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The TWO Analysis – Introducing a Methodology for the Transboundary Waters Opportunity Analysis

Note to the Reader

This report was prepared by David J.H. Phillips, J. Anthony Allan, Marius Claassen, Jakob Granit, Anders Jägerskog, Elizabeth Kistin, Marian Patrick and Anthony Turton and was published by the Stockholm International Water Institute (SIWI).

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Photo: Jakob Granit, SIWI

1. Executive Summary

With growing economies, population, and superimposed climate change, there is a global trend towards a much more constrained freshwater resource base to support societal development and maintain key services. Especially in a regional context, decision-makers need improved tools, to be informed on trade-offs between development and management choices, to identify options, and to mitigate against the impacts of rainfall variability and climate change.

This report represents the output from one component of a broader initiative addressing the development and management of shared river basins.[1] The initiative seeks to enhance the management of fresh water resources in transboundary basins (i.e. fresh water catchments including surface waters and/or aquifers, crossing international borders). The component of the initiative presented in this report involves the generation of a conceptual framework for identifying development opportunities. Options to realise those opportunities, through attaining the necessary social and political agreement amongst the involved riparians, are also indentified. In subsequent development of the methodology, quantitative aspects using indicators will be developed, and case studies will be generated.

Key Concept

This report presents a conceptual framework that can be used by stakeholders concerned by the development and management of shared freshwater resources. The objective is to promote the sustainable and equitable use of transboundary water resources, and to clarify trade-offs relating to development. The report outlines a concept for analysing potential benefits in a transboundary river basin to optimise economic growth, political stability and regional integration. The conceptual framework is intended to be used by basin State Governments, Regional Economic Communities, and financing entities.

The conceptual framework presented here has been developed to be a flexible tool to support decision-making at the level of basin States, within Regional Economic Communities, and for potential investors engaged in the identification and implementation of

[1] The Transcend-TB3 project.


Photo: Getty Images

the development opportunities. It can be used in a developing country context, and in any transboundary basin. The conceptual framework is also configured in a way that is useful for training purposes. For developing regions, it can be of value in determining the preferred and/or optimal uses of fresh waters, especially in relation to the primary driver of the desire to eliminate poverty and hunger.

The conceptual framework is termed the 'Transboundary Waters Opportunity Analysis', or 'TWO Analysis'. Particular emphasis is placed on the potential for developing baskets of benefits at the regional level by identifying Positive-Sum Outcomes (PSOs) or 'win-win solutions' which would benefit all basin States. This is achieved through the use of a simple but robust analytical methodology. The conceptual framework can be used by stakeholders in a wide range of different circumstances to aid their own decision-making, by developing insights into different options that might not be apparent at first glance.

The conceptual framework of the TWO Analysis consists of a matrix with four key development opportunities, and two main categories of sources of water to realise those opportunities (see the matrix at Table ES.1 for a summary). The framework allows for context-specific analysis, which brings the possibility to add other factors and categories for creative analysis and to realise change in particular transboundary basins. In the summary table ES1 we have illustrated some potential opportunities that could be realised by analysing a river basin using the TWO Analysis. Examples of opportunities include the re-use of waste water or the siting of multipurpose dams in optimal geographic locations in a river basin. The factors of primary relevance to the TWO Analysis are enumerated below.

Development opportunity factors:

1 Hydropower production and power trading: The link between water management and hydropower for electricity production and power trade, to support economic development.

2 Primary production: Options related to improvements in primary production using Green and Blue Water resources, e.g. in agriculture for food and bio-energy production; and in forestry, where this is of particular importance in developing countries.

3 Urban and industrial development: The potential for an inter-sectoral reallocation of fresh water from

uses with low economic returns to applications with higher returns, involving urban growth and industrial development.

4 Environment and ecosystem services: Ensuring key environment and ecosystem services for future generations. Two specific forms of economic ecosystem services addressed here relate to fisheries and tourism.

Context-specific opportunity factors also exist in certain scenarios that are determined by the specific political, economic and hydrological contexts in particular transboundary basins. As a result, the above list of development opportunities is not considered to be exhaustive.

Categories of sources of water:
The two most important cross-cutting options relating to the water resources are as follows:

a New Water: The potential for 'New Water' to be developed within the basin (i.e. for an increased volume of fresh water to be made available).

b The efficient use and management of water: Options for improving the existing efficiency in the use of fresh waters by the basin States in transboundary basins. This can include institutional strengthening, joint management regimes and physical infrastructure.

In basins that are not under water stress (not 'closed') and have unutilised water, the water resources can be brought into service to drive economic development. Once again, context-specific categories exist in relation to the fresh water resources that are determined by specific political, economic and basin parameters. These include opportunities for inter-basin transfers, regional cooperation, and desalination.

Categories: Sources / Factors: Development	a) New Water	b) Efficient use of water	c) Other sources in basins that are not closed
1. Hydropower and power trading	Location of reservoirs in high altitudes to minimise evaporative losses	Siting of multipurpose dams for e.g. hydropower and irrigation in optimal locations	Additional electricity generation through hydropower schemes and power pooling
2. Primary production	Re-use of treated wastewater for irrigation Interbasin water transfer schemes	Green Water use to increase agricultural outputs Increase efficency in irrigation	Investment in bio-energy crops Introducing aquaculture
3. Urban growth and industrial development	Strengthen institutional management for water allocation to more high value use	Maximising economic returns per unit of water in industry	Recharge of groundwater
4. Environment and ecosystem services	Use of "green credit schemes" through e.g. water purification in wetlands	Optimising economic returns from developing fisheries and tourism sector	Allocate water to restore ecosystems
5. Others (every basin is unique and other opportunites may exist)	Desalinate water for high value use	Drought-proofing through improved land management	Flood protection

Table ES.1. The conceptual framework for the TWO Analysis. The table includes examples of opportunities that could be realised using the TWO analytical framework in a specific river basin. A full version of the conceptual framework can be found on page 12. An empty version of the conceptual framework matrix is provided in the annex on page 35.

