure therefore grows, with a new corridor opening up for road, rail and energy pipelines direct from northern Mozambique into South Africa. The status of Mozambique is elevated as a regional power so economic growth in that country starts to hit double digit rates. At the same time South Africa increasingly looks towards the DRC for, hydropower from Inga in the west. Given the sheer scale of this development, it lags behind the Mozambique transaction, but is still seriously considered.

- Botswana has invested into thermal energy based in the east of the country, but this is placed at risk because of water insecurity. The government therefore looks north towards the DRC, and the Zambezi and invests into the infrastructure corridor across the Zambezi River as Kasane. Road, rail and energy infrastructure upgrades in Zambia are routed to Botswana. Given the known stance of the Government of Botswana, they leverage this advantage with South Africa in order to form a joint venture between the two countries for the development of this infrastructure corridor. Significant development thus takes place in Botswana, between Botswana and South Africa, and *via* Zambia into the DRC. Botswana invests wisely and finds water, energy and food security at regional level along this major infrastructure corridor.
- Namibia is the first to be plunged into crisis as the north of the country desiccates, resulting in a humanitarian disaster in the Cuvelai basin. The planned energy projects along the Kunene downstream of Calueque are all placed in jeopardy as major financial institutions call for a revaluation of the viability of those projects. Attention shifts to the offshore gas fields, but also towards the north where the logical first stop is a hydropower joint venture with Angola in some of the westerly flowing rivers of that country. The Namibian government is also aware of the Grand Inga scheme, so they apply their minds to the strategic implications of opening an infrastructure corridor to South Africa *via* Angola from Inga. They leverage advantage from this position to offset the crisis unfolding in the north of the country.

Implications for CRIDF

Given the CRIDF mandate to focus on infrastructure development, climate change adaptation and poverty alleviation, the scenarios presented above have a number of direct implications. These will be assessed in brief below.

Infrastructure Development

There is a general low level of infrastructural development in the SADC region, specifically with respect to water, transport and energy. More significantly, there is a coincidence between a growing need for water by the four Pivotal States of the SAHPC, and the growing need for infrastructural development within the region that various donors can contribute to. In terms of the CRIDF focus a unique set of opportunities arise in the following:

- Aquifer storage and recovery (ASR), also known as managed aquifer recharge (MAR) is an emerging technology that is increasingly being mainstreamed in water-constrained parts of the world (Moore *et al*., 2011). This type of project is ideal for a targeted, small scale infrastructure development project, specifically where the technology is being piloted as a demonstration for sceptics (Tredoux *et al*., 2002)**.** Some of these are transboundary systems which have a different set of opportunities and challenges (Davies *et al*., 2012; Scheumann & Herrfahrdt-Pähle, 2008). It is even possible to engineer such systems, specifically if mine rehabilitation involving an open pit is involved (Turton & Botha, 2013). The significance of such systems is that they are very efficient because they reduce the evaporation losses associated with open dams in areas of high evaporative demand (Hut *et al.,* 2008).
- It is clear that the region is facing a major challenge in the energy field, to the extent that the quest for viable solutions could potentially be a game changer for those directly involved. There is an opportunity to assist with the mapping of new energy sources, specifically those involving low grade heat sources such as those found along the southern-most extremity of the Great Rift Valley as it intersects the Caprivi Strip, and trading in the difference between average and firm energy to the south. These smaller resources are capable of being developed for localized small scale energy conversion, using technology developed in Europe and piloted on one of the small Greek islands. The larger resources are found further north and are already being exploited (Economist, 2008; Mbuthi & Yuko, 2005).
- Water infrastructure, specifically suited to small-scale agriculture focussed on poverty eradication and climate change resilience-building is a potentially low hanging fruit, but would require significant replication to make any substantial impact on regional poverty. Of particular interest are low maintenance concepts such as rainwater harvesting, specifically where this might be linked to the production of food or the recharging of localized aquifers. Water harvesting and reuse is also likely to be of increased importance, specifically in the rural areas of the Pivotal States as water constraints inhibit substantial development in the future. More importantly, corridors that are suitable for multiple forms of infrastructure, such as those used in Botswana, where electricity, roads, railway lines and pipelines all run parallel in a well-designed system that is easy to service and maintain.

- The water stewardship roles of the private sector, expanding CSR roles, and an increase in the numbers of outgrower schemes could serve as a key driver of rural development. This may help push agricultural production northwards making better use of the regions green water resources – particularly in the face of poor runoff coefficients.
- Transport infrastructure is going to be a key element in regional integration, specifically under conditions identified in the scenario presented in this paper. There are likely to be three major north-south transport corridors, each capable of multiple use for electricity and potentially even water or gas pipelines. The Eastern Corridor is likely to go from South Africa up to the northern portion of Mozambique. The Central Corridor is likely to go from Botswana to the DRC *via* the bridge over the Zambezi located at Kasane. The Western Corridor is likely to go from South Africa, *via* Namibia and Angola to the DRC, driven mostly by the need to service the electricity grid should Grand Inga come online. This transport infrastructure will need to be serviced by rapid border crossing facilities, specifically if fresh food is to make it to the markets in the south in an unspoilt manner.
- Climate change is likely to create a new set of health-related opportunities and threats (Bradshaw *et al*., 2003). Opportunities will present as increased penetration into the rural areas arising from infrastructure development (energy, transport, pipelines). Threats are likely to arise from a change in disease vectors such as mosquitoes, along with the types of problem associated with DDT use (Aneck-Hahn *et al*., 2007; Bornman *et al*., 2005; 2009). Another specific category of threat will be associated with the exposure of persons with compromised immune systems to microcystin toxins in hypertrophic waters (Codd *et al*., 1999; Doyle, 1991; Falconer, 1998; 2005; Humpage *et al*., 2000; Oberholster *et al*., 2004; 2005).
- Food production is likely to undergo a major change in the SADC region in the next few decades. One manifestation will probably be the relocation of major production centres to the wetter north, more specifically in the DRC, Angola, Zambia and northern Mozambique. While this is likely to favour large-scale commercial farming, there is a strong need to foster a parallel system centred on small-scale farmers, possibly organized around cooperative structures capable of servicing the market needs in the south where better prices are likely to be found. This represents a specific targeted opportunity for early assessment and intervention. Another area is that associated with the monitoring of water quality for crop production, specifically from hypertrophic water where microcystin might be a limiting factor (Abe, 1996).

King's Demographic Trap as a Concept

While King's Demographic Trap is contested by some (Sen, 1989; 2000), it remains a useful tool in understanding how water might become both a national and regional risk. In the professional opinion of the author, this should not be dismissed without a thorough interrogation in a SADC context. It must be noted that the pathway to King's Demographic Trap is not a linear one as shown in Figure 4.11, being driven by a combination of growing population pressure, increased generation of waste and manifesting as accelerated water pollution – the exact type that is becoming evident in South Africa as eutrophic ecosystems.

King's Demographic Trap

The survival of a population depends ultimately on a sustainable supply of essential resources, particularly fresh water and food. If these are not available in sufficient quantities to sustain the people living in a nation or region, the population has exceeded the carrying capacity of that nation or region. Both populations and supplies of fresh water and food are dynamic, not static. Usually, in most nations, there is a positive balance - the nation or region either has, or can afford to import, a sufficient supply of fresh water and food to enable all currently living to survive, with enough left over to allow for natural population increase. However, sometimes the rate of increase of a nation's or region's population is greater than the capacity of the local or regional ecosystems to produce the food that is necessary for all to survive, and there are no financial resources to import these necessities for survival. Moreover, natural or manmade disasters can tip the balance by disrupting food supplies. A population that has exceeded the national or regional carrying capacity is said to be caught in a demographic trap (King & Elliott, 1993). Such a population must migrate out of the region, or it will starve unless it receives food aid. Another possible consequence may be violent armed conflict if the demographically trapped population encroaches on the territory of neighbouring nations who regard them as unwelcome intruders. The concept of the demographic trap first appeared in the annual report of the Worldwatch Institute in 1987. It was discussed at a major World Health Organization (WHO) conference in 1988, and has been much discussed since then.

Source: Encyclopaedia of Public Health (http://www.answers.com/topic/demographic-trap)

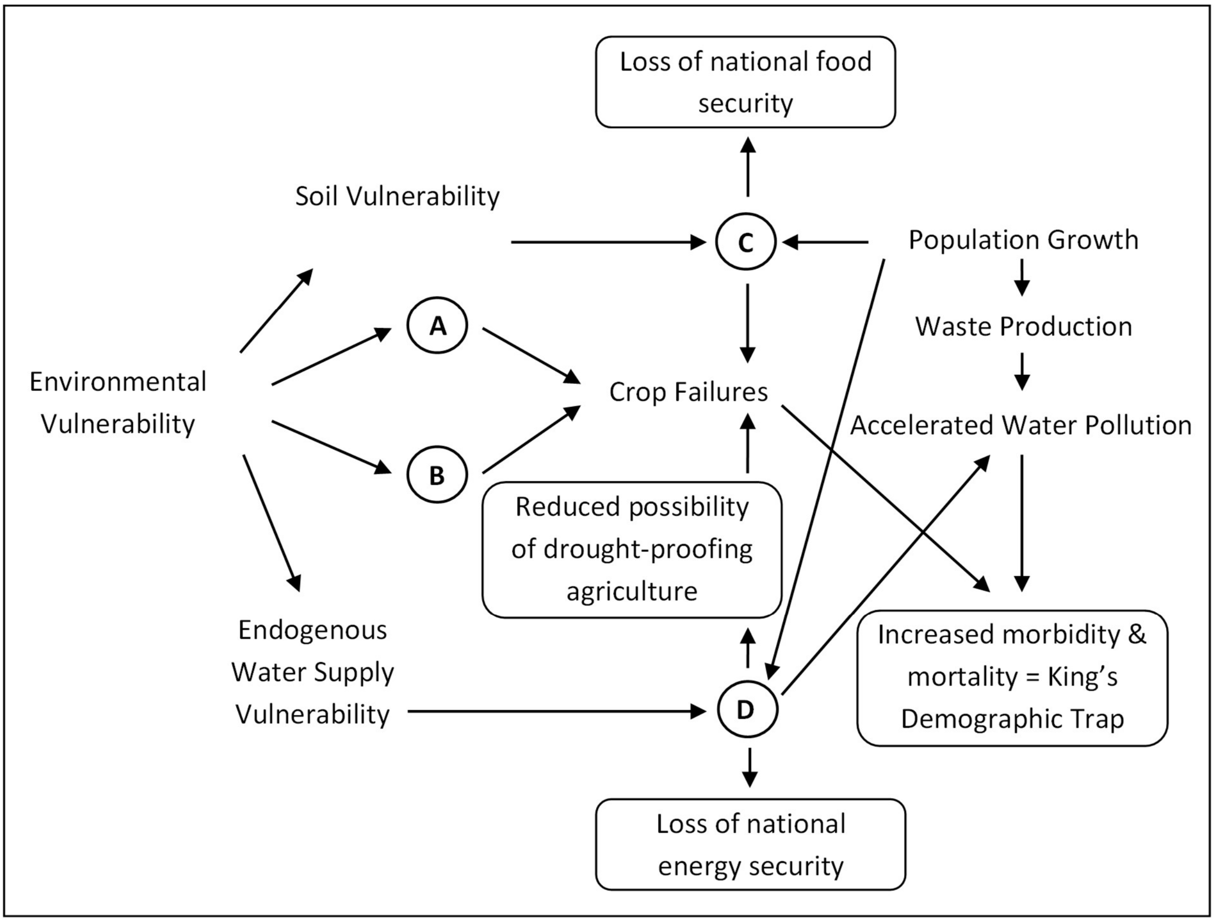


Figure 4.11 Schematic representation of the main sovereign risks (shown in boxed areas) along with different pathways to environmental vulnerability (adapted from Falkenmark, 1994:20).

In order to understand the different pathways that sovereign risks might arise from water, **Figure 20** makes use of four distinct modes of water scarcity as defined by Falkenmark (1993; 1994). The ramifications of these are as follows:

- **Mode "A"** – a lack of "green water" (water used in the production of biomass arising from natural precipitation). This can be thought of in its most simple form as a short growing season arising from rainfall that is late or erratic. Technically this is what happens where localized rain falls but a major drought prevails in the broader region. (sometimes referred to as meteorological droughts)
- **Mode "B"** – intermittent drought such as that which occurs over much of the SADC region. This is the type of drought that would arise from an *el Nino* event (see Chapter 2)
- **Mode "C"** – manmade desiccation of the landscape arising from poor agricultural practices. Typically this occurs in areas with a high water crowding index (WCI) value.
- **Mode "D"** – a lack of "blue water" (water that has been trapped in dams and engineered systems) both endogenous (occurring inside the country) and exogenous (arising outside the country but flowing into it

via aquifers or rivers). This is where eutrophication would feature, because it impacts water in dams, rendering it unfit for purpose even if it is available in a volumetric sense of that word. (sometimes referred to as hydrological droughts)

From the conceptual model shown in Figure 4.11, four significant and distinct risks arise from water. The ramifications of these is shown in a rounded box and can be described as follows:

- Reduced possibility of drought-proofing agriculture. This is driven mostly by **Mode "D"** and is most likely to manifest in areas with a high WCI. A sub-set of this is human health impacts, such as those now manifesting as intersexed babies in areas with a high WCI superimposed onto areas with endemic malaria (typically Limpopo). (**Note**: A study by Bornman *et al.,* (2009) has shown that in a test sample of 3,310 new-born male babies in the Limpopo area, 357 (10.8% of the total sample) had various forms of urogenital birth defects. A statistical analysis of this sample revealed that a mother living in an area that was sprayed with DDT from 1995 – 2003 had a 33% increased chance of giving birth to a male child with a urogenital birth defect. By being a homemaker and thus unemployed further increased the risks by 41%. There are other examples such as impaired semen quality (Aneck-Hahn *et al*., 2007) and urogenital defects in males (Bornman *et al*., 2005). This has significant implications if these findings are accurate, because they become yet another driver of what is already manifesting as increased vulnerability of subsistence agriculture to **Mode "D"** risk).
- Loss of national energy security. This is also associated with **Mode "D"** risk and is driven by vulnerability to national water resources as a result of the overall demand for water (most notably for food production) exceeding sustainable supply and thus becoming a constraint to hydrothermal energy production.
- Loss of national food security. This is driven by **Mode "C"** risk, arising from a high WCI in combination with increased soil vulnerability.
- Increased morbidity and mortality arising from King's Demographic Trap. This is driven by population growth in water-stressed areas (manifesting first as a high WCI) combining later with **Mode "D"** risk as systems start to exceed design parameters and fail.

Conclusion

This paper has attempted to generate a set of scenarios, based on three core assumptions: that climate change is likely to make the SADC region both hotter and drier; that a hydro-political complex exists in the region in which the tendency for inter-state behaviour is to converge around cooperation rather than competition; and that sovereignty can be managed in a way that need not necessarily mean a direct challenge to the supremacy of the state. If correct, then the countries located in the more economically diverse south are likely to be increasingly unable to create national self-sufficiency in water, energy and food. This will drive a hard set of decisions that will have to be made. Inevitably however, the solutions to these three vexing problems are likely to be found at regional rather than national level. The better-watered north will increasingly become the regional breadbasket, with the DRC, Angola, Zambia and northern Mozambique emerging as major players. If one overlays the energy crisis onto the food challenge, then we start to see the need for three major infrastructure corridors – the eastern, central and western – capable of servicing the water, energy and food needs of the south from the north. Intra-regional trade is likely to change in a significant manner, driving the need for liberalization and faster border crossings at selected choke points. Policy integration will therefore be necessary and can be considered soft infrastructure. Within this process, CRIDF can play a major role, with a number of key focal areas having been identified.

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Chapter 5: Virtual Water and the Nexus in national development planning

By

Mike Muller

Complementary endowments offer opportunities

Minister Trevor Manuel, chairman of South Africa's National Planning Commission and champion of the SADC/Nepad North-South Corridor project, has highlighted the opportunities offered by greater regional cooperation:

> "As we imagine different futures for our different countries, we should also have the courage to imagine ourselves working together as a single region. If we do that, we find that the balance of our endowments looks a little different. If we combine our access to capital as a region, with the diversity of human resources that we have, the independence dividend that is now maturing in the region, with our extensive natural resources [...] a completely different set of opportunities would arise. And while we would still have large numbers of relatively unskilled people, they would have far wider opportunities than if we simply worked as individual countries."

(Manuel, T, 2011. Keynote address at the workshop on "Regional approaches to food and water security in the face of climate challenges", 23–24 May. DBSA, Midrand. Online: http://www.npconline.co.za/pebble.asp?relid=590)

Abstract

While freshwater is an important factor of production in many sectors, it is a renewable natural resource and does not need to be produced but must rather be developed and managed to meet the needs of its many and diverse "users". Where competition between users emerges, the challenge is to balance the needs of poor users whose water use is important for their livelihoods against commercial users whose production may contribute significantly to national economies and to the welfare of the wider society. In rare situations of absolute scarcity, the available resource is allocated between economic sectors by a variety of measures which range from the purely administrative to conventional economic instruments such as markets and prices.

Since water resources are part of the natural environment, their management must also take account of the need to sustain the resource and its underlying biodiversity for which other activities, such as wastewater discharges and environmental flows. The resource is likely to be affected by climate change which may amplify the destructive impacts of both flooding and droughts. However, the challenges posed by current climate variability already require a structured management response which for many communities is the immediate priority. Strengthening the ability to manage current climate variability is a preferred strategy to build community, country and regional resilience to climate change.

Because of its great variety of uses and impacts, water resource development and management has to be closely coordinated with the needs of users, and water resource management institutions

should be able to inform user sectors of the opportunities and constraints that water may pose for their activities. Two broad macro-approaches to introducing water issues into national development policy and strategy can be distinguished, hydro-centric and hydro-supported; this distinction applies equally to transboundary water issues.

Hydro-centric approaches place water at the centre of development and seek to convene stakeholders to participate in water-focused processes. Such processes are generally organised on the scale of river basins (because they are seen as a basic environmental unit) rather than political or economic units and, over the past few decades, have tended to emphasise environmental conservation rather than resource development. There is limited evidence for their impact at a national level and less in transboundary systems. Nonetheless, they have been widely applied in less-developed donor-dependent regions where they are required by donor agencies. Their outcome has largely been to constrain infrastructure development, reduce water security and encourage user sectors to promote single sector projects to serve their needs.

Hydro-supported processes seek to work with user sectors at the scale of political units, including multilateral development communities like SADC, and focus on demand centres and supply systems rather than river basins, although these are still important technical units within which to evaluate resource availability and quality. Hydro-supported processes develop responses to strategies emerging from user sectors and integrate these, where appropriate, into multi-purpose rather than single purpose responses. These processes have not been as well characterised as the hydro-centric approaches but are dominant in most more-developed countries. Even in the European Union, where water resource development management is formally governed by the environmentally focused Water Framework Directive (WFD), many countries "work around" the WFD to focus on specific management challenges in "problemsheds" rather than "watersheds". Indeed implementation of the WFD has been criticised as many countries choose to designate water bodies as 'heavily modified' in order to escape the requirements for "good ecological status".

While concepts such as "virtual water" and the "water-food-energy nexus" have hydro-centric origins, they may contribute to hydro-supportive approaches if raised in the context of national development planning, in which the issues they raise are usually addressed implicitly. Thus in all countries, agricultural and energy production tends to be located in areas where conditions are favourable and the production traded internally to places where there is demand. Products which are not produced locally are then imported while surpluses are exported. There is limited evidence that hydro-centric instruments have a significant influence on development decisions and outcomes or that they will perform better than more conventional multi-sectoral approaches to development planning.

Generally, national development planning uses a range of economic and social metrics to compare alternative strategies and tradeoffs between sectors and within society, to develop strategies for their implementation and to engage with interest groups and decision-makers. So, for example, national food security is dealt with by considering local production capacities and competitiveness (in which water availability and costs may be an issue but livelihoods and prices are invariably more important) as well as the risks and benefits of a reliance on trade. Similar considerations apply in the energy domain. In South Africa, water has been a fundamental consideration for energy planning since the early 1970s, Similarly, it has been the obvious basis for hydropower generation in other SADC countries.

While inter-sectoral tradeoffs and synergies can be addressed through planning processes at a national level, this becomes more difficult when a number of countries are involved at a regional level. Where rivers cross national boundaries, the situation with respect to water-related sectors is further confused by hydro-centric approaches which concentrate on relationships within a single river basin rather than hydro-supported approaches which would consider overall national economies.

The determination and evaluation of the opportunities and constraints posed by water resources – and other endowments - involves coordination between different political jurisdictions and across multiple sectors whose priorities and criteria, implicit and explicit, may be expressed in a range of different metrics. This explains why apparent benefits that could be achieved through regional planning and cooperation have often been identified but much less frequently acted upon. Indeed, in some sectors and regions proposals for greater cooperation have been rejected despite the apparent benefits that they offer – the SADC power sector provides a current illustration (see Chapter 7).

It is generally agreed that successful regional cooperation and integration depends on a clear identification and equitable and reliable distribution of costs and benefits. Development planning processes can make an important contribution to this but are still in their infancy in SADC and structures and methodologies that allow the various inter-sectoral trade-offs at national level to inform decision-making about regional integration have yet to be established. The hydro-centric focus on planning within shared river basins rather than between national economies may weaken cooperative inter-sectoral work since it tends to exclude water from mainstream planning processes. The political economy that determines whether potential economic and social benefits are translated into political decisions remains poorly understood although it has been identified as a priority area for further research. However, Virtual Water and Nexus approaches, with a focus on trade between countries, may help to identify potential regional inter-sectoral trade-offs, thus informing hydro-supportive approaches.

In this context, the concepts of virtual water and the energy-food-water nexus may usefully inform a range of discussions and be used to illustrate potential challenges of and responses to climate change. They are however unlikely in themselves to provide the basis for national policies on which regional cooperation and action depend, given the many other factors that have to be considered.

Introduction and background

Water in "development"

Water is a factor of greater or lesser importance in many economic and social sectors and its management (as a resource) and provision (as a service) are often considered to be economic and social "sectors" in their own right. To the extent that there is a generic goal for water resource management, it is to achieve water security for society, defined as *"the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems, and production, coupled with an acceptable level of water-related risks to people, environments, and economies."*

The management of water as a renewable, "common-pool" natural resource whose presence is both variable and unpredictable, poses many challenges. Although freshwater is an important factor of production in many sectors, it does not need to be produced; the resource must rather be developed and managed. The immediate attention of "user" sectors is usually the quantity of water available to them. However, the need to maintain water resource quality both to sustain desired environmental conditions as well as to avoid prejudice to other users becomes increasingly important as levels of use increase. In many countries, management of flood impacts is also an essential function.

From a development policy and strategy perspective, water is a contextual resource endowment rather than a driving force. While, historically, early agricultural civilisations may have developed into "hydraulic societies", the linkages between water and societal economic and social development have weakened as our ability to manage water to meet development needs has increased. Outside of agriculture and hydropower, water availability is seldom a dominant determinant of the location of economic activity and water resource development and management is guided by demand rather than used to catalyse activity through supply. The dominant approach to water management has been to get the water to where it is needed, rather than to develop where the water is available – particularly in southern Africa.

The nature of management activities is often complex since it has to deal with extreme variability and uncertainty as well as the geographic location of the resource which is often not found in adequate quantities and requires infrastructure investments to make it available where it is required. As use intensifies, there is often competition between users for access to limited supplies and a system has to be established that guides the allocation of what is usually considered to be a public resource. This process has to take account of changing social and economic priorities and preferences. A further challenge is to take account of the need to sustain the resource and its underlying biodiversity and to reflect the environmental preferences and priorities of society.

While there are always likely to be infrastructure solutions to water availability and variability, these may become increasingly economically and environmentally expensive. Regional differences in water endowments may similarly require the transfer of water over longer distances between basins and nations or demand other responses.

Climate variability and change

There has been extensive discussion about the potential impacts of climate change on water resources, with warnings that it may amplify the destructive impacts of both flooding and droughts. There is however a widely held view amongst practitioners that current climate variability already requires a structured management response, which many communities and countries are still not able to provide. The preferred strategy for climate change is thus to build community, country and regional resilience by building the capacity to address current climate variability.

Water resource planning is contested terrain

If water-related development decisions are to be influenced today, it is useful to understand how decisions about water resource development, management and use are made and how diverse water-using sectors are engaged. It is also important to recognise that this is a contested terrain and to understand and track the recent evolution of different approaches is beyond the scope of this paper.

Because of its multi-sectoral use and impacts, water resource development and management has to be closely coordinated with the needs of users and water resource management institutions should be able to inform user sectors of the opportunities and constraints that water may pose for their activities. Two broad macro-approaches to introducing water issues into national policy can be distinguished, hydro-centric and hydro-supported.

Hydro-centric processes

A variety of “hydro-centric” planning processes have been promoted, often by environmental conservation interest groups. These are characterised by an attempt to “put water at the centre of development”, to make the physical boundaries of river basins the primary scale at which water is planned (e.g. European Water Framework Directive) and to seek to resolve development trade-offs between different sectors in forums established by water sector institutions. An earlier generation of hydro-centric processes (the USA’s TVA scheme is the flagship for these) sought to stimulate development through investments in water infrastructure. These had mixed results.

Hydro-centric processes are also particularly difficult to apply in transboundary river systems. While the core principle behind transboundary water management is that water resources are shared between nations and should therefore be managed jointly by all the riparian States, trade-offs where the benefits accrue to one State, and the impacts in another have been difficult to achieve. Benefit sharing, while touted as the solution, have also been hampered by the complexities of agreeing a reasonable and equitable share of those benefits, particularly where these accrue to and from different sectors of economy and society.

Hydro-supported processes

Hydro-supported processes are those in which the development and management of the resource is guided primarily by the requirements of the sectors that use or are affected by water. Most obvious is the requirement for supplies of the quantity of water needed at the quality and reliability needed. Less obvious are the requirements placed on the impact of economic and social actors on resource quality, which can impose significant regulatory burdens. While the requirements on individual users can be complex and onerous (for instance, to treat waste discharges to certain standards), the management of diffuse impacts from a range of activities can be even more so. Examples include “diffuse” pollution caused by water draining from agricultural and urban areas as well as local subsidence which may result from excessive abstraction of water from groundwater for self-supply.

Hydro-supported processes are underpinned by making water available where it is needed through infrastructure solutions, and these solutions are informed by the economic and environmental costs of these processes. However, as the differences in regional water availability and variability become starker, infrastructure solutions will become increasingly costly and the large intra-regional water transfers mooted as a solution to SADC wide variability in water availability (outlined in Chapter 4) are unlikely to be economically viable. Other trade-offs within the regional economy may thus become more attractive if informed by these realities.

The emergence of competing approaches

At a global policy level, the water-sector has, in recent decades (1992 – present), been encouraged to follow what are effectively hydro-centric processes in which the conservation and even “preservation” of the resource is prioritised (WFD, IWRM, river basin planning) but these processes have had relatively limited impacts and outcomes. An earlier (1930 - 1990) set of hydro-centric approaches focused on the promotion of large water resource infrastructure programmes intended to catalyse economic and social development. Some of these are considered to have been successful (TVA, 3 Gorges) while others have had more mixed results (Kariba, which has not seen significant irrigation development) and some are widely regarded as failures (Mekong, where the instability after the Viet Nam war paralysed any possible infrastructure development). While large hydro-centric resource programmes have often captured the imagination of both water sector managers and politicians, it is suggested that, in terms of economic and social impact, it is the hydro-supported processes that have the greatest impact although, because this is "indirect", it is less visible. If water-related development decisions are to be influenced today, it is useful to understand and track the recent evolution of these approaches.

UN Water Conference Mar del Plata, 1977

Because of the contribution that water resources and their management make to so many different areas of human social and economic activity, it has long been suggested that water resource development and management should be addressed as part of overall national development strategy and planning. This was explicitly stated in the 1977 UN Conference on Water at Mar del Plata which sought to identify and recommend the actions needed for the "accelerated development and orderly administration of water resources". Its Action Plan placed considerable focus on the need for a more coherent approach, emphasising the need for a

> "*…. shift from single-purpose to multipurpose water resources development as the degree of development of water resources and water use in river basins increases, with a view, inter alia, to optimizing the investments for planned water-use schemes. In particular, the construction of new works should be preceded by a detailed study of the agricultural, industrial, municipal and hydropower needs of the area concerned. …. This analysis would take into account the economic and social evolution of the basin and be as comprehensive as possible; it would include such elements as time horizon and territorial extent, and take into account interactions between the national economy and regional development, and linkages between different decision-making levels*." (UN 1977a para 41)

To achieve this, it was recommended that the management of water resources should be effectively integrated and explicitly proposed that this should be through the mechanism of national development planning:

> "*Each country should formulate and keep under review a general statement of policy in relation to the use, management and conservation of water, as a framework for planning and implementing specific programmes and measures for efficient operation of schemes. National development plans and policies should specify the main objectives of water-use policy, which should in turn be translated into guidelines and strategies, subdivided, as far as possible, into programmes for the integrated management of the resource*." (UN 1977a para 43)

Rio Summit on Sustainable Development and Agenda 21 1992

This theme was taken up again 15 years later at the UN Summit on Sustainable Development in Rio de Janeiro. The Action Plan prepared there, Agenda 21, states that:

> "*The holistic management of freshwater as a finite and vulnerable resource, and the integration of sectoral water plans and programmes within the framework of national economic and social policy, are of paramount importance for action in the 1990s and beyond*." (Chapter 18)

However, divides emerged between the developed countries that wanted to emphasise environmental sustainability and developing countries that sought greater emphasis on their economic and social development.

Dublin IWRM 1992

This is illustrated by the way in which the currently dominant hydro-centric approach was outlined in the final statement of a preparatory meeting held in Dublin before the Rio Conference. It focuses exclusively on basin level planning (its only mention of national development plans is in relation to training needs).

> “*The most appropriate geographical entity for the planning and management of water resources is the river basin, including surface and groundwater*.” (Dublin 1992)

Water sector planning processes were seen as essential to the resolution of water conflicts. The Dublin statement also explicitly gave priority to environmental objectives:-

> “*Integrated management of river basins provides the opportunity to safeguard aquatic ecosystems, and make their benefits available to society on a sustainable basis*.”

Many of the key proposals made in Dublin were rejected by the Rio Conference. Aside from its emphasis on economic instruments over social objectives, recommendations from Dublin that were NOT taken up in Agenda 21 included: that river basins should be the unit of decision making; that stakeholders should participate fully in decisions; that future international meetings on water should be convened as multi-stakeholder fora in which governments would have the same role as business and NGOs. Nevertheless, the so-called “Dublin Principles” were widely adopted, particularly by donor countries in relation to their aid recipients.

World Commission on Dams 2000

One outcome of the Dublin Principles focus on environment, river basins and stakeholder participation was the convening of a World Commission on Dams. The Commission was dominated by anti-dam NGOs and its recommendations for reviews of alternatives to dam development and full prior consent by affected parties before development were widely regarded as unworkable. The result was that its report, in the words of one long-time observer of the water sector put it,

> “*… contributed to a concerted action by the developing countries which were forced to unite by the biased report which otherwise may not have happened. With a combined voice, they could tell developed countries who had already constructed most of their large dams, that infrastructure construction is important for their socio-economic development and that they need such structures to produce food, generate energy employment and income, provide basic services and improve the overall quality of life of their citizens*.”

One outcome was however that donor countries and agencies became very reluctant to finance large water infrastructure and, although this position has moderated somewhat, the negative attitudes are still in place as demonstrated by the fact that large hydropower dams are still not eligible for Clean Development Mechanism financing.

Europe's Water Framework Directive 2000

The approach inherent in the Dublin Principles was also reflected in the European Union's Water Framework Directive which was approved in 2000. This again focused on the environmental integrity of river basins, with basins as a unit of planning and full stakeholder participation. As described by the European Commission, the environmental requirements appear particularly onerous:-

> "…. *ecological protection should apply to all waters: the central requirement of the Treaty is that the environment be protected to a high level in its entirety. … the controls are specified as allowing only a slight departure from the biological community which would be expected in conditions of minimal anthropogenic impact*." (EC WFD introductory note)

But European politicians refused to endorse proposals for river basin organisations to take responsibility for trans-boundary rivers – the requirement for "coordination" allowed most to carry on with business as usual although with additional reporting requirements. There were, nonetheless, requirements for aligning monitoring and reporting systems, to ensure 'good' status was not reported as 'fair' just over the border. Aspirations to re-establish natural conditions were considerably diluted and sufficient loopholes were left to give national governments extensive discretion – the Netherlands simply declared the majority of its watercourses to be artificial (Heavily Modified Water Bodies), which only need to achieve good chemical status. The requirement for stakeholder participation is also being questioned; some governments find that they can only comply by paying participants to attend meetings.

WSSD 2002 and IWRM plans

After 1992, two institutions (the GWP and WWC), which were established outside the UN system to give effect to the Dublin Principles (rather than Rio's Agenda 21), focused on this approach. The GWP and the Scandinavian governments that backed it, took the lead in promoting IWRM plans and elaborating how they should be produced. Although characterised as integrated approaches, they were conceived as water sector led initiatives.

> "*The promotion of catchment and river basin management is an acknowledgement that these are logical planning units for IWRM from a natural system perspective. Catchment and basin level management is not only important as a means of integrating land use and water issues, but is also critical in managing the relationships between quantity and quality and between upstream and downstream water interests*." (TAC4)

The consequence of this hydro-centric approach was to concentrate on water sector based instruments rather than effective coordination with broader social and economic development – and political - processes.

> "…. *in many cases stakeholders represent conflicting interests and their objectives concerning water resources management may substantially differ. To deal with such situations the IWRM should develop operational tools for conflict management and resolution as well as for the evaluation of trade-offs between different objectives, plans and actions*."

In 2002, at the Johannesburg World Summit on Sustainable Development, after strong lobbying by European delegations, it was agreed that all countries should prepare IWRM Plans by 2005. This marked a turning point since it subsequently became clear that the nature and purpose of these plans was unclear and was based on a poor understanding of how water resource related matters were managed in practice. While a number of developing countries were funded to prepare such plans, they have had little impact, not least because the guidelines for their preparation focused on institutions and management instruments and almost completely ignored the infrastructure needed in most countries to enable such institutions and instruments to operate.

Water security 2004

In response to the overwhelming emphasis on process and institutions and the underwhelming practical outcomes it become clear that a different focus was required. One response, emerging from the World Bank, was to focus on the achievement of the practical goal of water security, “the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies". The overarching strategy to achieve this was to invest in the institutions, information and infrastructure needed to achieve the goal. At the same time, the World Bank sought to re-engage in infrastructure for water resource management.

The Nexus 2008

A related but more specific response subsequently emerged from the business community, which recognised the need for practical outcomes to address the growing economic and social challenges in rapidly growing economies. This focused on the need for a sustainable set of relationships between water, power and agriculture (“the nexus”).

> “*Business leaders at the World Economic Forum Annual Meeting in 2008 set out a Call to Action on Water, to raise awareness and develop a better understanding of how water is linked to economic growth across a nexus of issues and to make clear the water security challenge we face if a business as usual approach to water management is maintained. This report captures where the debate is now and sets out the challenge we face if nothing is done to improve water management in the next two decades*.”

While the practical mechanisms to address these newly defined challenges remained unclear, the emergence of the “nexus” concept offers the opportunity to reconnect water resource planning with broader development planning; although it focuses primarily on the agriculture and energy sectors, practical approaches may spill over into other sectors. Unfortunately, nexus thinking has subsequently been driven primarily by the water sector, with little or no input from the energy and agricultural sectors, thus negating much of the value of the nexus to reconnect water to broader development planning in a hydro-supportive role.

New configuration of infrastructure investment in Africa

More recently there has been a shift in African perspectives on infrastructure investment, driven by the demand from African Ministers, through their “AMCOW”, for water to contribute more to the continent’s growth and development as well as by the recognition that Africa is the ‘under dammed’ continent (African Development

Bank)[52]. From an African perspective, perhaps the most important development has been the emergence of new sources of finance for large water infrastructure projects from China, Brazil and India which, more than any other intervention, has changed the water resource management discourse. Many donor-dependent countries now have alternative sources of assistance. They need no longer spend years in stakeholder consultations to justify clear infrastructure requirements and can often get responses that, while not always positive, are rapid in comparison to their experience with their traditional western development agencies. As a consequence, the rate of investment in large water infrastructure has increased significantly, the "revealed preferences" providing evidence of the impact of prior investment boycotts.

The contribution of China to this changing dynamic has in turn seen international environmental organisations, make considerable efforts to influence China's policies. The strategy of international NGOs to link with business and finance partners to influence a major government is an interesting innovation in the broad strategy of promoting global regulatory harmonization which has been described by Drezner (All Politics is Global 2008).

Water in mainstream development planning – could virtual water and nexus contribute?[53]

Development planning is also contested

As with water resource planning, national development planning has had a chequered history. In the 1960s, it was the mainstream approach in many countries, particularly newly independent developing countries but also in a number of developed economies. It declined in importance, in part for ideological reasons. But:-

> "*There were also well-founded concerns about the performance of planning since the outcomes often fell far short of the objectives. There was a variety of reasons for this, from unrealistic assumptions about internal capabilities and external markets as well as slow responses to external pressures such as the oil price shocks of the 70s. These problems were compounded in many cases by weak governments that were unable to link planning theory to implementation practice while economic technocrats, often from abroad, dictated development paths with little attention to local social and political geography*".
>
> "*…. However, the legitimacy of the idea of planning for development was sustained by the fact that the countries that proved best able to navigate the global financial turmoil of the 1990s turned out to be the East Asian "tiger economies*"
>
> ..whose centralized planning systems were an important contributor to their economic success.

[52] SADC States have an average per capita storage of just of 500 m^3/person, against the global average of 1,500 m^3/person.

[53] This section is drawn from the discussion document for a workshop for national planning agencies of SADC countries on Understanding National Development Planning and its Contribution to Inter-Sectoral Regional Integration, organized by the NPC and DBSA in August 2012

There has been a revival in planning for development but in a modified form. Poverty Reduction Strategy Papers (PRSPs) addressed not just the socio-political impact of structural adjustment programmes but also helped to re-establish a budget framework and development strategy for donor-dependent countries. These were, however, short term measures:-

> “*There was a clear need in many countries for a better structured, more generic, long term development framework and the institutional arrangements to prepare and maintain it. Indeed, it has been argued that few developing countries have made significant economic progress without a long term development plan. A more substantive set of approaches has emerged which seeks to frame longer term and more comprehensive development programmes. They continue the trend away from detailed long term forecasting and avoid engaging in the detailed decisions on individual projects and investment allocation and focus rather on countries' strategic direction*”.