Photo: Manfred Matz, SIWI

1. Introducing the Transboundary Waters Opportunity (TWO) Analysis

1.1 Background to the TWO Analysis

The conceptual framework for the Transboundary Waters Opportunity (TWO) Analysis has been developed within a broader research initiative on the sharing of benefits in transboundary basins undertaken by Phillips Robinson and Associates of Namibia; the Council for Scientific and Industrial Research of South Africa; and the Stockholm International Water Institute of Sweden.[2] The initiative focuses on the management of fresh waters in transboundary basins with an emphasis on promoting optimal economic development, and the attainment of social and political agreement on development opportunities and trade-offs, based on sound technical information. Transboundary basins are defined as the geographical boundaries of natural hydraulic flow of water in rivers and/or aquifers across a political jurisdictional boundary. This implies that the resources in question should at least theoretically be shared by the parties involved (the riparians) according to the principles of customary international water law.

An important aspect of the TWO Analysis relates to data, which are often contested and invariably incomplete. A philosophical point of departure in this analysis is that this data paucity does not necessarily need to be a fundamental impediment to progress on transboundary water cooperation. The best available data, which are often in the public domain, are used here. In order to overcome the limitations of those data, the methodology used features a unique method to quantify uncertainty and factor it into the generation of various scenarios. This unique aspect of the TWO Analysis makes it highly suited for situations where a hegemonic riparian may seek to entrench

[2] The initiative is called the Transcend-TB3 project. The initiative is part-financed by the Swedish Ministry for Foreign Affairs; Swedish International Development Cooperation Agency; Water Research Commission of South Africa; the Global Environment Facility; and the Swedish Research Links programme.

the status quo by relying on the argument that data scarcity prevents future negotiations.

In certain transboundary basins, it is known that the status quo in terms of water allocations or the generation of benefits arising from the shared waters may be improved, to the benefit of all the riparians involved. This is known as a 'win-win solution' or a Positive-Sum Outcome (PSO). PSOs contrasts with a frequent outcome in transboundary basins where more equitable solutions to sharing waters are seen as only being achieved through the simple reallocation of the resources. This is known as a Zero-Sum scenario, where anything gained by one riparian is lost in equal share by one or more other riparians. The Zero-Sum dynamic is a major obstacle to progress in many transboundary basins, because it is inherently unstable with a high conflict potential locked-in (Turton, 2008a). Identifying and introducing an analysis of broader benefits from the utilisation of water and potential PSOs can potentially help overcome the Zero-Sum dynamic. This greatly increases the likelihood that riparians agree to specific methods to improve upon the status quo and enlarge the basket of benefits to all parties. This also enables the riparians to identify opportunities for cooperative development and to move towards optimal economic growth from the sustainable use of the available fresh water resources more easily.

The Transboundary Waters Opportunity Analysis presented here is a conceptual framework to analyse transboundary basins for their development opportunities and for specific forms of PSOs. In subsequent work, the quantitative aspects of the methodology will be further developed, focusing on the development of robust indicators.

1.2 The objective of the TWO Analysis

The conceptual framework presented in the TWO Analysis can be used by stakeholders concerned with the development and management of shared freshwater resources to 1) promote the sustainable and equitable use of transboundary water resources, 2) clarify trade-offs in relation to development. It outlines a concept for analysing potential benefits in a river basin to optimise economic growth, political stability and regional integration. The conceptual framework is intended to be used by such parties as basin State Governments, Regional Economic Communities, and financing entities.

The TWO Analysis has been developed in response to a background that:

- Assumes that transboundary water resources are rarely utilised either sustainably or equitably at present. There is evidence that many transboundary basins are mismanaged, and equitable allocations of either the fresh waters themselves or the benefits arising from them, are rare.
- Recognises the intimate link between water resource utilisation and national and/or regional economic growth. Water is a critical input for economic growth, and this is especially the case in developing countries. While it is self-evident that fresh water is important in arid regions, such as the Middle East and North Africa, the resource remains a vital driver of economic growth elsewhere, even in regions where rainfall and run-off are abundant. The allocation of fresh water to particular sectors (agriculture; industry; services) is an important element in the linkage between transboundary water resources and national/regional economies.
- Acknowledges the importance of water management to political stability and regional integration. In the transboundary context, this link is evident in many basins. For example, authors have commonly referred to the potential for water-related conflicts to spill over into the broader political arena; and the potential for the converse dynamic has also been raised, with cooperation over shared water resources potentially giving rise to greater regional stability (and even sometimes acting as a trigger for peace; see Phillips et al., 2007, in press; Turton, 2008a).

1.3 The strategic use of the TWO Analysis

The TWO Analysis can be of use in a range of circumstances:

1. By exploring development opportunities determined to be PSOs the TWO Analysis can demonstrate possible alternatives for countries sharing transboundary water resources. It can be used in both formal negotiations and in training situations.
2. The TWO Analysis can act as a 'compass' that identifies the need for subsequent detailed investigations

by riparian countries falling into two broad tracks:
a) political negotiations to be undertaken by the countries concerned; and
b) cooperative strategic pre-investment analyses to identify development options and trade-offs.

3 The TWO Analysis can act as a scenario tool to illustrate longer-term changes and future options in a non-threatening manner.
4 The TWO Analysis can identify opportunities for public and private financiers to support initiatives taken by riparian countries. This could lead to feasibility studies, and to investment and transaction advice to support development that could be either transboundary or intra-State, depending on the circumstance involved.

1.4 Development trade-offs

By jointly managing a river, riparians can generate 'public goods' such as flood and drought protection, increased biodiversity and improved conservation, enhanced water quality, and even greater possibilities for peace and regional stability. However, not all of these public goods will necessarily be regional in nature. Care must be taken when managing transboundary water resources, in order to avoid the generation of 'public bads' (Jägerskog et al., 2007). Development within a transboundary basin can distribute local and external costs and benefits unevenly between States, regions and communities (such as pollution which moves downstream). This can result in sub-optimal outcomes for certain stakeholders, the effects of which must be considered when determining preferred development options. Even where PSOs are possible at the strategic level, all parties may not necessarily benefit simultaneously. The TWO Analysis can function as a strategic tool to determine the scale and scope of trade-offs related to management and development opportunities and choices.

Photo: Jakob Granit, SIWI

2. The Conceptual Framework for the TWO Analysis

This section describes the conceptual framework for the TWO Analysis. In its most basic form, this consists of a matrix with four key factors of development opportunities, and two main categories of fresh water sources to realise those opportunities (see the matrix in Table 1). The framework also allows for context-specific analysis, including the possibility to add other factors and categories for creative analysis. Each factor and category is described in detail in subsequent sections of the report.

2.1 The basic framework

Development opportunities:

The four development opportunities for PSOs in transboundary basins highlighted in this report show distinct types of possibilities for providing economic and other returns from fresh water use. These are as follows:

1) Hydropower production and power trading: The link between water management and hydropower for electricity production and power trade to support economic development. Many developing countries have large untapped hydropower potential and lack transmission interconnection and power trading regimes which are common in more economically developed regions.
2) Primary production: Options related to improving primary production using Green and Blue Water resources; for example in agriculture for food and bio-energy production; and in forestry, where this is of particular importance. In most developing countries, the bulk of the available fresh water resource is allocated to the agricultural sector. Improvements in the output from this sector will generally combat poverty and hunger directly.
3) Urban and industrial development: The potential for an inter-sectoral reallocation of fresh water from low-value uses to uses with higher economic returns, involving urban growth and industrial development.
4) Environment and ecosystem services: Ensuring key environment and ecosystem services for future generations. Two specific forms of ecosystem services include fisheries and tourism/ecotourism.

Additional context-specific opportunity factors that are determined by the specific political, economical and hydrological context may also exist.

Categories of water sources:

Two main cross-cutting categories of options to allocate finite amounts of water resources to specific development opportunities are identified here. Both categories relate to the hydrological cycle; specifically to 'New Water' and to the efficiency of water use.

a) New Water: The potential for New Water to be developed within a basin (i.e. for an increased volume of fresh water to be made available). 'New Water' is a term utilised by Phillips et al. (2006, 2007, in press) in studies on the Jordan River basin, and represents additional volumes of fresh water that can be introduced to the hydrological cycle, through various means. The economic output from a transboundary basin can clearly be enhanced where New Water can be made available, and it is also possible under particular circumstances to attain more equitable allocations of water to the basin riparians, in such a scenario. It has been argued that in highly securitised basins (see Turton, 2003), New Water may represent the only means for attaining more equitable allocations of volumes, especially where a strong hegemon is present (Phillips et al., 2006).
b) The more efficient use and management of water: An increase in the efficiency of water use in a transboundary basin will give rise to enhanced benefits – whether these arise from agricultural output or from other uses of water which provide greater economic returns. The efficiency of water utilisation in a transboundary basin is especially important in circumstances where the basin is 'closed' or is approaching closure (i.e. where all, or nearly all, of the Blue Water is in use). It is notable that many of