> “*These approaches go beyond technocratic efforts to identify global and national trends, to identify interventions and allocate resources to take advantage of them. Rather, they recognize the need, in complex societies, to bring focus to and generate consensus around key national priorities and coherence in pursuing them, mobilizing support from broad sections of society rather than simply managing governmental action. To the extent that they address development strategy their focus is on the development of long term national visions and then seeking strategies to achieve them, built on an understanding of local endowments, challenges and opportunities*”.

In this new approach, the plan is a process rather than a product; it is effective to the extent that there is political leadership in its development, substantive involvement of the institutions concerned in its elaboration and discipline in its implementation.

> “ *… the plan can only be as good as the quality of the policies that are in it, which in turn will be largely determined by the quality of the institutions, in government and beyond, that contribute to it … A useful contribution of development planning has been to force sectoral agencies to consider the feasibility of their policies and proposals in the broader national context. In this sense, development planning can contribute to institutional strengthening*.”

A critical feature of national development planning in SADC is that it is conducted within a country political framework where national governments have direct authority over the public sector and considerable indirect suasion over other stakeholders since they set the direction of both regulatory and public spending interventions.

Planning for regional cooperation and integration

The political environment for planning at regional level in southern Africa differs from that at national level primarily because it is undertaken on a cooperative basis without the benefit of direct political authority and with no system to hold national governments to account if they fail to meet their obligations. Inter-sectoral coordination is a particular challenge. While national development planning, which falls under the authority of a head of state and single executive, can achieve integration between sectors at national level the same is not true at a regional level. While decisions may be taken and announced, implementation may falter if regional discussions and decisions have not been adequately informed by national considerations. For this reason, regional plans are often not acted upon, as is highlighted in the electricity sector in SADC and described in Chapter 7 of this report. This has been identified as a generic underlying issue by SADC in the course of its review of the progress made with its 2005 – 2015 RISDP.

Regional planning for cooperative activities

To date, SADC's main successes have occurred where cooperation has been required between single, inter-linked sectors. So transport networks, electricity grids and telecommunications systems have evolved with some degree of success. This reflects the abilities of single sectors to convene to identify areas of mutual interest and cooperate to address them, a process which regional agencies such as SADC can facilitate.

In areas where inter-sectoral cooperation is required, progress has been notably slower, perhaps because of the higher transactional costs, but also perhaps a result of a lack of a clear regional framework for cooperation for mutual benefit. So agricultural development which requires transport, trade and, potentially, water sector support has been less successful, judging by trade flows. The extent to which national interests may conflict in cross sectoral planning is also greater; for this reason, progress in trade in services has also been slow.

Regional development planning is thus usually of a consultative and indicative nature and sectoral planning will still reflect national priorities and trade-offs between sectors and, in strategic sectors like water, trade and energy, efforts to promote "regional best options" will have to address sovereign security concerns.

Regional integration in national planning

National development planning brings together the different sectors within an overall framework of policy and strategy seeks to identify and address potential linkages, synergies and constraints between them as well as to make trade-offs between different priorities. A critical question is the extent to which regional cooperation and integration are included as objectives in national development planning processes and efforts made to ensure that development strategies are coordinated. A formal process of coordination would help to identify costs and benefits of regional policies at national level and guide negotiations and decision making. A review of national development plans in SADC found significant variation; while some national plans had entire chapters on regional integration, others ignored the subject completely. It has been suggested that approaches that could more effectively mobilize national development planning in support of regional integration need to be developed and implemented. The potential advantages of considering regional best opinions have rarely been effectively quantified and there has been little effort to address sovereign security concerns which are clearly justified given ongoing instability in some SADC countries.

Water in development planning, national and regional

Water is addressed in Southern African national development plans, regional integration less so

All southern African countries' national development plans address water and related issues and many make clear linkages between water and energy and water and agriculture, although not always in a coherent manner. The expansion of irrigation has long been recognised as an important intervention to increase the productivity and reliability of agriculture. The practical examples of Kariba and Cahora Bassa hydropower installations have highlighted the further potential of water to produce energy although not as clearly the potential multi-purpose opportunities.

Beyond the Zambezi dams, South Africa has long dealt explicitly with the water-energy nexus, the strategic outlines of which were spelt out in the 1970 Commission of Enquiry report on water matters; interestingly, that report was not unduly concerned with the potential impact of water scarcity on irrigated agriculture, concluding simply that increased water use efficiency in agriculture would address most of the growing pressures. More recently, the national Department of Water Affairs identified the potential role of regional cooperation in agriculture as a strategy to address water constraints (see Text Box 1). The economic evidence is that South Africa will be a net exporter of agricultural products (some of which will be irrigated) for decades to come.

In other Southern African countries, there is an understandable priority on water supply and sanitation matters although increased emphasis on hydropower, not least as a consequence of the failure of regional cooperation to provide energy security and the success of efforts to develop mining. Given the donor emphasis, language on IWRM is also prevalent in the water chapters of national development plans – one consequence of this is that much water-related development is addressed in the planning of other sectors, notably power and agriculture.

Hydro-centric regional development planning

The current SADC focus is water-centric, reflecting SADC's overall approach. Thus it has promoted the establishment of river basin organisations and encouraged them to engage in sector-led, basin-bounded planning exercises. Beyond contributing to a better understanding by water practitioners of their water resources, it has not helped national water sector agencies to engage with their own national development processes nor undertaken work at the regional level that could support that kind of endeavour.

This approach reflects both donor preferences (strongly expressed by the provision of technical assistance under the control of donor officials) as well as SADC's generic working models. However, it is becoming clear that these approaches are not producing significant results.

So major projects are proceeding (or stalling) without significant contribution from the regional water sector. Zambia is developing its hydropower resource on a national (or, in the case of Kariba, bilateral) basis and waited until most of the projects were underway before ratifying the Zambezi Watercourse Agreement in 2013. Development of the Batoka Gorge and Mphanda Nkuwa projects on the Zambezi is also being led by the power sector on a bilateral basis, with only limited input from a water resource management perspective.

Recent (2013) efforts by SADC to convene an investment conference for the water sector was poorly attended, not least because the major projects presented were already well known and under development through other channels while smaller projects appeared to reflect national wish-lists rather than strategic projects of regional significance.

The challenge for hydro-centric processes is to convene not just water sector representatives but also stakeholders from other sectors. Globally, few regional water institutions have any sovereign authority either to convene or to take decisions in respect of water management and use. The exceptions are the European Union which has an overarching political framework and the Senegal River basin where governments have formally delegated specific water management powers and responsibilities to a joint water management institution, the OMVS.

Even if there were substantive political framework, it would only be effective if the regional representatives of the different sectors were adequately briefed on the national issues and inter-sectoral trade-offs. In the absence of such a framework, it is necessary to place greater focus on generating and sharing information and participating in other sectors' processes and less on trying to tell other sectors what to do and how to organise themselves.

Hydro-supportive regional development planning

Hydro-supported planning in water resources focuses on identifying and engaging with strategy and planning activities in key user sectors. Where this has occurred, there have been notable successes. One example is the Lesotho Highlands Water Project, which emerged from engagement with urban and industrial users, during which it became clear that the demand for water would increase beyond the ability of the Vaal system to support it.

At a smaller scale, Swaziland's agricultural development required additional water to enable its sustainable expansion; the LUSIP project became one of the catalysts that led the national water sector institutions to negotiate the Interim IncoMaputo Agreement which was signed in 2002.

After many years of argument, Namibia has now indicated that it intends to proceed with plans to tap the Okavango river to meet its development needs, despite continuing objections from environmental interests.

In the agricultural sector, there is renewed interest in water as a factor of production that has potentially opened the way for greater collaboration with water resource managers. There is however as yet little evidence to suggest that this is being translated into practical action. Similarly, while multi-sector modelling has demonstrated the potential of synergies on the Zambezi river between power, agriculture and environmental conservation, this has still to be translated into terms which the user sectors relate to – for example, in the power sector, there is a concerted move towards ensuring energy self-sufficiency even as the water-related studies demonstrate the benefits to be reaped from cooperative development and management.

SADC's constraints

One reason for the failure to make more progress with regional cooperation and integration in the water sector is the institutional and transactional demands that it imposes. This is a generic challenge. Integration cannot simply be driven by a single regional organisation. Many of its elements have to be implemented cooperatively by sovereign national governments. If its potential benefits are not understood – and preferably experienced in a practical way – by a significant proportion of a country's citizens, it will be hard to convince them to support it.

Judging by the slow progress made to date, southern Africa's regional and national institutions have not generally succeeded in demonstrating those potential benefits. The problems with SADC's approach are recognised by the organisation itself and are generic and not limited to water. The organisation's own recent assessment includes, amongst ten "lessons learned" that:-

> *"There is no effective link between the SADC Secretariat, the SADC National Committees and relevant key stakeholders who are supposed to oversee and effectively implement SADC activities and programmes at national level*". (SADC, Desk Assessment of the RISDP 2005 - 2010, Gaborone, 2011)

Mekong experience

A failure to engage with broader development priorities and to focus instead on water centric issues has been blamed for the failure of the approach, most recently in the Mekong river basin where coordination efforts have been ongoing for over 50 years. As the former CEO (2004-2007) of the MRC has commented,

> *"Hydro-diplomacy tends to be more environmentally than economically oriented …. since the signing of the "Mekong Agreement" in 1995, donors have oriented MRC's activities mainly toward information and knowledge management, while downplaying its investment facilitation role.*
>
> *With such a vision of the role of basin organizations, there is a risk that they will continue to be excluded from the national investment planning process. Governments will continue to complain about the lack of tangible results for the direct benefit of the population. They will also remain reluctant to increase their financial contributions.*
>
> *Basin organizations may well get stuck …. playing an insignificant role in the negotiations about the most critical issues. No doubt that knowledge is essential for informed decision-‐making, but its generation and communication should first and above all be developed at national level, on the basis of the subsidiarity principle*". (Cogel: 2014)

This in spite of the fact that the four countries of the Mekong River Commission signed an 'Agreement on Cooperation for the ***Sustainable Development*** of the Mekong River Basin' [my emphasis] and Article 2 of that agreement calls for "with emphasis and preference on joint and/or basin-wide development projects and basin programs."

Indeed the first prior consultation process under the 1995 Mekong Agreement, the Xayaburi Hydroelectric Project, focussed on the hydro-centric notion on potential impacts on the mainstream of the Mekong, and not on the contribution to regional energy security and growth. This process failed to establish any clear agreement on the acceptability of the project on that basis.

Text Box 1: Practical approaches to regional water food issues -An assessment of rain-fed crop production potential in South Africa's neighbouring countries, 2010

South Africa uses 60% of its scarce water resources on irrigation, a substantial portion of which is used to irrigate crops which are regarded internationally as rain-fed crops. The question is therefore being asked about the extent of alternative production areas in southern Africa (particularly in selected neighbouring countries) for the range of crops which are presently produced sub-optimally under irrigation in South Africa.

The objective of this study is therefore to provide an answer to this question with adequate confidence to allow the rational pursuit of this concept which could have far-reaching mutual benefit for southern African countries. The countries that were considered are Mozambique, Zimbabwe, Malawi and Zambia.

This broad assessment revealed that the four target countries possess a net area of about 26,6 million ha of high-potential rain-fed cropping land (referred to as “Premium” land use potential) with the following breakdown per country: Zambia 11,1 million ha; Mozambique 8,8 million ha; Zimbabwe 6,3 million ha; Malawi 0,4 million ha;

The constraints include land tenure issues (the majority of the high potential rain-fed cropping area is occupied by subsistence farmers on communally owned land), population (the high rural population spread presents a challenge to commercialisation of agriculture), present land use (widespread subsistence farming), poor or lacking infrastructure and poor agricultural support services., However the constraints are not considered insurmountable. With the appropriate vision, investment and support from the governments of the respective countries there are significant opportunities for extensive commercial agricultural development which could involve and benefit local farmers and their communities. The recent examples of South African farmers operating successfully in Mozambique and Zambia, with full government backing, have shown that these constraints can be overcome.

Whilst the principal objective of this study is to identify areas that are suited to rain-fed crop production, the existence of a considerable network of largely “un-tapped“ surface water resources, especially in Zambia and Mozambique is highlighted. There is therefore an opportunity for expanded utilisation of the water resources in these countries for irrigation where there is a higher irrigation potential, in terms of both soils and climate, than exists for many of the irrigation areas of South Africa.

(Ex:- An assessment of rain-fed crop production potential in South Africa's neighboring countries, 2010 Report: P RSA 000/00/12510, Rutherford RJ, DWA, Pretoria)

Political economy of regional development planning:

Energy: "National sovereignty with a cherry on the top"

As outlined above, the determination and evaluation of the opportunities and constraints posed by water resources – and other natural resource endowments - involves coordination between different political jurisdictions and across multiple sectors whose priorities and criteria, implicit and explicit, may be expressed in a range of different metrics.

While at a national level, development planning processes can establish a common metric to assess costs and benefits, this is more difficult to do regionally, across a diverse set of administrative systems. So while apparent benefits that could be achieved through regional planning and cooperation have often been identified at a conceptual level, it has proved difficult to detail their practical implications at a national level. As a consequence, many apparent opportunities have not been acted upon.

An example is provided by the power sector. According to the economic metric, the region would benefit considerably (in terms of cheaper energy) if a regional perspective was taken and a complementary suite of generation projects promoted (see Chapter 7 for the details). In practice however, this has not occurred. Aside from the economic analysis of investments and operating costs, other metrics have been introduced. So countries are concerned about reliability of supply and their experience has been that there are higher risks to dependence on neighbouring countries than on their own capacity.

This situation has led to a preference for sovereign national rather than regional solutions – and indeed, a rejection of proposals for greater cooperation, despite the apparent benefits that they offer. In this case, a second-best regional strategy has emerged from CRIDF, "sovereignty with a regional cherry on the top" – once all countries have adequate generating capacity to meet their needs, they may use the regional power pool to trade and to purchase cheaper electricity if it is available elsewhere. This may realise financial gains for the sellers and buyers, may reduce regional carbon emissions, and may realise (albeit modest) water savings, an illustration if not a product of the nexus and Virtual Water Approach, with power as a driver.

Agriculture: livelihoods are a key metric

There is already extensive recognition of the potential for regional synergies in agriculture and water to be exploited to strengthen regional food security at country level. However, if there is to be support for exploiting the extensive land, water and human resources outside of South Africa to produce food for the region, local metrics will have to guide the argumentation and prioritisation.

In most cases, a priority will be to ensure that agricultural development is accompanied by livelihood enhancement – certainly that livelihoods of poor rural populations should not be undermined. To the extent that the resource outside of South Africa is developed using farming models that expand livelihood opportunities for small scale farmers, this should also contribute to household level food security.

In this context, any support by CRIDF to the development of resilient, more productive, small scale agricultural production in the region will enhance resilience and food security across the region as well as providing direct household benefits. The regional benefit of these approaches will depend on wide-scale replication, whose local impacts and cumulative effects will have to be carefully assessed. While it may be possible to describe this in terms of virtual water and the nexus and investments in water infrastructure may be a necessary part of such a strategy, they will only be complementary to the wider challenge of developing the farming systems, markets, the establishment of farmers with the appropriate skills and support institutions and enabling infrastructure required to enable competitive production and trade to occur.

Similarly, to mobilise the benefits of locating agriculture to take advantage of higher rainfall, and hence reduce the dependence on blue water (see Chapters 3 and 6) will also require significant investment in other (non-water) infrastructure and institutions. Virtual Water and Nexus thinking may help to highlight the need for hydro-supportive integrated national planning into perspective, and may introduce other options and trade-offs to this process.

The different dynamics of top-down and bottom-up approaches

These examples highlight the general principle that successful regional cooperation and integration depends on a clear identification and equitable and reliable distribution of the costs and benefits of any regional development initiative. One advantage that has been posited for “top-down” institutional structure of regional integration rather than *ad hoc* sectoral “bottom-up” approaches is that it is easier to negotiate packages of initiatives with an acceptable mix of costs and benefits in a multi-sectoral context than in a single sector. The high level of coordination both within regional institutions and between national and regional that this requires continues to present a strategic challenge to the achievement of the broader regional integration goal.

Text Box 2: Trade-based food security in South Africa’s National Development Plan

It is necessary to make a distinction in policy discourse between “national food self-sufficiency”, “food security” and “access to food by poor people”. South Africa is food-secure and has been for a number of decades. This means that it earns a trade surplus from agricultural exports and is able to cover the cost of food imports from those exports. The country has also produced enough of the staple cereal (maize) for all but three of the past 50 years (the exceptions being the droughts of 1984, 1992 and 2007). The composition of the maize harvest is changing, however, with more yellow than white maize planted. This reflects the trend towards higher consumption of animal proteins and the fact that wheat, rice and potatoes are becoming the preferred staples as the population urbanises and becomes more affluent. In this regard, the national food-security goal should be to maintain a positive trade balance for primary and processed agricultural products, and not to achieve food self-sufficiency in staple foods at all costs.

“Region-based approaches to food security should be investigated. As South Africa's agriculture becomes more specialised and efficient, there may be a trend away from the production of staples to higher-value crops. As there is only limited correlation between climatic events in South Africa and countries to the north of the Zambezi (although the drought of 1991 / 1992 was regional in nature), regional cooperation may offer greater supply stability and resilience to droughts. Regional economic integration is best served when there are complementary interests and advantages between the parties, which may be the case in food production. Regional expansion of production, as seen in recent years, is favourable. South Africa should benefit from the opportunities this brings for trade, food stability and value-chain consolidation.” (National Development Plan p.230)

Text Box 3: Regional food security and water in SADC - The potential for sectoral-synergies within CAADP

" ……the European Centre for Development Policy Management (ECDPM) undertakes, with its African partners, relevant policy-oriented analysis and multi-stakeholder dialogue facilitation around the regional CAADP issues and processes as well as on their linkages with the broader regional integration dynamics, in various African regions. This paper focuses on **regional water management and cooperation in the Southern African Development Community (SADC)** and its Regional Agricultural Policy (RAP), with the objective to stimulate further discussions among involved stakeholders, to contribute to the consultative processes and implementation of CAADP at regional level, as well as contribute to lessons-sharing across Africa on regional approaches to water for agricultural production.

Whereas global, regional, national, and local **realities of water management** are fundamental to consider in the preparation and implementation of the RAP - essentially the CAADP Regional Compact in Southern Africa - water issues do not feature prominently in CAADP processes in the SADC region. This is despite the Region's strong efforts to address water resource management through transboundary frameworks and organisations. Water has played a unifying role to spearhead cooperation in the Region with the Protocol on Shared Watercourses being the first treaty to be ratified at the level of SADC. As a result of this historical and political standing of water governance in the machinery of SADC regional cooperation, the Region presents interesting cases of Transboundary Water Resources Management (TWRM).

Linking TWRM processes with CAADP objectives has remained minimal in SADC. As a result of recent regional planning processes however, the SADC RAP, adopted by the SADC Ministers in June 2013, acknowledges this crucial link between the agriculture and water sectors. The RAP emphasises in this sense that integrating water management concerns into agricultural policy and investment could generate considerable economic and social gains for the region and its member states.

Food security is very much a regional issue and requires transnational trade and agricultural cooperation. This paper therefore focuses on regional food security issues while linking to the national as well as the household levels where food is produced, distributed and consumed.

EX: Regional food security and water in SADC The potential for sectoral-synergies within CAADP for the implementation of the SADC Regional Agricultural Policy. Francesco Rampa and Lesley-Anne van Wyk. ECDPM, March 2014

Conclusions

It has already been demonstrated that mobilising synergies and exploiting complementary resource endowments between countries could increase the productivity of agriculture and power production and reduce risks due to climate variability and change, potentially benefitting a range of economic interests and communities across the southern African region. The major challenge remains to give effect to this approach.

Some of the policy synergies would reflect the concept of virtual water by encouraging agricultural production in most favoured and least vulnerable areas. The "nexus" could be reflected in increased availability of relatively reliable and "green" hydropower to countries of the region, traded through the SAPP. Similarly, trade-offs between irrigation and hydropower, albeit on a temporary basis during drought, could be informed by nexus and Virtual Water thinking. This should make it possible to enhance both food security and energy security for poor people in the region although that outcome would not necessarily be automatic.

However, decisions about the adoption of such policies will be taken primarily at national level and will depend on the political economy in each country. While regional cooperation may play a role and can certainly inform the process, the costs, benefits and trade-offs will need to be acceptable at each level of decision making.

The implications for policy advocates is that, while regional institutions may be useful to develop understanding of potential synergies and channels through which to communicate this information, greater attention should be paid to national political economies and to national costs, benefits and trade-offs.

Development planning processes could make an important contribution to elaborating such multi-component regional integration ”packages” processes but are still in their infancy in SADC and structures and methodologies that allow the various inter-sectoral trade-offs at national level to inform decision-making about regional integration have yet to be established. This imposes constraints on the potential for the development of cooperation on water-related opportunities.

In this context, the use of hydro-centric approached to water resource planning within shared river basins rather than encouraging cooperation at the level of national economies may weaken cooperative inter-sectoral work since it tends to place water above and apart from mainstream planning processes.

The political economy that determines whether potential economic and social benefits are translated into political decisions remains poorly understood although it has been identified as a priority area for further research.

In this broad context, the concepts of virtual water and the energy-food-water nexus may usefully inform a range of discussions and be used to illustrate potential challenges of and responses to climate change.

They are however unlikely in themselves to provide the basis for national policies on which regional cooperation and action depend, given the many other factors that have to be considered.

Chapter 6: Mechanisms to influence water allocations on a regional or national basis

By

Barbara Schreiner[54] and Gavin Quibell

Abstract

One of the more pervasive challenges facing SADC is the variability in water availability over space and time. In response, SADC States have largely opted for large scale water storage and transfer infrastructure. However as climate and demographic changes, together with rapid economic growth, increase water stress and variability, larger scale infrastructure solutions will become increasingly expensive and environmentally unsustainable. As more basins face closure this will become a regional rather than national challenge, raising pressures around the reasonable and equitable use of water.

A virtual water and nexus perspective may offer a different view for national planners, making better use of the total water footprint to support economic growth, as well as to meet social and environmental needs. This will require the allocation (or re-allocation) of water between sectors to formalise and regulate entitlements which optimise allocations across the full water footprint and which balance the water requirements of food and energy production. Similarly, inter-State allocations based on the reasonable and equitable use principles espoused in the SADC's Revised Protocol on Shared Watercourses, may have to consider both the blue and green water contributions to the national economies of the riparian States.

World-wide, with some exceptions, both national and inter-State water allocation mechanisms focus on the apportionment of blue water. In most SADC countries there are considerable institutional capacity challenges, and hydrological and water use information is often not sufficiently reliable to support these blue water allocations. The capacity of SADC States to allocate water on a Virtual Water and Nexus basis in pursuance of a coordinated growth policies, appears even more questionable. At the basin level, most River Basin Commissions are not directly mandated to allocate water, and few Basin Agreements actually apportion water between the Parties. Nonetheless, basin-wide IWRM plans, which are increasingly seeing the light of day, may implicitly allocate water. However, the legal status of these plans is questionable.

On a regional basis, while there has been some attention paid to importing of Virtual Water in agricultural products rather than to produce them locally, this concept has not gained much traction. It is therefore perhaps unrealistic to suggest that Virtual Water and Nexus based allocations per se would be a viable option to introducing the concepts to SADC. Nonetheless, the authors argue that the introduction of the concepts into the national planning processes places other options on the table, promoting better trade-offs and an improved understanding of the contribution of water to the economy as a whole.

[54] Executive Director, The Pegasys Institute, Pretoria

Introduction

One of the more pervasive challenges facing the SADC region and its Member States is the variability in water availability across the region and over time. To date the adage, "water allocations follow the economy" (or hydro-supportive approaches as referred to by Muller in Chapter 5) seems to have held in responding to this challenge. Generally engineering solutions have been developed to get the water to where the formal economy needs it, as well as to provide for basic water supply and sanitation services. In this scenario, factors other than water costs, drive both the direction and location of economic growth, while water managers respond to these needs through infrastructure solutions.

However, as climate and demographic change, together with economic growth, increase water stress - larger scale engineering solutions will be demanded. Water delivered through these schemes will become increasingly expensive and environmentally unsustainable. As more basins face closure, and as variable water supply becomes a regional rather than national challenge (see Chapter 3), larger international inter-basin transfers may be seen as the solution to regional water challenges. Turton's analysis in Chapter 4 highlights some of the planned schemes (particularly transfers from the Zambezi Basin) in this regard. These schemes appear to be underpinned by the notion that SADC's wetter northern countries have more than sufficient water, and that royalty systems (like that between Lesotho and South Africa) hold net benefits for all Parties. Conversely, however, the World Bank's Multi-Sector Investment Opportunities Analysis for the Zambezi basin shows that increased abstraction from the Zambezi can have significant impacts on the hydro-power potential of the basin (World Bank, 2010). Nonetheless, a stakeholder to the development of the IWRM for the Zambezi noted that *"Consider taking a regional perspective rather than a Basin perspective in the analysis of projected water use, as there's a strong demand for Inter-Basin Water Transfers in Southern Africa."* (Mott-Macdonald, 2008)[55]

However, the transboundary implications of these schemes may raise regional pressures around the reasonable and equitable use of water, particularly in times of drought. The better watered northern countries are likely to want to retain access to water for future use. As a regional expert noted in the Zambezi IWRM Strategy; *"….whereas actual water use in the basin is presently small, the actual demand is much higher. We should not assume there is plenty of water to go around." (Mott-Macdonald, 2008)[2].* Ultimately, the drier southern nations may have to push water towards sectors that provide more income and jobs per drop, rather than rely on large regional transfer schemes to sustain economic growth. The management and allocation of water both nationally and regionally will therefore become increasingly important.

Hard choices will consequently have to be made between allocations to various water use sectors and between sovereign States. The hypothesis lead by CRIDF in this regard is that a virtual water perspective may offer a different view for consideration by national planners, providing an alternative to large scale regional water transfer infrastructure and making better use of the total water available to support economic growth and rising water demands. These approaches may help build regional resilience to variability in water availability and climate

[55] Mott-Macdonald (2008) Integrated Water Resources Management Strategy and Implementation Plan for the Zambezi River Basin; available at; http://www.zambezicommission.org/index.php?option=com_content&view=category&layout=blog&id=16&Itemid=178

change, and provide the necessary food, energy and environmental services across the region. Ultimately, CRIDF believes that this may further strengthen cooperation, avoiding the potential regional tensions that may lie in large scale north to south inter-basin transfers.

The allocation of water between and within States and sectors will play an important role in effecting this scenario. Virtual water thinking recognises the blue, green and grey water components of water use and their implications in decisions on water allocation. The cross cutting themes of the availability of allocable water and the requirements for assured water supply to encourage and sustain investment, add complicating dimensions.

This paper outlines the mechanisms and opportunities to shift water use patterns on a national and international basis in the SADC region, set against the broader water challenges for the region as outlined in Chapter 2, to respond to potential benefits that may be gained through the Virtual Water and water, food and energy Nexus perspective. It addresses the challenges facing these allocation and re-allocation processes both with respect to allocations between sovereign States as guided by the Revised SADC Protocol and basin specific agreements, and allocations between users and sectors as provided for in national legislation.

Current situation

There is significant hydrological variability in the SADC region from the humid well-watered DRC to the arid regions of Namibia and Botswana. In addition to the spatial variation, there is significant temporal variation over the region as well. **Error! Reference source not found.** shows the extreme vulnerability of the region to droughts, while **Error! Reference source not found.** shows the vulnerability of the eastern part of the region in particular to floods.

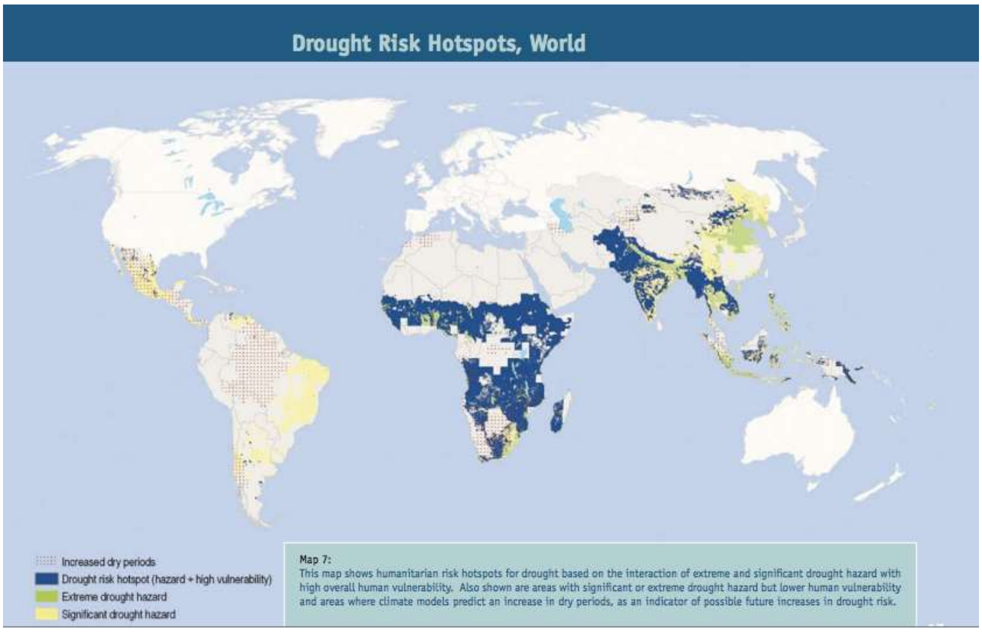


Figure 6.1: Drought hotspots (http://www.careclimatechange.org/files/reports/Implications_drought_risk_world_7.jpg)

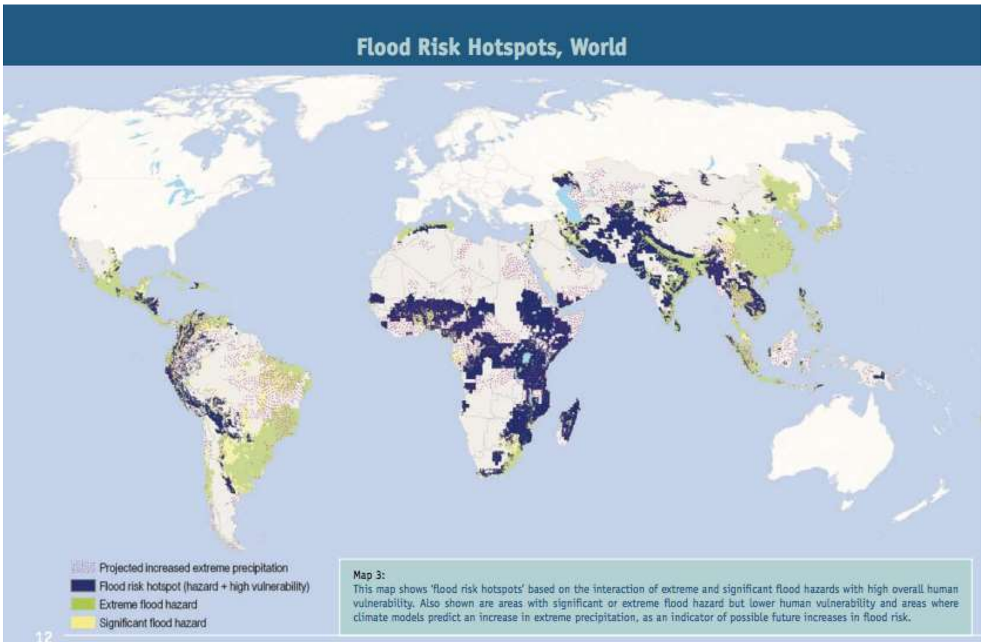
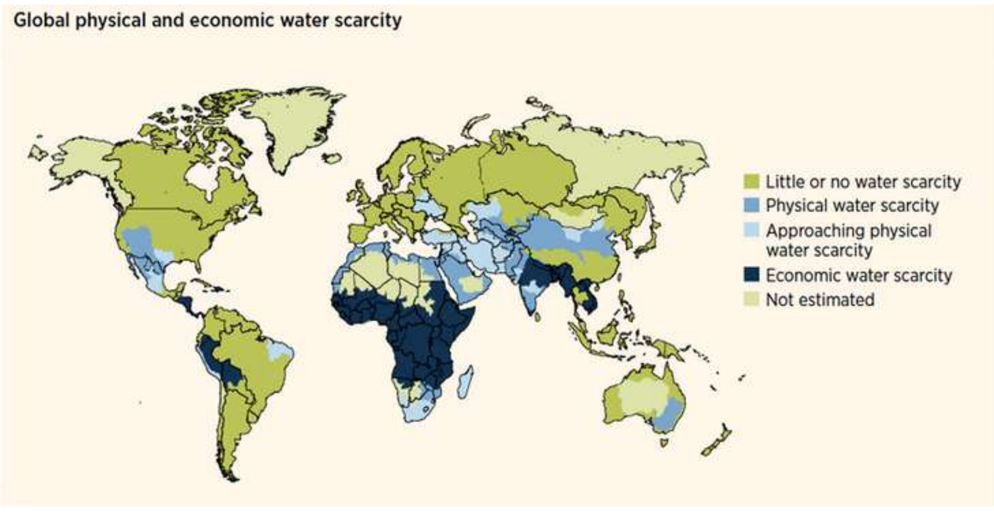


Figure 6.4: Flood hotspots (http://www.careclimatechange.org/files/reports/Implications_all_hazard_hotspots_world_12.jpg

In addition, Figure 6.5 below shows the levels of economic and physical water scarcity in the region. A significant portion of the SADC region suffers from economic water scarcity, while most of the rest of the region is approaching or experiencing physical water scarcity. The management of water in the region is thus critical.



Source: World Water Development Report 4. World Water Assessment Programme (WWAP), March 2012.

Figure 6.5: Areas of physical and economic water scarcity

Drivers of change

There are a number of drivers of change in the SADC region which are placing increasing demands on the water resources of the region. Several countries are experiencing unprecedented GDP growth rates in primary economic sectors (agriculture, mining, oil and gas), and the IMF places 3 of SADC's Member States in the top ten fastest growing economies of the world. This will have a significant impact on the region's water resources for both water demand and quality. While GDP growth rates are variable throughout the region, Angola, the DRC, Mozambique, Tanzania and Zambia are experiencing growth rates of over 6.8 per cent (see Figure 6.4). A further complicating dimension therefore lies in the fact that the wetter northern basins are largely experiencing these rapid growth rates. Nonetheless, the larger economies of the south, while growing slower, are likely to experience large net increases in water use.

While these growth rates are positive for social and economic development, they provide additional pressures on water and energy (electricity) resources. Rapid economic growth, particularly in the extractive sectors, fundamentally changes how the region is going to have to address water issues. Several basins that are currently not stressed are likely to become more heavily utilized and contested in the relatively near future, while the regional demand for electricity seems set to continue to outstrip or match the generation capacity (see Chapter 7). Most of the economies in the SADC region are still dependent on resource extraction in the agriculture, mining, and gas sectors. Increased production in these sectors means increased water abstraction, increased likelihood of water pollution and higher energy requirements with associated water requirements.

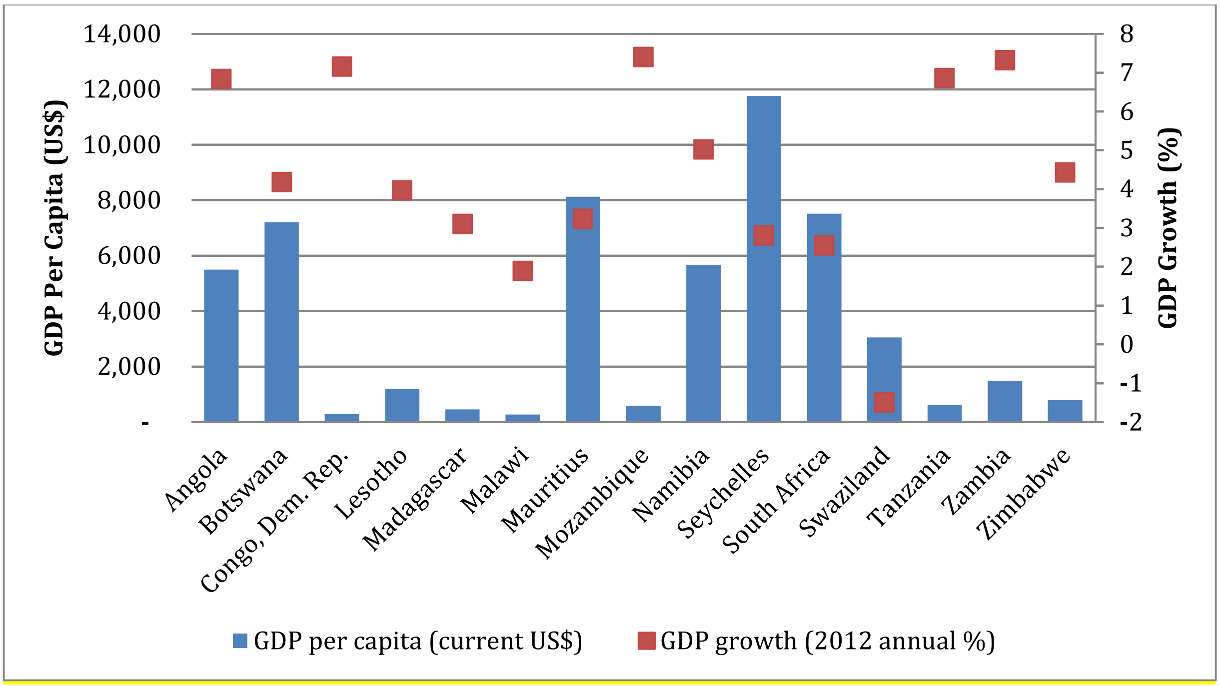


Figure 6.6: Per capita GDP (US$) and GDP growth (2012 annual %) for SADC countries (Pegasys 2014)

Hydropower is already major source of energy in the northern SADC countries, and there is significant potential for further hydropower potential. The current installed hydropower capacity in the Zambezi is 5000 MW, with the potential for an additional 13,000 MW. Evaporation off the existing hydropower reservoirs is seen (in the Zambezi IWRM plan) as the single largest user of water, and the Zambezi River Authority allocates water volumes to the generation facilities in Zambia and Zimbabwe. However, this hydropower comes at considerable climate risk as increased evaporation from higher temperatures and reduced runoff limits the hydropower capacity (Beilfuss, 2012[56]). Plans for an increase of some 184% in the area under irrigation in the Zambezi adds a complicating dimension for allocations between hydropower and irrigation, with transboundary implications (World Bank, 2010[57]). Zambia's Energy Policy is nevertheless set to become a net energy exporter through hydropower, while its national growth and agricultural strategies aim to increase the contribution of irrigated agriculture to GDP. Zambia, as one of the key countries of the Zambezi basin, generating up to 40% of the runoff, is also virtually entirely dependent on hydropower as a source of electricity.

Climate change also has major implications for water management elsewhere in SADC. The hydrological cycle is the primary pathway through which climate change impacts are felt. The basins of the region are expected to experience more extreme floods and droughts as the climate changes, as well as significant increases in temperature. While, most global climate models indicate increases in temperature in the inland areas of SADC, the impacts of this on rainfall and runoff are much more tenuously understood, and appear to depend on the position of the Inter-Tropical Conversion Zone (see Chapter 2), which lies across Angola, Zambia, Malawi and Tanzania.

Population growth and migration patterns are also placing changing demands on water resources. The proportion of the SADC population that is urban has changed from 33% to 40% over the last decade, while the total population has increased from some 220 million in 2001, to 281 million in 2011 (SADC, 2011[58]) – an increase of some 20%. In the year 2000, freshwater withdrawals in SADC mainland states (excluding Zimbabwe) totalled 18.78 Billion m^3, in 2009 withdrawals totalled 20 billion for these same States (SADC, 2011) – an increase of some 10%. Over 50% of the total withdrawals are in South Africa, but South Africa holds only some 1.4% of the total renewable water resources of the SADC mainland states, with around 21% of the population.

These changes are taking place in a context of planned regional integration in SADC and Africa more broadly. This has a direct impact on water resources of the region, both with respect to shifting the main regional water demand centres as well as changing water availability unequally across the region. Optimal regional use of water in support of the integration agenda has considerable implications for the allocation of water to the agricultural, energy and mineral extraction sectors, but also provides strategic opportunities when taking a Virtual Water perspective. The import and export of goods that require significant water in their production may prove an alternative to the typical inter and intra-State water allocation processes.

Water allocation mechanisms

Water allocation is the process of sharing this limited natural resource amongst competing users, sectors or administrative regions. Allocation becomes increasingly necessary when the natural distribution and availability

[56] Beilfuss (2012) A Risky Climate for southern African Hydro: Assessing the hydrological risks and consequences for Zambezi Basin Dams. International Rivers; available from http://www.internationalrivers.org/files/attached-files/zambezi_climate_report_final.pdf.

[57] World Bank (2010) The Zambezi River Basin: A multi-sector investment opportunities analysis. Available at; http://documents.worldbank.org/curated/en/docsearch/report/58404

[58] SADC (2011) http://www.sadc.int/information-services/sadc-statistics/sadc-statiyearbook/

of water fails to meet the needs of all water users – in terms of quantity, quality, timing of availability, or reliability. In simple terms, it is the mechanism for determining who can withdraw water, how much they can take, from which locations, when, and for what purpose (Speed *et al*, 2013[59]).

There are different allocation mechanisms that operate at the inter- and intra-State level. The former, in the SADC context, is governed by the revised SADC Protocol on Shared Watercourses, or basin specific arrangements that specify required cross border flows such as the Interim Inco-Maputo Agreement, or the Lesotho Highlands Water Treaty. The latter is governed by the specific allocation mechanisms established by national policy and legislation. These give rise not only to sectoral allocations, but also to water use authorisations for specific users. Figure 6.7 shows the scaling of these forms of allocation.

At the basin level in SADC, water allocation processes between riparian states are covered by Articles in the Revised Protocol requiring the notification and reasonable and equitable use of water, as well as the permitting of waste discharges. In some cases, for example the Interim Inco-Maputo Accord and the Lesotho Highlands Treaties, international treaty governs actual cross border flows. National water allocation processes are governed by various national water laws.

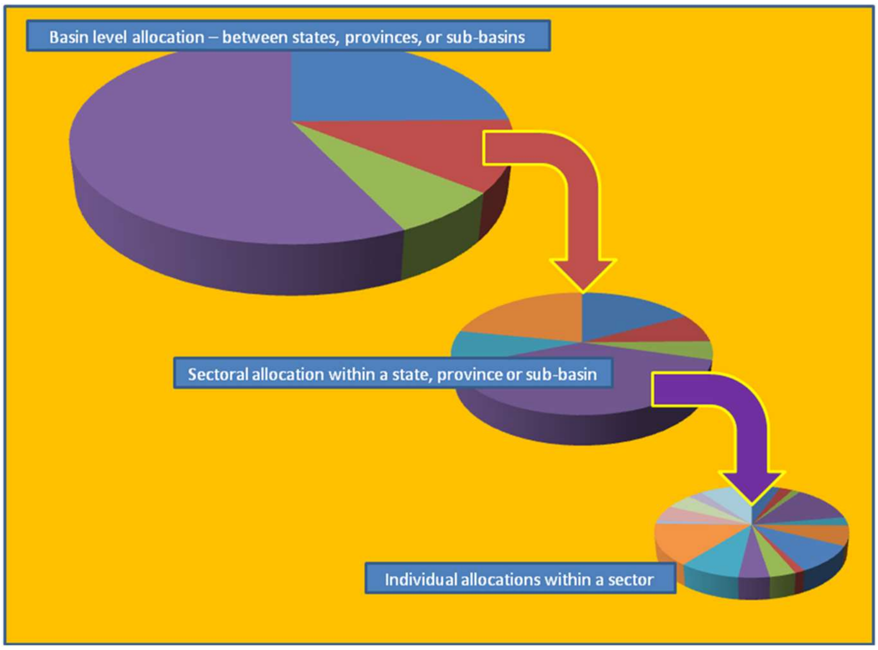


Figure 6.7: Different forms of allocation at different spatial scales (Speed *et al* 2013)

There are various different approaches to the allocation of water including:

- *"Automatic entitlement".* Some water allocation processes recognise an automatic minimum entitlement to water for basic social purposes, or the maintenance of minimum environmental requirements. This is noted in most SADC mainland state water legislation at varying levels of sophistication.
- *"Administrative or bureaucratic process".* The right to abstract water is given by some authority, either a state agency or a user group (e.g. an irrigation board). This is the most widespread formal type of allocation process.
- *"Communal or traditional processes."* An enormous range of allocation process exist that are based on traditional, non-state law or custom.

59 Speed R, Li Y, Le Quesne T, Pegram G and Zhiwei (2013) Basin Water Allocation Planning. Principles, procedures and approaches for basin allocation planning, UNESCO, Paris.

- *"Market allocation*." In some parts of the world, water rights are reallocated on the basis of trade rather than by administrative allocation. Both formal and informal water markets exist.
- *"With land."* Water rights may be attached to the ownership of land. Transfer of the land through sale or inheritance implies transfer of the water right. In some cases, landowners abutting a surface water resource are entitled to water rights. Similarly, groundwater below private property is often regarded as an entitlement of that property.

  (Speed *et al* 2013)

In the SADC context, since the wave of water reform in the 1990s, formal water allocation systems are largely based on administrative systems, through licences or permits, with automatic entitlement for subsistence level activities. However, in large parts of the region, communal or traditional water allocation processes also still operate, largely outside the formal legislative systems.

South Africa has allowed a system of trading of water use entitlements for many years, although this is now under threat from a policy proposal to removal the option of water trading from the legislation. In Zambia, water trading is not recognised under the water policy, but is encouraged under the agricultural policy.

> "*No single means of allocating water takes preference over another, and a plurality of water rights systems operate in any basin, starting from the transboundary level and cascading through the national, often to local systems. Although in most countries in SADC, basic human needs and environmental water are recognised as a priority allocations. The suitability of an allocation system is determined by local conditions, including the capacity of the State to effectively administer the system. In this regard, "any effective allocation mechanism is entirely dependent upon the development of significant institutional capacity from the national to the catchment level … to assess available resources and any necessary ecological requirements, and administer, monitor and enforce the water allocation process."* (Speed *et al* 2013)

In addition to institutional capacity, the effectiveness of allocation systems is dependent on accurate information on water availability (including seasonable and inter-annual availability, sustainable surface and groundwater volumes, and the interaction between surface and groundwater), existing and potential water use, water quality issues and impacts arising from existing or proposed water use, and who is using what amount of water and for water purpose. Within the SADC context there are considerable challenges in terms of both institutional capacity and the reliability of hydrological and water use information that beg the question of the efficacy of the allocation systems that are in place to both ensure adequate protection of vital human needs and the environment, as well as economic growth. This is in spite of the fact that the Revised Protocol requires State Parties to determine an appropriate balance between the socio-economic needs of their populations and the protection of shared watercourses.

The capacity of SADC States to allocate water between the sectors in pursuance of a coordinated growth policies, against the full water footprint of these sectors set against the water, food and energy Nexus, appears even more questionable.

Differentiating Between Blue, Grey and Green Water Allocation

Current water allocation systems primarily deal with blue water i.e. ground or surface water that is abstracted for a particular use, and to some extent with grey water, or the pollution related implications of water use. Agriculture, on the other hand, uses large quantities of green water through rain fed agriculture, and in SADC as a whole green water makes up some 92% of the water footprint of agricultural goods traded within the region (CRIDF database). However, with the exception of South African legislation which has provisions for declaring Stream Flow Reduction Activities, there are no formal mechanisms to directly 'allocate' green water. Nonetheless, land use planning and the development of other infrastructure (transport and marketing) can influence placement of rain fed agriculture, thus acting as an indirect or proxy allocation mechanism.

In some countries in the region waste discharge permitting acts as an allocation function for grey water, but this does not deal with issues of pollution from dispersed sources such as agriculture.

World-wide, very few countries actively consider water footprints in their water allocation planning. The exceptions are Egypt and Israel who are deliberately following policies to import food, and hence Virtual Water, and rather allocate internal blue water to commercial and industrial users. China is also actively pursuing policies to reduce allocations to agriculture in favour of industrial and commercial users, while Saudi Arabia has deliberately reduced irrigation from groundwater within its borders, and has a policy of buying land in Africa to produce the food needed for its population.

Water allocation between states

The Revised SADC Protocol on Shared Watercourses

The allocation of water between riparian states in shared river basins in SADC is guided by the provisions of the Revised SADC Protocol on Shared Watercourses (the Protocol)[60], which require that State Parties use the waters of shared watercourses in a reasonable and equitable manner. This will become an increasingly complex allocation challenge as water stress grows, placing the overarching objective of the Protocol to, "*foster closer cooperation for judicious, sustainable and coordinated management, protection and utilization of shared watercourses, and advance SADC's agenda of regional integration and poverty alleviation*." (Protocol, Art. 2) even more in the spotlight.

The mechanisms for achieving reasonable and equitable use include:

- Establishing specific shared watercourse agreements and institutions (SWI);
- Advancing the equitable, reasonable and sustainable utilization of shared watercourses;
- Promoting coordinated and integrated environmentally sound development and management of shared watercourses;
- Promoting the harmonization and monitoring of policies and legislation related to shared watercourses;

[60] With the exception of Zimbabwe which has not ratified the Protocol. However, Zimbabwe is Party to the ZAMCOM Agreement which includes similar provisions – and is in effect also bound by these principles.

- Notification of planned measures; and
- Promoting information exchange, capacity building, and research and development to support effective management.

Each of these mechanisms is elaborated in the Protocol. However, the following Articles are of particular relevance to the issue of allocation of water between states:

- Article 3.8 (a) - borrowed from the 1997 UN Watercourses Convention - sets out the factors to be considered when establishing the reasonable and equitable use of water.
- Article 4.1 sets out the requirements for notification, information exchange, and negotiation/coordination among riparian States over planned measures that may have significantly adverse impacts on a shared watercourse.
- Article 4.2 requires Member States to jointly and individually protect and preserve transboundary watercourse ecosystems and the aquatic environment, and to prevent, reduce and control pollution and environmental degradation of the watercourse (including the introduction of invasive species).

States parties are required to take steps to harmonize their policy and legislation in this regard, and to consult with each other on the setting, monitoring and enforcing of joint water quality standards and practices to address point and non-point source pollution.

- Article 4.3 requires Member States to enter into consultations on the joint management of a shared watercourse, including the establishment of shared management institutions. States must also co-operate the regulation of flows and participate on a reasonable and equitable basis in the construction and maintenance or defrayal of costs of regulation works and to protect and maintain installations.

Member States are required to jointly take all appropriate measures to prevent or mitigate conditions that may be harmful to another riparian state, whether resulting from natural causes or human conduct, including regulating the actions of persons within their respective territories to prevent pollution or harm through the establishment and implementation of permitting/licensing systems.

While the Protocol defines a 'watercourse' to include groundwater implementation has, to date, only focused on surface water.

In advancing the equitable and reasonable utilization of shared watercourses, the Protocol requires that State Parties take a number of factors into account, summarised as follows;

- Physical or natural elements of the basin;
    - The ***length of the river*** lying in or adjacent to the regions;
    - The ***area of the basin*** lying within the territory of the regions; and
    - The ***contributions made to the runoff*** by the regions.

- Social or human needs and economic dependency on water;
    - ***Water demands*** exerted by the economy;
    - ***Population dependent*** on the shared waters;
    - ***Extent and history*** of that dependency; and
    - ***Vital human needs***, the water required for basic human needs like drinking and sanitation.

Generally the courts have, in disputes between administrative regions over water, tended to favour the social and economic dependency on blue water, although sometimes adjustments are made to accommodate the physical and natural elements (McIntyre, 2008[61]). However, while this has to date not been considered in SADC, green water availability and its contribution to the economy, may affect the extent of the dependency on blue water resources. The consideration of the full water footprint could therefore result in different approaches to water allocations between States in a transboundary basin. For example, countries with higher rainfall could be seen as being less dependent on irrigation (blue water) and hence could have water allocations limited in favour of countries with less rainfall. Similar arguments have been made in the Cauvery Basin in India, where the downstream state argued that the upstream state had the advantage of a double monsoon season.

Basin level and bilateral agreements

At the basin level, either basin-wide and/or bilateral agreements may determine the actual conditions for water allocation between signatories of these agreements. Any revision of these agreements requires a negotiated process between the relevant countries, which is a complex and time-consuming process. These agreements are seldom responsive to changing conditions, such as climate change, particularly where firm cross border flows have been agreed, although many include 'escape clauses' allowing deviation in cases of 'severe drought'. In many basins firm cross border flow agreements have proven very difficult to implement and sustain – particularly in times of water stress (Speed *et al*, 2013). However, there may be scope for shifting the way countries manage transboundary waters, towards a shared drought and flood risk approach using the infrastructure and blue, green and grey water allocations across the whole shared basin.

Table 6.1 summarises the basin level agreements in place in the transboundary basins of the region. What this does not capture is the many and varied bilateral agreements that are also in place in these basins. In many cases the actual details of water sharing are captured in the other (mostly) bilateral agreements rather than in the basin wide agreements which tend to be enabling rather than prescriptive.

Table 6.1: Summary of agreements in place in transboundary basins in the SADC region

BASIN	AGREEMENT	DATE AGREEMENT SIGNED	DATE AGREEMENT ENTERED INTO FORCE
Kunene	Agreement between the Government of the People's Republic of Angola and the Government of the Republic of Namibia on General Cooperation and the Creation of the Angolan-Namibian Joint Commission of Cooperation	18 September 1990	18 September 1990 (Self-executing)
Okavango	Agreement between the Governments of Angola, the Republic of Botswana and the Republic of Namibia on the Establishment of a Permanent	15 September 1994	15 September 1994 (Self-executing)

[61] McIntyre O (2008) Factors relating to equitable utilisation of shared freshwater resources

	Okavango River Basin Water Commission (OKACOM)		
Orange-Senqu	Agreement between the Governments of The Republic of Botswana, the Kingdom of Lesotho, and the Republic of Namibia and the Republic of South Africa on the Establishment of the Orange-Senqu River Basin Commission (ORASECOM)	3 November 2000	
Inco-Maputo	Tri-partite Interim Agreement between the Republic of Mozambique, the Republic of South Africa, and the Kingdom of Swaziland for Cooperation on the Protection and Sustainable Utilization of the Water Resources of the Incomati and Maputo Watercourses	29 August 2002	
Umbeluzi	Agreement between the Republic of Mozambique and the Kingdom of Swaziland on the establishment of a Joint Water Commission	1986	
Limpopo	Agreement between the Republic of Botswana, the Republic of Mozambique, the Republic of South Africa, and the Republic of Zimbabwe on the Establishment of the Limpopo Watercourse Commission	27 November 2003	November 2011
Pungwe , Busi and Save (and potentially others shared between Mozambique and Zimbabwe	Agreement Establishing the Joint Water Commission for 'waters of common concern'.	2002	December 2002 (self executing)
Zambezi	Agreement on the Establishment of the Zambezi Watercourse Commission	13 July 2004	June 2011
Rovuma	Agreement Establishing the Rovuma/Ruvuma Joint Water Commission	2006	
Congo	Accord Instituant un Régime Fluvial Uniforme et Créant La CICOS	6 November 1999	23 November 2003
Lake Tanganyika	Convention on the Sustainable Management of Lake Tanganyika	2003	September 2005

However, some basin-wide agreements are more comprehensive, delegating more authority to the transboundary river basin organisations, and that including more procedural and substantive obligations on the riparian states in line with the Protocol. For those agreements that pre-date the Protocol, various actions have been taken to broaden the scope of authority of the river basin organisations to facilitate more meaningful cooperation on substantive issues without altering the agreements themselves.

The ZAMCOM agreement is the most recently ratified agreement in the region and includes requirements for national level policy and legislative harmonization across the basin. Many other agreements[62], however, only establish the basin-wide Commission as an advisory body. Harmonized national standards, instruments and mechanisms for basin-wide planning, information and data collection and management, water quality, and impact assessment procedures have only been established in a few basins, all of which would assist in improved understanding of allocation of water in transboundary basins.

Basin studies have been done in the majority of the basins in SADC, and a large percentage of these have formed the basis for the development of basin management strategies. However, there are a limited number of comprehensive basin management plans in existence for shared watercourses. While there are some in progress, a number of factors (most notably the requirement for approval from each of the members states of the basin), mean this process can take some time.

Baseline studies have been completed for at least 11 of the transboundary basins in the region, while 3 management plans have been concluded (Congo, Inco-Maputo and Zambezi), 2 management plans are in progress (Orange-Senqu and Limpopo), and there are an additional 5 basin strategies or strategic action plans that may be considered as strategic plans (rather than strictly as management plans). However, the extent to which these plans have rigorously interrogated the requirements for reasonable and equitable use is debateable. As such, the extent to which these plans could be considered as inter-state water allocation mechanisms is uncertain, and would depend to a large extent on the way they were adopted, and the powers and functions that have been afforded to the Commission. Certainly, it may be argued in some cases that 'approval' of basin wide plans by all riparian states which note plans for increased water use reflects an agreed water allocation. However, the enforceability of the plans in this regard is highly unlikely.

Water allocation and re-allocation

Water re-allocation between sectors

The issue of water allocation between sectors is particularly pertinent where a basin is stressed, is approaching closure, or is already closed. In many of these cases, after water efficiency measures have been accommodated, continued growth will require the reallocation of water between sectors, or the development of new water storage or transfer infrastructure. Recognising that 'new' water delivered through additional storage or transfers may become increasing expensive, and (in the face of increasing regional water stress) difficult to beget on a political basis, water managers may consider the importation of Virtual Water in agricultural products, rather than to produce them locally. Text Box 3 in Muller's Chapter 5 highlights one such investigation done by South Africa's Department of Water Affairs. This would have to be effected through shifting allocations between water use sectors, primarily to reduce the allocation to irrigation in favour of uses that provide greater income and jobs per drop – opting for more optimal financial, economic and environmental solutions. This approach remains nonetheless a legally and socially contentious approach.

[62] LIMCOM, ORASECOM, OKACOM, and the Joint Water Commission (Mozambique and Zimbabwe).

The reality of the SADC context is that there is often an unregulated and informal transfer of water between sectors. For example, many cities and towns use more water than they are formally entitled to, not as the result of a formal allocation process, but through increased physical withdrawals from surface and groundwater systems. The same pertains to many irrigation farmers. In most cases the 'user' that suffers is environmental flows, or weaker downstream users. Thus, in the face of weak regulation, allocation is often determined by the physical ability to abstract water rather than by the formal allocation system. This begs the question of how effective allocation systems are in the SADC region, and the potential impact this may have on regional cooperation – particularly in the face of severe drought and / or climate change. For example, climate change may reduce outflows from Lake Malawi, but not to the extent that users within Malawi would be compromised. But the impacts on Mozambique and the Zambezi delta may be considerable. The extent to which Malawi's water allocation processes could accommodate these impacts, reducing allocations to sugar irrigation, in the face of potential concerns raised by Mozambique is questionable. This particularly in light of the fact that the export of sugar derived from irrigated cane is a major foreign exchange earner for Malawi (see Chapter 3), but is also directly pertinent to their commitments under the Protocol.

In 2009 GWP-SA conducted a survey on progress in the implementation of IWRM in the Southern and Eastern Africa. As Table 6.2**Error! Reference source not found.** indicates, there were, at that point, limited achievements in relation to allocation mechanisms in the region, and similar weaknesses in terms of monitoring and information, which is a key element of implementing effective allocation. While there has been progress since then, a recent review of implementation of the SADC RSAP III revealed ongoing weaknesses in institutional capacity and monitoring and information. The issue of allocation mechanisms was not considered in this review.

Thus, the context of the allocation of water between sectors and users in the SADC region is one of weak institutional capacity and limited information.

Moreover, in Chapter 5 Muller postulates hydro-centric versus hydro supporting approaches, suggesting that there is little evidence that hydro-centric approaches have successfully driven development. It is therefore perhaps unrealistic to propose that a process of re-allocating water between sectors *per se* would be sufficient to shift planners away from large scale storage or transfer infrastructure as a solution to water stress. However, Virtual Water thinking may place powerful economic and politically savvy alternatives on the table. Done timeously, this may shift longer term planning in time to exert a gradual influence and shift.

Table 6.2: Progress on the implementation of management instruments for IWRM (Towards a Water Secure Africa - Progress in IWRM in Eastern and Southern Africa

Country	IWRM Planning	Allocation mechanisms	Monitoring and information
Angola			
Botswana			
Lesotho			
Madagascar			
Malawi			
Mauritius			
Mozambique			
Namibia			
Seychelles			
South Africa			
Swaziland			
Tanzania			
Zambia			
Zimbabwe			

= little or nothing achieved
= some, but limited achievements
= substantial achievements or progress

Prioritisation of water use and assurance of supply to address variability

User Sector	Assurance	Maximum curtailment
Primary domestic needs	100%	0%
Strategic	99%	5%
Industrial	98%	20%
Urban	95%	30%
Irrigation		
- High value	95%	30%
- Medium value	90%	50%
- Low value	80%	70%
- Opportunistic	70%	100%

Table 6.3: Assurances and Curtailments considered viable under South African circumstances

Most countries in the region have some degree of prioritisation of water use, particularly for water for basic human needs, and for the environment. For example, Zambia prioritises water for domestic, livestock and urban use, but then affords all other uses the same priority. In the case of South Africa, this is taken one step further in the NWRS-2 which sets out a prioritisation of all water use and which should guide sectoral water use allocations at the national and basin level. This prioritisation also underpins the assurance of supply principle, as is highlighted in Table 6.3 below.

This allocation system specifically accommodates variability in supply, while seeking to maintain the economic viability of the water use, or its role in the country's economy. Varying the assurance of supply in this way frees up water for further allocation. For example in the Crocodile sub-catchment in South Africa, a maximum of 342 million m^3/yr is available for allocation 100% of the time, this increases to 427 million m^3/yr at a 95% assurance, 463 million m^3/a, at a 90%, and 499 million m^3/a at an 85% assurance.

A Virtual Water perspective can also play a role in establishing fair assurance of supply rules. Users that can rely on higher rainfall and hence green water contributions may be able to accommodate reduced assurance while still remaining economically viable. An improved understanding of the water footprint of the various water users, set against their contributions to employment and the economy may place water managers in a better position to build climate resilience through water allocations.

Challenges for considering Virtual Water in water allocations

Background

Apart from the proposals outlined in the previous sections, there are a number of specific issues that need to be examined when considering the potential role for, and practicality of, virtual water in water allocation systems, these are;

- To what extent are blue and green water adequately considered in the cost drivers' and allocation picture?
- Do decision-makers have the information, framework and tools for considering the possibilities of using green water in one area rather than blue water in another area?
- To what extent can the choice between infrastructure, further developing groundwater sources, or Virtual Water be informed by a water footprinting approach?
- How do Virtual Water principles influence issues of direct cost, job creation, risk and political imperatives?

It is worth noting, at this point, that apart from South Africa, Zimbabwe, and to some extent Namibia, the region is poorly served with major storage infrastructure, making it extremely vulnerable to even short term drought. Drought, and the water, food and energy nexus also plays into the scenario of hydropower development in the region. In the Zambezi basin, States will have to increasingly make trade-offs between irrigation and hydropower. Similarly, States reliant on hydropower (either imported or locally produced) from basins potentially prone to variable water availability, may also need to consider their strategic risks or to consider alternative sources of electricity in droughts. The consideration of Virtual Water in allocation decisions therefore has to be underpinned by a broader understanding of the full water footprint in the national and regional economy. The following sections address these challenges from the SADC perspective.

Economic Accounting for Water

Currently water allocation is based on the use of hydrological modelling to determine water availability, and to allocate this water to various economic sectors according to demand and levels of priority of those sectors in the economic development framework of the country. In many cases, basic water supply has the highest priority. The allocation sometimes involves drought rules that determine which sectors receive priority and which are most heavily curtailed in times of drought or water shortages. This approach ensures the allocation of water to those sectors that are envisaged of being high priority. However, according to the SADC project on Economic Accounting for Water,

> "*it does not lead to **pareto optimality** – that is allocation of the scarce water resources in such a way that maximises the social welfare benefits for the River Basin. In order to achieve pareto optimality information is required on **Value Added**, **Water Productivity**, and **Water Use Intensity** and this information is usually not included in current models which are used by river basins to allocate water.*"[63]

[63] (http://www.sadcwateraccounting.org/policy/5.5WaterAllocation.aspx)

However, the economic accounting for water still does not accommodate the full impact of water on the economy, and only addresses blue water, thus missing some 80-90% of the water in agricultural products that is derived from green water. Section 7.5 below addresses these aspects in more detail.

The nexus approach

It is very clear, in the SADC context, that there are regional and national benefits to be derived from appropriate siting of energy generation and crop production (rain fed and/or irrigated). Where possible the siting of irrigation abstractions below hydropower plants can allow for the dual use of water and hence deriving greater benefits from the available resources. Similarly, the careful conjunctive operation of hydropower plants and irrigation abstractions can hold net benefits across the basin (World Bank, 2010). Given adequate transmission capacity, electricity trading from basins with significant runoff at a high assurance, like the Congo River, can meet significant regional demands, but SADC States have shown a reluctance to forgo sovereign electricity security – allocating water perhaps preferentially to irrigation (see Chapter 7).

Moreover, on a national basis, hydropower dependent countries may have to make difficult allocation decisions between hydropower and irrigation. While countries like Zambia earn considerably more in agriculture exports than electricity exports, a lack of power has much greater impacts on the economy, while irrigation itself often relies on electricity. However, the sugar industry may provide for its own electricity through bagasse, and this may be an important consideration in countries where the sugar industry is an economic mainstay, like Zambia and Malawi. Appropriate water allocations and assurance of supply in these countries will therefore also be influenced by electricity demands and possible surpluses, variable runoff (and climate change) and the viability of purchasing regional electricity surplus through the SAPP. Conversely there transnational risks arising from the off-shoring food production, and the potential costs (and foreign exchange implications) of importing food. Regional integration has not yet reached the level at which SADC States see national interest within the context of the general regional interest.

Benefit Sharing as an allocation approach

The concept of benefit sharing in transboundary basins has been widely talked about. Benefit sharing is “the process where riparian countries cooperate in optimising and equitably dividing the goods, products and services connected directly or indirectly to the watercourse, or arising from the use of its waters” (Phillips and Woodhouse, 2006).

The concept of benefit-sharing is closely aligned to the concept of virtual water, although it is generally applied only within the confines of one basin, while virtual water can be regional or even global in scope. A benefit-sharing approach enables one to move from a focus on the physical volumes of water to be shared, to an analysis of the economic, social, political, and environmental benefits to be derived from the water use. In theory, at least, it allows allocation of water to generate the optimal social, economic and environmental benefits in the basin. The challenge, however, is enabling riparian states to understand the potential for a positive-sum outcome from this approach, rather than the constrained approach arising from a volumetric allocation, through the Virtual Water and economic accounting lens. For example, the Lesotho Highlands scheme is an oft quoted example of such a benefit sharing approach. However, this was not driven on the basis of the equitable sharing of the full benefit of the use of water in South Africa, versus Lesotho, but rather on the incremental difference in the cost of infrastructure built in Lesotho, as opposed to on the Orange River once it entered South Africa.

Taking a truly benefit sharing approach (as with a virtual water approach) requires a quantification of the costs and benefits associated with using the water from a particular resource, and the application of agreed valuation techniques to assess the full economic and social value of the costs and benefits. There has been some work done around this by the SADC Water Division through a programme on Economic Accounting of Water, which has been piloted in the Orange-Senqu river basin.

Challenges of accurate information

One of the major challenges of any water allocation system, whether between states, between sectors, or to individual water users, is the accuracy of the hydrological and water use data on which it is based. Unfortunately, in the SADC context, such data is limited, and not particularly reliable. The hydrological and meteorological monitoring systems in the region are under-developed and poorly maintained, resulting in limited data generation. In addition, records of actual water use are also weak or non-existent in most places.

Weaknesses in hydrological monitoring are compounded by climate change and the difficulty of linear projections based on historical patterns which are no longer valid. From the climate change perspective, there is weak downscaling of climate change models in the SADC region apart from South Africa, leaving high levels of uncertainty in relation to the hydrological and meteorological impacts of climate change.

Applying a Virtual Water and water foot print layer to this may result in further uncertainty and inaccuracies. Although, for most of SADC rainfall data is somewhat better maintained and available.

Enabling environment to use water

A further challenge that exists in the SADC region is weaknesses in the enabling environment in order to be able to use water for economic development, including export of agricultural produce through adequate transport infrastructure and energy provision to the more remote areas. This links back to the issue of economic scarcity of water as outlined in Chapter 2.

Taking this issue further, and looking at the trade of virtual water in relation to agriculture, as captured in Table 6.4, an interesting picture begins to emerge. Water allocations are focused on apportionment of blue water, with 80-90% of blue water used in irrigation in developing countries. It is, therefore, worth examining the issue of blue water content in agricultural imports and exports in the region. States with a high blue water content in their agricultural exports, and where those exports are significant earners relative to the GDP, and where there is little storage, are vulnerable to short term changes in runoff, and potentially the multiplier effects of increased temperatures and reduced rainfall on runoff. Conversely, those economies that are heavily green water dependent, may be vulnerable to even a month with less rain than expected. Indeed, in many African countries reduced economic growth tracks rainfall patterns.

On the other hand, countries that are dependent on agricultural imports are at risk from droughts in the countries from which they are importing, or even global food price fluctuations. For example severe drought in the Former Soviet Union countries in 2012 forced up global wheat prices, and with that overall food prices. The allocation of water during times of drought in particular, and the implications of water allocation and curtailment decisions on the economy, therefore particularly relevant.

Malawi and Swaziland, and to some extent Zambia appear to be vulnerable in this regard (Table 4). Their trade surpluses in agricultural goods an important contributor to GDP yet, apart from Swaziland, they have virtually no storage (and much of Swaziland's 'storage' lies in South Africa). Climate vulnerability may therefore further constrain economic growth in these countries. Breaking out of this trap will require a broader enabling environment through both improved storage and transport infrastructure (spreading the agricultural base to wetter regions) and accommodating shorter term droughts, improved water governance and the introduction and policing of variable assurance of supply across the irrigation and energy sectors, and a diversified economy. A lack of this enabling environment is likely to be the biggest challenge to effectively building Virtual Water thinking into water allocations. Certainly a catch 22 may arise where Virtual Water thinking is required to make best use of variable water availability in growing the economy of these countries, but this cannot be introduced effectively because the economy is not large enough provide an appropriate enabling environment.

Table 6.4: Virtual water imports and exports in SADC per country

Country	Renewable Water m3/cap	Storage m3/cap	GDP U$ / PPP (U$ Billion)	GDP U$ / cap	Virtual Water Imports in Agricultural Goods%			Virtual Water Exports in Agricultural Goods%			Agric Export earning from blue water (u$ Millions)	Agricultural Trade Surplus / Deficit (U$ Billion)
					Blue	Green	Cost $ Billion	Blue	Green	Earn $ Billion		
Angola	7 333,82	468,40	114,15	6006,34	9	82	2,4	0	100	0,015	0	-2,385
Botswana	1 208,03	221,00	14,50	16104,91	11	81	0,5	4	96	0,92	37	0,42
DRC	27 220,00	0,76	17,20	415,34	14	77	0,45	0	100	0,038	0	-0,412
Lesotho	2 576,97	1 272,00	2,45	1931,21	7	83	0,02	12	86	0,005	1	-0,015
Malawi	1 044,15	2,63	4,26	753,38	14	76	0,14	10	84	0,9	90	0,76
Mozambique	4 080,33	3 165,00	14,24	1007,23	14	78	0,43	13	86	0,52	68	0,09
Namibia	2 777,76	299,70	13,07	7442,34	10	76	0,6	14	85	0,56	78	-0,04
South Africa	868,56	601,70	384,31	11021,02	9	84	4,73	13	82	4,97	646	0,24
Swaziland	2 177,93	479,50	3,74	5161,14	10	80	0,023	40	60	0,24	96	0,217
Tanzania	1 812,12	2 187,00	28,24	1574,78	12	80	0,88	2	97	1,11	22	0,23
Zambia	5 882,44	250,00	20,59	1682,86	5	90	0,35	8	88	0,88	70	0,53
Zimbabwe	917,75	400,00	9,80		9	82	1,13	15	71	1	150	-0,13
SADC Average	**4 824,99**	**778,97**	**52,20**	**4 827,32**	**6**	**91**	**11,7**	**10**	**86**	**15,7**		

Allocation mechanisms that function within state capabilities

The previous section underpins one of the key constraints faced with respect to successful water allocation mechanisms; the capacity of the state to effectively implement them. Not all of the allocation systems contained in law are implementable within the human, financial and data resource limitations in the region. All allocation systems, whether administrative or market based, require a minimum platform of infrastructure and systems, particularly information on existing and current water use, and water availability.

In addition, allocation systems need to be able to deal with inter-annual variability and the impacts of climate change. This requires adaptive and flexible systems, and the ability to analyse changes in rainfall and run-off. While there are considerable hydrological skills and capacity in most SADC countries, it is likely that sectoral and even individual allocation is taking place organically, rather than systematically due to a lack of institutional resources and the high transactional costs of hydro-centric approaches. For example, municipal water use in many countries is increasing not through a formal allocation of water, but simply through increased abstraction, and expansion of the urban boundary.

Land and water grabs

One of the ways that allocation of water takes place, is through the purchasing of land with associated water entitlements. There is increasing concern, that large scale 'land-grabbing' by more wealthy States, particularly from outside the region, may result in local people being disposed of their right to land and water.

After the recent food price crisis, several countries and companies bought land in Africa, and foreign land purchases in central Africa now totals some 16 million hectares (although this number is in some dispute). In some cases, this has contributed to the local economy by creating jobs and providing ready markets for agricultural products, albeit outside of the region (hence representing a net Virtual Water loss to the region). However, in many cases little has been done to develop and use the land, thus trapping the potential blue and green water associated with that land. This is a form of virtual land and water allocation, but without sufficient regulation or necessarily assessment of the regional impacts.

Nonetheless, as indicated in Chapter 3, SADC is a net Virtual Water importer, yet earns more foreign exchange in its Virtual Water exports.

Conclusion

Muller's (Chapter 5) observation that hydro-supportive approaches, allocating water in support of demands, rather than hydro-centric, using water allocations to drive demands, is most likely to be the dominant paradigm is broadly supported by these authors.

However, in this regard, Wichelns notes that:

> “*The virtual water metaphor, while not a sufficient criterion for determining optimal strategies, still serves an important role in gaining the attention of public officials. Once that is accomplished, the discourse can be extended to include consideration of opportunity costs and comparative advantages, as strategies are determined and policies are selected.*”[64]

Through the Virtual Water lens, policy makers can examine the issue of scarcity of water and optimal allocation options in and between countries and sectors. However, the current inter-country agreements are largely volumetric in nature, and a move towards a consideration of virtual water approaches would require a considerable

[64] (Wichelns 2001 in Dabrowski, J. 2014. Virtual water. Understanding the Food Energy Water Nexus. WWF-SA, South Africa.)

paradigm shift. Similarly, SADC States and transboundary basin Commissions do not seem ready to thoroughly examine reasonable and equitable use principles even on a blue water, let alone water footprint basis.

At the level of inter-sectoral allocation, it is not clear that the allocation systems currently in place, or the monitoring and information systems, are sufficiently well-developed to accommodate effective allocation of water through a Virtual Water lens, in spite of the potential that the concept offers.

Nonetheless, similarly to Wichelns, it is the opinion of these authors that looking at water allocations through the virtual water, water footprint, and nexus lens places other options on the table. These options may indeed influence management decisions away from solely examining large infrastructure solutions to variability and stress in water availability. CRIDF would be well placed to introduce these concepts to larger regional strategic infrastructure investment programmes, regional negotiations around inter-State water allocations, and national water allocation processes. The development of powerful economic and politically savvy messages, as outlined in Chapter 10, would lend further weight to influencing regional national planning processes.

Chapter 7: Electrical Power Planning in SADC and the role of the SAPP

By

Simbarashe E. Mangwengwende, Lawrence Musaba and Simon Krohn

Abstract

Recognising the benefits of regional integration SADC countries established the Southern African Power Pool (SAPP) through an intergovernmental Memorandum of Understanding signed in August 1995. SAPP's mandate is to provide non-binding regional masterplans to guide electricity generation and transmission infrastructure delivery, with countries retaining the right to develop and prosecute their own national plans. Although SAPP masterplans have been able to demonstrate considerable financial savings and other benefits of regional cooperation, countries have instead continued to develop plans for achieving electricity self-sufficiency.

SAPP interactions have demonstrated that regional cooperation requires the adoption of multi-sector planning approaches to establish credible demand forecasts, and a multi-criteria approach to selection of project options going beyond identification of regional least cost options, to incorporate sovereign electricity security national interests. In particular, regional plans must be able to demonstrate the national benefits of integration, while addressing the legitimate national security and political concerns.
An iterative planning process is required based on the following:

- *Harmonisation planning criteria and minimising information and data asymmetries.*
- *Development of national plans that take account of non-negotiable and negotiable national interests.*
- *Development of regional plans that respect national interests of participating countries, while providing information on the national and regional benefits of cooperation.*
- *Review of national plans to maximise opportunities for reliability and economy afforded through regional cooperation, based on an informed cost-benefit analyses of the additional costs for national security interests, made explicit through Virtual Water and regional risk sharing concepts.*

This iterative process will create win-win outcomes where each country will have internal generating capacity that can be used to meet local demand with increased supply assurance, while being in a position to purchase power from the least-cost regional sources under normal operating conditions. However, the development of these options is likely to require significant investment in transmission infrastructure, without a promise of a power purchase agreement.