Categories: Sources / Factors: Development	a) New Water	b) More efficient use of water	c) Other sources in basins that are not closed
1. Hydropower and power trading	New Water can be created by the siting of dams where evaporative losses are minimised. The interplay to Green and Blue Water dynamics should be addressed.	The siting of dams in transboundary basins influences the geographical pattern of water availability. This has a profound impact on the net benefits arising from a transboundary watercourse.	Power trade provides the opportunity to optimise complex power-supply alternatives allowing for a mix of sources of fuel, including hydropower, fossil fuels, nuclear, and renewable energy such as sun and wind. It reduces costs and provides for transparency in all transactions for the consumers.
2. Primary production	Desalinated sources of water are generally not suitable for agricultural use, due to cost and quality-related constraints. However, there is great scope for the re-use of treated wastewaters in many developing countries. Inter-basin transfers are also likely to become much more common in the future.	The key method of relevance to increasing the efficiency of water use for primary production involves closer attention to the Green Water-Blue Water interface. The output of the agricultural sector can be greatly enhanced in many transboundary basins, if this is taken into account.	Many opportunities exits for increasing the production of biomass by optimising land and water use. This provides opportunities to produce bioenergy to meet the growing demand for energy at the global level and scaling up e.g. aquaculture to meet growing food demands.
3. Urban growth and industrial development	The much higher economic returns from water in the industrial and services sectors (compared to the agricultural sector) provide a route to enhanced economic growth for many developing countries. However, societal effects must be addressed.	Where inter-sectoral allocations occur and move water from agriculture to the sectors with higher economic returns, it is most important that the resource is used efficiently, maximising the economic returns per unit volume.	To ensure reliable supplies of water for growing urban and industrial needs, water should be managed and stored so that losses are minimised. Water can be stored underground through recharge of aquifers for both water supply and to protect coastal aquifers from salt water intrusion.
4. Environment and ecosystem services	Enhanced attention to the upstream Green Water-Blue Water interface can improve or guarantee aquatic ecosystem services in downstream stretches of shared watercourses. Benefits from this can be transferred upstream, as in the 'Green Credit' proposals.	All forms of more efficient water use will alter river flow dynamics, and this offers potential for optimising returns from ecosystem services. Fisheries and tourism are especially important generators of income in such scenarios.	In basins that are not closed ecosystems such as wetlands that have been degraded can be restored by allocating water to restore their capacity to generate ecosystem services. This provides benefits such as water purification and increased biodiversity.
5. Others (every basin is unique and other opportunites may exist)	Many urban areas are found along coastlines. Desalination of seawater provides, where economically feasible, a new water source for high value use. The use of desalinated water may reduce the pressure to abstract water for e.g. urban areas in water stressed basins.	Recurrent droughts are a major obstacle for farmers relying on rainfed agriculture to receive a return on their investment. By improving the natural storage capacity through improved Green/Blue Water management and groundwater storage a basin system can be less vulnerable to the impacts of drought.	Floods destroy physical infrastructure and social and economic systems in many basins globally. Flood protection and early warning systems may be important strategies to increase the resilience of basins providing downstream benefits. Storage infrastructure or restoring watersheds are tools to consider.

Table 1. The conceptual framework for the TWO Analysis.

the basins in southern Africa are in this category (Turton, 2003; Turton and Ashton, 2008; Ashton and Turton, 2008). Options also exist for improving the existing efficiency in the use of fresh waters by the basin States in transboundary basins. These can involve institutional strengthening, joint management regimes and physical infrastructure.

Context-specific categories again exist here, these being determined by specific political, economic and basin-related parameters such as opportunities for inter-basin transfers, regional cooperation, and desalination. Additional water may also be brought into use, where basins are not 'closed' in nature (i.e. where all the available water is not yet being utilised). The TWO Analysis can be used as a broad framework for analysing development opportunities in basins where water is not a constraint and allows for an analysis in which barriers are removed to optimise benefit generation and sharing. Barriers are many and include borders, boundaries between local and regional jurisdictions, religious, ethnic, social and economic. Good water management needs to overcome these barriers to development to improve the livelihoods of people in the basin and beyond.

2.2 The factors relating to development opportunities

This section discusses the four key factors relating to the development opportunities of a transboundary basin:

- hydropower and power trading potential;
- primary production;
- urban growth and industrial development; and
- environment and ecosystem services.

2.2.1 Hydropower and power trading potential

The scale of river regulation

The ability of humans to alter the global hydrological cycle is perhaps best exemplified by the degree to which the major rivers worldwide have been subject to regulation. Figure 1 shows a summary of the present situation, using the data of Nilsson et al. (2005), updated more recently by Nilsson (2006).

The impacts of dams on the environment as a whole – both negative and positive – have been reviewed in detail by the WCD (2000). This text does not seek to repeat this procedure. However, certain aspects of the effects of dams are of direct relevance to the search for shared benefits and PSOs.

All impoundments in watercourses affect the local and regional hydrological cycle. The impacts of many dams are far-reaching. They can change total and seasonal flow patterns, evaporation rates, and many other factors of relevance to the availability of Blue Water and how it may be utilised in transboundary basins (Puckridge et al., 1993; Davies and Day, 1998; Snaddon et al., 1999).

In certain instances, dams enhance the overall availability of Blue Water to one or more of the ripar-

Figure 1. A broad classification of river regulation globally. After Nilsson et al. (2005) and Nilsson (2006).

ians of transboundary rivers (usually due to their smoothing out of seasonal flow fluctuations). In other cases, dams reduce the overall availability of Blue Water, usually because of high evaporation rates from the impounded reservoirs. Other effects of major impoundments in river systems are less immediately obvious, but may be of significance. An increase in greenhouse gas emissions commonly eventuates due to decaying vegetation within newly constructed reservoirs, and there is an intriguing link here to climate change effects. Alterations to sediment transport due to dam construction can also be of importance, although the downstream effects of this may be either positive or negative, depending on the precise situation within the basin. In certain instances, considerable changes to the flow dynamics result from dam construction (especially on the main stem of rivers), raising concerns in a number of major rivers (e.g. the Mekong River and the flood pulse; see Fox and Sneddon, 2005; Phillips et al., 2006). The regulation of river flow also affects fisheries, both within the river itself and in estuaries. In some countries, eutrophication is an emerging problem, specifically where Cyanobacteria produce microcystins that are toxic (Oberholster et al., 2004, 2005, 2008; Oberholster and Ashton, 2008).

Issues to consider when evaluating benefits and PSOs involving hydropower

Key issues to consider when evaluating benefits and PSOs involving hydropower in a transboundary river basin are:

- the existence of significant hydropower potential in the geographically distinct parts of the basin;
- asymmetry in the volumes of water available to the co-riparians;
- a gap between electricity supply and demand for individual riparians, basin-wide or regionally; and
- a reasonably desecuritised character of the basin, implying that the riparians are prepared to at least consider cooperation.

The objective relating to hydropower facilities

Decisions on dam sites are complex, and should take account of many aspects. The present analysis suggests simply that the net effect of dams on the availability of Blue Water to all the co-riparians in transboundary basins are not always taken into account – or sometimes, the net effect on Blue Water availability is simply not given the weight that this factor deserves.

Power trading

Power trading between countries is gaining momentum in many regions. In much of Europe and the Scandinavian countries, power trading is an important market-based regulated activity that allows the sale of excess power to utilities in different countries. This provides the opportunity to optimise complex power-supply alternatives allowing for a mix of sources of fuel, including hydropower, natural gas, coal, diesel, nuclear, solar, wind, etc.). Power trading locks countries together in a day-to-day trading relationship that benefits all parties. In Southern Africa, the Southern Africa Power Pool provides an important framework for spreading risk and developing the region in a cooperative fashion. Several power pools are under development in (for example) East Africa and the Mediterranean area, including certain of the Middle Eastern countries. Synergies can also arise when New Energy becomes an option (harmonising with the concept of New Water discussed in Section 2.3.1 below).

2.2.2 Primary production

Key indicators for inclusion in a TWO Analysis relating to the potential for a PSO in the agricultural sector are:

- asymmetry in temperature and/or rainfall amongst riparians;
- asymmetry in the potential agricultural yields amongst riparians, sometimes relating to soil quality in addition to other factors;
- a significant consumptive use of Blue Water in upstream stretches of the basin; and
- potential for expanding the irrigated area in downstream reaches of the basin.

These factors are possible to quantify with data from meteorological records; agricultural statistics from both national and international sources (the latter, mainly through the Food and Agricultural Organization); and databases on consumptive uses of water (AQUASTAT and several additional sources, varying according to the specific basin involved).

However, other factors are also important in certain circumstances pertaining to a PSO in the agricultural sector, and these include:

- the existence of sub-optimal existing yields in the agricultural sector, for one or more riparians;
- the availability of effective transportation systems for agricultural products, both within the basin and to external markets;
- the existence of regional free trade areas which would allow agricultural produce from one country in the region to be sold in other countries in the region;
- the absence of trade sanctions and the existence of developed (or at least potentially available) markets within and outside the basin for agricultural produce, the external markets preferably offering high economic returns for cash crops; and
- a political scenario which offers the potential for benefit-sharing, in recognition that collaboration amongst the riparians offers higher order solutions compared to any preference for notions of absolute sovereignty and food self-sufficiency.

Some of these factors can only be qualitatively assessed in basins based on detailed expert knowledge. The intensive interrogation of transboundary basins for their potential for a PSO in the agricultural sector is therefore best attained within the framework of a Co-operative Regional Analysis or similar form of study, as suggested by Sadoff and Grey (2002, 2005).

2.2.3 Urban growth and industrial development

The development opportunity relating to urban growth and industrial development was selected in recognition mainly of the much higher economic returns available from water allocated to the industrial and services sectors, compared to the agricultural sector.

Most developed countries have already made the transition from agriculturally-dominated economies (in which Blue Water generates very poor economic returns, in general) to service-based and industrial economies. The huge differences in per capita GDP between the developed nations and the transitional or developing economies reflect in part the higher economic returns realised by the developed countries from the use of their available water resources. This also generates a self-sustaining scenario, as the richer countries can solve any problems involving water scarcity by importing virtual water in foodstuffs and other commodities (Allan, 1998, 2001, 2002, 2003).

It is clear in many transboundary basins – especially those in arid regions of the world – that a strong reliance on the agricultural sector cannot continue indefinitely without the prospect of a future catastrophic failure. This is because the growing human populations of such basins generate an increasing demand for domestic supplies of fresh water, effectively 'squeezing' the agricultural sector over time (see Phillips et al. [2007] for a discussion of this in relation to the Jordan River basin). Under such circumstances, a shift of Blue Water away from the agricultural sector and towards the higher economic returns available in the industrial and services sector represents the only manner in which the economies may survive. In many instances, this is the only option for significant economic growth.

Current and anticipated urban trends

In 2005, the urban population in the world was 3.17 billion, of a total 6.45 billion. In 2007, the proportion of the global population living in cities surpassed 50 percent. With nearly one billion people currently living in slums, the State of the World Cities Report for 2006-2007 has questioned the entire notion of urban sustainability (UN-HABITAT, 2006). However, the current trends suggest that the number of urban dwellers will keep rising, reaching almost 5 billion by the year 2030, compared to a global population total of 8.1 billion. Between 2005 and 2030, the world's urban population is expected to grow at an average annual rate of 1.78 percent, almost twice the growth rate of the total world population. After 2015, as more people occupy cities, the population of rural settlements around the globe will begin to contract (UN-HABITAT, 2006).