Introduction

The Climate Resilient Infrastructure Development Facility (CRIDF) Virtual Water and Nexus Project seeks to provide evidence based recommendations to assist policy and decision makers in the water, agriculture and energy sectors to plan, develop and operate large infrastructure projects in a coordinated manner that takes account of the need to ensure pro-poor and climate resilient outcomes. The Project seeks to strengthen national strategic planning, promote greater and peaceful regional integration and encourage cooperation across different sectors.

This paper addresses energy sector planning issues focussing on the electricity supply industry which has the most significant impact on the SADC region's carbon footprints, and is an important component of the regional water footprint. Electricity planning takes place at both national and regional levels through the Southern African Power Pool (SAPP). The SAPP was established in August 1995 at the SADC Summit held in South Africa when an inter-governmental memorandum of understanding (IGMOU) was signed. A revised IGMOU was signed on 23 February 2006 to allow for new SADC members and new enterprises created as a result of the restructuring of the power sectors of the member countries. Current membership of SAPP comprises the national electricity utilities of the 12 continental members of SADC, an independent power producer (IPP) and independent transmission company (ITC) from Zambia. An IPP and ITC from Mozambique are observer members.

Mandate of SAPP

The SAPP mandate is guided by the SADC Protocol on Energy signed in Maseru on 24 August 1996 which is the principal policy document governing the SADC energy sector. The protocol defines the guidelines for co-operation in the electricity sector, which include the development and updating of a regional electricity masterplan, development and utilisation of electricity in an environmentally sound manner, and emphasising the need for universal access to affordable and quality services.

The SAPP IGMOU expresses the clear intention of member countries to enhance regional cooperation in power development and trade and defines the basis for the establishment of the power pool as the need for all participants to:

a) Co-ordinate and co-operate in the planning, development and operation of their systems to minimise costs while maintaining reliability, autonomy and self-sufficiency to the degree they desire;

b) Fully recover their costs and share equitably in the resulting benefits, including reductions in required generating capacity, reductions in fuel costs and improved use of hydro-electric energy; and

c) Co-ordinate and co-operate in the planning, development and operation of a regional electricity market based on the requirements of SADC member states.

Consistent with the principle that member countries are free to choose the degree of autonomy and self-sufficiency desired, a separate Inter-Utility Memorandum of Understanding (IUMOU) states that the regional generation and transmission masterplan shall be "purely indicative and shall not create an obligation upon members to comply" (clause 12.5.2 (vi), SAPP IUMOU - April 2007). Any regional generation and transmission masterplan must therefore hold considerable regional *and* national benefit after satisfying the desired level of autonomy and self-sufficiency, in order for it to attract attention and investment.

Methodology

In order to introduce the Virtual Water and nexus concepts to policy and decision makers involved with the electricity sector the paper adopts the following approach:

- Provide information on current and projected power supply and demand situation and Virtual Water implications of electricity trades;
- Provide information on projected demand and the factors influencing that demand, as well as the regional and national options for fulfilling that demand and the factors driving the demand for electricity;
- Analyse the regional versus national planning challenges based on the experience of the SAPP in the discharge of its mandate;
- Outline a conceptual scenario for how Virtual Water and nexus concepts can help to fulfil the legitimate expectations of all stakeholders, including governments (and their development partners), regulators, utilities, private sector, civil society and consumers, especially the poor and marginalised.

Current Power Supply and Demand in SADC

The latest available electricity power and energy supply and demand statistics for the year ending 31 March 2013 published in the SAPP Annual Report are summarised in Table 7.1.

Table 7.1: SAPP Power and Energy Demand (2013/14)

Country	Utility	Installed capacity (MW)	Dependable capacity (MW)	Peak Demand* (MW)	Energy sent out (GWh)	Energy Sales (GWh)
Angola	ENE	2028	1805	1333	5613	3427
Botswana	BPC	892	460	580	372	3118
DRC	SNEL	2442	1268	1342	7411	6688
Lesotho	LEC	72	72	138	486	488
Malawi	ESCOM	351	351	278	1809	1476
Mozambique	EDM/HCB	2308	2279	763	390	2380
Namibia	NamPower	501	392	635	1305	3648
South Africa	ESKOM	44170	41074	38775	237430	224446
Swaziland	SEC	70.6	70	222	288.1	1018.6
Tanzania	TANESCO	1380	1143	898	3034	3770
Zambia	ZESCO/CEC/LHPC	2128	2029	2287	11381	10688
Zimbabwe	ZESA	2045	1600	2267	6951	7 367
Total SAPP		**58388**	**52543**	**56821****	**276470**	**261148**
Total Interconnected		**54628**	**49244**	**54312****		

Source: SAPP Annual Report, 2013/14. *Includes estimate of suppressed demand; ** includes reserves

The difference between the total interconnected capacity of 54,628 MW and the total capacity of 58,388 MW is due to the fact that three countries, Angola, Malawi and Tanzania are not yet interconnected. It is also important to note that the dependable capacity (49,244 MW) is lower than the peak and suppressed demand including required reserves for several countries and for the region as a whole. Suppressed demand is an estimate of additional consumption that would be on the public network if there were no supply constraints. It represents the demand of deferred investments or what is self-generated. The best practice reserve margin for a hydro-thermal system is about 15% of the total peak demand of 49,563 MW which gives a total supply requirement of 56821 MW. The region has therefore a dependable capacity shortfall of 4,278 MW or close to 10%. Many countries are therefore having to resort to regular load shedding which adversely affects economic and social development. For several countries the benefits of interconnection are evident in that their sales exceed their generation. However, the fact that they are now having to load shed because the supplying countries are unable to export enough to meet demand, has highlighted the need for importing countries to increase investment at national level in order to become more self-sufficient. The capacity of ongoing and committed projects in the short term for the different countries are highlighted in Table 2.

Table 7.5: MW Capacity of Committed Short-term Generation Projects

Country	2014	2015	2016	2017	TOTAL
Angola	204	0	1280	2271	**3771**
Botswana	150	0	0	0	**150**
DRC	0	580	0	240	**820**
Lesotho	0	0	35	0	**35**
Malawi	0	0	0	34	**34**
Mozambique	175	0	40	300	**515**
Namibia	0	0	15	0	**15**
South Africa	4836	1805	3717	1918	**12276**
Swaziland	0	0	0	0	**0**
Tanzania	450	240	660	250	**1600**
Zambia	195	735	40	126	**1096**
Zimbabwe	0	15	0	1140	**1155**
TOTAL	**6026**	**3375**	**5787**	**6279**	**21467**

Source: SAPP (Unpublished internal report, April 2014)

South Africa has nearly 80% of the generating capacity, and 85% of the energy generated in SADC is consumed in South Africa. The country also accounts for almost 60% of the new capacity to be developed in the next 4 years. With coal accounting for 86% of South Africa's generation capacity and hydropower accounting for the bulk of the remaining countries' generation these two technologies are the main sources of electricity in the region (Figure 7.1). The DRC, Malawi, Mozambique and Zambia are almost entirely reliant on hydro-power.

Projects completed in 2013 and due to be completed in 2014 comprise; 3,269 MW of thermal generation, mainly coal in South Africa and Botswana and gas in Mozambique, South Africa and Tanzania; 1,976 MW of hydro, mainly in South Africa and Zambia; 2,112 MW of other renewables, mainly solar and wind in South Africa which also has an additional 30 MW nuclear. The generation mix for additional power added in these two years will be 44% thermal, 27% hydro and 29% other renewables and nuclear.

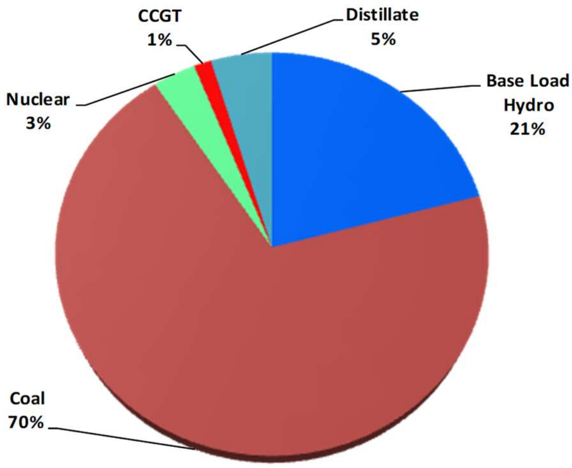


Figure 7.8: Generation Mix in SAPP (Source: SAPP Annual Report 2013/14)

Electricity trading

Electricity trading in the SAPP is 99% based on bilateral contracts of one month or longer duration and 1% on short term day ahead market (DAM) (24 hour duration). In 2012/13 there were 28 bilateral contracts but only 15 of these were active due to generation and transmission constraints (SAPP Annual Report, 2013). The following Table 3 highlights the most active bilateral contracts for 2013. In Table 1 Zimbabwe is shown as one of the countries with a significant supply shortfall and yet it is noted that it is one of the large trading partners. This is a unique arrangement where NamPower pre-paid for the power by providing financial support for major overhaul at Zimbabwe's Hwange Power Station, thereby increasing the output of a power station that would otherwise have been shut down. While Zimbabwe is still short of power and has to load shed, the extent of the load shedding would have been worse without the NamPower support. It is a good example of the benefit of having the regional interconnected grid.

The DAM is a competitive market administered by the SAPP Coordination Centre which seeks to utilise the uncommitted generation and transmission capacity to help utilities cope with their day to day operational requirements. The sale and buy bids received are matched to establish a market clearing price but the actual trading depends on the available transmission capacity. Between December 2009 and March 2013 there was a total of 230,131 MWh of matched sale and buy bids but only 62,154 MWh (27%) could be traded.

Table 6: Bilateral Contracts in SAPP for 2013

Exporting Country & Utility	Importing Country & Utility	Capacity (MW)	Total (MW)
South Africa (ESKOM)	Mozambique (MOZAL)	950	1950
	Mozambique (EdM)	300	
	Swaziland (SEC)	250	
	Namibia (NamPower)	200	
	Botswana (BPC)	150	
	Lesotho (LEC)	100	
Mozambique (HCB)	South Africa (ESKOM)	1150	1670
	Mozambique (EdM)	270	
	Zimbabwe (ZESA)	250	
Zimbabwe	Namibia (NamPower)	150	150
Mozambique (EdM)	Swaziland (SEC)	50	135
	Botswana (BPC)	45	
	Namibia (NamPower)	40	
TOTAL			**3905**

Source: SAPP Coordination Centre (unpublished internal report, April 2014)

Barriers to Proposed Transmission Projects to Relieve Trading Constraints

The priority transmission projects to facilitate improved trading fall into two categories - (a) the interconnection of Angola, Malawi and Tanzania to complete the interconnection of all member countries, and (b) the reinforcement and upgrading of transmission corridors used for wheeling power. The first category projects include internal transmission reinforcements in Zambia and a 400 MW Zambia-Tanzania interconnector which is envisaged to be extended to Kenya, 300 MW Mozambique (Cahora Bassa) to Malawi interconnector, 600 MW DRC to Angola interconnector and 400 MW Angola to Namibia interconnector. The second category projects included the 600 MW Zimbabwe/Zambia/Botswana/Namibia (ZIZABONA) interconnector, reinforcements of the Central Transmission Corridor (CTC) in Zimbabwe, and transmission upgrades in South Western Zambia and North Western Botswana.

Experience has since proved that project implementation can be very slow notwithstanding obvious technical and financial benefits. Nearly twenty years have passed without completing the interconnection of the remaining three countries), namely Angola, Malawi and Tanzania. The interconnection of Angola to the power pool was originally envisaged as part a Western Corridor (Westcor) designed to supply power from the Inga scheme in DRC all the way to South Africa through Angola, Namibia and Botswana. A special purpose company was created with an office in Botswana. The project was however aborted when the countries failed to agree on the formula for sharing benefits and other conflicting interests (see Text Box 1).

Text Box 1: WESTCOR - Project collapses over lack of shared benefits expectations

The Westcor project was conceived by the SAPP in 2002 with the objective of developing Inga-III in the DRC to supply power to South Africa with the three countries in between the DRC and South Africa , namely Angola, Namibia and Botswana also taking a share of the power. The project was not only serving to interconnect Angola to the SAPP grid but would also facilitate the establishment of a telecommunication system to link the five countries. With five participating countries this was an ideal regional cooperation project. In 2003, inter-governmental and inter-utility Memorandums of Understanding were signed by the Energy Ministers and national utilities of Angola, Botswana, DRC, Namibia and South Africa. A joint development agreement was signed and a shareholders' agreement for a company to serve as the Special Purpose Vehicle for development of the project. The five utilities each paid US$100,000 into the establishment of the SPV. Botswana was selected to host the SPV and an office was established in Botswana.

After that things went downhill as the DRC stopped attending without formal notice. The following are *suspected* to be some of the reasons:

i. The DRC felt that the signed MOUs were no longer binding. In their understanding once MOUs are signed the signatories should commit funding to the project which was not done in this case.
ii. The DRC also felt that they needed more royalties from the Inga-III since the land and water all belonged to the DRC and they were against the idea of sharing benefits equally with other Members.
iii. On top of being a member of the SAPP, like the other Members of Westcor, the DRC was also a member of other power pools like CAPP and EAPP. The other power pools which are even closer to Inga also wanted a share in Inga-III as the DRC had earlier promised them. This was therefore going to be a challenge for DRC to fulfil all the obligations.

In hindsight the signing of the IGMOU at Ministerial level and not Presidential level could have undermined the project. However several pre-SAPP projects such as the Interconnectors from Zimbabwe to Cahora Bassa and to Matimba through Botswana were successfully implemented through agreements signed at ministerial level.

The above reasons were enough for the Westcor project to collapse.

The Malawi-Mozambique interconnector progressed to the point of financial closure but still failed to take off for unrelated political reasons and perceptions of inequity in the sharing of benefits (see Text Box 2).

Text Box 2: Mozambique Interconnector - Politics overrides technical and financial feasibility

The Mozambique-Malawi Interconnection Project is a project that is aimed at Interconnecting Malawi, a non-operating member of the SAPP, to the SAPP grid via Mozambique.

In the year 2007/8, the project had reached financial closure and funding was available from both the World Bank and the government of Norway. The World Bank had availed funding to both governments without the requirements for a power purchase agreement (PPA). The funding from Norway was to reduce the cost of the power to be supplied by Mozambique to Malawi and it would act as a subsidy. Despite the fact that funding was available and the project would benefit both countries and the region, the project still collapsed due to some of the following reasons:

i. The government of Malawi had wanted to use the Shire River as a gateway to the Indian Ocean via Mozambique. The President of Malawi, President Bingu wa Mutarika at that time, had planned to establish an inland port in Malawi at the shore of Lake Malawi. Ships were to dock at this inland port from the Indian Ocean via Mozambique using the Shire River. The government of Mozambique had refused this arrangement as no feasibility studies had been done to use the Shire River in this manner right across Mozambique. Because the government of Mozambique refused to allow Malawi this request, the Government of Malawi also felt that they should refuse to accept the Mozambique-Malawi interconnector that would pass through Malawi and also supply the Northern part of Mozambique.
ii. The government of Malawi concluded that Mozambique would be the largest beneficiary of the project as it was felt that the proposed tariff was too high and Malawi would be held captive by Mozambique

Other constraints in the implementation of power projects in the SADC region include the following:

- *Lack of political commitment to implement cost reflective tariffs*: The extent to which countries are committed to projects is demonstrated by their commitment to their sustainability and this in practical terms means having project beneficiaries pay prices that cover investment and on-going operation and maintenance costs. Current average tariffs in the region are within the range of 4.8 to 11.5 USc/kWh (SAPP Annual report, 2013) and are not linked to long run marginal costs which are much higher than the sunk costs of existing plant. By comparison average tariffs for other sub-Saharan Countries is 13 U$c/kWh and as high as 20 U$c/kWh in West Africa.
- *Absence of a project driver or champion who is both resourceful and persuasive and who derives his mandate or authority from the highest authority*: This is another factor that demonstrates weak political commitment to regional cooperation. Countries have or are considering self-sufficiency as the answer to their national energy security concerns.
- *Weak institutional frameworks and project preparation capabilities*: - The lack of a harmonized framework across the region, which was of concern given the importance of these factors towards the success of credit enhancement techniques, and the generally poor relationships and lack of coordination between utilities and their regulators in some cases are significant barriers. Potential funders, (and some of the

regulators and utilities) all have bemoaned the fact that projects are brought to them while they are still very raw, and in need of a lot of project preparation/ structuring/ packaging work.

- *Dependence on Power Purchase Agreements (PPAs) to implement projects*:- Most utilities in the region have very weak balance sheets; a number are technically insolvent and would not be deemed to be Going Concerns without continued government support. This makes it difficult for such utilities to attract finance to their projects. Eskom is by far the largest utility in the region. It is also one of the few that are credit rated. As a result of these two factors, potential funders have tended to insist that Eskom be not only the major off-taker, but also take up a lot of the risk on a project, by way of a PPA. On the other hand, the South African Government and Eskom seek to minimise risk by preferring to transact in Rand thereby passing on exchange risks to the project developers, hence the failure to conclude any PPAs.
- *The perception that dependence on other countries for electricity supply is a security risk*:- Countries are pursuing electricity independence as far as possible, limiting their dependence on imports. This is not only due to the perceived security risk (or lack of sovereign control – being at the 'mercy' of countries which may renege on deals to meet their own needs), but also because of the perception that it would limit opportunities for national investments in energy generation and the associated job creation.

The cardinal principle in limited recourse funding is that the person who can best manage the risk takes the risk. For example, the private sector should take the technology risk, while Government should guarantee the financial credit-worthiness of its utility and the risk of closing the gap between current tariffs and cost reflective tariffs required in PPAs. The region needs to realise that it is competing with other regions globally for private funds, and these will be invested where the governments are creating the right environment for such investment. It is a given that from the onset, the private sector, in general, do not want to take up much risk and they will try to pass as much of the risk to the utility or the government and seek a rate of return well beyond what they would get in developed countries. Accordingly, it will be important to ensure an appropriate risk sharing matrix is developed for the region, so that both the developers, governments and utilities are aware of what is acceptable, which will then facilitate standardisation of PPAs. The dependence on PPAs in the current funding models is certainly a factor, as is the dominance of Eskom as a supplier to the region. In this regard, further concerns stem from the negative impact of the downgrading of Eskom's credit rating on new projects.

Plans to meet Future Demand

The plans to meet future demand are largely a function of the forecast and the criteria used to select options to meet the demand. The forecasts are done at national level and then aggregated to give an indication of the regional demand. Since most of the national demands tends to be coincident in terms of the time of peak the regional demand is taken as the sum of the individual national demands. In practice there is some diversity that provides opportunities for meeting demand with reduced generating capacity.

Table 7.7: SAPP Power and Energy Demand Forecasts

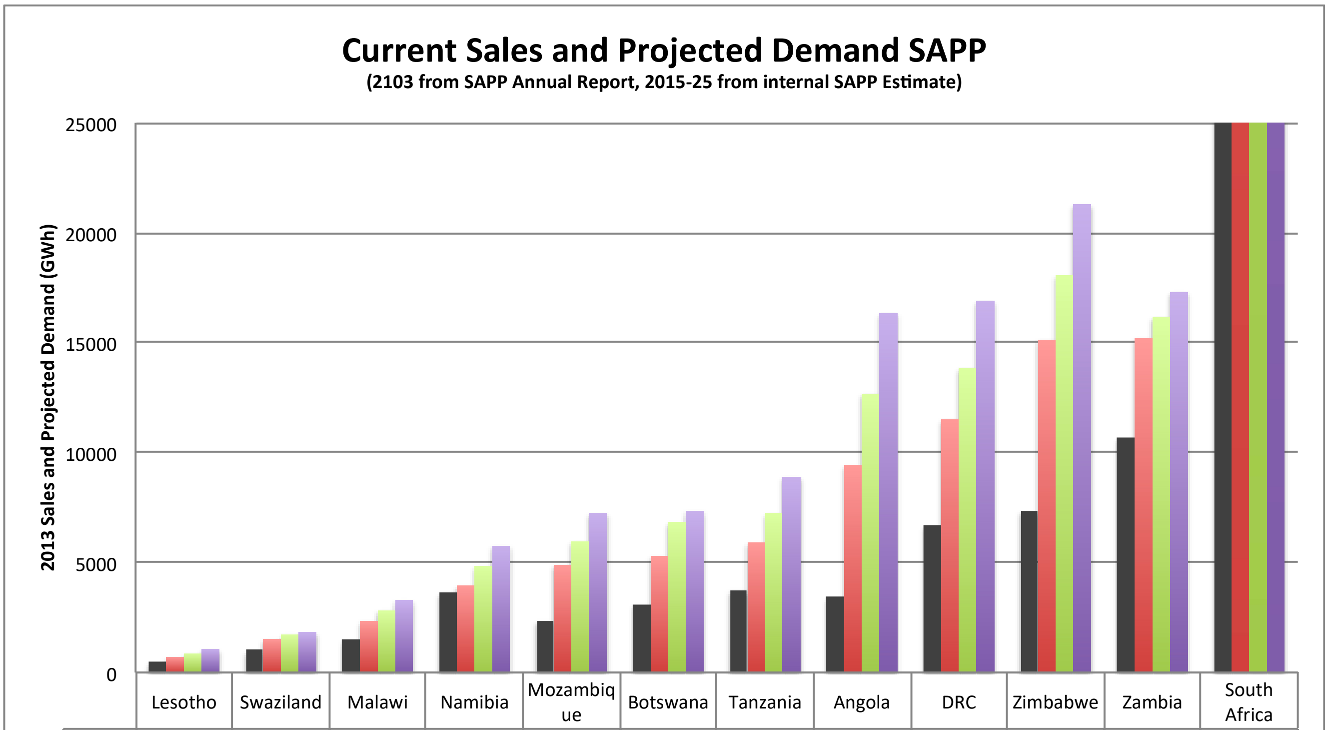
Country	Power (MW)			Energy (GWh)		
	2015	2020	2025	2015	2020	2025
Angola	1657	2226	2871	9437	12674	16345
Botswana	711	924	1111	5298	6848	7336
DRC	1510	1772	2054	11514	13848	16915
Lesotho	141	175	215	706	866	1063
Malawi	340	541	629	2347	2833	3293
Mozambique	714	876	1240	4898	5966	7262
Namibia	598	771	830	3956	4838	5767
South Africa	40659	46759	54264	311474	341021	365152
Swaziland	271	304	323	1534	1720	1828
Tanzania	1365	2881	4017	5911	7252	8900
Zambia	2922	3552	4052	15188	16168	17291
Zimbabwe	2535	3174	3751	15137	18055	21295
SAPP TOTAL	**53423**	**63955**	**75358**	**387580**	**432089**	**472447**
SAPP Interconnected	**50061**	**58307**	**67842**	**369885**	**409330**	**443909**

Source: SAPP (Unpublished internal report, June 2014)

The following shortcomings in the demand forecasts are evident:

- The power and energy demand forecasts are a simple extrapolation of the current situation in each country. This does not take into account the universal access to modern energy by 2030 which is the United Nations Sustainable Energy For All (SEFA) initiative adopted by all SADC countries.
- The forecasts do not take into account significant economic growth and structural changes in the economic situation of the different countries (see Chapter 4). This is where inter-sector coordination (the nexus) is critical because economic and social activities have a direct correlation to energy demand. The composition of GDP affects energy demand because of the differences in energy intensity which is a measure of the relationship between electricity consumption and economic output. Household consumption is estimated on the basis of the percentage with access disaggregated by social class and the average consumption by each class.

It is also interesting to see the projected electricity demands against the actual sales in each SAPP member country in 2013. This is shown in Figure 7.2 below. Note that in some cases the demand is projected to increase significantly in the short to medium term (2103-2015) from existing sales (e.g. Angola, Zimbabwe). Existing sales are potentially constrained by supply, however, demand projections should be closely examined by SAPP.



	Lesotho	Swaziland	Malawi	Namibia	Mozambique	Botswana	Tanzania	Angola	DRC	Zimbabwe	Zambia	South Africa
2013	486	1018	1476	3648	2380	3118	3770	3427	6688	7367	10688	224446
2015	706	1534	2347	3956	4898	5298	5911	9437	11514	15137	15188	311474
2020	866	1720	2833	4838	5966	6848	7252	12674	13848	18055	16168	341021
2025	1063	1828	3293	5767	7262	7336	8900	16345	16915	21295	17291	365152

Figure 7.9 : Current (2013) Electricity Sales and Projected Demand in the SAPP

Criteria for selection of supply options

Electricity planners aim to ensure that supply options are reliable (able to meet the expected quality of supply), secure (resilient, able to cope with variability and uncertainty due to human or natural causes) and affordable (available at prices that people are able and willing to pay). In practical terms reliability is achieved by ensuring that the dependable or firm capacity is equal to expected demand (see Text Box 3), security is achieved by having adequate reserve capacity or emergency response measures and affordability is achieved by selecting the least-cost projects, system optimisation and transmission efficiency. In addition to these technical and economic issues, policy and decision makers also consider social and political factors which often determine the projects that get to be implemented.

Text Box 3: Sovereign Security in Hydropower dependent Countries – Firm versus Average Power and Climate Change

Countries planning energy security through hydropower (in the SADC case, primarily Zambia and Malawi), should typically do so through firm power based on the lowest possible flows. A climate resilience focus would suggest that this should, as far as practical include some assessment of the potential impact of climate change on runoff. Including closing

This would mean that, for the majority of the time, these countries should have excess power to sell. Given that hydropower is generally cheaper than thermal generation, and would hold a lower carbon footprint, there would be immediate cost and carbon benefits to thermally dependent countries purchasing that power.

As we will show later in this paper, this may also hold benefits in reduced water demand.

At a regional level SAPP has a Master-plan developed in 2009 that demonstrates the reliability and cost savings to be achieved through least cost regional projects, rather than through least-cost national plans. At that time, the least cost regional plan to meet the forecast demand to 2025 was estimated to cost US$ 89.3 billion while the alternative of meeting demand based on uncoordinated national plans cost US$138.6 billion, a saving of US$ 47.5 billion. The regional plan had projects with a total capacity of 56,686 MW comprising 18,045 MW hydropower (32%), 23,883 MW coal (42%), and 14,758 MW (26%) gas and petroleum products. The plan was very much dependant on South Africa substituting nuclear power with imports from regional hydropower projects. This was going to require the development of an extra high voltage grid of 765 kV (in contrast to the current levels of 400 kV) from DRC through the Western and Central Transmission Corridors.

However, in 2010 South Africa developed its own Integrated Resources Plan (IRP) for the period 2010 to 2030 which requires new capacity of 42,600 MW to be met through 6,300 MW coal, 9,600 MW nuclear, 2,600 MW hydropower, 9,400 MW solar, 8,400 MW wind and 6,300 MW gas turbines. In 2012 the SAPP then compiled a list of regional priority projects that take account of the IRP. The list comprises 14646 MW hydropower (26%), 9650 MW coal (17%), 9600 MW nuclear (17%), 14,100 MW wind and solar (26%) and 7,620 MW gas, heavy and light fuel turbines. (14%). This list of project totals 55,616 MW which is comparable to the 2009 regional plan although with a very different generation mix, with South Africa largely pursuing sovereign electricity security in generation. This would not only require substantially more capital investment, but also would limit (but not eliminate) potential benefits to be had as outlined in Text Box 3 (see Table 7.8).

Table 7.8: Generation options under consideration

	Generation Options (MW)		
	SAPP Masterplan	SA IRP	SAPP Reg Priorities
	2009	2010	2012
Coal	23883	6300	9650
Nuclear		9600	9600
Hydro	18045	2600	14646
Solar		9400	14100
Wind		8400	
Gas	14748	6300	7620
	56676	**42600**	**55616**

The differences in the generation mix is due to the fact that the regional masterplan was optimised on the basis of minimising financial cost whereas the South African IRP, which really determines the regional plan, is based on a multi-criteria approach that takes account of the need to minimise carbon emissions, maximise local employment creation and other economic and social benefits, mitigates uncertainties associated with renewable energy technologies, and minimises water usage. Although support for regional development is considered in the IRP its weighting is less than the other factors.

Coal remains a predominant supply option in South Africa with substantial resource base. The water consumption of this electricity supply option is relatively low but the CO_2 emissions are high.

South Africa in the IRP considers a mix of low carbon supply options including substantial proportions of **solar and wind energy.** The take up of these options will depend on the investment environment and the incentives for renewables. These supply options also have low water consumption per kWh. Integration to the grid and the "firming" of this temporally variable supply option will be a factor. This issue is discussed further in the section on potential role of hydropower.

Controversy and public perceptions around **nuclear** options will need to be overcome. However, it is likely that nuclear power will become a more common option internationally as safety matters are resolved and reduction in CO_2 emissions becomes critical.

Gas fields in the North of Mozambique and South eastern Tanzania could provide considerable resource for generation with lower CO_2 emission and low water use per kWh. There are also reserves of shale gas that are proposed for exploitation. The water use of the "fracking" process (quality and quantity) will need to be considered should this option be explored.

Distribution of Resources

Phillips in Chapter 3 notes;

> "*SADC countries with limited hydrocarbon reserves continue to rely heavily on hydropower, with major facilities planned or under development at sites such as Batoka Gorge (Zambia/ Zimbabwe), Lower Kafue Gorge (Zambia), Mphanda Nkuwa (Mozambique) and Inga III (the DRC). Extensions to existing hydropower stations are also envisaged, substantially increasing the present electricity generation portfolio of SADC as a whole."*

Table 7.9 below shows the firm and average generation on the Zambezi Basin for Malawi and Zambia. The 2025 demand in both cases is not met by firm hydropower supply, although joint coordinated operation of hydropower means that the firm hydropower generation is closer to the projected demand (World Bank. 2010). Malawi and Zambia will therefore most likely have to import power at times (unless other electricity sources can be found). However, in both countries the average projected energy production is in excess of 2025 demand, which means that these countries could (if development occurs as planned), opportunistically sell electricity into the SAPP. Given the hydrology of these countries, this could perhaps be done with a lead time of some months – ready to meet winter peak power demands in the 'thermal south'.

Table 7.9: Projected Hydropower Supply and Demand - Malawi and Zambia

Scheme	Firm Energy (GWh)	Average (GWh)	Projected Demand 2025
MALAWI			
Songwe I	21	41	
Songwe II	138	245	
Songwe III	114	207	
Lower Fufu	134	645	
Kholombizo	344	1,626	
Nkula Falls	460	1,017	
Tedzani	299	721	
Kapichira	541	1,063	
TOTAL (GWh)	**2,051**	**5565**	**3,293**
With Coordinated Generation	**2604**		
ZAMBIA			
Batoka Gorge North	950	4800	
Kariba North	3180	4180	
Itezhi Tezhi	284	716	
Kafue Gorge Upper	4,542	6,766	
Kafue Gorge Lower	2,301	4,092	
TOTAL (GWh)	**11257**	**20554**	**17291**
With Coordinated Generation	**14300**		

Hydropower in the Generation Mix

The role of hydropower in the mix of energy options for SADC needs careful consideration of the following;

- The apparently high water 'consumptive use' of this energy option in some project locations (evaporation losses – 1,000litres/kWh for Kariba versus 1.5 litres/kWh for South African thermoelectric[65])) must be weighed against the net economic benefits including the lower carbon footprint. The hydropower water use per unit of electricity will decline as more capacity is installed on the existing dams allowing better

[65] This excludes that water used for coal production, as well as evaporation from storage used primarily for securing water supply to Eskom.

usage of the same water. Water use is also lower in the new hydropower stations with smaller reservoir areas.

- The need for a multi-sector approach to optimise the benefits of the water infrastructure according to the needs and priorities of Member States (the water food and energy nexus). Future national priorities and a desire for sovereign energy, water and food security may preclude cross border electricity trade unless this is seen to be mutually beneficial.
- The inter-annual and seasonal hydrological variability in some basins means the **firm** energy available from these schemes is a lot lower than the **average** energy production (e.g. Zambezi hydropower firm = 30,000GWh versus Average of 55,000 GWh[66]);
- Firm and average energy can be substantially enhanced through joint operation of clusters of schemes as shown by the World Bank (2010);
- The World Bank in its multi-Sector Investment analysis on the Zambezi assumes a value of Firm Power at U$ 0.058 / kWh, and Secondary Power at U$ 0,021 / kWh, for its economic analysis. Eskom's estimated costs of generation from coal are U$ 0.042 / kWh[67] (Ham, 2012[68]);
- Climate change is projected to significantly reduce the firm and average production from some schemes. While the presence of the dams and associated storage can assist in flood management and water security, the economics of current and future projects will need re-consideration[69]. This also points to an alternative role for hydropower in the regional electricity supply in the medium to longer term (see below).
- The need for substantial upgrades to the transmission network to properly facilitate useful cross border trade and system optimisation. As detailed above, there are several constraints both physical and geo-political, in the construction of these interconnections that need to be overcome.
- How will the Virtual Water transfers be taken into consideration in the future plans for energy security and electricity supply?

Longer term objectives for Hydropower

In the longer term, once immediate electricity supply constraints have been relieved, the more strategic use of hydropower in the overall SAPP system (less base load - more peaking) needs consideration. This would aim to shift hydropower from a base load low value supply option to one where it works in conjunction with other renewable energy options to firm the capacity of solar or wind energy.

66 World Bank, 2010: "The Zambezi River Basin - A Multi-Sector Investment Opportunities Analysis"
67 Using 1 U$ = 10 ZAR, and does not include capital redemption on new plants.
68 Found at: http://www.probus.org.za/cost-of-power.html
69 Beilfuss, 2012

Climate Change, Virtual Water, Carbon and Cost benefits of electricity trades

A general overview of consumption of water in the generation of electricity and the consequent Virtual Water embedded in electricity trades is provided in Chapter 3. However, such a broad assessment only provides a limited overview of the potential for water, carbon and cost benefits to be had in electricity trades through the SAPP, and detailed assessments of specific transfers will need to be considered. The import and export of electricity across the SAPP depends on the supply and demand situation in any particular year, while the actual trades may be constrained by a lack of suitable transmission infrastructure. The future electricity supply situation in turn depends on the construction of the planned infrastructure (generation and transmission), the maintenance requirements of generation infrastructure, and at least in the case of hydropower the rainfall and runoff. Demands will depend on economic growth, the nature of that growth as well as short term weather events (in South Africa, particularly cold weather in the winter causing peak demands).

As outlined in Chapters 2, 3 and 4, the impacts of climate change on the electricity supply situation in SADC as a whole might be heavily dependent on the siting of the ITCZ across the Zambezi Basin in that year. Climate projections generally suggest that the area north of the ITCZ will receive more rain, while that area to the south may get less. The enormous complexity of the meteorological conditions determining the position of the ITCZ makes it difficult to postulate its likely movement under climate change, and Global Climate Models often differ in their predictions. The additional complexity of rainfall / runoff ratios (Chapter 3) makes it even more difficult to project the impacts on hydropower in the Zambezi. Nonetheless, both World Bank and International Rivers studies suggest up to a 50% decrease in firm power, and an average power decrease of some 25%. In spite of this Table 6 shows that *on average*, Zambia and Malawi *could potentially* have an average surplus of 5,535 GWh/a, should all the planned hydropower be installed.

This *average* surplus, if sold into the SAPP, has Virtual Water, Carbon and Cost benefits to the region and particularly South Africa. Sold into the SAPP at the Secondary Power value used in the World Bank study, it has a value of some U$ 116 million (as an annual average). The cost of generating that power in South Africa's coal fired thermal stations is twice that value. The water saved, using the average water use in ESKOM's thermal stations would be nearly 8 million m^3/a, which is 2.5% of that facility's total water use. This is enough to irrigate about 800ha or provide free basic water (at 6000 L / household / month) to over 100 thousand houses for a year. ESKOM's CO_2 emission factor is 0.99 kg/kWh[70] for 2012, with a target of 0.68kg/kWh. This means a $C0_2$ emission saving in the average surplus (assuming zero emissions from hydropower) of some 5,500 million tonnes or some 2.4 % of the facility's total annual emissions. Comparing not unfavourably with Kyoto's 8% emission reduction target, although ESKOM's other initiatives could reduce total emissions by more than 30%.

While these analyses are, given the data available, necessarily superficial they do nevertheless show that there is some potential for water, carbon and cost savings in electricity trading through the SAPP, which would warrant further investigation.

[70] From http://urbanearth.co.za/articles/eskom-announces-unchanged-electricity-emission-factor-2012

Conclusions and Recommendations

SAPP uses national plans as input but has no mandate to influence national planning except by providing non-binding regional masterplans. Unfortunately national plans are developed without taking account of regional opportunities resulting in sub-optimal developments, but with sovereign electricity security advantages. Clearly political and social factors can, and do, often override technical and economic considerations in the energy sector.

While it is easy to demonstrate the benefits of regional cooperation in economic, water and carbon terms, introducing this into national planning processes will be challenging. It is therefore important that the core message carried to national policy and decision makers shows the relative advantages of regional integration, after electricity security and other legitimate national concerns have been addressed – what CRIDF refers to as;

“*sovereign security with a cherry on top*”.

Perhaps more importantly, these messages must be based on sound analysis and the best available information. The experiences in the SAPP highlight that regional cooperation requires the adoption of multi-sector planning approach to establish credible demand forecasts and multi-criteria approaches to selection of project options that go beyond identification of the least cost to incorporate the national interests of participating countries. This can be achieved by using an iterative planning process as follows:

- Harmonisation of planning criteria and minimising information and data asymmetries - policy and decision makers need to agree on a common planning horizon and to invest resources to establish demand forecasts and project feasibility studies for candidate projects to be considered for national and regional plans.
- Development of national plans that take account of non-negotiable and negotiable national interests.
- Development of regional plans that respect national interests of participating countries but provide information on the economic and other benefits of regional cooperation.
- Review of national plans to maximise opportunities for reliability and economy afforded through regional cooperation. Countries can also make informed cost benefit analyses of the additional costs for national security interests which would now be explicit.

This process should also be based on:

- An improved understanding of the impacts of climate change on firm and average power, and the availability of surplus hydropower for sale through improved downscaling of GCMs. .
- Identification of methods to provide ‘early warning’ of the likelihood of surplus power, and when that may be made available on the annual and daily cycle, for example it has been shown that the flow in the Zambezi is heavily reliant on the previous season’s rainfall.
- An assessment of the feasibility and operation of systems to ‘ramp down’ thermal power plants to maximise opportunities for water, carbon and cost savings – the need for maintenance and margins. This would include the impacts on coal purchase contracts, and the opportunities to sell the coal to other buyers.

It is believed that this iterative process will lead to win-win outcomes in which each country will have internal generating capacity that can be used to meet local demand in emergency situations but also having the opportunity to benefit by purchasing power from the least-cost regional sources under normal operating conditions. The development of large hydropower in the region can help in the development of a clean low carbon energy future by supporting the deployment of more solar and wind energy, and using the considerable average energy potential to reduce operating costs for thermal systems.