In the face of this ongoing and increasing trend towards urbanisation and the accompanying industrialisation, it is instructive to contemplate the political rhetoric within particular transboundary basins. Several of the basin hegemons continue to promulgate statements concerning the intimate link of their people to the land, and the importance of the agricultural base of their economies (Zeitoun and Warner, 2006; Zeitoun, 2008). Israel provides a prime example of this, although it is clear that the use of more than 60 percent of the regional water resources by Israel to generate a mere two percent of its GDP does not support this negotiating position.

In any event, certain of the developing countries are part-way through a transition between an agriculturally-based economy and a 'developed economy' in which water is allocated in increasing volumes to industrial and services applications which have higher economic value.

Gleick (2006) has noted that the general global trend towards industrialisation and service-based economies is threatened by concerns over both water quality and quantity, especially in arid areas. The same is also true for the agricultural sector. Developing countries face these challenges related to water quality and quantity on an urgent and daily basis, whatever decisions are made in relation to the inter-sectoral allocation of their fresh water resources.

The scale of inward investment, the abundance nationally (or nearby) of raw materials, and the available technical skills-base in industrial applications are perhaps the most important factors that determine the degree to which developing countries can reallocate fresh water inter-sectorally away from the agricultural sector. Major shifts of this type will not occur rapidly, and the dynamic in most or all countries will reflect gradual transitions. Recognising the gradual nature of these processes is important in a socio-economic sense, as the transition between agriculturally-based activities and the industrial and service sectors is challenging – both socially and politically. Importantly, any shift towards the industrial and services sectors should take account of the interplay between these and the agricultural sector (e.g. the potential for the re-use in agricultural applications of treated domestic wastewater, and also the potential re-use of certain types of industrially-derived wastewaters).

Where developing countries opt to reallocate water inter-sectorally, it is most important that appropriate decisions are made in relation to the specific preferred uses of the water in the industrial or the services sectors. All too often, the profligate use of water in the agricultural sector in arid regions is replicated by an inappropriate choice of industrial developments, e.g. involving 'thirsty' users such as textiles. In arid regions especially, the drive to harness the higher economic returns from water within the agricultural sector should also be respected within the other two sectors. Israel provides good examples throughout these scenarios, having markedly improved its yields per unit water volume in the agricultural sector over the last two decades, and having also developed high-quality industrial facilities, many of which utilise very little fresh water (e.g. its software and electronics industries).

2.2.4 Environment and ecosystem services

Types of ecosystem services

Ecosystem services represent the benefits obtained from ecosystems by humans. The term 'services' encompasses both the tangible and intangible benefits involved (some authors preferring to separate 'goods' and 'services' from each other). The main forms of these are shown in Table 2 below.

We considered these various goods and services, and concluded that two specific areas offer possibilities as elements of PSOs for transboundary basins. These involve fisheries and tourism (the latter term also encompassing ecotourism). In relation to ecosystem

Provisioning Services [Products obtained from ecosystems]	**Regulating Services** [Benefits obtained from the regulation of ecosystem processes]	**Cultural Services** [Non-material benefits obtained from ecosystems]
Food	Water regulation	Recreation; tourism
Fuel wood	Water purification	Aesthetic; inspirational
Fibre	Climate regulation	Spiritual and religious
Biochemical products	Disease regulation	Cultural heritage
Genetic resources	Pollination	'Sense of place'
		Education

Table 2. Forms of ecosystem goods and services, presented in broad categories. Modified after the World Resources Institute (http://www.wri.org/).

Photo: Jakob Granit, SIWI

services, the analysis provided here has therefore been restricted to these two aspects.

Fisheries

Fisheries are an important source of both income and food in many developing and developed countries sharing transboundary watercourses. Some such basins offer huge fishery-related yields and benefits, such as in the downstream stretches of the Mekong River (Phillips et al., 2006), but it is a common finding that the fishing success in transboundary basins remains sub-optimal, especially in the developing world (e.g. see Cowx et al., 2004; FAO, 2004). It is also most important to note that the flow of rivers is of critical importance in determining downstream secondary productivity, as has been shown very convincingly for a range of estuaries (e.g. see FAO, 1995; Nixon et al., 2004). The recent study of the important prawn (Penaeus indicus) fishery in Maputo Bay – receiving flows from three transboundary rivers shared by South Africa, Swaziland and Mozambique – has again emphasised the integrated nature of land use and water allocation practices within river basins, and the estuarine/offshore fishery success (Monteiro and Matthews, 2003; Monteiro and Marchand, 2008).

In some instances the alteration of freshwater flows, with the attendant impact on sediment transport, nutrient cycling, physical changes, and destruction of habitats, has a quantifiable economic impact. The economic loss from reduced fisheries landings following alterations to the Zambezi River flows (due to the reduction in nutrients entering the Indian Ocean at the Sofala Bank fishery), has been estimated at between USD 10 and USD 20 million annually (Turpie, 2006). In South Africa, altered hydrological characteristics arising from a half-century of aggressive dam building combined with failing sewage treatment works are leading to growth in microcystin-producing Cyanobacteria. This has unknown implications on the population that has a high prevalence of HIV-AIDS (Oberholster and Ashton, 2008). Likewise, elevated levels of partially metabolised medical chemicals, specifically anti-retrovirals (entering aquatic ecosystems that have reached a point of closure and thus have lost their dilution capacity) is becoming an issue of growing significance to some water-constrained countries (Turton, 2008b).

Generally, for most transboundary river systems, improved fishery yields are likely to exert only local or small-scale regional impacts on the reduction of poverty and hunger. However, a few examples exist where this is not the case (mainly for major rivers such as the Mekong, the Amazon or the Zambezi) and the effects are more widespread.

Photo: Jakob Granit, SIWI

Tourism
Tourism represents one of the biggest and fastest growing industries globally. It is also an important source of hard currency income to many developing countries. This trend is expected to continue and strengthen in the foreseeable future, and sustainability issues are coming to the fore (UNEP, 2005; Conrady and Buck, 2007; Honey and Krantz, 2007).

With its abundance and range of natural ecosystems and its huge tourism potential, the African continent is of special interest. 'Ecotourism' represents a particularly fast-growing sector, and this depends on the minimisation of negative human interference in natural ecosystems and the regeneration of habitats to enhance their diversity. In certain states in Africa and elsewhere, tourism represents a significant contributor to overall GDP. For example, Botswana receives approximately ten percent of its foreign income from the tourism sector, with the downstream reaches of the Okavango River being of exceptional importance in this regard (e.g. see Kalikawe, 2001).

2.3 The factors relating to the hydrological cycle

This section discusses the two categories identified in the present study as being of key importance in relation to the hydrological cycle: the capacity to generate 'New Water' within transboundary basins; and the efficiency of water utilisation.

2.3.1 New Water

'New Water' represents additional Blue Water supplies that can be made available to the riparians within transboundary basins. New Water can be developed in several fashions:

- **The desalination of brackish or marine supplies.** Desalination technologies have improved markedly over the last two decades in particular. Desalinated water can presently be produced at unit costs as low as USD 0.70/m^3. This will alter the dynamic in many transboundary basins, as such costs are within the range of bankable projects (Phillips et al., 2006) and are comparable to those of the higher-cost surface waters or groundwaters (e.g. those requiring considerable pumping and/or extensive pre-treatment). Recent decisions to develop desalination in widespread geographies (e.g. Algeria; California; Jordan; Namibia; Spain) reflect this altered dynamic, but many other countries are yet to recognise the new opportunities afforded.
- **The re-use of treated wastewaters.** While this might be accounted for in the improved efficiency of water use, wastewater re-use in fact increases the total volume of water available to riparians sharing a transboundary resource. In most instances, wastewaters arising from domestic use are treated and re-used for agricultural purposes. Where sewage treatment is already required to attain environmental standards, the marginal cost of polishing effluents for their re-use in agriculture is often affordable. Quality-related issues require care in relation to the specific use involved, but problems of this type are well-documented and the technologies relating to their solution are widely available.
- **The improved management of the flows of transboundary waters.** This method of increasing the Blue Water volumes available for allocation requires understanding of watercourses. Watercourses represent flows, not stocks. This means that the volumes that can be withdrawn for use vary according to management practices. A range of methods exists to minimise losses from evaporation. This also links to Green Water, because certain management tech-

niques relating to Green Water affect Blue Water flows. Hoff (2008) has pointed out that the afforestation (or re-afforestation, in many cases) of upper catchments – rather than enhancing downstream flows, as was once considered the case – reduces the downstream availability of Blue Water because of the much higher transpiration losses from trees (compared to grassland, for example). A complex basin dynamic will emerge from such factors, especially where drivers involving carbon sequestration (due to concerns over climate change) interplay with desires to maintain downstream Blue Water flows. This interplay has not yet been considered in any detail, but will be important in certain transboundary basins.

- **Inter-basin transfers of water.** This involves the transfer of water in bulk (usually by canal or pipeline) between discrete basins. Inter-basin transfers are a common feature in certain areas of the world such as South Africa (Turton, 2000, 2003), although their construction is somewhat controversial (Davies and Day, 1998), with some authors considering that ecosystem damage may eventuate (e.g. see Snaddon et al., 1999). However, it appears likely that such transfers will become more common, as populations increase and specific areas become more heavily water-stressed.

These methods of increasing the water volumes available to the riparians of transboundary basins are not mutually exclusive. As an example, both desalination and wastewater re-use are quite common in the Jordan River basin. Inter-basin transfers of water have also been considered (by Israel in particular, with a scheme for transfers from the Manavgat River in Turkey having been shelved, but other possibilities remaining of interest).[3] Indeed, the Red Sea-Dead Sea conduit currently undergoing a Feasibility Study involves an inter-basin transfer, desalination and environmental services (Benvenisti, 2004; see also the World Bank website at http://www.worldbank.org). Phillips et al. (in press) suggest that inter-basin transfers are most likely to occur in the future in this geography, in part to satisfy the rapidly growing domestic demand for fresh water.

2.3.2 The efficiency of water utilisation

The efficiency of utilisation of the existing water supplies represents the second of the two main factors identified by the project team relating to the hydrological cycle. If these utilisation efficiencies can be improved, transboundary fresh water resources should generate higher levels of economic growth. The present analysis considers this initially from the perspective of Blue Water only, and then addresses the interplay between Blue Water and Green Water.

Considerations relating to Blue Water

The sectoral allocation of Blue Water is all-important in any analysis of the potential economic returns from water utilisation. Sectoral allocations are generally measured in relation to three broad end-uses of water: for agriculture; industry; and services. The last of these covers a wide range of economic activities, and in certain instances will require 'unpacking' to investigate potential added value from altered inter-sectoral allocations of water. In relation to the present analysis, it is important to consider water utilisation efficiencies within all sectors, as well as between sectors.