It is clear that CRIDF's Virtual Water and Nexus Project can add significant value to both the national and regional planning processes by promoting multi-sector collaboration, and the studies outlined above. Importantly also, with the exception of South Africa many countries do not have a formal participatory planning process and the introduction of hydro-supportive approaches highlighted by Muller (Chapter 5) to other SADC Member States can prove useful in this regard.

Chapter 8: Virtual Water and the Private Sector in SADC

By

Guy Pegram

Abstract

The concept of a water footprint is useful in two ways: 1) helping to understand the role of water in the economy and 2) facilitating the engagement of the private sector.

From the perspective of understanding the role of water in the economy:

Water is strategically important in SADC for the production of agricultural products, industry, mining and power generation. Water is also important in food security and poverty eradication through the support of a range of livelihood practises. The use of water by different sectors of the economy is distinct. For example, rain-fed wheat grown in South Africa has distinct water requirements to irrigation of table grapes in Namibia, which is distinct to the water needs of mines in Zambia, Mozambique or the DRC.

Water in southern Africa is stressed and unfettered use of the resource is not possible. Trade-offs between one water user and another become important discussions as scarcity progressively increases within the region. The concept of a water footprint has been useful in gaining traction in selected areas, especially with regard to bringing water use data in alignment with economic data.

- *It is especially useful in explaining where areas of an economy are more or less resilient once the intensity of different forms of water (green, blue and grey) are understood relative to the water availability and variability, and hence the resilience of the economy to changing water availability due to climate change.*
- *It is also useful in supporting and understanding the trade-offs of water use between different sectors of the economy, perhaps in response to climate change.*
- *It is a useful tool to illustrate the relative amounts of water used where different goods are grown or produced.*

From the perspective of private sector engagement:

The role of the private sector in poverty alleviation through wealth creation and employment generation is firmly accepted by all SADC Member States. Indeed, evidence suggests that the economic multipliers benefiting the poor are greater where the private sector is involved. Although there is no specific policy instrument to guide and support the development of public-private sector partnerships, various committees have established consultative mechanisms with the private sector on various topics.

There exists an opportunity with the water sector too, in formulating partnerships which promote adequate water resources management and governance. This paper explores the nature of private sector engagement with managing water risk, and the use of water footprinting as a tool to facilitate this. Already water footprints have been used by the private sector in assessing their business risks with a product supply chain, operations or a region – including the risks posed by climate change. This paper indicates that the concept of virtual water may also be a useful tool in building dialogue between the public and private sector.

Why is the private sector engaged in water?

Water security risks are becoming increasingly important for businesses

Corporates are increasingly beginning to recognise the risks posed by an insecure water future. In the recent WEF Global Risks Report (2014), water crises were ranked as the third highest global risks of highest concern in 2014. This illustrates the continued and growing awareness of the global water crisis as a result of mismanagement and competition of scarce water resources. Considered together with other high ranking risks such as climate change, extreme weather events, biodiversity loss, environmental concerns and income disparity, water security throughout the value chain and with respect to their 'social licence to operate' are becoming increasingly prominent in corporate decision making.

Not only is water quantity a concern, but water quality too. Pollution incidents have been known to paralyse business operations in parts of China and elsewhere in the Globe, while the impacts of corporates on the quality of domestic water supply has come under increasing scrutiny. As competition for the scarce resource increases, the private sector needs to consistently show their commitment to sustainable water resources management.

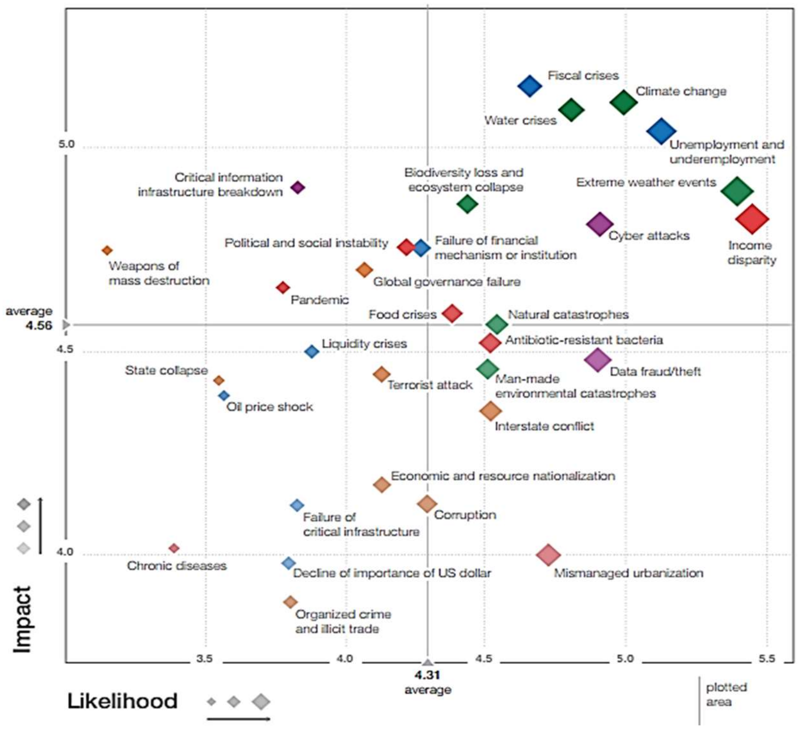


Figure 8.1: Global Risks Landscape, 2014[1]

The increasing awareness of water security risks, as indicated by the WEF Global Risks Report, has led to increasing interest from the private sector in mitigating their water security concerns. Recognising that these risks cannot be mitigated alone, there has been growing interest in collaboration and partnership in order to manage water risks within a catchment.

Corporate experiences of water security risks

The risks highlighted by WEF are not purely academic in nature. There are a number of cases globally where significant physical, regulatory or reputational risk was experienced by companies due to water security risks within a catchment. Poor water quality or water shortages are often blamed on business, even when businesses fully comply with regulatory requirements. Regardless of whether the private sector is solely responsible or not, they are often major economic contributor within a catchment. Therefore, the perception of being a water polluter for example may be as damaging.

Lake Naivasha Cut Flowers[71]

Situated in the Rift Valley of Kenya, Lake Naivasha is an internationally renowned Ramsar site. The Lake is also home to a blossoming agricultural industry, exporting high value fresh vegetables and cut-flowers to European and English markets. Popular news, implicates the lake's ecological degradation on the cut-flower industry surrounding the lake. As a result, the valuable GDP contribution of the flower industry to Kenya has been at risk, as retailers come under scrutiny of consumers in Europe and England. With the onset of a drought in 2009, tensions within the basin began to escalate as competing water users such as agriculture, livelihoods and the functioning lake ecosystem became under pressure.

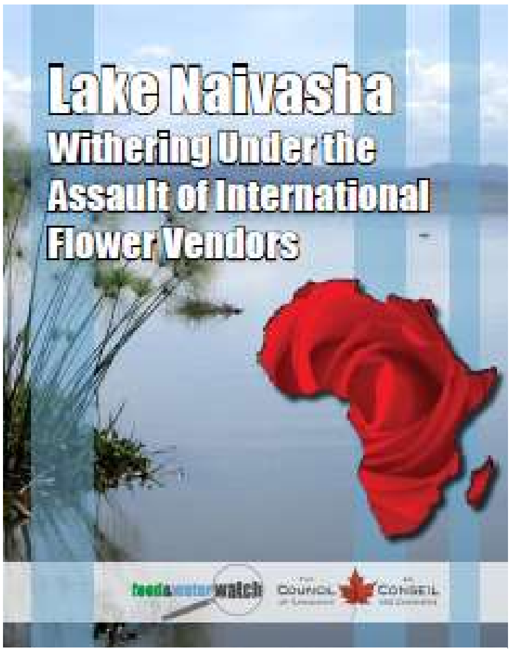


Figure 8.2: Lake Naivasha Report

The response to increasing pressure on Lake Naivasha between all of the competing users was to collectively optimise the management of the water resource. Increasing water use efficiency was carried out through three interlocking strategies: improved governance, fostering partnerships and promoting more responsible individual water use. With solid governance, regulation and enforcement, a broad framework is created which is able to incentivise water users to be more responsible. In the context of Naivasha, partnerships between the different water users helped through the sharing of resources, skills and knowledge, building institutional capacity and collaboration. Finally, the benefits of individual water users taking responsibility of their actions and pursuing better practises that are attuned to the local social and hydrological context[72].

Future irrigation or urban abstraction will continue in Lake Naivahsa, further pressurising the system in parallel with climate change. The already significant development impacts will continue and increase over time due to development pressures, population increase and economic growth in the country. Without adequate communication and collaboration between the stakeholders in the basin, social and economic development will not take place alongside an ecologically sustainable Lake.

[71] http://awsassets.panda.org/downloads/navaisha_final_08_12_lr.pdf
[72] http://awsassets.panda.org/downloads/navaisha_final_08_12_lr.pdf

Kerala Coca-Cola[73]

In 2004, Coca- Cola experienced intense reputational risk as a bottling plant in South Kerala was forced to close down after residents claimed it was draining and polluting their ground water supplies. Globally, the reputational brand value of Coca Cola was believed to decrease in the eyes of many consumers. The incident took place during a time of drought. One school of thought believes that the meteorological effects of the drought would have led to equivalent water shortages in the region, regardless of the water use of Coca Cola.

Figure 8.3: Protests against Coca-Cola in India, Kerala

The incident in India galvanised awareness about water risk among global companies, catalysing action such as collective action, in partnership with communities or public sector organisations in basins which face particular water risks. The incident forced the recognition that perceived negative impacts to the local water supply are as dangerous as actual impacts, due to the civil action and loss of social licence to operate for Coca Cola.

As a result of experiences such as in Kerala, Coca Cola has a well-developed strategy for investigating their water risks associated with particular bottling facilities across the globe.

[73] http://www.ft.com/cms/s/0/16d888d4-f790-11e3-b2cf-00144feabdc0.html#axzz36DuTZ6nZ

Peru Asparagus[74]

A high level search on news regarding Peru asparagus brings the following headline from 2010: “How Peru's wells are being sucked dry by British love of asparagus.” This headline indicates the risks associated with production of particular high-value crops (such as Asparagus) in areas which are water scarce (such as the Ica Valley in Peru). This is especially the case when the high value crops are not consumed within the country, but instead exported to Europe, England or the USA. In some cases in the Ica Valley of Peru, the aquifers are dropping by 8m year, the fastest rate of aquifer depletion in the world.

Figure 8.4: Progressio Drop by Drop Report

The complexity arises when considering the economic value of the crop export to the economy of Peru, where the Ica Valley is home to 95% of Peru’s asparagus. The awareness of consumers in the UK and EU has led to some innovative measures in order to reduce the significant water use of the agricultural practise. Water footprinting has been instrumental in bringing this subject to light. The trade of produce with high amounts of embedded water has been initiated through the concept of virtual water and water footprinting.

Investor concerns

Not only companies, but many investors are also becoming increasingly concerned with respect to water security risk and their investments globally. This is evident through the increase in tools and guidance such as the Lloyds 360 degrees risk report on Global Water Scarcity or the Carbon Disclosure Project on Water Component.

“In Deloitte’s work with the Carbon Disclosure Project to survey and report on executive awareness of global water issues, an upward trend over the past couple of years has been seen in the perceived level of risk exposure associated with water scarcity in both direct operations and supply chain operations. In 2011, the CDP survey indicated that 59% of companies were reporting at least one water risk, and more than 65% of these same respondents report having a potential for this type negative impact now or within five years.[75]”

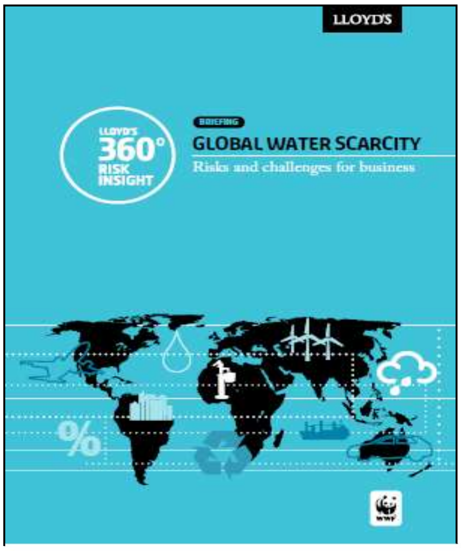


Figure 8.5: Lloyds 360 Global Water Scarcity Report

[74] http://www.progressio.org.uk/sites/default/files/Drop-by-drop_Progressio_Sept-2010.pdf
[75] http://blogs.deloitte.com/greenbusiness/2012/05/investor-interest-in-water-risk-on-the-rise.html

Water insecurity may also be seen as an opportunity. In the CDP 2012 report, 63% of respondents consider water scarcity as a potential driver of innovation in their companies. Opportunities in water efficiency, revenue from new water products or services, and improved brand value through effective handling of water issues are some of the opportunities listed.

The interest of investors is pertinent due to the potential disclosure requirements which may be needed of companies should they begin stakeholder engagement to mitigate water risks for example. A lack of disclosure, implying a lack of adequate consideration of the challenge may forfeit particular sources of funding for projects which are particular at risk.

Motivations for engagement

The motivations for engagement may be varied from the private sector perspective. Water risk may result in a range of associated risks to the private sector, as indicated in the following figure. Risks include physical risk, which is directly related to too little (scarcity), too much water (flooding) or water this is unfit for use (pollution), as well as water quality risks (not necessarily directly associated with the business operation), each of which is associated with the management of the water resources. Regulatory risks are related to the government's management of water resources, particularly during times of physical water risk. Reputational risk is related to the exposure of companies to customer purchasing decisions, associated with the perceptions around business decisions, actions or impacts on water resources, aquatic ecosystems and communities that depend on them[76].

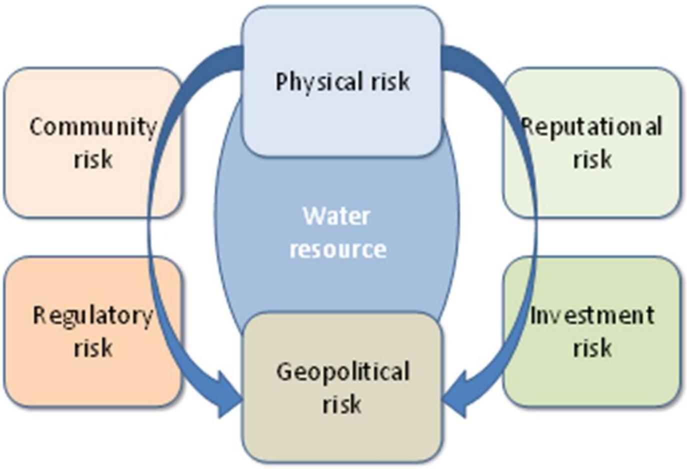


Figure 8.6: Managing the suite of water risks

The previous three examples (Lake Naivasha, Kerala and Peru), although resulting in different forms of engagement around water risk mitigation, all stemmed from a reactive response to an operational crisis. In all three cases, the future of the water supply was under threat.

A range of motivations for engagement from the private sector include the following:

- A reactive response to existing operational crisis as seen in the example from Kerala, India. Following that, Coca-Cola has changed the procedure in which risks are analyzed within catchments where they operate.

[76] http://www.pegasys.co.za/pdf_publications/Investigating%20Shared%20Risk%20in%20Water_Corporate%20Engagement%20with%20the%20Public%20Policy%20Process.pdf

- A strategic risk in the future to operations or supply chains is often carried out once the current risk to the operation or supply chain is explored.
- External pressure from investors and consumer advocates is evident through a number of requirements from disclosure reports such as CDP Water or corporate governance requirements.
- Leadership positioning related to corporate social responsibility may be an additional driver for engaging water stewardship initiatives to minimize water risk.
- Competitive advantage in marketing the company may be an additional benefit to managing water risks in a collective manner within a catchment. It is critical that this is done strategically alongside other drivers for engagement to reduce the perception of "green washing."

As indicated, there are a range of drivers motivating engagement of the private sector in water risk management. These drivers are not mutually exclusive, and can be used as a suite of motivating factors for a company to engage.

Corporate risk assessment tools

In order to improve corporate water management, and ultimately to support sustainable water resources management, corporates need to be cognisant of their particular water use and related impacts. Without knowing their relative total water use footprint or polluting effect, real engagement cannot take place. Corporate water accounting needs to be done in unity with other corporates and public institutions to understand the broader context of water risks within a catchment.

There are a wide range of corporate water risk assessment tools which have been developed to support companies or investors in assessing the water risks being faced. Depending on the audience or the nature of the risk, different tools may be used. This may also pose a risk in some cases, as corporates have been known to use assessment tools only when the results suit their needs. The challenge of business interests driving the metrics used in the water sector is a real concern. Critical analysis needs to take place before taking on board assessment tools, to ensure that the metric has not been developed solely to support a business's own interests. Therefore there are challenges associated with which risk assessment tool or guide to follow because the development of corporate interest is relatively new.

Figure 8.7: A range of water risk assessment tools

Tools may either be web-based or excel based, and may use global data-sets or be based on internal facility information alone. Some of the most often-used tools include the DEG-WWF Water Risk Filter and the WBCSD Water Tool. ISO have also been developing a water risk assessment guideline, and have been moving towards the establishment of an ISO standard for water footprinting.

Water footprinting is one of these tools, which has been used by a range of companies in assessing the intensity of their water use in relation to a wider catchment. Water footprinting was originally developed as a quantification of the concept of Virtual Water, coined by Tony Allan. It has since been used in the calculation of a number of trade-flows, indicating the movement of embedded water between countries.

The Water Footprint Network (WFN) has done major work in establishing guidelines on how to carry out the water footprint methodology at a number of scales, including a facility, product, regional or national level. Corporate Water Footprints measure the total volume of water used directly and indirectly to run and support a business. The corporate water footprint is equal to the sum of the direct and indirect water footprints of all products including raw material production, manufacturing and distribution.

Where does the Water Footprint have traction?

As indicated previously, some water risk assessments are useful depending on the information availability or risks of concern. The same is true for water footprinting. The concept of the water footprint has traction in a number of ways for the private sector. The areas of traction include understanding the water footprint of: supply chains, operations, use phase and regional implications. These areas of traction are supported by high level case examples.

Supply chain

At a supply chain level, the concept of the water footprint is especially useful to identify high water intensive inputs into your product and the source of that water (as blue water – extracted from surface or ground water or green water derived from rainfall and soil moisture). This can also be done for inputs across a range of regions, to identify the water risks associated with sourcing inputs from one area as opposed to another. Schreiner and Quibell in Chapter 6 highlight the role water allocation may play in building climate resilience.

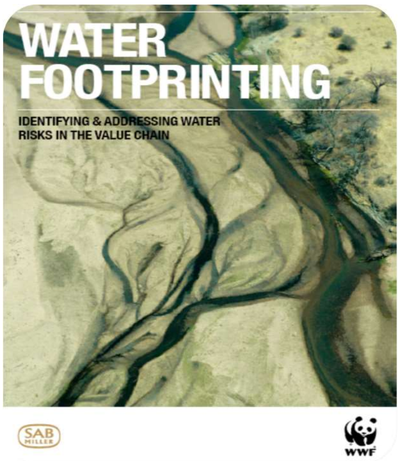


Figure 8.8: SAB Miller Water Footprint Report

SAB Miller

SAB Miller is one of the most well-known cases of a company carrying out a water footprint for the purpose of supply chain water intensity identification. SABMiller carried out a water footprint for their supply chain, calculating the water embedded into their entire value chain, across a range of locations where they source their inputs. They found that the majority of the embedded water in their beer products was situated in the cultivation of the crops used in beer (i.e. barley and maize represent 90%). The relative water use in the crop processing, brewing, distribution and consumer phase of the product lifecycle was significantly less (10%).

In addition to finding of the relative intensity of embedded water across the supply chain, SAB Miller also investigated the relative water footprint of crops such as barley, or hops or maize across a number of countries globally.

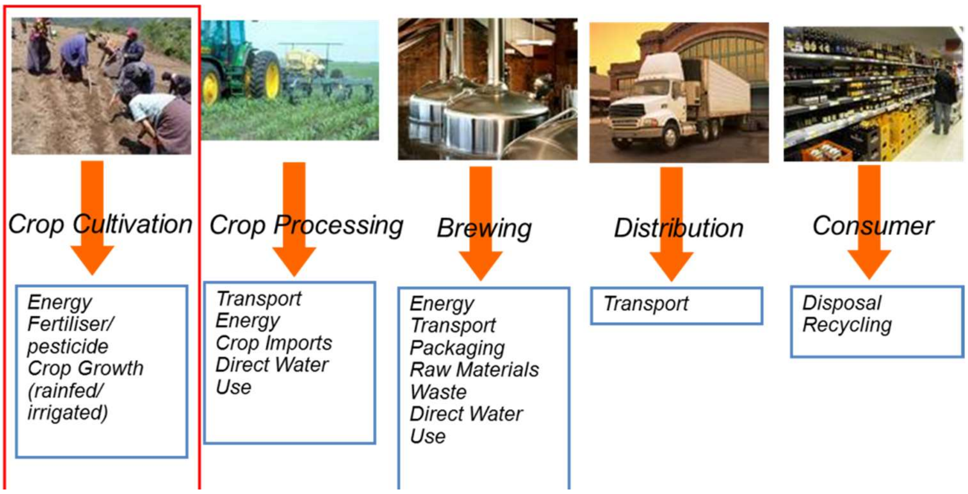


Figure 8.9: Beer Production Supply Chain

A comparison was done between beers produced in South Africa vs. the Czech Republic. It was found, that in absolute numbers, the water footprint for beer in South Africa (155 litres per litre of beer) was more than three times the Czech Republic's footprint (45 litres per litre of beer)[77]. The SAB Miller Report is quick to add that this is not due to any difference in efficiencies, but rather due to the higher evaporative demand for crops in South Africa and the increased reliance

[77] http://www.sab.co.za/sablimited/action/media/downloadFile?media_fileid=918

on irrigation, adding a significant blue water portion. Nonetheless, that in itself is a telling metric with respect to climate change.

Therefore, a supply chain water footprint can be helpful to corporates, not only in identifying the relative embedded water requirements across the supply chain, but also to compare supply chains across different regions.

Illovo (Zambia Sugar)

Like SAB Miller, Illovo have carried out a water footprint for their supply chain. Focussing on their major operations in Zambia Sugar, they focussed on the nature of the different water types, and therefore the relative requirements of each in terms of quality and assurance of supply.

As indicated in the figure, the majority of their water footprint stems from crop cultivation, with a large proportion attributed to blue water irrigation.

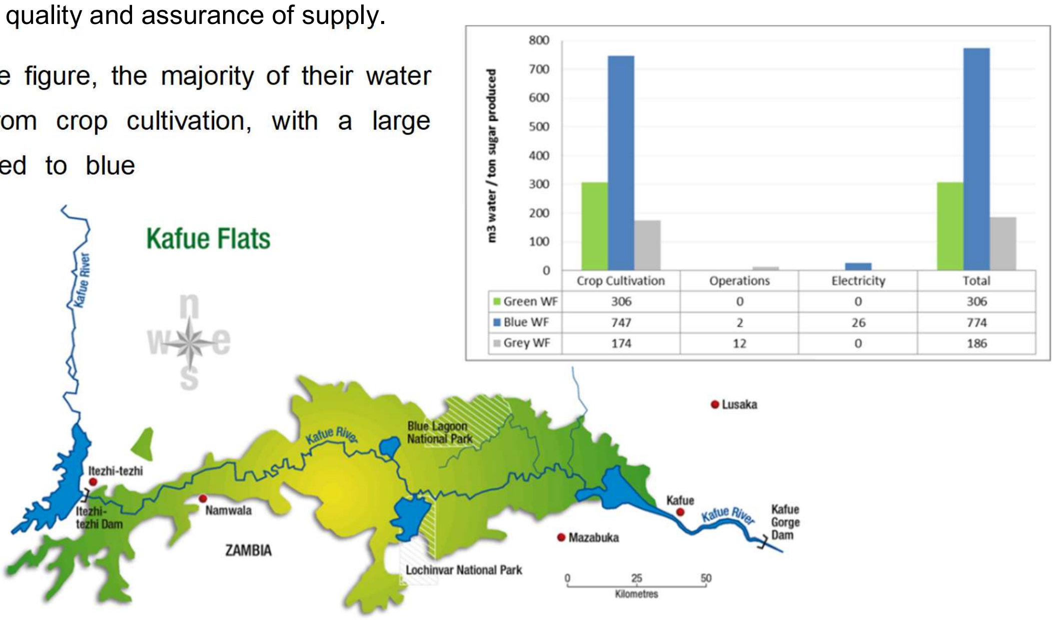


Figure 8.10: Zambia Sugar Water Footprint in the Kafue Flats

The value of doing the water footprint, was to better understand the relative water use in the context of an already water stressed Kafue River Basin in Zambia.

Setting these findings against the water footprint of total agricultural exports from Zambia also provides for useful metrics. CRIDF's Virtual Water database shows that sugar exports from Zambia include some 72% blue water and some 28% green water, and earn the country some U$ 128 million/a in export earnings. Total agricultural exports from Zambia include some 8% blue water, and 88% green water, earning some U$ 880 million in export earnings. Illustrating the relative importance of irrigation of sugar to Zambia's agricultural export earnings, and hence its vulnerability to the potential combined effects of reduced rainfall and runoff, as well as competition with other users.

Operations

Some corporates may use the water footprint methodology at the operational level. In this case, the water footprint alone may not be as useful, as the number itself may vary widely depending on the growing season, variability of rainfall or temperature or even where the crop is grown. The tool is useful however, in conjunction with additional information collected at an operational level.

Coca Cola

Coca-Cola uses a range of tools in the determination of their operations facility vulnerability to water risk. The company has faced significant challenges in the past with regards to water security. In many cases, it was a lack of knowledge regarding the wider catchment water security and social context which led to the significant reputational risks in Kerala for example.

In light of the risks which Coca-Cola has faced, they use systemic method to identifying and investigating all of the risks in a catchment. Through a tiered approach, they have a framework which considers where the plant is located, the relative water use of the facility in the catchment and other indicators which may give light to the water risks in the catchment. These elements include the runoff, irrigation, night lights and population of the region where the plant is located.

Figure 8.10: Information layers for Coca-Cola vulnerability assessment

The wide range of information helps identify not only physical, but reputational and regulatory risks associated with the local social and economic context.

A water footprint alone to identify and motivate corporate water risks at an operational level is not sufficient. However, as indicated by Coca-Cola, when supported with additional information, a water footprint may be useful.

Use Phase

Traditionally, most water footprinting analyses consider the upstream water use of a product of facility in order to understand the relative weight of embedded water in the product or facility. In some cases however, a product may have a higher water footprint at the consumer use phase. This is the case for P & G Fabric Care.

P & G Fabric Care

P & G Fabric Care have carried out a high level water footprint analysis to identify the relative importance of efficient water use at the consumer level for their product. Unsurprisingly, the majority of embedded water in fabric products is at the user stage. This has implications for the focus of P & G in terms of being good water stewards. In light of the information from the water footprinting assessment, their focus may arguably need to be around reducing the rinse requirements of their products or supporting water saving techniques at household level.

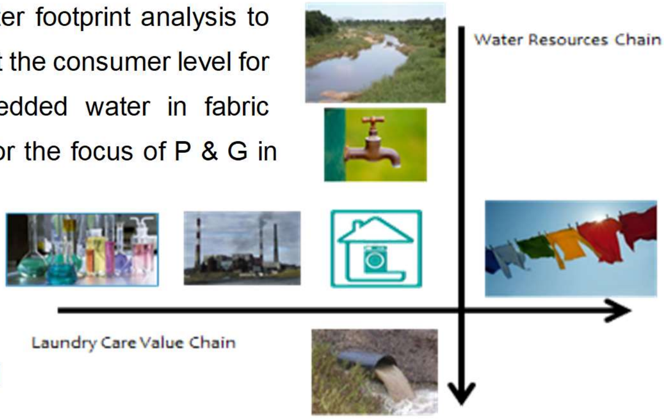


Figure 8.12: Laundry care value chain and water resources chain

The value chain of fabric care products is essentially the complete opposite to that of beer production for SAB, where 90% of the embedded water is attributed to the consumer use phase.

Figure 8.11: Fabric Care Supply Chain

A water footprint is useful in this regard for corporates due to the ability to clearly communicate to consumers the relative importance of their washing practises for water efficiency. The water footprint is also useful in this respect in justifying additional focus from P &G in managing their future customers water needs to secure the future market.

Regional implications

Water footprints need not be done on a single product from a corporate perspective. Corporates may also compare, or analyse their respective water footprints and associated risks across a region. Carrying out a water footprint in relation to the water scarcity context in which the footprint is situated is particularly helpful in identifying water risks both for the company, but the catchment in which they are situated too.

SAB Miller

SAB Miller has carried out a range of water footprints for their products across the globe. As indicated previously, the water footprint to produce a litre of beer in South Africa is three times that of The Czech Republic.

SAB Miller have further taken the water footprint of their respective input needs, and overlaid this with an understanding of water scarcity in the region where produced. Although the water footprint for beer in South Africa is higher, the local context of being a South African company, with inputs being sourced from its home country, makes it difficult to move input sources. Indeed, as Muller's paper (Chapter 5) points out, water is usually a relatively less important metric in the siting of large developments. Nonetheless, the value of the water footprint at a spatial level is the insight of overlaying where inputs are sources with areas of significant water scarcity within South Africa. Through assessments such as these, the information gathered can help substantiate a business case for increased engagement in water saving technology, or catchment management for example.

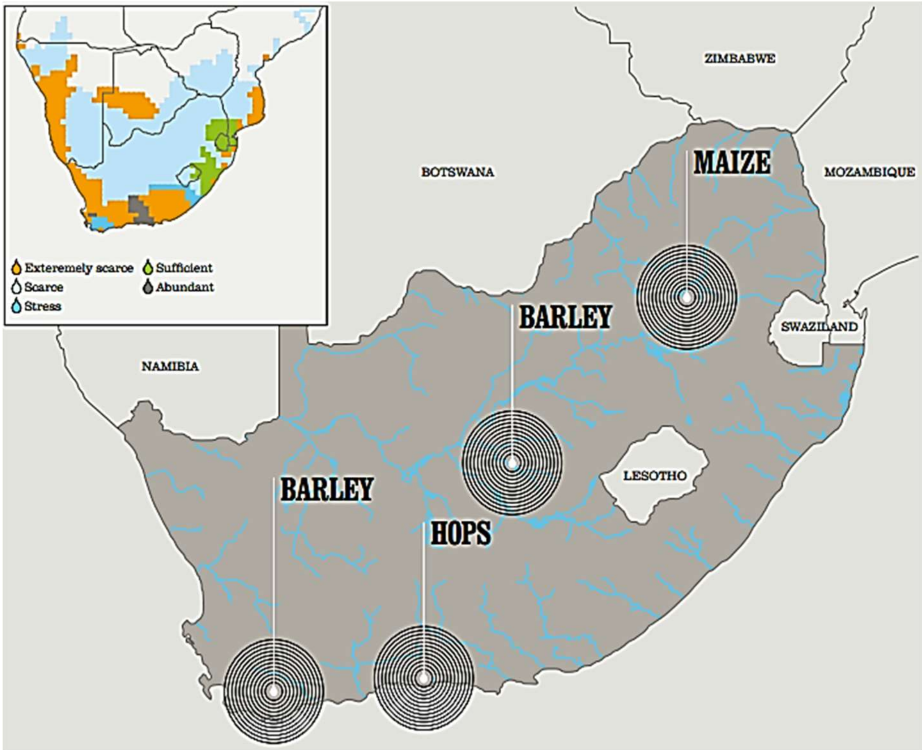
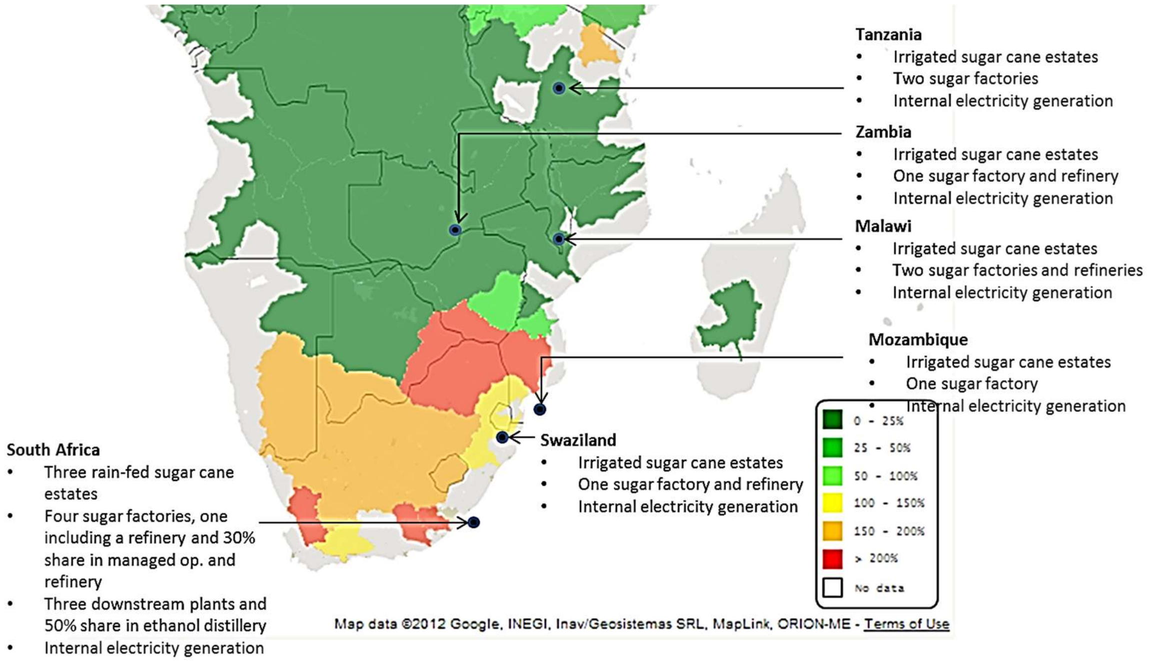


Figure 8.14: Crop growing regions across South Africa (large map) and annual renewable water supply per person (insert map)[1]

Illovo Sugar

Illovo Sugar has also carried out an assessment of their product water footprints at a regional scale. In the case of Illovo Sugar, the focus of the water footprint method was to identify the different nature of water use for sugar production in each Southern African country. With an improved understanding of water use needs (i.e. blue vs. green), Illovo are better able to understand their risk to droughts or climate change. Where there is a larger blue water footprint, irrigation is used more, and therefore vulnerability to irregular rainfall is reduced, although in the absence of significant storage the vulnerability to the multiplier effects of reduced runoff coefficients and reduced rainfall increases (Chapters 2 and 4). In the case of Illovo Sugar, the exact water footprint number is less of relevance than using the concept to map and identify approximate areas of concern.

The figure below indicates the Illovo Sugar major sugar cane growing regions. The base map is the WWF-DEG Water Risk Filter, indicated areas which experience water stress. The map shows the vulnerability of sugar cane grown in Swaziland and South Africa to drought stress and competition for water. However, as indicated in the annotations, these areas are mostly irrigated cane growing regions with significant storage, and are therefore protected against some of the climate variability. The increased irrigation however, means that the water use is in competition with other users such as industry or urban development, and therefore may still be under threat.



What is the value of the water footprint to the private and public sector?

The concept of the water footprint is useful to the private sector in better understanding their supply chain, operational, consumer and regional embedded water use. However, the concept is also valuable in building dialogue between the private and public sector.

As indicated in the figure below, the concept of the water footprint helps to translate 'water-centric' concepts of water resources into more politically tangible 'water-supportive' (Chapter 5) concepts such as economic activity (GDP contribution or employment) or even further into trade. The development of a common language for b

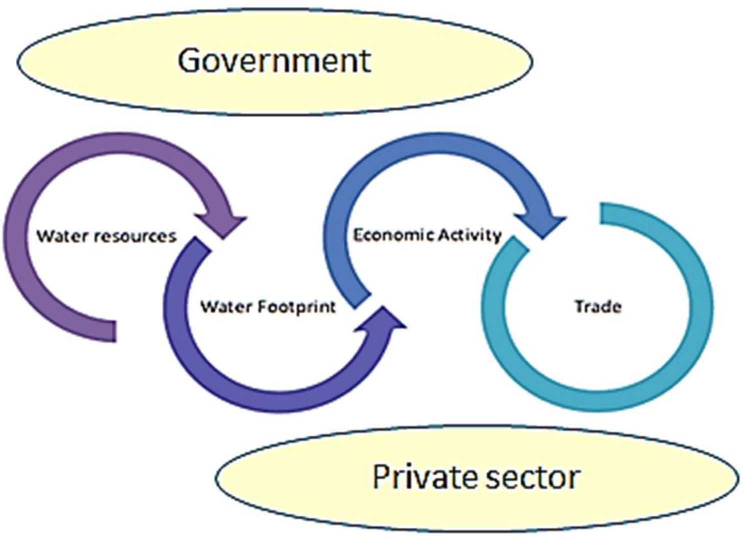


Figure 8.12: The role of water footprinting in building dialogue between the private and public sector

in the economy is invaluable in the creation of conversations around economic investment and development. Indeed this is a key recommendation emerging from Tekateka's Chapter 10.

At a basic level water footprinting is useful at the each scale for the answering the following key questions:

- Supply Chain:
  - Where is water use the most intensive?

This helps corporates or farmers identify how to use water better, ensuring less loss at a field & system level. At a supply chain level, a water footprint may also help in using water smarter and selecting the best crops / practices for the region.

At a consumption orientated supply chain level, the water footprint can help in education towards consuming less embedded water.

- Operations
  - How to use less water better?

Like in the supply chain, at an operational level, the water footprint is useful in identifying where the majority of water is being used, so that efficiencies can be gained.

- Regional level
  - Is this the best use of water considering the stress and economic value of the product?

A water footprint at a regional level may help with the identification of economic activities using comparative advantage. Comparing the relative water use intensity vs. the GDP contribution or employment may support decision-makers at a regional level with regards to which economic activities to support.

The regional water footprint lens may also help identify development opportunities for livelihoods and equity. The uses of a water footprint at a regional scale are also especially helpful for building dialogue. Moreover, for corporates like SABMiller and Illovo there may be opportunities for regional risk pooling to increase climate resilience, particularly in terms of limiting the risks to outgrower schemes.

- Dialogue
  - WFs help to develop a common understanding of the value of water in the economy between government and business.

Effective dialogue between the private and public sector is absolutely necessary for risk sharing and collaborative management of water resources to take place. The concept of embedded water and water footprinting is especially useful in highlighting the water imports and exports associated with trade. This may help in the selection of developing particular products for import or export, or highlighting the contribution of rain-fed or irrigated crop production to the national economy.

The value of understanding the water footprint between different sectors and regions is also through the potential for regional integration. The concept of embedded water is useful in illustrating the concept of benefit sharing between countries.

At a SADC level, water is stressed. Although water footprinting alone is unable to meet all the needs for adequate water resources management, it is a useful tool for the purposes mentioned above. In many parts of SADC for example, crops are grown where the embedded water is far greater than if the crop was grown elsewhere. Notwithstanding the hydro-centric versus hydro-supportive concepts debated in Chapter 5, and the fact that the locations for crop production are influenced by a number of metrics, the concept of embedded water allows planners to compare the comparative advantage of particular crops and economic activities, in light of their water needs.

The real benefit of using the concept of embedded water in the SADC region however, is through the development of a dialogue. Whether between the private and public sector, or between different countries within SADC, the use of a neutral water risk assessment tool will greatly benefit communication. As indicated previously, the tool alone is not adequate. However, it is able to translate complex water resources and economic jargon into accessible illustrations of the flow of water through an economy.

Chapter 9: The International Experience

By

Tony Allan

Abstract

The purpose of this chapter is first, to throw new, if very belated, light on the challenges associated with conceptualising what we shall refer to as the grand nexus of water-food-energy; including the key associated processes of international trade and climate change. The challenges are evident at both the international and regional scales.

Secondly, it will trace the emergence of the terms water-food-trade sub-nexus and of the energy-climate change sub nexus. It will be shown that, separately, the two sub-nexi, of water/food and of energy, have been relatively effectively conceptualised. But the attempts to combine them have proved to be problematic. This is a significant difficulty if water and energy professionals and private sector parctitioners are to analyse and interact about them.

Thirdly, it will identify the political economies and the global regimes in which the two sub-nexi are embedded, highlighting the role of the separate private sector markets in the food and the energy supply chains. It will be concluded that it has not been possible to develop a grand conceptualisation of the water-food-energy nexus that includes trade and the consequences of climate change. In the absence of a sound conceptualisation it will be suggested that the tendency to deploy a hot-spots approach will prevail - evident in for example the water resource use contradictions associated with developing shale gas and tar/oil sands and in producing ethanol from corn and other food crops. This hot-spots approach will continue to be deployed until the private sector players - who operate rather than conceptualise the complex food and energy supply chains in the two sub-nexi - recognise that they are taking unacceptable associated risks. The risks are the result of not promoting policies that take into account the essential mutuality of water security and energy security. It will be concluded that the major problem is that current private sector reporting and accounting rules do not capture the value of natural resources as inputs nor the consequences of misusing them in private sector supply chains. In the private sector world in which food and energy are managed and mismanaged it will be necessary for an informed coalition of investor and regulatory influences to be brought to bear.

Key words: water-food trade sub nexus. energy and climate change sub-nexus, water-food-trade-energy-climate change grand nexus, private sector supply chains, reporting and accounting rules, investor influence

Introduction - the *water food and trade* and the *energy and climate change* sub-nexi - conceptual and operational problems

> No effective analytical framework will be available until the private sector players - who operate rather than conceptualise the complex food and energy supply chains in the two sub-nexi - recognise that there are unacceptable risks in *not* promoting policies that take into account the essential mutuality of water security and energy security.

This section explores the relationships between the *water, food and trade* sub-nexus, the *energy and climate change* sub-nexus and the political economy in which they are embedded, but not mutually integrated. It addresses the impacts of volatile markets and climate change and changing trade patterns, and the global systems around the food supply chain and global energy system.

The ways that natural resources such as water and energy have been developed and consumed by society have *not* been shaped by awareness of their scarcity or their value. As a consequence the current generation of scientists, legislators, and those managing private sector supply chains have a special responsibility. They find themselves coping with what can be called the second failure of capitalism, a condition mainly brought about by assuming that natural resources come free and that there are no consequences of misuse. The first failure of capitalism became evident at the end of the eighteenth century at a time when those with power believed that labour came free. Slavery existed and other labour did not need to be treated fairly. These lethal and unsustainable assumptions were progressively eroded by an increasing focus on fundamental rights of people. Social democratic movements saved neo-liberal capitalism in what are now OECD economies by forcing it to treat labour more fairly and install infrastructure and welfare systems that made the evolving neo-liberal market systems potentially sustainable. Labour had a collective voice that made the risks of volatile politics and revolution very evident.

Natural ecosystem services, which are currently at risk, do not yet have the same power behind a collective voice. The environment is gradually being given a voice, and a similar discursive political process is in train in some cases leading to legislative support. However, the political heat is not yet high enough - at least regarding water. This, it may be argued, is not yet a *visibly* critical and potentially catalytic obstruction, but as resources become increasingly limited it may well become so. The term 'NEXUS' has so far not helped establish the urgency of society's predicament in this regard; it could mean Natural Ecosystems eXpect Understanding Stewardship. A better acronym would be ***NEXAS*** - Natural Ecosystems eXpect Accountable Stewardship, a shift from understanding the issue, to one where one is held accountable for a duty of care.

Coping with this second failure is proving to have its particular challenges. First, as already mentioned nature's systems do not have a loud collective voice. Secondly, again as indicated, the risks associated with the ways that ecosystem blind private sector supply chains manage natural resources are incremental and can be invisible for decades. Thirdly, there is no capacity or motivation to consider such risks when the costs of adopting environmentally sustainable measures seem to be counter-intuitive. They would be too costly with potential benefits perhaps lying beyond the horizon. Investment in stewardship has to compete with more urgent investment priorities. These include the interests of shareholders, employees and customers, many of whom exist in poverty. Fourthly, in the case of the food supply chain for example - where a significant proportion of food supplies have to be cheap - commercially weak farmers who manage food production and 90% of the water needed by society - face impossible challenges. Debt, death and aging. It will be shown that farmers manage and mismanage 90% of the water resources consumed in food supply chains, which impacts on the atmosphere and water and other ecosystems. Society needs farmers, at this point in history more that ever, to be (or become) good stewards of natural ecosystems. But, unfortunately, private sector food supply chains that connect consumers with those who produce food are dysfunctional in terms of accounting for ecosystem health. Current food supply chains are not ecosystem sustainable.

There are four reasons for the above conditions. First, food is very emotional and food prices are very highly politicised. Food supply chains are impacted by subsidies that are of vital significance to poor communities in OECD countries. Secondly, there are serious asymmetric power relations in food supply chains. Farmers are generally weak but farm lobbies in OECD countries are very powerful and the resulting OECD agricultural policies - the EU CAP (Common Agricultural Policy) and the US Farm Bill - generate low global staple food prices. Supply chains that have to produce cheap food at all costs make life impossible for would-be commercial farmers in regions facing poverty. Thirdly, those with power in private sector food supply chains, the corporates, usually handle a very small proportion of the embedded natural resources that occurs inside the fence of their operations. They have potential contractual leverage over farmers who do manage the vast volumes of water in the supply chains, but they have as yet had few incentives to engage outside their warehouses, silos, factories and wineries. This is however changing as Pegram points out in Chapter 6. Fourthly, market signals and the reporting and accounting systems that track them are dangerously partial, as well as blind to the values of natural resource inputs, especially of water. They also do not capture the costs of mismanaging them. Any progress towards a sound approach to managing natural resources requires the constructive engagement of private sector corporates with their suppliers and with governance processes more generally (Muller 2013).

By the mid-twentieth century major, often very long international private sector supply chains, had been established. These very important and very long international supply chains, in which water and energy are embedded, have existed for over a century. They have supplemented, in major ways, the short private sector sub-national supply chains that have secured food and energy for the world’s increasingly urbanised populations. Most of the world’s 220 or so national economies are net food importers, despite some of them having significant land and water resource endowments. This condition is a good example of poverty determining water poverty. The SADC economies are mainly net food-water (Virtual Water) importers despite some of them having significant land and water resource endowments (See Figure 9.1). South Africa is the biggest participant in SADC international food-commodity trade, accounting for 32% of SADC exports and 40% of SADC imports, thus strongly influencing the regional trade metrics. The farms and vineyards of South Africa produce high value crops which are also water-efficient. As a consequence, Virtual Water exports from SADC, while volumetrically less than ½ the imports, are net earners of foreign exchange. In this context the CRIDF small infrastructure programme is a very appropriate approach. It has the potential to increase the water using efficiency of poor farming families by facilitating the installation of essential works that might otherwise not get built. If this supports a decrease in the dependency on food imports it may have broader regional multiplier benefits.

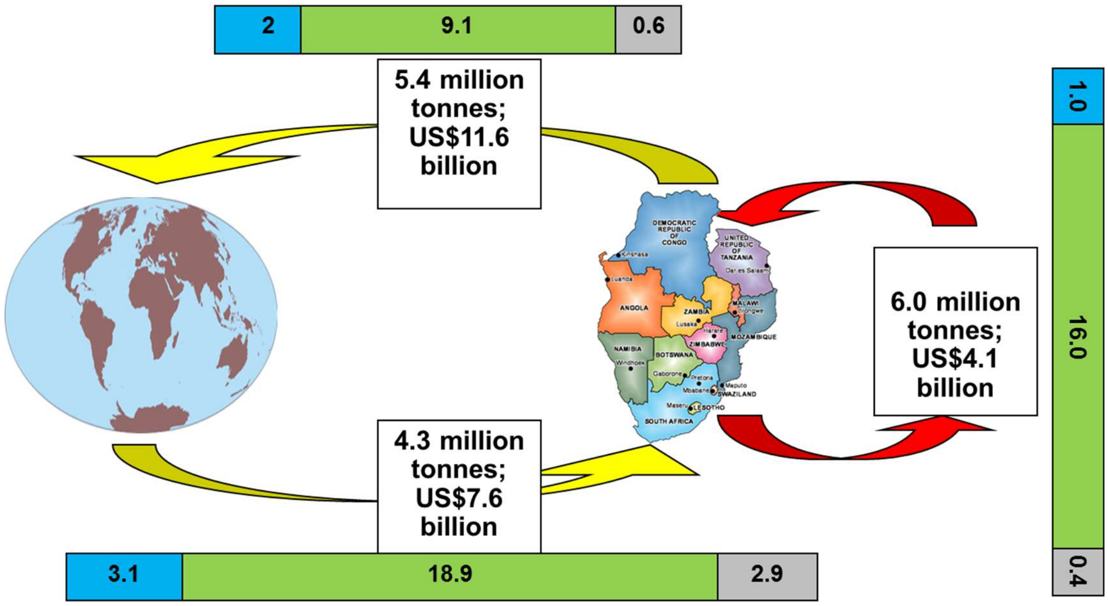


Figure 9.1 The imports and exports of agricultural products (in total) in 2012 amongst the continental SADC countries, and between these and the rest of the world. Tonnages and values are shown in text boxes; the accompanying blue, green and grey virtual water transfers are shown by 'colour' in cubic kilometres. (re-drawn from Phillips – Chapter 3)

The food and energy supply chains are both market systems. But they have taken very different approaches to valuing water, food and energy. Food and energy have always been of high strategic significance to societies and to the governments that are responsible for their security. The ways that food and energy are priced are the result of existential processes in the political economies of food and energy. Both food and energy are also extremely emotional at all levels of social organization. In addition they are also deeply embedded in the social contract between society and those who govern. As a consequence, the tools available to States in intervening in their political economies - taxes and subsidies - feature very prominently in food and energy policies (Paarlberg 2013). Once in place taxes and subsidies have proved to be even more difficult to remove as they were to install. Those in power have judged that they can best stay in power by ensuring that their poorest citizens enjoy access to cheap food and enjoy stable energy prices by minimal changes in business as usual tax and subsidy regimes. As a consequence food supply chains are associated with a myriad of direct production subsidies - for example the policies of the EU Common Agricultural Policy (CAP) regime and of the US Farm Bill. In many low-income economies the subsidies are indirect through the provision of subsidized diesel or electricity to pump water for irrigation. These energy subsidies in poor economies are as invisible as the taxes on petrol and diesel in OECD countries. Such diverse pricing regimes have in common extreme politics that determine the political feasibility of introducing ecosystem stewardship.

At this point in history, at beginning of the twenty-first century, the outcome of the past two hundred years of the evolution of the political economies of food (Paarlberg 2013) and of energy (Pascaul and Elkind 2009) is that global food prices are determined by massive policy interventions by the OECD economies. These OECD policies also determine in some cases, and in others have a deep influence on, the prices in emerging and especially in developing economies. They have impacts on the SADC economies. These distortions have been reinforced by

World Trade Organization arrangements. Water resources have been dangerously impacted by these interventions because it has been assumed that there were no costs associated with over-using, depleting and polluting unvalued or under-valued water ecosystem services and the atmosphere.

In the case of energy, prices have been even more distorted. Until about 1980 it was assumed in the energy sector that the consuming and misusing, in this case of fossil fuels, had been environmentally costless. But consumers of dirty coal, and especially more recently of dirty oil and gas, have been prepared to pay prices for petrol that have been loaded with taxes. In the extraordinary period between the early 1900s and 1972 crude oil was priced at the oligopolistic level of $2/per barrel. This non-economic price was in place for 70 years until the price spikes of 1973 and 1979. In its aftermath in the early 1980s the US global energy regime was able to force prices back down to pre-spike levels, taking into account inflation. Doing the wrong thing extremely well is a common feature of capitalism. With such unsustainable processes society can enjoy some short term benefits but some communities, the atmosphere and natural ecosystems have paid a very high price.

It will be a recurring theme in this analysis that the scarcity values of water and energy embedded in food and manufactured commodities, are not reflected in the prices paid by consumers for the goods they purchase in private sector markets. Nor are the use values of water and energy captured. In addition, the exchange values along the supply chains have been very severely distorted by subsidies and taxes. As a consequence the costs of degrading water resources, the atmosphere and other ecosystem services cannot be signalled in the prices consumers pay for food and energy.

The emergence of the sub-nexi and the grand nexus

What follows is not a comprehensive review of the literature on the water-food trade nexus, the energy-climate change sub-nexus and the grand nexus. Rather it is an account of my involvement in attempts to observe, analyse and contribute to their conceptualisation. In 2008 the World Economic Forum, the activities of which I began to contribute as a member of its Water Advisory Council, identified water, food, energy and climate change as a nexus where risks for society, the economy and the environment were very serious. The Forum (WEF 2011) concluded that the risks were being multiplied by ignoring the contradictions of current rates of water and energy use in hot-spots and more generally.

The water-food-trade sub-nexus and the energy and climate change sub-nexus were reviewed by WEF, and an attempt was made to address the integration of the two sub-nexi - *the water-food-trade* sub-nexus and the *energy-climate change* sub-nexus, into a grand nexus. The 2011 edited WEF (2011) publication was rich in scope but the editorial team and its contributors, of which I was one, failed to provide an accessible framework that identified the important key assumptions, key issues, and vital players in what are identified as the key private sector supply chains. The WEF Water Advisory Council had strong private sector representation but the water professionals and water scientists did not engage constructively with each other. The members of the WEF Advisory Council on water did not identify private sector consumption of water and energy in food and energy supply chains as the appropriate underpinning analytical framework. Nor did we identify incentives that would bring together the *two* very powerful operational supply chains responsible for the way society was using and abusing the strategic natural resources of water and energy. I contributed to the WEF publication and later took full responsibility for not providing an approach which would have enabled editors to produce, and readers to read, a well conceptualized and well framed analysis. (Allan 2011)

In another potentially important initiative in the 2010 and 2012 period three departments of State of the Federal Republic of Germany convened a suite of international nexus meetings attended by numerous scientists, as well as by government, private sector and NGO professionals. I participated in a minor way. The courteous convenors allowed me to contribute a videoed critique of the frenetic engagement on the grand nexus at that time (Allan 2011). In this video I argued again that a profound and useful conceptualization of the grand nexus was lacking. I also suggested that the absence of an over-arching theoretical frame was making it impossible for those engaging to communicate effectively. I emphasised that the sub-nexus of water-food-trade had been effectively conceptualized. But the energy-climate change sub-nexus and a theorisation of the water-food and the energy sub-nexi into a grand nexus had not been achieved. In addition I also emphasised that the operations of private sector food supply chains and energy supply chains had determined the priorities as well as the blind-spots. These blind-spots were integral to the business-as-usual sub- and grand nexus operations where water and energy were being managed and mismanaged. In addition it was also noted that these major supply chain players would be the agents that could most effectively analyse, and constructively engage, to address the contradictions that were becoming evident as a consequence of the attempts to develop a grand nexus approach.

The analysis in this section has also revealed that in any contest to explain why the food and energy services are delivered as they are and impact natural ecosystems as they do; it is unlikely that a NEXUS, science based, analysis will be as effective as a political economy market based approach. It is suggested that the survival of the NEXUS explanatory framework depends on the extent to which its advocates can incorporate the rich explanatory evidence in natural resource blind supply chains.

How the sub-nexi and the grand nexus fit within an operational mega-nexus, the global political economy, in which the political economies of water and energy operate: evidence of knowable unknowns and consequent contradictions

The purpose of this section is to take some initial steps to establish a conceptual frame that embraces the two sub-nexi - *1. water-food-trade* and *2. energy and climate change* - in an as yet poorly understood *grand nexus* where both interact. It will be concluded that the grand nexus is one way of characterizing parts, in practice very important parts, of the overarching political economy or mega-nexus where productive, trading, processing and marketing activities deliver goods and services to consumers. They deliver these goods and services at the expense of inadequately stewarded ecosystem services. Awareness of this hierarchy of engagement, the global political economy, the grand nexus and the two sub-nexi, is essential in any attempt to understand and conceptualise the grand nexus of water-food-energy. Deconstructing elements of dynamic global and regional market operations is at best likely to be inconclusive and at worst it will be very misleading. Private sector firms are constantly merging and demerging in response to the shifts in the political economy both within and between numerous supply chains. The supply chains that we are analysing here are only two of many.

Those who operate the private sector supply chains of *food* and *energy* are best acquainted with the challenges in the sub-nexus in which they respectively operate. They are, and will be in future, the agents that know most about their respective sub-nexus operations and constraints. They will also be the agents who could potentially identify and adapt to the risks of ignoring the mutualities and contradictions of grand nexus operations. Farmers, big-ag corporates and other major corporates in food processing, trade, super-markets, oil and gas operations, vehicle manufacture and transportation will all be key players. Subsidies, taxes and the poorly informed choices by consumers in both sub-nexi supply chains will also play significant roles in steering decision-making that involve water and energy. They do this in the as yet uncoordinated sub-nexi supply chains.

The grand nexus of water-food-energy is dominated by market mechanisms and supply value chains. These supply chains in the grand nexus are not yet equipped to expose the environmental and social risks associated with the otherwise rather effective market systems that produce and deliver food and energy. Unfortunately these market systems fatally lack reporting and accounting rules for water and those for energy are only just emerging. Such rules, for example the approach proposed by the carbon disclosure project (CDP 2013), would signal to those who manage vulnerable and sometimes very scarce water and energy resources the consequences of not understanding natural resource scarcities and values. In depleting and potentially damaging natural resource inputs in food and energy supply chains market players have risked the planet, profits and society as well as the sustainability of their own enterprises. Understandably, it has proved to be easier to get their attention on the corporate operations and interests. In the past decade there is much evidence that corporates have become aware of their vulnerabilities to local water scarcity and to their role in accelerating global energy problems (Hausmann 2010a and 2010b, Larson 2011, Miles et al 1994, Nestlé 2007, 2010, 2014, SABMiller 2014 , WBCSD 2014). To date this corporate awareness has not been self-reflective. The 2014 WBCSD report shows this condition very clearly. Its focus is on the very relevant issues of existing competition for natural resources and future constraints. It does not mention food and energy supply chains. Nor does it identify the problems associated with the dangerous assumptions that underpin the way water and energy are mismanaged and are inadequately reported on and not accounted.

The approach suggested here requires a different point of departure from that which has resulted from the assumptions of water scientists and of water and energy professionals. Scientists and economists assume that there is some rational knowledge based, potentially optimisable, way of allocating and managing water and energy. On the contrary it is assumed here that farmers, manufacturers and other market players have operated the water-food-trade sub-nexus for at least two millennia in ways that are politically rational but blind to underlying fundamentals. It is further noted that the energy and climate change sub-nexus has also been determined by long established private sector supply chains and an extraordinary alignment of the interests of major corporates and a few governments.

A number of important fundamentals are obscured by existing levels of knowledge on the part of government, corporates and consumers. For example Figure 2 illustrates a number of important knowable unknowns. It shows that separate food and energy market systems use very different proportions of embedded water and energy to deliver food and energy to consumers. The separate supply chains have not been able to engage over the unknowns. For example, first, they have not engaged, over the risks in food supply chains - both economic and environmental - of consuming vast volumes of uncosted water associated with inadequately accounted embedded energy associated with pumping water. Secondly, they have not engaged over the consequences of wasteful allocation and management of water and energy in the production, conveyance and wasteful consumption of goods and services in which the real, but unaccounted, costs of water and energy are substantial. Thirdly, the potential benefits of adopting a wider understanding of competition and of mutuality in resource use with respect to profit have not been operationalised.

Profit has not proved to be a sound metric to incentivise sound stewardship of natural ecosystems. But it is the main incentive for the market players who deliver water intensive food and energy services. Profit is the *statutory* concern of those who manage the enterprises in food and energy supply chains. It is their duty to generate returns for shareholders. Responsible approaches to people and the planet are also needed but those who operate the supply chains can only protect natural ecosystems to the extent that existing inadequate regulatory regimes require them to do so. As yet there are very few reporting and disclosure rules and no accounting rules for water by which to steer.

A very useful preliminary to identifying and mapping the grand nexus and the two sub-nexi are answers to the question - What are the proportions of water and energy used in different sectors of the world's economies? Figure 2 reveals some major asymmetries in the use of water by economic sector in the two sub-nexi of water-food-trade and of energy-climate change.

The first purpose of Figure 2 is to highlight the huge volumes of green and blue water utilised in food supply chains. Consumers and even water professionals are unaware that about 90% of water consumed by society is devoted to food production. Only about 10% of water is consumed by society in its industries and for domestic services, and much of that water is in practice recycled. In a few economies, for example in Singapore and Israel, almost all domestic and industrial water is recycled and all urban water could potentially be recycled in most economies. All the water used for the production of non-food commodities and services is blue water. Blue water is the water we can divert, pump, convey and relatively easily value, and as pointed out in Chapter x, is the water that is most usually licensed and allocated.

A second purpose is to highlight the significance of the use of green water in the production of food and fibre. Green water is the water held in the root zone and is consumed by natural vegetation and crops. Over 70% of the water used to produce food and fibre is green water, but is rarely licensed and allocated.

The third, and main, purpose of Figure 2 is to contrast the extraordinary asymmetry in water use between food and non-food sectors with the opposite asymmetry with respect to energy. The approximate 90/10 ratio in water consumption for food/non-food contrasts with the 20/80 ratio for the consumption of energy in the food/non-food sector.

Blue water is available in rivers, lakes, reservoirs and in underground aquifers. Blue water can be diverted, pumped, conveyed and polluted and is the main concern of hydraulic engineers and of water resources and water quality scientists. Blue water can also be valued and even priced. It is usually priced in non-food uses but very frequently mispriced, which makes it the focus of economists. Blue water is very rarely properly priced as food-water.

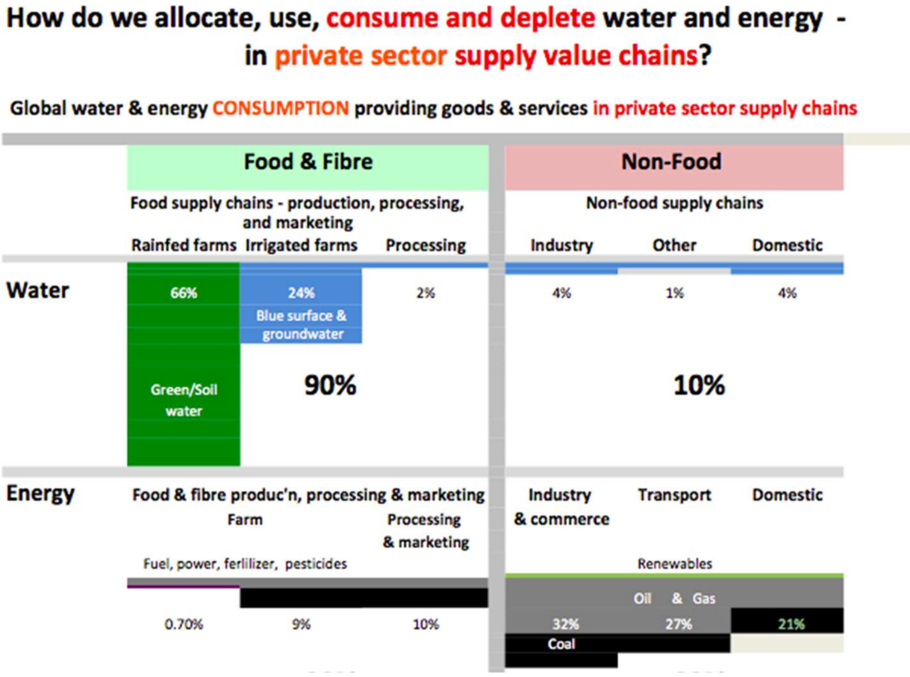


Figure 9.2 Some striking global asymmetries in how we allocate, use, consume and deplete water and energy in private sector food and non-food supply value chains

Green water comprises most of the water used to produce food and fibre - in private sector food supply chains. Of the 90% of water in food supply chains about 70% is green water, although this varies from place to place and product to product (Chapter x). Green water is the water held in the soil profile after rainfall. Natural vegetation and crops draw on this water which they transpire to the atmosphere. All this food-water is lost to local users. It is recycled to the atmosphere in the global hydrological system but it cannot be recycled locally (in some sugar extraction processes green water extracted from the cane can be discharged to surface waters). Green water is an essential resource in food production and it also provides important ecosystem services.

Blue water in agriculture is different. It is used for irrigation and, most importantly, using it competes with other blue water users in industry, in other services like electricity production, in the provision of recreational amenity, the provision of domestic water services and environmental flows. The very vulnerable ecosystem services of blue water are increasingly highly prized by society but their value is not yet captured. Poor farmers cannot afford to steward them. Providing irrigation infrastructure and related funding to improve farm livelihoods is only sound to the extent that the blue water resource can be sustainably used over the long term for irrigation, and is usually underpinned by water allocation and licensing processes. Although, in many SADC countries these processes are inadequate (Chapter x).

Unfortunately the role of farmers as the managers and stewards of water is not recognized by engineers, water scientists, economists, or by society and governments more generally. Food consumers are especially under-informed. The market systems that connect consumers with blue and green water are dysfunctional in terms of informing the food choices of consumers. Food supply chains are very complex systems. In many ways very effective systems. They deliver vast volumes of food in long international and short local supply chains. But they are rough and ready in the sense that they recognize many, but not all, of the inputs in very selective and very partial accounting systems. Misleading contracted prices connect the agents in the food supply chain markets.

Green and blue water differ greatly in their vulnerability to depletion and over-use. Green water can be said to look after itself. Farmers cannot use last year's soil profile water, although high soil moisture from previous rains do affect current runoff. Nor can they use the moisture of the year before. They certainly cannot borrow moisture from next year's rains nor from those of the following year. In contrast blue water can be managed to use water from earlier years stored in engineered reservoirs. Farmers can also pump blue water from groundwater aquifers that may not be replenished in following seasons. Wherever farmers have irrigated they have run out of blue water and the main reason we have debates on water security is because water used for irrigation is already competing very seriously in many hot-spots world-wide with other demands for blue water. Water used in other sectors - such as in industry, mining and services - can command prices orders of magnitude higher than farmers can pay in producing food. In the food supply chain consumers, legislators and markets conspire to provide under-priced cheap food. In this system *the cost of water cannot be accommodated*. There is also increasing competition for water in many hot-spots world-wide where the need to restore the ecosystem services of blue water has become vital.

Figure 9.2 has highlighted the very significant asymmetries in the use of water and energy in two of the major global private sector supply chains. There are other asymmetries that are possibly even more important in impacting any attempt to integrate or synergise the two sub-nexi that are the focus of this analysis. Figure 9.33 is a preliminary attempt to conceptualise the differences to highlight first, the nature of the renewable and non-renewable water and energy resources in the respective supply chains. And secondly, it illustrates the stark differences with respect to diversity and substitutability. There is one type of *non-renewable blue water - namely fossil groundwater,* which is a very minor source of water overall amounting to less than 0.01% of water consumption world-wide. Although it is very important in some desert economies such as Libya and Saudi Arabia. Volumes of manufactured (desalinated) water are also as yet almost invisibly small. In contrast society has mobilized more than a dozen types of energy. There are at least *six types of renewable energy and at least six types of non-renewable energy*. The two supply chains are especially different in relation to *substitutability*. In water supply chains the substitution for water is unusual. In energy supply chains the substitution for energy is normal (See Figure 9.3)

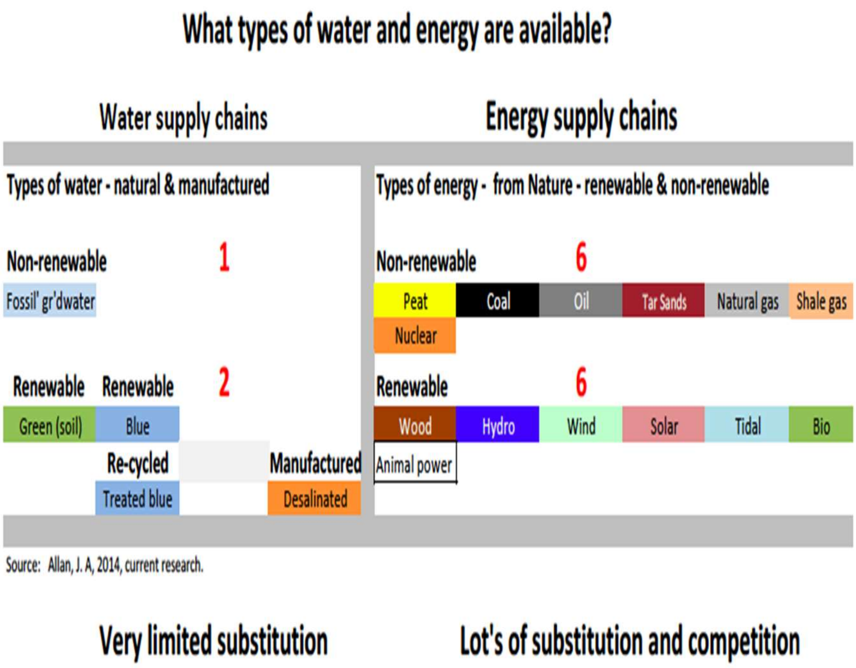


Figure 9.3 Water supply chains as distinct from energy supply chains. (Source: Author)

The problems of inadequate reporting and accounting rules: more contradictions

Having established the types of water and energy available and the volumes used in the two supply chains the next challenge is to highlight the importance of recognizing that water and energy are mobilized and used in private sector supply chains that have inadequate reporting and accounting rules.

Figure 9.4 shows a widely recognized way of understanding the structure of a neo-liberal society and provides an easy to communicate approach to analysing advanced political economies. Other political economies, emerging and developing, to a substantial extent can also be understood via the lens of the four ways of life approach. Figure 9.4 shows that there are three - what social theorists (unhelpfully) call *social solidarities* that do things to, and for, a fourth solidarity, namely *civil society.* The three solidarities that do things to civil society are - first the *public* state, secondly, *private* markets and thirdly, collective *civil movements* - such as unions NGOs and other activists. Civil society is all of us at breakfast time after which we go out to contribute to public and private sector activities. Others contribute to civil movements and to union and religious activities which often have activist dimensions. Human rights, rights to water, rights to livelihoods and environmental protection are prominent concerns in this solidarity. Civil movement advocacy explains a disproportionate amount of the progress being made in ecosystem protection. Private sector bodies that deliver food and energy could take the lead in protecting the atmosphere and water ecosystems but they are only required to comply with reporting and accounting systems that privilege the delivery of under-priced food and energy. Accounting rules ensure that the costs of most inputs are captured. However, the contribution of natural ecosystems are not accounted for. In competitive markets there is no incentive currently to highlight the contradiction of damaging natural ecosystems.

Civil movement advocacy explains a disproportionate amount of the progress being made in ecosystem protection. Private sector bodies that deliver food and energy could be in the lead in protecting the atmosphere and water ecosystems but they have reporting and accounting systems that privilege the delivery of under-priced food and energy. Stewardship is currently mostly unaffordable, except in those cases were the private sector has directly recognised a direct risk to their supply chains.

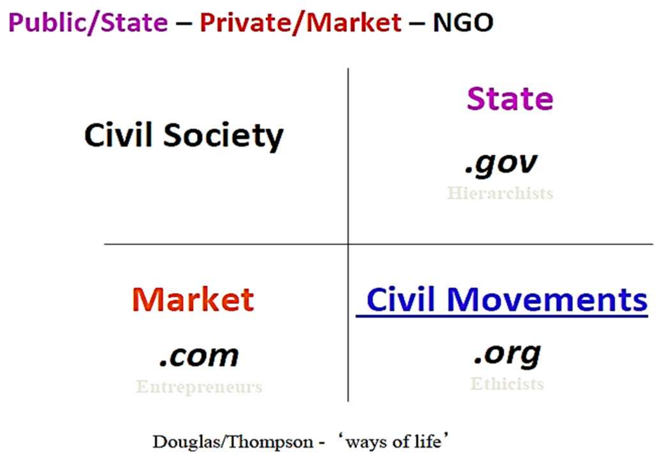


Figure 9.4 The three social solidarities that engage constructively or not to achieve sustainable outcomes for civil society and the environment.

The structure set out in Figure 9.4 is useful for mapping one of the sub-nexi considered in this study. It provides the underlying frame for Figure 5. Figure 5 shows how the water-food-trade private sector market supply chain - or sub-nexus - can been mapped very effectively on to the four ways of life structure shown in Figure 9.4.

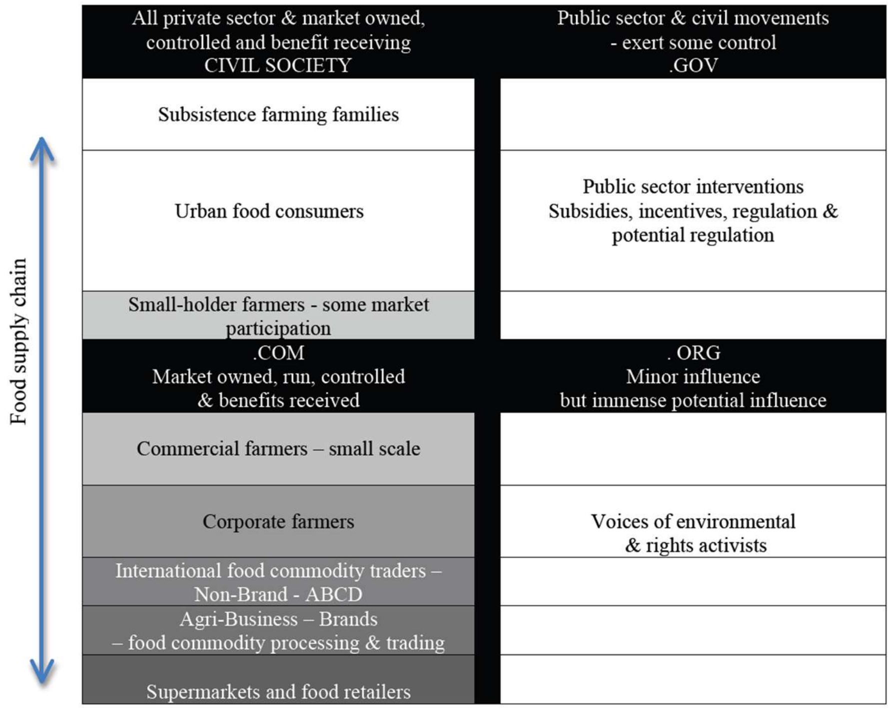


Figure 9.5 The four ways of life with the private sector food supply sub-nexus mapped on to it.

All the agents involved in the water-food-trade supply chains can be accommodated within first, the civil society solidarity where food consumption patterns and wasteful food choices and wasteful behaviour are the norm. The rest of the supply chain lies in the private sector market solidarity operated by commercial farmers, corporate commodity traders and food processors as well as by local shops and corporate super-markets. Subsistence farmers do not engage in markets. All the other agents engage with each other via contracts which ignore or misprice the value of natural resource inputs.

One of the asymmetries identified above - the massive volumes of water devoted to food and fibre production can also be illustrated. Figure 9.6 summarises how water resources are allocated with respect to the four ways of life frame. 90% of the water consumed by society is in its private sector food supply chains. That is in the *water-food-trade sub-nexus. Farmers* manage, mismanage and use 90% of this water in crop production. This supply chain operates as a market but in the absence of the necessary reporting and accounting rules this market is water value and externalities blind.

Figure 9.6 also shows that the other 10% of water is handled mainly by public sector service providers, and often through formal allocation processes (Chapter 6). Local authorities and other municipal bodies provide domestic and industrial water services world-wide. Private sector companies only have responsibility for between 10% and 20% of water domestic and industrial water and sewage services world-wide under umbrellas of national regulation. The non-food water and sewage services has a recent chequered history which is not

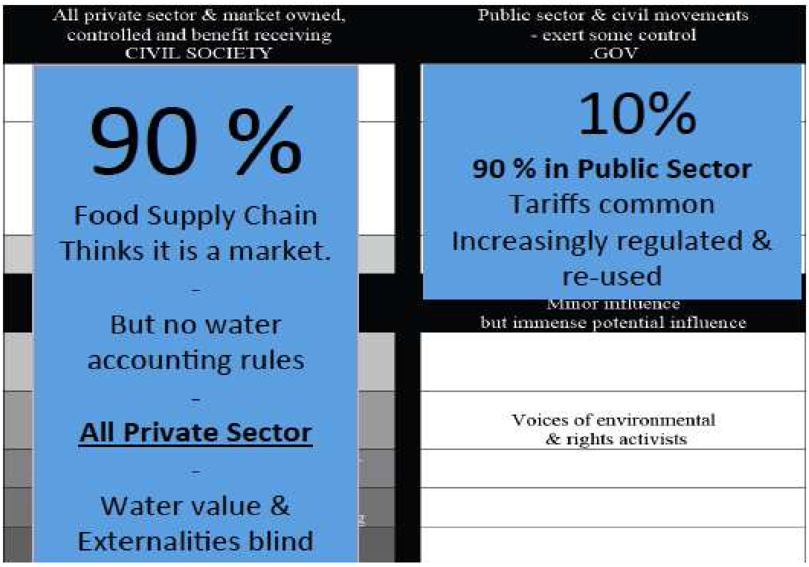


Figure 9.6 Showing how society has allocated water resources. Mainly green and blue water to private sector food supply chain markets. The other 10%, which is blue water is provided by mainly public sector organisations - usually municipal agencies.

the concern of this analysis. Privatisation of these services is gaining ground but gradually.

The conceptualization presented in this section can be summarized as follows. There are very powerful - long established - private sector supply chains for food and energy. The logistics of these complex and separate supply chains are managed by extremely well informed, and increasingly well equipped, professionals from farm to super-market and from oil-well to consumer. Collectively professional farmers, commodity traders and food processors and supermarkets know more about their respective sub-nexus than any water scientist or economist. Other extremely well informed private sector professionals operate and research the energy sub-nexus markets.

The water-food-trade sub-nexus and the energy-climate change sub-nexus are separate and very different in character and operate in very different global regimes. They both ultimately serve seven billion global consumers. But this is one of the very few things they have in common. There is no equivalent in the energy supply chain nexus to the half billion farmers at the beginning of the water-food-trade supply chain sub-nexus. Nor is there an equivalent *for water* in the food-water supply chain to the spot and forward pricing systems that operate in global energy markets. There are for food. But not for water. Some unsteady steps are being taken in the Murray-Darling Basin in Australia to set up water markets. But the world- volumes of water involved world-wide are as yet trivial. As pointed out in Chapter 6, South Africa's policy for allowing water markets is under threat, while water trading is not advocated in Zambia's Water Policy, but is in its Agricultural Policies.

The history of the global food and energy regimes is also relevant to the analysis of the way natural resources are consumed and stewarded (Friedmann 1993, McMichael 2009). The regimes are different. The global energy regime was dominated until 1972 by the alliance of three governments - the United States with the UK and Netherlands, and seven oil companies which were known as the Seven Sisters. Five were US corporations. BP and Shell were UK and Netherlands based. The oil price shocks of the 1970s changed the nature of power relations as the national oil companies of the producer economies were able to substantially increase their proportional take of the financial returns. The OECD economies should have read the signals four decades ago and have taken the opportunity to develop renewable energy. There would have been a twofold benefit. First, renewable energy technologies would by now be affordable. Secondly, we would have avoided four decades of full on degradation of the atmosphere. The current fall in energy prices following 2008 and 2011 price spikes has paused. Food commodity prices that track global energy prices are continuing to fall.

The global food regime has been dominated for even longer by the United States than was the global energy regime (McMichael 2009). The challenge that shocked the global energy system occurred in the 1970s. Another major challenge to the global food system is currently in train and is increasingly intense. Global dominance by another alliance of the US State and private sector has existed since the second half of the 19th century. The ABCD (ADM, Bunge, Cargill and Dreyfus- French) food, mainly grain, commodity traders have been moving about 70% of global food trade by volume. In this food commodity trading they have been joined by Glencore.

But there has been a recent major shift in the global food commodity trading regime. It is in some ways equivalent in impacts to the global energy shock in the 1970s. It has been brought about by the activities of East Asian corporate traders. Keulertz (2013) spotted a new group of global traders, the East and South-East Asian, - the NOWS. Noble, the 'N' in the NOWS, was a Hong Kong based trader with revenues as big as ADM by 2013. It has recently been acquired by Chinese corporate State investors. Such acquisitions are part of a trend and reflect a shift in the global political economy. The trends shown in Figure 7 confirm the phenomenon and reflect the strategy of China with respect to food and energy. These are the supply chains which are the focus of this analysis. There are significant upward trends in the international acquisition of corporate food and energy interests. Meanwhile China is not investing significantly in water and land for food production in Africa (Brautigam 2012).

In brief, the powerful food and energy corporates operate in separate markets; in separate sub-nexi. If oil companies owned irrigated farms and if farmers were intimately involved in mining there would be an automatic awareness of unsustainable competitive utilisation of water and of its different values in alternative uses. Their accountants would be aware of and alert to profit impacting contradictions such as asset depletion and asset impairment. Awareness of the role of what we have identified as the *grand nexus* would without thought be operationalised. In practice the separation of the two supply chains, the two sub-nexi, means that there is no incentive to know about the dangers of using un-valued and un-priced water resources with respect to people, profit and the planet.

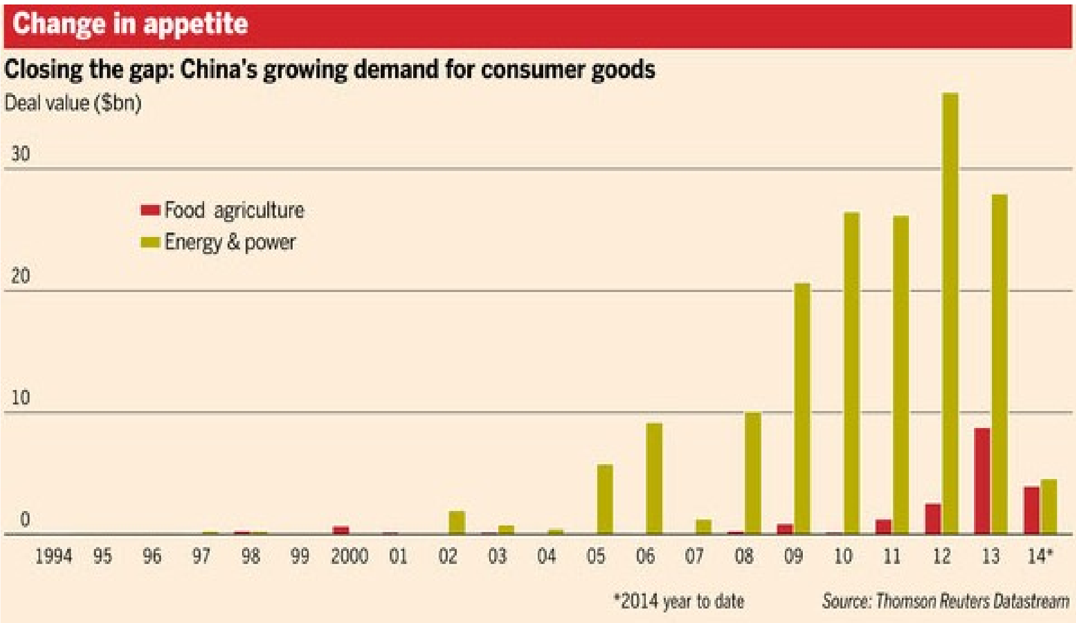


Figure 9.6 China – global corporate acquisitions in energy and food/agriculture – 1994-2014 (Source: Bloomberg 2014)

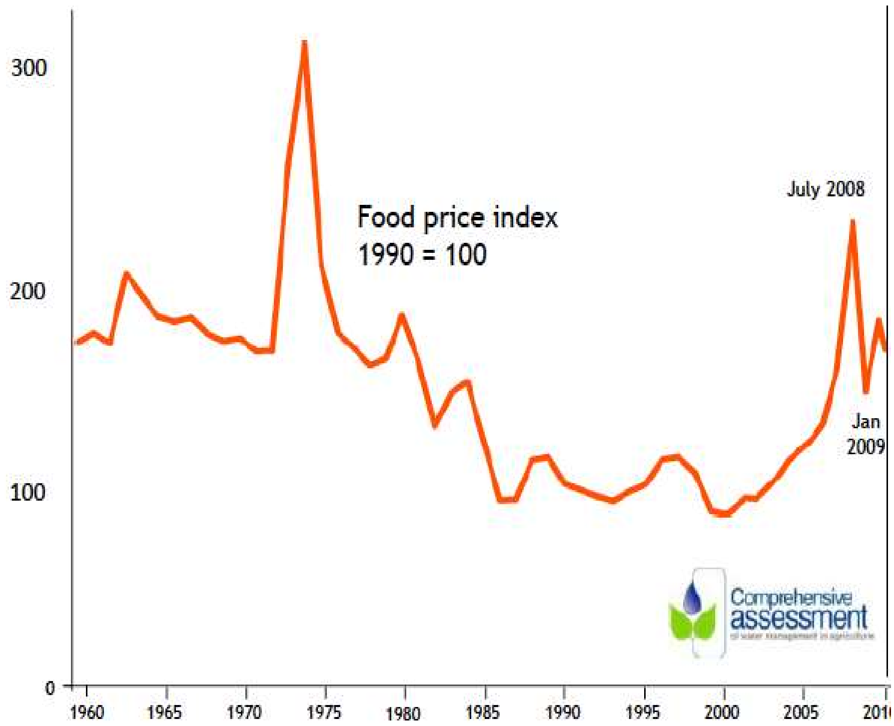
It should come as no surprise that it is *investors* who invest in different supply chains and in many different companies, and consider it a safe strategy to do so, that have been the first to spot the contradictions. Responsible investors are emerging as an influential force, both as a consequence of their investing power as well as because they are beginning to coordinate their responsible - that is in this case environmentally considerate - investment behaviour (Yach et al 2001, Greczy et al 2005).

In the absence of a grand market nexus tracked by accountants the ad hoc and poorly informed hot-spots approach will prevail when engagement is unavoidable over water, food and energy. When the hotspots become evident - usually too late to remedy easily - they will always be politicised. They have, for example, become evident in the water resource use contradictions associated with developing shale gas and tar/oil sands as well as in producing ethanol from corn and other food crops. This hot-spots approach will continue until the private sector players, who operate rather than conceptualise the complex food and energy supply chains in the two sub-nexi, recognise that there are unacceptable risks in not promoting policies that take into account the essential mutuality of water security and energy security.

Finally, it is necessary to highlight the problems generated by producing ever cheaper food. It has been shown that the exisiting political and commercial incentives have driven farmers, traders, food manufacturers and supermarkets to deliver cheap food. Consumers have become addicted to it. Advances in technical efficiency, especially on farms, have played a role in reducing food prices as has not accounting for the costs of environmental inputs and of impaired ecosystem services. Figure 8 shows how successful the drive to provide cheap food has been since 1960. Food prices have very closely tracked energy prices. Perhaps the way food prices track energy prices is - as yet very poorly understood - evidence of the nexus between the two supply chains.

Figure 8 illustrates the scale of impact of the oil price hiatus of the 1970s which caused food prices to spike. Success in making food cheaper has for the past half century made it impossible to foreground the idea that the environment needed to be stewarded and accounted for. The expectation of cheap food has made consumers blind to the unsustainable tendencies of private sector food supply chains.

Figure 9.8 The trend in the global price for food - 1960 to 2010 - showing the tendency for prices to fall except in periods of global instability in energy and finance. The major price spike in the 1970s was closely related to oil prices. The price rise beginning in 2003 was also oil price related. The major spikes of 2008 and 2011 were brought about by the dual impacts of oil price rises and by the financial crises of 2008 and 2011. Food prices are falling again but it is too early to say where they will settle when the world economy, oil prices, inflation and interest rates return to what has become regarded as normal. The data reflect constant prices - with 1990 being 100. Source: Molden et al, 2007 - the trend was calculated on the basis of World Bank and FAO data updated by IWMI to 2010.



Food prices are falling at the time of writing - 2014. Pessimists want the current higher prices to swing the politics to foreground stewardship. But the path dependence determined by subsidies in the OECD countries will tend to determine outcomes as they are so important in determining price levels. The 2014 US Farm Bill will, over the next decade, put very close to one trillion dollars in to food supply chains. $780 billion will be for food stamps. (Washington Post 2014) The annual food stamp budget in the US will be 78 billion. Only 60 countries (of the 220 or so) in the world have total annual GDPs in excess of this figure. The coming decade has policies locked in place that will continue to make it difficult for consumers to detect the underlying environmental and economic fundamentals.

Will society pay the farmers to steward ecosystems as well as produce enough food? There are two main ways to answer this question. The most politically difficult path would be to include the costs of stewardship and environmental protection in the price of food. A second way, less politically difficult, would be to introduce new subsidies for stewardship. The EU Common Agricultural Policy and the US Farm Bill have both initiated such payments but at a scale and a pace determined by complex legislative and farm level politics. At present stewardship is primarily underpinned by Corporate Social Responsibility (see Chapter 8).

Challenges in capturing the values of water and energy resources as inputs and the impacts of mis-allocating and mis-managing them

> “.....*current private sector reporting and accounting rules do not capture the value of natural resources as inputs nor the consequences of misusing them.*

Water and energy are essential natural resources. They sustain societies, economies and ecosystems. Scientist and specialist professionals such as water engineers and scientists have been tempted to deconstruct complex natural systems and to study and theorise them in separate disciplines. Equally separate professions that manage and audit in the markets for food and energy have established physical infrastructure and rules and market organisations to consume natural water and energy resources. But not to account for them.

In the late 1980s it was noted that water security and food security were very closely linked but little progress has been made in theorizing or understanding the links in the three decades since then. This study has explained why it has proved to be very challenging to both theorise and to explain the operation of the sub-nexi of water and energy. It has also explained the difficulties in foregrounding the grand nexus in which they could be rationally embedded.

What have been the main failures of water science and of water professionals in making the key unknowns knowable. Water scientists have failed, for example, to expose the very different characteristics of water and energy consumption that have been revealed in this analysis. They have also tended to assume that the hydrological cycle and economic principles will explain water and energy using behaviours. In practice the approach of political economy and private sector supply chains has been shown here to provide much richer sources of explanation.

The necessary analytical expertise exists in private sector food and energy supply chains. But the separate sub-nexi expertise that could have provided informed accounting practices has been locked in supply chain operational practices based on assumptions that nowhere reflect the underlying fundamentals of hydrology and economics. These practices have been blind to the value of natural resource inputs and unable to capture the costs of mis-managing natural ecosystems.

Why are the reporting and accounting rules inadequate? Accountants have installed procedures to address challenges just as difficult as valuing water. For example the concepts such as depreciation, accounting for depletion and the value of good-will have all been captured. The inadequacy of the reporting and accounting rules in value of water and energy have not yet been sufficiently politicised to get the attention of those who establish and police private sector accounting systems. Capturing the value of water is being made progressively more difficult by the race to the bottom by those who sell cheaper and cheaper food in shops and super-markets.

There is much evidence that prominent CEOs in major corporate supply chains would like things to change. Influential corporate leaders such as Paul Polman of Unilever, an accountant, Peter Braabeck of Nestlé, Indra Nooyi of Pepsi and Paul Bakker of the World Business Council for Sustainable development, also an accountant, have identified the direction that should be taken in both the food and energy supply chains (see Chapter 8). But the inertia implicit in the existing regime of accounting rules makes it very difficult for the managers and accountants in their respective companies to adopt the policies and practices which they advocate. Boards have to be persuaded that natural ecosystems are a legitimate priority. The corporate accountants, as well as the national and international commercial regulatory systems with which they comply, will also have to change. Until then there cannot be consistent, sustainable supply-chain wide behaviour that recognises the contradictions in the way the food and energy supply chains operate. The current lack of recognition of the mutuality of water and energy demand and the utility of coordinating the management and stewardship of them in commercial supply chains is just one important negative consequence of the business as usual approach. An informed coalition of investor and regulatory influence needs to be brought to bear.

Concluding comments

> “*One of the roles of international assistance such as that extended by DFID should be seen as a remedy to the damage done to the farm sectors in developing economies by the OECD dominated food trade regime.*

The international perspective taken in this analysis has highlighted how the global regimes that provide food and energy operate in ways that make it very difficult for farmers to be responsible stewards of nature’s ecosystems. This condition is a universal global problem. The poor farmers of the SADC economies are very seriously affected by these global food and energy systems and have no power to change them. The dominant global food and energy regimes have evolved from the alliance of US and EU Governments with the Big-Ag, Big-Ag-trade and Big-energy corporates. These global systems are natural resource value blind.

Cheap food, and in more normal economic times, plentiful and cheap dirty energy, lead those managing the private sector food and energy supply chains to manage water and energy resource unsustainably. Farmers are key with respect to water as they manage about 90% of the water consumed by society world-wide. The proportion is smaller in the SADC economies and the SADC metrics has not been researched. But it must be higher than 70%. It is likely that it will approach 90% across the SADC region once the humid northern economies develop their farm potential.

The approach of CRIDF to enable communities and farmers to acquire infrastructure that cannot otherwise be afforded is sound. But it is a remedy to a problem caused by the UK Government and the other OECD Governments. Arguably these same OECD economies have caused the climate change which CRIDF aims to help SADC communities to remedy. The US Farm Bill and the EU CAP ‘export’ their extraordinary cheap food policies. Poor farmers in less capable developing economies cannot invest improve their livelihoods in their impoverished circumstances as long as this global cheap food regime exists. One of the roles of international assistance such as that extended by DFID should be seen as a remedy - paradoxically a balancing subsidy - to the damage done to the farm sectors in developing economies by the OECD dominated food trade regime. Solutions actually lie in the corridors of DC, Brussels and Whitehall where decisions that would impact the ecologically dysfunctional food and energy supply chains could be reformed.

The experience of the SADC region is similar to that of other regions of Africa. The problem of the yield gaps cannot be addressed because of the problems of mobilizing investment in farming. This investment needs to be local and national and delivered by responsible international investors. Crop and livestock yields could be trebled and more in the better watered northern SADC economies (Morris *et al* 2012), but would require investment in transport and other infrastructure (Chapters 4 and 5). Responsible inward investment in agriculture has been much talked about recently but despite the rhetoric the record to date has been slow and mixed with respect to outcomes (Allan *et al* 2012). China's strategies are appropriate. Their investment is in infrastructure, usually in major structures such as ports, roads, power and communications. Such infrastructure enable responsible and effective farm investment in green and blue water that will make land productive. No doubt they will do that as it becomes evident that commercially viable supply chains can be installed.

The CRIDF focus at community level is also appropriate and complementary. But in the opinion of this author both the scale and the focus of the Chinese approach will have the most sustainable impact. It will by provide the necessary conditions for the expansion of environmentally and economically resilient agricultural rural livelihoods. It will enhance the impacts of all farm and rural investment including that by CRIDF. The author is aware that not all of Chinese investment has been successful and the SADC region has experienced problems in the energy sector (see Chapter 7).

Finally, the analysis has highlighted the importance of accounting for the inputs of natural resources such as water and energy as well as for the consequences of depleting and polluting them. Any nexus approach that aspires to have significant impact requires effective reporting and accounting rules to guide investors and shape on-farm behaviour. This study has emphasized the consequences of the absence of effective reporting and accounting on ecosystem use. Those who use the term nexus want it to have an impact. It would help if they could make the term more than an arm-waving moment in a conference presentation. We could devise a memorable acronym such as *Natural Ecosystems eXpect Understanding Stewardship*. But the message would be much moreclear if we adopted an acronym such as NEXAS - *Natural Ecosystems eXpect Accountable Stewardship*. It emphasizes stewardship and accountability.

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Chapter 10: Embedding the Virtual Water Concept in SADC

By

Reggie Tekateka

Abstract

The Climate Resilient Infrastructure Development Facility's (CRIDF) decision to embark on a project to champion the introduction of Virtual Water (VW) as a SADC regional strategy marks the difference between the concept's earlier appearance on the scene and today. In the late nineties up to and including its high profile treatment at the World Water Forum in Kyoto, Japan in 2003, VW was largely seen as a highly academic proposition that offered little by way of contribution to the key identified challenges of the water sector in the region and the achievement of regional economic integration. VW was largely seen as failing to convince in its ability to help bridge the infrastructure gap that led to economic water stress that is typical of much of the SADC region. This assessment prevailed at a time when the region was particularly receptive to progressive ideas that promoted cooperation around water resources management and sharing.

This forward looking regionalist stance that was led by a well-knit inner group of water ministers of the time was not able to eradicate strong national sovereign impulses that continued to influence country choices often in conflict with agreed collective approaches. This remains the case in river basin and regional spheres alike. Also there remained a strong sense of unease at the relatively high level of infrastructure development enjoyed by some countries. Any proposal that appeared to favour the more highly developed rather than level the playing field was not likely to elicit enthusiastic support. VW, like any new concept in the water sector is likely to be assessed against its ability to address these concerns while enhancing water's role in regional development.

Importantly, however, VW and the Water, Food and Energy Nexus, as potentially rather complex concepts, are not necessarily the ideal propositions to posit as opposed to those that utilize more familiar and accessible language and imagery. The unpacking of VW may, in this sense, imposes additional challenges on public servants in communicating the concept. Moreover, VW must position itself as a satisfactory alternative to the infrastructure development goal that most of SADC aspires towards. Importantly, also, countries that are relatively well-endowed with water and land would have to devote those resources to producing goods for trade inside SADC, rather than to the rest of the world.

An astute multi-tier communications strategy aimed at broad dissemination of the benefits, while recognising the legitimate sovereign concerns will therefore be required. It will be helpful to also target countries individually as well as collectively at the basin and regional levels within SADC. Another important element of the strategy will be to put VW squarely on the SADC agenda. This can be done through bodies and forums such as the Global Water Partnership's Multi-stakeholder Forum, the Water Resources Technical Committee of the SADC Water Sector, the SADC River Basin Organisations' (RBO) Forum and targeted individual RBO's, the Water Strategy Reference Group (WSRG) and the SADC Water Ministers.

A means will also be needed to reach the SADC Secretariat directly, working through the water division to access other sectors such as agriculture, trade, energy etc. The primary value of working through these bodies lies in the ultimate access to decision makers at country level that they offer and the assurance that the concept has been adequately thought through by the mandated and trusted bodies of SADC at the various levels and spheres.

Introduction

In the late 1990's and soon after its conception leading into the new millennium, Virtual Water (VW) became the after-hours pub debate topic among senior water sector officials attending regional meetings of the SADC water sector. To some it was seen as a fascinating academic issue which, however, had little relevance to the solution of the problems of the day. To others it was an important topic that required deeper understanding in order that its relevance is appreciated. The words of a Tanzanian colleague during one of these discussions late into the night still ring audibly. "Never come to my village and tell my people about water they can never drink".

It should be noted that the concept emerged at a time when the main focus of the water sector was on how it should be strengthened such that it could meaningfully contribute to regional integration and poverty alleviation in southern Africa. To many, VW did not appear to reflect this. Moreover there was a lot on people's minds. The region had barely completed the process of formulating and agreeing on a regional water policy and strategy, on internalizing and agreeing on the applicability of the key principles of the United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses, formulating and agreeing on the SADC Water Protocol, negotiating and ratifying river basin agreements, participating in the formulation of a regional contribution to the World Water Vision and going through the difficult process of rolling out and implementing the revised regional structures of a recently transformed SADC.

Within this context, the initial introduction of the Virtual Water concept found very little traction in SADC. Clearly, should CRIDF wish to re-introduce the concept, it must be done in a very different manner.

Background

The prospect of water becoming a sector in its own right free from the shadows of agriculture and the environment created much excitement in the region and fuelled the fire of regionalism within the sector. Movements such as the Southern African Regional Technical Advisory Committee (SARTAC) thrived in this new dispensation. A small but activist group of water ministers emerged in the region that was personally and collectively committed to the regional approach, literally staking their reputations in support. They appreciated the limitations of going it alone as countries, seeing the benefits of basin approaches and regionalism. They also understood how cooperation around water resources management and development could support regional integration. They therefore welcomed the fact that SADC had created the unprecedented opportunity for water to play this all important role. This inner group of ministers was to play an important role in galvanizing the energies of officials, SADC staff and even civil society in support of this regional project.

In turn this led to a similar development among middle level and senior government officials in the sector. Officials felt empowered to work towards the success of the vision and in several instances bureaucratic corners were cut with the assurance that there would be backing from a significant number of ministers. It became quite difficult to oppose a regional idea in SADC water meetings. Over time this group was to break up due to normal attrition and it was not in all cases that replacement ministers or officials had similar zeal.

Nonetheless the lesson learnt from this period was the important role that the "group within the group" can play in leading and energizing cooperation around an issue of regional importance. The challenge today is to consider how such a group of champions can be forged to promote acceptance of VW across relevant sectors.

Infrastructure Development as a Regional Priority

The need to develop water infrastructure to address the imbalances of access and equity as well as energy development were already among the key issues preoccupying regional governments during this period. Infrastructure development was to become the mantra of the African Ministerial Council on Water (AMCOW), established in 2002, led to a large extent by a group of SADC water Ministers who had had a head start thanks to the processes cited above. The key test for any initiative at the time was whether it supported water infrastructure development. The establishment of the African Water Facility (AWF) later to be housed at the African Development Bank (AfDB) and aimed at catalyzing infrastructure development was the direct result of this burning desire on the part of AMCOW Member States. The decision to house the AWF at the AfDB was taken in the hope that this would create the necessary confidence on the part of potential donors to contribute to the facility.

However, even after this decision on its location was made, many still felt that it would become encumbered by the bureaucratic regulatory framework that is typical of international financial institutions, and thus slow down access to the urgently required funding. This was despite the fact that Africa was never able to propose a credible alternative location for the AWF. Many African observers saw as a sinister betrayal the "sudden decision" by the European Union to establish its own separate European Water Facility (EUWF) in parallel while purporting to work towards the same goal as AMCOW. Policy responses to the recommendations of the World Commission on Dams were also formulated on the basis of the extent to which the recommendations were deemed not to be in conflict with this goal. Many African Ministers openly described the Commission's work as a ploy to slow down Africa's development or divert Africa away from its chosen development path.

Other regional dynamics also played a part, fuelled in part by attitudes attributable to the southern Africa region's still very recent apartheid past. The relatively high levels of development by South Africa of two key rivers in the region; the Orange-Senqu and the Limpopo rivers (two Pivotal basins as outlined in Chapter 3), whose benefits were seen by some as accruing only to South Africa, and doubts about South Africa's willingness to be a team player in the region were important aspects of this. Some in the water sector welcomed the high profile that water enjoyed in the new South Africa and that country's strong leadership in the processes leading up to the formation of the SADC Water Sector. Others were suspicious of South Africa's motives even to the extent of feeling that Pretoria intended to take over the stewardship of the nascent sector at the expense of Lesotho. A lot of time and resources have gone into addressing this unease about South Africa's motives as manifested in several basin wide projects, some ongoing, aimed at confidence building. While South Africa was lauded for the lead role it was playing in promoting regional cooperation in the sector including through initiating and hosting ministerial meetings to this end, her motives remained suspect. Zimbabwe was also seen by some as having had a head start that needed to be taken into account as the region moved forward together.

An observation that begs to be made in this regard is that the question of suspicion around the motives of the new South Africa with particular reference to the water sector has still not been raised openly 20 years later. What this ultimately indicates is that no serious collective attempt to address it will likely be made in the foreseeable future, and it remains a sensitive political matter which should not be tackled directly. Nor as a result will South Africa itself fully appreciate the need or how best to work harder in reassuring her sister states of her good neighbourly intentions.

The other unfortunate reality is that too often a regional initiative can become subject to suspicion as soon as it is seen to benefit South Africa in any way. In fairness it is also understandable that countries that are lagging behind in the development journey would feel that regional initiatives should be aimed at primarily assisting them in catching up with those historically more developed. It should not be forgotten that countries forego sovereign rights in order to promote sovereign interests. This quest for regional equity is a political reality that will not likely just go away. Importantly, however, this must be seen in the context that South Africa, as demonstrated in most of the other Chapters of this report, is a pivotal State in economic, electricity, trade and water matters. This creates a real challenge for CRIDF – How does the Facility make the most of the regional benefits to be had from VW concepts, without seeming to be too South Africa centric?

Sovereign Considerations

While purist pundits of shared management of and equitable access to trans-boundary water resources have continued to stress the need for riparian States to accept sacrifices in regard to national sovereignty, basin politics have continued to remind us that we are still some way away from that “perfect state” even within a fast paced SADC water sector. Zambia stood firm throughout the years often to the frustration of fellow Zambezi Basin partners as well as sector officials keen to see an important upstream country ratify the basin agreement of one of the region’s potentially most transformative rivers. It remains to be seen whether the decision to designate a senior Zambian water official as the Executive Secretary of the Interim Secretariat of the Zambezi Watercourse Commission (ZAMCOM) - now Permanent Secretariat - contributed in any way towards the change in position on the part of Zambia that has led to ratification. Or indeed whether the appointment of another Zambian in that position in the permanent Secretariat will promote the resolution of what is seen as one of the first tasks of ZAMCOM, the determination of approaches towards the reasonable and equitable use of the waters of the basin.

Moves to develop the transportation potential of the Shire River a tributary of the Zambezi, has been frustratingly slow, and this has spilt over into agreements to establish electricity transmission lines between Malawi and Mozambique (see Chapter 7). While it would seem unimaginable that either of these infrastructure development options will not eventually happen, for now sovereignty and environmental considerations between Malawi and Mozambique have held back progress in this regard.

Elsewhere, Botswana with its rather robust stance against Namibia’s wish to draw more water from the Okavango to meet essential water supply needs, also adopts a national interest stance, albeit similarly citing environmental concerns.

The demise of the SADC Tribunal raises concern, not so much because a Member State felt exposed and betrayed by the system[78], but rather because recovery has proved so difficult to achieve. In fact the decision to disband the Tribunal was, as per the Rules of Procedure of the Summit, unanimous. How this is reflective of the regional appetite for integration remains to be seen, although it is not necessarily a foregone conclusion that the region is politically moving away from integration principles. For now bi-lateral solutions are the only recourse on offer to resolve disputes in the water sector contrary to regional agreements

There is certainly still no evidence that countries will deliberately sacrifice the national interest for the regional goal of integration, particularly in the light of the need for rapid development. From the evidence of the relative progress achieved in the establishment of river basin organisations (RBOs) it is evident that that they will embrace the collaboration option where national gain can be demonstrated, although in many cases the countries are opting to limit the powers and functions of these RBOs to an advisory role.

A weakness that one notes with SADC is the absence of a regional ethos among the region’s citizens. By design or omission, there has not been a deliberate, and in any way sustained, effort to court the peoples of the region. Where such efforts have been made, it has consisted of isolated and disconnected competitions such as essay writing and sporting events that in their execution do not necessarily promote any sense of belonging. One suspects that this may well remain the case until the people of the region are more intimately involved in its processes and programs. A regional sense of empathy needs to be cultivated such that this can exert influence on governments. Ideally issues of regional interest could then feature on party platforms in national elections. For the time being countries are in no way compelled to be sensitive to public opinion beyond their respective borders.

The highly visible nature of electricity load shedding, its existing media profile and the benefits of the SAPP and regionalisation (discussed in Chapter 7) may make this a useful platform for this kind of profiling.

Virtual Water Concept

The reintroduction of the virtual water concept to the region as a possible region-wide strategy may initially be met with scepticism following its initial failure to take root. As regards the water sector, one can also expect that it will be scrutinized against the infrastructure development standard. A critical point here is that the relative complexity of the virtual water debate may be its undoing. VW does not easily ring true to the average ear. It does not readily demonstrate its benefit as well as its relationship to the infrastructure deficit and debate. As suggested earlier, the majority of the countries of the region consider their situation with regard to water storage and water conveyance infrastructure as woefully inadequate. How does VW address this challenge? Does VW independently bring benefits that would otherwise accrue from increased infrastructure, without bringing with it additional political and risk related costs? Similarly, water abundant countries would also need the assurance that

[78]Indeed, the specification in the SADC Treaty that Tribunal decisions should be ‘final and binding’ (Article 16.5), would seem to be unusual in international treaty terms.

VW would positively contribute to their economic growth opportunities, and that diverting water and land use to trade is indeed the way to go.

The treatment of the subject in the southern Africa region has tended to be in the rather high level intellectual space. This has of course been necessary in attempting to understand VW's essence, implications, its relevance and applicability, as well as how best to adapt it to different political, social and economic scenarios. However we need to look critically into whether a strategy that focuses on the VW concept *per se*, as opposed to one that uses the concept to demonstrate added value, is likely to achieve optimum buy in. We might also find that we are shifting the burden of defending, unravelling and articulating it onto already overextended government officials. Rather, we may want to consider reverting to already familiar terminology and imagery such as, for instance, "promoting the optimal use of water, land and infrastructure (new and existing) resources, to the benefit of Member States both individually and collectively." It is worth noting that a big difference between the introduction of VW in the nineties and today is that today the concept has a champion in CRIDF that is deliberately searching for ways to avoid the impediments and pitfalls of the past. The opportunity lies in having a capable and adequately resourced entity that is prepared to judiciously select entry points, mobilize the necessary resources to among other things cultivate relations with carefully selected regional personalities of note, as well as with various regional, sector specific and international cooperating partner (ICP) bodies involved.

VW will therefore need to be disseminated systematically, broadly and intelligibly if it is to be embraced. To do so effectively will require a multi-tier communication strategy also targeted at specific sectors and interests outside water, in particular but not limited to agriculture, trade, energy etc. Intelligibility refers to its accessibility to those who will need to understand the dynamics of the farming, trading and other opportunities it would seek to create. Targeting Ministries of planning (often also held jointly with the finance portfolio) should also be considered. These Ministries in particular have become quite adept at interpreting complex ideas and theories into intelligible and implementable policy options. Nonetheless, it is recommended that the focus of the dialogue should be on using the concept to deliver added benefit, both in terms of providing stronger arguments for financing infrastructure, as well as in economic and environmental benefits to both individual countries and the region as a whole.

There is also merit in considering broad dissemination independently of inter-sector penetration at the very outset. Private print media houses within the region tend to be open to carrying regionally relevant stories and think pieces in their opinion columns. Similarly, Inter-Press Services have shown a willingness to carry transboundary water and regional integration success stories, and could be explored as an option. These wider initiatives will help to broaden understanding and create social demand to nudge political processes forward.

While the initiative is to be rolled out within the context of SADC's core mandate of regional integration it is prudent that the strategy should seek to stress the VW benefits to countries individually. Thus a country by country cost/benefit assessment will need to be developed probably in collaboration with the countries concerned. This has the benefit of carrying the countries along from the onset and in so doing creating demand. In this exercise it would again be a good idea to find a way to involve entities outside government including chambers of commerce, agricultural unions, etc. It will also be wise to shed light on how the region as a whole will benefit. In other words, demonstrate how VW would ultimately strengthen the integration process as well as the integrating economic region itself?

The Role of the SADC Secretariat

As a regional body established and mandated to steward regional integration the SADC Secretariat is going through arguably it's most challenging phase since its establishment. It is ill-resourced financially and is consequently grossly understaffed. Moreover, due to its rather limited mandate it has historically tended not to champion independent initiatives or innovations not already endorsed by Member States. However it should be mentioned that whatever its current condition the Secretariat's core mandate of regional integration remains intact. It is not to SADC as the agent for change that one turns, but rather as the region's official and duly mandated regional vehicle for progressive change.

Thus, in order to effectively introduce new thinking or promote new initiatives including policy options within the region one should tactfully identify entry points and use SADC's own institutional bodies at various levels or partner institutions to solicit and cultivate support from Member States and promote the initiative, the SAPP (Chapter 7) is a case in point. Often it will be necessary to do spade work within countries as a parallel process, targeting public and non-governmental entities where the latter exist, in order to mobilize the necessary support. The aim here is not necessarily to win support from SADC *per se* but to have access to and to utilize its mandated purpose which is to commend duly processed ideas, initiatives and policies for collective approval or adoption by governments. Sometimes the value of this approach lies in merely assuring governments at country level that a particular idea, initiative or policy proposal has been adequately considered and debated and is deemed valid, acceptable and implementable by Member States.

Some recommended entry points include the following:

- ***Water Resources Technical Committee (WRTC)***

  The Water Resources Technical Committee is the sector entry point and clearing house for issues due for eventual consideration by SADC water ministers. Issues are added to the agenda of this annual meeting through the initiative of Member States, the Secretariat itself, or through the Secretariat by a recognized sector partner. Ideally one would want to have a Member State suggest inclusion on the agenda with prepared support from one or two Member States. It always helps to have two or three delegates who are conversant with and supportive and of the issue under discussion.

- ***SADC River Basin Organisations Forum***

  This bi-annual forum also offers a good opportunity to introduce a topic into the SADC water sector agenda. Its limitation lies in the fact that participants rarely include people from outside the regional RBO fraternity. It is nonetheless an important regional forum occupying an increasingly important and influential space in the region as RBO's grow in cohesion, experience and stature.

- ***Targeted RBO's***

  SADC RBO secretariats have grown in confidence and effectiveness over the years in their advisory role to governments. They present the opportunity to target a particular cluster of countries through a trusted medium that is also intimately familiar with the countries individually and collectively. One carefully identified and properly cultivated RBO potentially sets up entry into the WRTC. ZAMCOM may prove to be a useful port of initial call in this regard.

- ***Global Water Partnership - Southern Africa (GWP-SA)***

  Collaboration with the Global Water Partnership – Southern Africa (GWP-SA) as a neutral platform could present useful options to reach a broad section of the target audience for the initiative. GWP-SA is a strategic partner of the SADC Water Division. A prime example of this would be use of the often televised GWP Multi-Stakeholder Forum to discuss and debate the strategy. The forum's big advantage lies in its being open to government, non-governmental entities, private sector and any formations interested in participating thus giving it high penetration potential, arguably the broadest on offer across all sectors. This could be co-hosted with GWP with targeted invitations to carefully chosen and sourced panelists including one or two that are *not* from the traditional regional economic powerhouses. Turton has in his Chapter 3, postulated a northward shift in hegemony driven by rapidly growing economies and to some extent perhaps less climate vulnerability. The courting of Angola, Mozambique and Zambia in this regard may prove useful. This meeting could be used as the launching pad for a broadening of the regional discussion on virtual water within SADC.

- ***Water Strategy Reference Group (WSRG***)

  The WSRG is the forum of all international cooperating partners collaborating with the SADC Water Division. The WSRG's concurrence with and support for the adoption by SADC of a VW based strategy would substantially enhance its credibility. It is conceivable that participating ICPs would also assist in promoting the approach in the other relevant sectors that many of them are also involved in. It would be advisable that care is taken to check if any of the ICP's that wield influence in other sectors are in any way opposed or unconvinced so that this reticence can be addressed early prior to any damage being inflicted. DfID as one of the core funders of transboundary waters in SADC already has a seat at this table, which could be exploited by CRIDF.

- ***SADC Secretariat***

  The Secretariat offers an entry opportunity in and of itself as a vehicle for further elaborating the concept and ensuring understanding. Entry into the secretariat also avails the opportunity to use contacts within the Water Division to reach SADC secretariat officials in other relevant divisions and through them access to their respective divisions. The Water Division of the SADC Secretariat plays a crucial role in preparing support documentation for matters put before ministers at their decisive annual meetings. The Division is also responsible for the wording of reports of official meetings. Their willingness to allow collaboration in the preparation of the documentation as well as agreeing to invite independent presenters to official meetings can play a key role in determining the fate of an initiative. Success or failure at this level determines whether or not a matter is approved and recommended for presentation and consideration by the political structures of SADC including the Summit. A matter with relevance for more than one sector such as is the case with VW could stand an even greater chance of success if chaperoned properly.

- ***SADC Water Ministers' Meeting***

  The different routes suggested above namely the WRTC which is the technical clearing house for issues eventually presented to ministers, the RBO's with their in-house access to respective ministers, and the SADC Secretariat through its official mandate all give support to and can thus provide a route to the Ministers' agenda. Again it will always help to have cultivated relations with some targeted ministers beforehand while obviously welcoming any others that might independently have found merit in the particular issue at hand.

- ***Southern African Power Pool (SAPP)***

  The clear water, carbon and cost benefits to be had by electricity trading through the SAPP makes this SADC institution an ideal point of entry. In this regard, the regular meetings of the various SAPP organs could be targeted for presentation of the core concepts.

Conclusion

In order for an arguably radical concept such as Virtual Water to win support within the SADC region:

- It needs to be seen as being in line with and in support of, and not in conflict with regionally adopted strategies and principles, chiefly;
  - It must support infrastructure delivery, not be seen to be *in lieu* of it;
  - It must promote hydro-supportive growth trajectories;
- It should, however, acknowledge and accommodate the inherent bias towards sovereign interests, while supporting the political goal of integration – CRIDF's '*sovereign security with a cherry on top*';
- It must be supportive of the regional desire and priority to develop water infrastructure;
- It must bring demonstrable and quantifiable benefits to countries both individually and collectively;
- It must not exclusively benefit the larger economies but also support the emerging and rapidly growing economies in their aspiration to catch up, recognising the benefits of stronger neighbours and trading partners rather than the risks of competition for resources and markets.

Critically,

- It must avoid appearing too elitist and esoteric in its orientation, specifically targeting the benefits of the concept rather than the concept itself;
- While tactically selective it must be broadly targeted and ultimately inclusive in its roll out;
- The role of the private sector as distinct from but together with the SADC citizenry must be recognized;
- A multi-tier communications strategy will be required;
  - It must have a multi-sector orientation; and
  - It must show familiarity with key strategies in other relevant sectors

There need also be recognition that it will take a while for the project to grow roots, and that this will likely overshoot the CRIDF lifespan as it now stands. Mechanisms to sustain the processes through the agencies outlined in the previous section will have to be developed.

Chapter 11: Key considerations for introducing Virtual Water and Nexus thinking into SADC

By

Gavin Quibell

Introduction

The Climate Resilient Infrastructure Development Facility (CRIDF) promotes the delivery of small to medium-scale infrastructure across SADC through technical assistance aimed at developing sustainable pro-poor infrastructure Projects, and facilitating access to finance to deliver the infrastructure. The Facility aims to build climate resilience for poor communities across the SADC region, to enhance cooperation in shared river basins, and to build an evidence base for the national and regional benefits of cooperation.

However, small to medium-scale infrastructure has limited transboundary impact, and CRIDF's infrastructure Projects will not be large or numerous enough to drive regional integration, or make a substantial impact on the overall shortfall. The sum total of beneficiaries expected to benefit from CRIDF infrastructure projects is expected to be in the region of 4.5 million people, against a total poor population in excess of 150 million[79]. CRIDF is expected to mobilise some U$ 816 million, against an estimated deficit of U$ 100 billion. While CRIDF's contribution to climate resilience and poverty alleviation through small infrastructure is certainly to be lauded, it simply cannot benefit a substantial portion of SADC's poor, or make a sizeable dent in the regional infrastructure deficit. Clearly, the Facility's legacy must also lie in creating the conditions for replication by SADC's Member States and potential financiers. This is related to both maintaining economic growth as a basis for improved governance and sustained climate resilience benefits for the poor, as well as creating a sound evidence base for the value (economic and socio-political) of both small and large scale investments in infrastructure. CRIDF must consequently also focus on the larger regional infrastructure projects, these are projects that can drive regional integration and build regional climate resilient economies on a much wider scale.

The Facility has often noted that one of the most pervasive climate resilience challenges facing the SADC region is the variability in water availability over space and time. The drier southern regions have typically responded through large scale hydraulic infrastructure, storing water and transferring it to where it is needed, while the wetter northern regions have not yet fully exploited their relative water abundance through water infrastructure. These northern basins and countries are vulnerable to intra-annual variability and shorter term drought but the crop and livestock yields in these region - as measured by returns to water - could be significantly increased. Higher returns to green water are likely be the main source of increased SADC food and water security. The expansion of the storage of blue water and improved water distribution infrastructures will also significantly improve levels of food and water security, The northern SADC economies will be able to double and even treble their crop and livestock

[79] Estimated against some 50% of the population that lie below the the national poverty line.

production. The drier southern basins and countries are vulnerable to ever diminishing water reserves and longer-term climate change induced droughts.

As climate and demographic change and economic growth increase water stress across the region, larger scale engineering solutions will be demanded to address climate vulnerability. Turton's Paper shows that ever grander scale north to south water transfers have been mooted to move water southward and driving the larger economies of the south with 'excess' water from the north. However, water delivered through these schemes will become increasingly unaffordable and environmentally expensive. As the southern 'pivotal' basins face closure, variable water supply and absolute water stress will therefore become a regional rather than national or basin challenge.

These larger north-south transfer schemes are likely to impact on regional cooperation. While this could serve as a source of regional cooperation, it could just as easily shift towards unilateral action and 'upstream (north) / downstream (south)' tensions. The implications of these schemes on the availability of water for growth in the donor basins may raise regional pressures around reasonable and equitable use of water, particularly in times of drought. The better watered northern countries are likely to want to retain access to water for future use. Hard choices will consequently have to be made to secure the water needed to drive all the economies of the region.

The hypothesis lead by CRIDF in this regard is that Virtual Water and Nexus perspectives may offer a different view for consideration by national and regional planners. Alternatives to large scale regional water *transfer* infrastructure, making better use of the *total water footprint* and *Virtual Water trades* in food and electricity across the region may promote regional integration and net benefits for the whole region, without threatening sovereign security.

This could have substantial benefits for peaceful cooperation. However, trading in agricultural goods and electricity is deeply embedded in the shifting political economy of the region, and introducing Virtual Water and Nexus thinking in this milieu is not for the faint hearted. It requires a carefully considered approach, founded in a sound evidence base of its social, economic, and environmental benefits, and which is consistent with the underlying metrics and ethos of national and regional planning for development.

This final Deliverable of the 'Expert Panel Activity' of CRIDF's Virtual Water and Nexus Project pulls some of the key considerations gleaned from the Panel discussions and Position Papers. These key considerations should underpin the Facility's efforts to support regional climate resilience, economic growth and integration through influencing large-scale infrastructure development and the operation of that infrastructure through Virtual Water and Nexus thinking.

It starts off by setting the jargon to rights, then highlighting the regional climate change risk, which together form the basis for understanding some of the key considerations posited by the Panel. It closes, as one may expect, with some recommendations for taking the work forward.

Setting the Jargon to Rights

At the outset the Panel of Experts highlighted the dangers of the bandwagon and jargon nature of 'Virtual Water and Nexus' thinking, warning that it may represent a distraction from the key purpose of building climate resilience for the SADC region, benefiting the poor and increasing cooperation. Tekateka's paper noted, in this context, that

Virtual Water thinking has previously been introduced into SADC, but that it had not gained much traction. He warns that any attempt to re-introduce the concept should avoid elitist thinking. Given the collection of egos in the room during both workshops, this must have been said with some irony. Tekateka also notes further that the

> "…*potentially rather complex concepts, are not necessarily the ideal propositions to posit as opposed to those that utilize more familiar and accessible language and imagery".*

As one delegate to a Nexus conference organised by the Mekong River Commission noted;

> "*The water, food and energy nexus is just another name for Integrated Water Resource Management*".

Importantly, a 'nexus' approach recognises the essentially political nature of development and responds to that, often IWRM practitioners attempt to find technical solutions to political problems.

Nonetheless, undaunted by its own cautionary tale, the Panel nevertheless used some jargon of its own, elaborated in Muller's Paper; *hydro-centric* thinking where water management is seen as the driver and coordinator of development initiatives, and *hydro-supportive* approaches where water resources management supports a wide spectrum of national growth priorities. Water allocation and management are very challenging because the priorities range from those that clearly synergise and those that fiercely compete. Synergies emerge when the domestic and industrial water is treated and re-cycled so that the total volume of water available in an economy is increased. Increasing the returns to green water is possibly the most important of synergistic measures. On the other hand, getting farmers, who are the major users of blue water, to reduce water consumption in order to steward scarce water is the most conflictual issue. Ensuring that water is available for all uses that advance politically feasible rates of reform and development will be achieved in political systems. Muller argues that politically feasible hydro-supportive approaches have actually been the overriding development paradigm world-wide, despite the dominance of the hydro-centric discourse in donor and water circles in SADC Water.

Allan, in his Paper, proposes an alternative to the Nexus; *"A better acronym would be **NEXAS** - **N**atural **E**cosystems e**X**pect* **A***ccountable* ***S****tewardship, a shift from understanding the issue, to one where one is held accountable for a duty of care*". Ultimately, however, most of the panel members recognised that concepts had value, albeit somewhat "jargonistic", but urged caution in its use. This raises the question; "*How will CRIDF define its 'Virtual Water and Nexus' approach going forward?*"

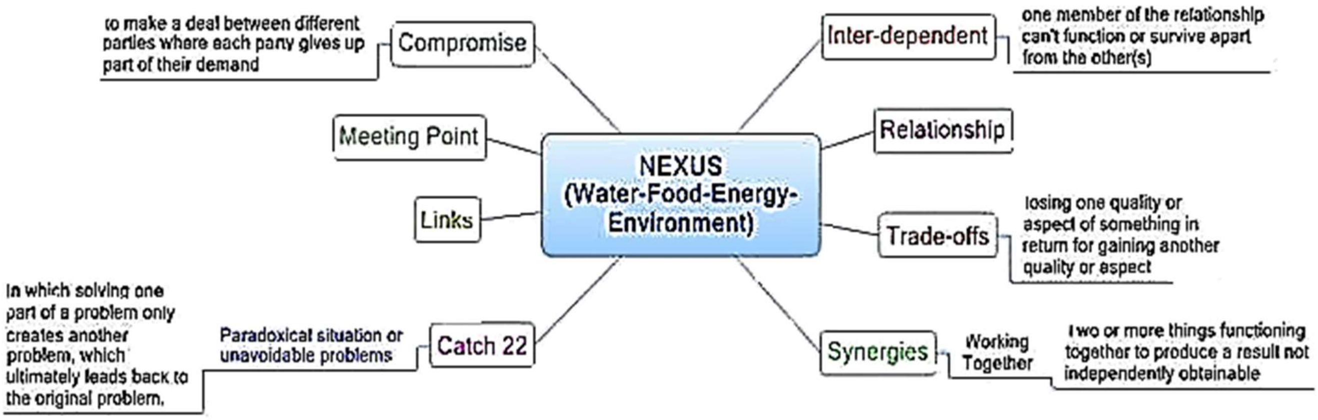
We need to turn back to the Facility's central thesis; that the transfer of Virtual Water in food and energy around SADC offers an alternative options for building regional climate resilience. Importantly, as was frequently argued during the sometimes animated debate, this does not mean the large scale infrastructure required to secure sovereign water, food and energy security should not be built, but rather that the operation of that infrastructure from a water footprint and nexus perspective could promote regional climate resilience, environmental, cooperation & integration and economic benefits without the need for physical water transfers.

From this, we can distil the following characterisation for Virtual Water and Nexus thinking going forward;

> *"A process that considers the additional trade-offs, regional climate resilience, economic and environmental benefits that may be gained from considering the water footprint and virtual water contained in agricultural products and electricity traded; when pursuing sovereign water, food and energy security through infrastructure."*

This is fundamentally a *hydro-supportive* process, using Virtual Water and Nexus concepts to highlight alternative options and motivation for supporting and financial regional development and poverty eradication through optimised larger storage and energy infrastructure.

Before stepping off the discussion of the tragically jargonistic nature of Virtual Water and Nexus thinking it is useful to remember the Mind Map of the Nexus produced by the Mekong River Commission Secretariat workshop in May 2013 (facilitated by this author) and reproduced below.



It is instructive to recognise, as you progress through the remainder of this report that a 'nexus' is at times any one or more of;

- Synergies between sectors;
- Trade-offs between sectors and benefits or dis-benefits in development;
- The relationship between sectors in enabling development;
- The inter-dependent nature of sectors and mutual development;
- Compromises required by the political economy, or needed to optimise development;
- The meeting point between sectors;
- The links between sectors; and
- Potential Catch 22's underpinning multi-sectoral growth.

Climate change and water vulnerability in SADC

Several of the Papers noted that climate vulnerability in southern Africa will be as much (or more) related to increasing variability, as to a trajectory of change. SADC's already capricious rainfall and runoff is likely to be exacerbated through climate change, driven primarily through the position of the Inter-Tropical Convergence Zone (ITCZ). Global Climate Models (GCMs) mostly suggest that areas north of the ITCZ are likely to receive more rainfall, while those to the south will get less. However, the impact of this on water availability is much more difficult to predict. SADC's rainfall / runoff ratios are already lower than those for parts of the USA and Europe (10% compared to over 30% - see Turton's Paper). This combined with projections of higher than average increases in temperature in SADC's interior, means that runoff may be lower, even in areas getting more rain. Increased temperatures will increase crop watering requirements and will increase evapo-transpiration off catchments and evaporation off the large hydropower reservoirs.

This brings the blue / green water mix in agricultural products into stark perspective, and in particular the challenges facing the Zambezi Basin. The ITCZ splits the Zambezi Basin, and currently more than 60% of the runoff in the Basin is generated to the north of this line. Already southern Zambia is characterised by the later onset and earlier termination of the rains, with significant intra-annual impacts on the rural poor. However, the economies of the many of the Zambezi's riparian States are substantially driven by hydropower and blue water (irrigation) users to the south of the ITCZ. The southern summer position of the ITCZ is affected by a host of factors, and the impacts of climate change in this regard are difficult to predict, although it is likely that runoff in the southward draining basins would be even more variable – largely dependent increased temperatures and the position of the ITCZ.

Predictions for hotter and drier conditions to the south are also central to understanding regional climate resilience in SADC. Overall South Africa dominates trade in agricultural goods and electricity, playing an important role in regional energy and food security. Inter-SADC trades from the dry south (often in maize and other staple foods) is driven primarily by rain-fed agriculture (92% green water content), and hence vulnerable to even short term drought. SADC exports to the rest of the world have a 78% green water content, and are driven more by irrigated agriculture and hence stored blue water. SADC exports to the rest of the world are therefore less vulnerable to short term variability and reduced rainfall than intra-SADC trade, particularly given South Africa's larger *per capita* storage. Moreover, the availability of green water to the north of the ITCZ is not yet contributing to regional food security and economic growth. Very little of the SADC's internal and external trade in agricultural products comes from the region. The two wettest countries of mainland SADC, Angola and the DRC, are net Virtual Water importers with outwardly looking economies. The Virtual Water database shows that Angola derives 85% of its agriculture imports from outside SADC, and the DRC 94%, but neither State is a significant exporter of Virtual Water, in spite of their higher rainfall. This is a pattern that exists in most regions of Africa and one that reflects a sub-optimum marshalling of both green and blue water and of land and especially of social, institutional and investment capital.

Climate vulnerability in SADC therefore has both infrastructure, Virtual Water trade, and water footprint dimensions. Higher *per capita* storage and water transfer infrastructure in the southern regions has long been the solution to variable water availability. However, as these basins reach closure, infrastructure solutions will become increasingly expensive and re-allocations of water between economic sectors, and regional changes in Virtual Water trades will be required to maintain water, food and energy security. Muller's paper notes that South Africa has for many years considered food imports from the north is again investigating the potential for food imports from SADC as a solution to growing water shortages.

In the north, small scale storage infrastructure may go some way to addressing intra-annual variability for the rural poor, but will not deliver economic climate resilience. Moreover, several Position Papers highlighted the vulnerability of large storage infrastructure in the Zambezi Basin to climate change. Climate resilient economies will therefore require attention to both the development and operation of infrastructure, but also the introduction of concepts such as water footprinting, the water food and energy nexus, and variable assurance of supply.

Perhaps most poignantly the gist of discussion on climate vulnerability in SADC was that;

> “*If we can learn to better manage the regional spatial and temporal variability in water availability in the shorter term, we would be much better placed to cope with climate change in the longer term.*

The following sections outline some key considerations for CRIDF’s ongoing work in this regard.

Key considerations for CRIDF

A Shifting Geographical Scope

Several Position Papers highlighted the SADC geographical conundrum; the largest water, food and energy demands lie in the drier southern basins, while the water available in wetter northern basins does not support regionally large economies. Turton describes both pivotal basins; the Orange-Senqu, Limpopo and InKomati, and pivotal countries; Botswana, Namibia, South Africa and Zimbabwe. The three pivotal basins support a substantial portion of the SADC economy, and the CRIDF Social Indexes database shows that the 4 pivotal States drive 67% of the regional economy with only 5% of the available water resource.

Turton also highlights the potential impacts of climate change on this pattern, making the point that the faster growing economies astride the ITCZ, Angola and Zambia in particular, but also Mozambique and Tanzania, are likely to become increasingly influential from a SADC water perspective. Recent finds of significant hydrocarbon reserves in Angola, Mozambique and Tanzania may further shift the focus northward. Turton also highlights countries that are particularly vulnerable to climate change impacts as a result of both changing water availability and water quality, as well as the population pressures and economic structure; Malawi, Swaziland and Zimbabwe in particular. These same countries stand out in Phillips’ analysis of virtual water trades, and Schreiner and Quibell’s assessment with respect to agricultural exports with a relatively higher blue water component, little internal storage resources, and hence increased climate vulnerability.

The shifting geographical scope again highlights the importance of the Zambezi basin and Zambia to the region; as a source of hydropower, the potential for expanded irrigation; and its critical position in terms of the north-south transport routes through the new bridge at Kasane / Kazungula. While only 20% of the mean annual runoff in the Zambezi is utilised (the majority as evaporation off the large hydropower reservoirs[80]), Schreiner and Quibell highlight that development of the Zambezi’s resources should not assume that there is plenty of water available for allocation. A fact also highlighted by the results of the World Bank’s Multi-Sector Investment Analysis in the Zambezi described in the paper on the Southern African Power Pool (SAPP). The future of irrigation and

[80] From the Zambezi IWRM plan

hydropower and the trade-offs or nexus between these sectors in the development of the Zambezi riparian States should form a critical component of building an evidence base for the regional climate, economic and social benefits to be derived cooperation, and CRIDF would be well advised to focus attention on this Basin in this context.

The political economy

Any successful prosecution of the Virtual Water and Nexus thinking as outlined in the 'jargon' section above must be firmly embedded in the SADC and global political economy. Turton points out that SADC had its origins in the movement against apartheid, and Mangwengwende, Musaba and Krohn, and Phillips note that the electricity trades which gave rise to the Southern African Power Pool in the early 1990's were enabled through transmission infrastructure created to minimise the dependence on electricity from apartheid South Africa. South Africa's regional economic dominance and its role in water, food and energy demands and regional trades nonetheless still remain, and currently efforts to build regional climate resilience must consider this potential hegemony, despite the shifting geographical focus outlined above. While there is some evidence of 'unease' regarding South Africa's role in this regard (Tekateka and Mangwengwende *et al*), politically SADC leaders remain deeply committed to regional integration. A sense of brotherhood, shared origins and linked destiny endures, albeit perhaps with a growing sense of realism.

The developing and hence vulnerable nature of the region both politically and economically makes its Member States somewhat hesitant to tie their destinies too tightly together. This is perhaps more notable in the electricity sector, where the Inter-governmental MoU to establish the SAPP notes that all participants should;

> *"Co-ordinate and co-operate in the planning, development and operation of their systems to minimise costs while **maintaining reliability, autonomy and self-sufficiency** to the degree they desire [**my emphasis**]."*

The equivalent objective of SADC's Water Division is stated on its website[81] as;

> *"To ensure that water in Southern Africa becomes a **sustainable resource through the coordinated management, protection, and equitable use** of its shared watercourses." [**my emphasis**]*

… underlining perhaps a perception that *"Ubuntu will always trump sovereignty".*

Tekateka points out that;

> *"While purist pundits […] continued to stress the need for riparian States to accept sacrifices in regard to national sovereignty, basin politics have continued to remind us that we are still some way away from that perfect state".*

81 http://www.sadc.int/sadc-secretariat/directorates/office-deputy-executive-secretary-regional-integration/infrastructure-services/sadc-water-sector/

This gives credence to Palmerstone's[82] assertion that *"Nations have no permanent friends or allies, they only have permanent interests".* Nonetheless, the commitment to seek mutual benefits from regional development remains. CRIDF has stated this basis for integration based on Virtual Water trades somewhat more elegantly as;

> "*Sovereign security with a cherry on top*".

Turton's paper reminds us that this is not unlike the Parallel National Action (PNA) approach used to align development in Scandinavia, and this approach should be explored in the context of CRIDF's work.

Allan's Paper on the international perspective is also relevant to this discussion with respect to the impact of global food and agricultural subsidies, which keep the global prices of key food commodities artificially low. This both makes it difficult for poor African farmers to engage in the global food market, but also to invest sufficiently in the stewardship of their water resources that will be increasingly necessary as a contribution to sustainable regional and global ecosystems.

Tekateka notes that;

> "*Many African observers saw as a sinister betrayal the "sudden decision" by the European Union to establish its own separate European Water Facility (EUWF) in parallel [to the African Water Facility] while purporting to work towards the same goal as AMCOW*".

These observations perhaps reflect a growing disenchantment with what may be seen as global approaches that ultimately favour the developed north at the expense of the developing south.

Allan's paper makes the point that OECD and US subsidies for large scale agriculture skew the actual cost of food production and its impact on the environment, specifically noting;

> "*At this point in history, at beginning of the twenty-first century, the outcome of the past two hundred years of the evolution of the political economies of food (Paarlberg 2013) and of energy (Pascaul and Elkind 2009) is that global food prices are determined by massive policy interventions by the OECD economies. These OECD policies also determine in some cases, and in others have a deep influence on, the prices in emerging and especially in developing economies. They have impacts on the SADC economies. These distortions have been reinforced by World Trade Organization arrangements. Water resources have been dangerously impacted by these interventions because it has been assumed that there were no costs associated with over-using, depleting and polluting unvalued or under-valued water ecosystem services and the atmosphere."*

Understanding this global political economy is also relevant to a politically savvy approach to inculcating Virtual Water and Nexus thinking in SADC.

[82] Lord Palmerstone (1784-1865), Minister of Foreign Affairs United Kingdom

The Role of the Private Sector

Allan's Paper also reminds us that some 90% of the water in the economy is managed by the private sector, mostly farmers in the form of green water. His proposal for the ***NEXAS*** acronym (see earlier) underpins the importance of Private Sector stewardship in this regard. Schreiner and Quibell note that, with the exception of 'Streamflow Reduction Activities' in South Africa, the use of green water is generally unregulated by water sector institutions and rules While they point out that spatial planning of agriculture can be a proxy for 'green water allocation', the limited influence of the water sector on this kind of planning (and the hydro-supportive context for development) makes this an unlikely source for proactive allocation by the public sector.

However, this is not necessarily the case for the private sector, which is increasingly considering the total water footprint in terms of 'blue', 'green' and 'grey' water in their water stewardship drives. Pegram notes that water footprinting is useful to;

- identify parts of the national and regional economy(ies) that may be vulnerable to changes in the availability and variability of green and blue water, and hence the resilience of the economy to climate change;
- support and understand the trade-offs of water use between different sectors of the economy, perhaps in response to climate change; and
- illustrate the relative amounts of water used where different goods are grown or produced.

[*para-phrased here*]

Pegram also highlights a number of cases;

> "*…where the private sector has been exposed to significant physical, regulatory or reputational risk due to water security risks within their value chain*".

This underpins the need for an increasing focus on Corporate Social Responsibility (CSR) and water stewardship within the private sector. This is evidenced, not only by specific water stewardship and water footprinting programmes by companies like Coca- Cola, Illovo Sugar and SABMiller, but also in the increase in tools and guidance such as the Lloyds 360 degrees risk report on Global Water Scarcity or the Carbon Disclosure Project - Water Component.

An improved understanding of the blue and green embedded water in their products will also allow companies reliant on agricultural inputs to better plan any potential expansion within the SADC region, and in so doing to minimise their vulnerability to climate change. This influences the 'allocation' of greater volumes of green water in supporting the economy. Schreiner and Quibell note that the private sector in large scale agriculture can also, by introducing concepts like variable assurance of supply and regional risk pooling, increase their total regional production, reduce their vulnerability to drought, and increase the number of small scale poor out-growers. Importantly also, in the face of very limited capacity in the public sector, self-regulation by the private sector using water stewardship can entrench Virtual Water and Nexus thinking into regional water management and economic development. Where these companies have a presence in more than one riparian State, and can balance their impacts in this way may also have a transboundary dimension. The presence of Illovo Sugar in the InKomati

Basin, in both Swaziland and Mozambique; and in the Zambezi Basin in both Zambia and Malawi is a case in point.

CRIDF has already established contact with the Illovo Sugar group, and has held preliminary discussions on the potential for an investigation on building regional climate resilience using their existing water footprint data as a basis. This will explore the potential for using variable assurance of supply to expand their out-grower schemes through a climate resilience lens. It is recommended that this engagement is intensified and elaborated.

The Role of Transboundary RBOs

The SADC Water Division and the transboundary RBOs place shared water management at the centre of development in transboundary basins, and as a consequence over 70% of the surface waters in mainland SADC. Donors have entrenched this, speaking for many years beguilingly of IWRM approaches, benefit sharing and the value of cooperation largely around a developed and European model. They have followed this up with considerable funding and support. Not surprisingly, these hydro-centric approaches are deeply rooted in SADC's transboundary River Basin Organisations (RBOs).

However, as Muller points out;

> “*Even in the European Union, where water resource development management is formally governed by the environmentally focused Water Framework Directive (WFD), many countries "work around" the WFD to focus on specific management challenges in "problemsheds" rather than "watersheds".*

Muller also notes that;

> “*Globally, few regional water institutions have any sovereign authority either to convene or to take decisions in respect of water management and use*.”

This is certainly the case for most transboundary RBOs in SADC, which are mostly set up as technical advisors to the Parties (examples are the JWC between Mozambique and Zimbabwe, LIMCOM, OKACOM, ORASECOM, and to some extent ZAMCOM). Indeed, the extent to which these bodies actually reflect national development objectives around the nexus depends to the degree their delegations consult with line agencies in water, food and energy development. This author's experience is that transboundary RBO's interaction with line agencies in this regard is often very limited.

Schreiner and Quibell also note that;

> “*… there are considerable challenges in terms of both institutional capacity and the reliability of hydrological and water use information that beg the question of the efficacy of the allocation systems*”.

Transboundary RBOs are often not best placed to negotiate potentially contentious trade-offs around water, food and energy security between riparian States. The cooperation imperative, and their own Rules of Procedure requiring consensus decision make these organisations very risk adverse. Formal notification processes as specified in SADC's Revised Protocol on Shared Watercourses have rarely, if ever, been effectively prosecuted.

Similarly, while Schreiner and Quibell note that the availability of, and dependency on, blue or green water for different water use sectors could be taken into account when determining reasonable and equitable use of water, but this has not as yet been investigated, or even considered in the abstract.

Schreiner and Quibell also note that many of SADC's transboundary RBOs have conducted basin-wide studies, but that few of these present a comprehensive plan for development of the water, food and energy sectors in the basin, Importantly, none of these address the broader regional inter-basin aspects. Moreover, these authors' note that;

> "*… it may be argued in some cases that 'approval' of basin wide plans by all riparian States which note plans for increased water use reflects an agreed water allocation. However, the enforceability of the plans in this regard is highly unlikely."*

Together, these analyses suggest that transboundary RBOs are not well placed to establish and give effect to water, food and energy trade-offs in infrastructure development.

Nonetheless, Tekateka points out that the SADC Water sector has always been innovative and notes that very early on;

> "*A small but activist group of water ministers emerged in the region that was personally and collectively committed to the regional approach, literally staking their reputations in support."*

This not only increased the profile of the role of water in regional integration, but also established fertile ground for taking on new ideas. SADC's water accounting project (outlined by Phillips) is a good example of the sector's willingness to engage in new thinking. Tekateka therefore recommends that SADC's transboundary RBOs form an important role in communicating and disseminating any message on the role of Virtual Water and Nexus thinking in regional climate resilience, integration and growth.

Schreiner and Quibell also point to the benefits of variable assurance of supply, and the role that green water can play in maintaining the economic viability of agricultural enterprises. Outside of South Africa, all water users (except urban supply, livestock watering and vital human needs), tend to be supplied at the same assurance irrespective of the impacts of short term reduced water supply on their economic viability. Reducing the assurance of supply for annual crops from 90% to say 70% means that the volume of water available for allocation can nearly double, while still maintaining the viability of many (annual crop) irrigation enterprises. This concept is being introduced into the Orange-Senqu IWRM plan (by the GiZ, UKAid, AusAID support to SADC), and the Save Basin (by CRIDF), but is largely not considered in the northern basins.

Where large agri-business has a regional footprint, regional risk pooling along variable assurance of supply lines can add further climate resilience, while still maintaining the viability of small scale out-growers. Involving the private sector in managing their own water allocations in this way can both help build capacity in regional water management institutions and help entrench climate resilient water apportionment strategies through legislation and basin planning.

The Role of the SAPP

Mangwengwende, Musaba and Krohn highlight a potentially significant role for the Southern African Power Pool (SAPP) in building regional climate resilience and cooperation. The SAPP already links the wetter north with the dry south through electricity transmission, and as highlighted in Phillips and the SAPP Paper the Virtual Water embedded in electricity trades can hold substantial water, economic and carbon benefits. Mangwengwende, Musaba and Krohn point out that the ‘surplus’ between firm and average power, if sold into the SAPP, has Virtual Water, Carbon and Cost benefits to the region and particularly to South Africa.

> “*… it has a value of some U$ 116 million (as an annual average). The cost of generating that power in South Africa’s coal fired thermal stations is twice that value. The water saved, using the average water use in ESKOM’s thermal stations would be nearly 8 million m^3/a, which is 2.5% of that facility’s total water use. This is enough to irrigate about 800ha or provide free basic water (at 6000 L / household / month) to over 100 thousand houses for a year. ESKOM’s CO_2 emission factor is 0.99 kg/kWh[83] for 2012, with a target of 0.68kg/kWh. This means a $C0_2$ emission saving in the average surplus (assuming zero emissions from hydropower) of some 5,500 million tonnes or some 2.4 % of the facility’s total annual emissions.”*

Importantly such trades have previously been established, and cooperation between South Africa and Zambia on the “electricity storage scheme” (see Text Box) held significant benefits for both countries (Masaba[84], *pers comm*).

Text Box 1: The electricity storage scheme between South Africa and Zambia.

Between 2002 and 2007, South Africa and Zambia operated the ‘electricity storage scheme’ as a means of optimising their respective costs. During the daily peak demands hydropower from the Zambezi was fed into the South African grid. During off peak times, thermal power from South Africa was fed into the Zambian grid. The resultant lower off peak demand for Zambezi hydropower allowed for water to be stored during off peak times, and made available during peak times. The resultant cost savings held benefits for both countries.

The scheme fell into disuse when even off peak power demands in South Africa precluded the transfer of electricity in this way.

[83] From http://urbanearth.co.za/articles/eskom-announces-unchanged-electricity-emission-factor-2012
[84] Dr Lawrence Masaba: Coordination Centre Manager, Southern African Power Pool.

Selling the Virtual Water and Nexus concepts through the SAPP holds a number of benefits, despite the lower volumes of Virtual Water and potentially smaller economic value compared to agricultural trades;

- The SAPP is already acting on a regional, transboundary and trans-basin basis, and is therefore well placed to contribute to addressing the economic versus physical water scarcity conundrum.
- Electricity demands and shortages are perhaps more visible and immediate than water shortages which may take years to emerge, which both helps but also urges caution in introducing the concepts.
- The SAPP representing a key water use sector provides the opportunity to demonstrate hydro-supportive approaches.
- The electricity sector offers both climate resilience (through using water better) and climate mitigation (through reduced carbon emissions) opportunities.
- The potential economic and water benefits are not insignificant.
- The electricity sector has already taken on board the need to balance sovereign security with regional benefits, as central to the regional political economy.

Involving the SAPP in the Virtual Water and Nexus Project should therefore for a key pillar of CRIDF's strategy going forward.

A dose of reality

Perhaps the most important outcome of the discussions within the Expert Panel has been the dose of reality dispensed at the outset of the first workshop. Water is rarely the driver of development, and a range of other metrics most often underpins the placement and development of water using development. Transport infrastructure, access to labour, access to markets, access to investment, international trade. global food markets (the global food regime), energy security, the presence of ore bodies, political history *et al* have all underpinned and deeply entrenched the current geographical spread of water demands across the region. These metrics are embedded in the regional political economy, and irrespective of how elegantly CRIDF argues for an optimal water, environmental, carbon and economic trade-offs, its arguments will have little impact on the predominant trade patterns in either electricity or agricultural products. For example the long established regional political economy of water will be hard to shift into a water ecosystem sensitive mode as long as water resources are not valued and the ecosystem impacts of damaging water managing practices are not costed (internalised).

Nonetheless, as argued here, the Facility can contribute to defining the "*cherry on top*" with respect to optimising these existing realities. This may be reflected as small adjustments to the operation of the SAPP to optimise water, carbon emission and economic benefits for all its participants, without compromising the desired degree of self-sufficiency; or through working with regionally based companies with significant water footprints on regional water stewardship and regional risk pooling – without seeking to change regional trade patterns. These approaches may also influence the expansion plans in these large regional companies to consider water footprints and minimising climate risks, while expanding their out-grower schemes. Similarly, introduction of the concepts to the key officials and players in SADC and its Member States, especially if backed up with a sound and quantified evidence base, may provide an enabling environment for the uptake of the concepts – even if this is a slow process.

In this regard it is important that CRIDF broadens its stakeholder basis both in SADC, and the Member States to include the energy, transport, finance and agricultural sectors. This may include engaging national planning commissions or their equivalents, or climate change focal points – to assist them in understanding trade-offs that may build climate resilience. Engagement with the SADC Water Division and its various bodies is also important with respect to influencing basin planning processes and to highlight the potential trade-offs that may be found through a regional and virtual water perspective. This needs to be further developed within a 'Communications Strategy'.

Recommendations

The basis for taking things forward

At this time, having noted your fortitude in ploughing this far along, it is appropriate to reward you by re-stating CRIDF's understanding of Virtual Water and Nexus for the purposes of this work;

> "*A process that considers the additional trade-offs, regional climate resilience, economic and environmental benefits that may be gained from considering the water footprint and virtual water contained in agricultural products and electricity traded when pursuing water, food and energy security through infrastructure."*

Beyond this it is important to note that any prosecution of this process must be consistent with the Facility's *raison d'être* and mandate; To build climate resilience through delivering infrastructure (or influencing the delivery and operation of infrastructure) for the benefit of the poor, while promoting peaceful cooperation and integration. It is also important to note the Facility's understanding of peaceful cooperation as;

> "*Rather than the absence of conflict and dispute, peaceful cooperation means the absence of unilateral actions and hegemony."*

Taking the process forward in line with this understanding, and cognisant of the discussions of the Expert Panel and their papers advises that the Facility should take the process forward along the following tracks;

- Underpinning and predicating its approaches with the *'Sovereign Security with a cherry on top'* concept.
- Building and communicating a better evidence base of the social, water, environmental and economic benefits of using nexus and virtual water concepts across SADC in both the electricity and agriculture sectors;
- Supporting the development of 'nexus' based agricultural and energy strategies for Zambia;
- Developing and executing a communications strategy targeting a range of sectors; and
- Using the databases to support virtual water trade balances for other CRIDF Projects.

Building a better evidence base

A soundly argued and quantified evidence base of the social, water, environmental and economic benefits to infrastructure development and operations to build regional climate resilience is critical to carry the message forward. This can be done along two lines;

1. Building on the work outlined in the SAPP paper, and the World Bank's Multi-Sector Investments Analysis for the Zambezi Basin;
    a. Highlight the potential economic, water and emissions benefits in regional electricity trading through the SAPP. This should project electricity demands and supply across the whole of the SADC region into the future, as is planned by the various power utilities. Then quantify the 'surplus' electricity that may be traded through the SAPP, and the potential regional carbon emission, economic and water (climate resilience) benefits that may result.
    b. Pending the results of this work; the SAPP and CRIDF should jointly approach potential funders to support the development of operational models to be housed and operated by the SAPP, using this evidence base. This model could be used to make recommendations to the utilities on an annual (or bi-annual basis) on optimal use of the generation capacity – against agreed guidelines, as well as to motivate for additional investment in transmission infrastructure.

2. Building on CRIDF's relationship with Illovo, and cognisant of the importance of involving the private sector in water stewardship and regional climate resilience, to;
    a. Build an evidence base of the social, water, environmental and economic benefits of regional risk pooling by better understanding and managing the climate risks for their various mills across the region. This may be developed by a joint application to the African Enterprise Challenge Fund (AECF) to investigate the modalities of building climate resilience for Illovo (through water footprinting, and assurance of supply concepts) while providing adequate protection for their small scale out-growers.
    b. Given enough of an evidence base from (a), this step would aim to encourage Illovo investment in developing and implementing recommendations for water stewardship programmes building climate resilience at specific mills and / or through regional risk pooling. This would aim at opportunities for long term expansion of the industry (and out-grower numbers), while considering the impacts of climate change on the sugar and energy sectors, as well as the national and regional economies.

3. Combining the results of (1) and (2) above specifically for Zambia, to develop recommendations for trade-off allocations of water in droughts, based on most economically and socially beneficial options between reduced assurance of supply to irrigation and electricity production (or 'Nexus' policy).

4. To develop water footprint and virtual water trade balances for specific CRIDF projects. As a start it is recommended that the virtual water trade balance and carbon footprint for the tourism industry in the KAZA area is quantified, and calculations made for the amount of irrigation that would have to be developed within the area to eliminate the need for inward trades.

A communications strategy

5. To develop a communication strategy targeting both the water and other sectors as recommended by Tekateka. This should entail;
    a. Preparing summaries of the water footprint, economic, trade and social data from the CRIDF databases in an easily digestible form for water, agriculture, finance and energy planners.
    b. Preparing powerful stories around the benefits to be had in the electricity trading, and agricultural sectors by considering the water footprint and Virtual Water contents of these sectors.
    c. Strategies for engaging national planning commissions, and the agriculture and energy sectors in each country and in SADC as a whole.

Finally, Virtual Water and Nexus thinking, as defined above, is unlikely on its own to substantially influence regional trades, the geographical placement of development, or even the timing of large scale infrastructure. Too many other metrics determine this, and these patterns are deeply entrenched in the regional political economy. However, this thinking may influence the way this infrastructure is used to optimise regional benefits – simply by highlighting trade-offs, inter-dependencies, compromises and synergies. This may in turn influence the financing of this infrastructure.