The importance of Green Water

The above analysis may be extended further through the consideration of Green Water and Blue Water in concert. The importance of Green Water has only recently become appreciated, and very little reliable quantitative information is available on the resource. While it is known that Green Water comprises the bulk of the available fresh water resource in most basins (being approximately twice the volume of Blue Water in the Nile River basin, for example; see LWRG, 2007), the precise relationships between the two resources vary considerably among basins and according to meteorological, geological, morphological and other factors.

2.3.3 Other water sources

Where basins are not 'closed', additional water remains available for allocation to particular development opportunities. The TWO Analysis can assist in determining the optimal allocation patterns for such additional flows.

[3] Israel's shelving of the importation of water from the Manavgat system in Turkey has been followed by more recent studies on the possibility of multiple undersea pipelines from Turkey to Israel, for the supply of oil, gas, electricity and fresh water (Chossudovsky, 2006).

3. The TWO Analysis in Context: Issues to Consider

The TWO Analysis is multi-disciplinary and considers many cross-cutting issues related to politics, economy, investment and the environment. These are discussed below, commencing with the political dimension and moving on to more technical issues of relevance.

3.1 The broad political context

This report has been prepared by a team that has very wide experience of international relations over transboundary waters. This experience has led them to recognise the nature of transboundary water conflict and the key roles of different Departments of State of the riparian Governments involved in transboundary international relations.

When the shared water resources are abundant, the level of conflict is generally low, as the sovereignty issues – over such waters – are 'low politics'. As awareness of water scarcity increases, transboundary waters become an issue of sovereignty and the stewardship of the resource moves from departments managing the water to entities that conduct foreign relations – the Ministries of Foreign Affairs. Even more important than the shift from water resource professionals to professionals in diplomacy and international relations, is the shift of responsibility to inner groups that run the really serious affairs – the 'high politics' – of State.

By the end of the twentieth century, highly developed economies with a wide range of economic and regulatory options were engaged constructively in transboundary relations. They could negotiate outcomes and development frameworks – for example the Water Framework Directive of the European Union and its daughter Directives – that lead to mutual advantage through the recognition of shared benefits. By contrast, political economies that lack these adaptive, economic and administrative options almost always lock the transboundary water issues into an inaccessible world populated by a few officials close to the national leadership – an inner cabinet or other political group trusted by the President or the monarch. It is very difficult indeed to introduce information such as that developed by the TWO Analysis into these inner sanctums that deal in high politics.

The impact of the TWO Analysis will be immensely increased if the principles and framework are adopted by these inner (shadow State) entities that have an intuitive and unhelpfully narrow grasp of sovereignty and national security – including water security. The issue is not new. At the end of the nineteenth century, US Attorney General Harmon, when asked for an opinion on the shared waters of the US and Mexico, adopted the narrow intuitive view of water security. On his mind was sovereignty. It took the US water professionals ten years to negotiate an agreement between the parties which included the notion of equitable utilisation. They ignored the Harmon opinion – although that opinion perversely remained in currency for the following century, in some quarters at least.

3.2 Socio-political issues of relevance

Underlying resource circumstances play an important role in determining the extent to which sustainable approaches to water use and management can be achieved. These are frequently invisible to water users and water policy-makers. They can, however, be identified by scientists – and especially by 'outsider scientists'. Working together, scientists and economists can also identify opportunities to achieve collective benefits through the cooperative behaviour of riparians, deploying principles of ecological security, and of economic security and efficiency. In addition, issues of equity play a role in identifying opportunities that could enable those riparians enduring inequitable access to shared waters, to improve their allocations. The asymmetric inter-riparian power relations that bring about these inequities are intensely political (see Zeitoun and Warner, 2006; Zeitoun, 2008).

Sustainability is a useful conceptual lens – at least when it is defined by the discursive political pressures of the three voices that contend to project their respective rationales of sustainability – namely the sustainability of society, the sustainability of the economy, and the


Photo: Jakob Granit, SIWI

sustainability of the environment. Sustainability is only partly about environmental red-lines. Environmental priorities are expressed by those who voice the importance of the environmental services of water, and of the ecological diversity of aquatic environments.

Equity in transboundary water relationships is associated with the notion of 'equitable and reasonable utilisation' – an approach that is central to the 1997 United Nations Convention on international watercourses, and also to earlier codifications of customary international water law, such as the Helsinki Rules of 1966.

Both sustainability and equity are associated with intense politics. Sustainability is politically constructed, whilst inequity is politically determined.

3.3 Water allocation and management

In general, the approaches of those who actually use water resources and make water policy in the political domain do not take the underlying ecological and economic circumstances or principles of equity into account. Ecological and economic principles are often not the currency of water management and water policy-making. Water resources, especially transboundary water resources, are subject to narrow collective interests, with views expressed in highly emotional terms. Hydrological securitisation (Turton, 2003; Phillips et al., 2006) is common, i.e. individual riparians capture water resources while not caring that neighbouring riparians will be denied previously shared waters. Under such circumstances, the observation of principles of equity is partial, at best.

Those responsible for managing national interests are driven by the requirement to meet water needs, and assume that the existing modes of water use and management are sustainable. They do not have any incentive to face the political stress of asking water users in their own economies to reduce the current levels of water utilisation to meet other needs (for example, ecological needs identified by outsider analysts). As Waterbury (2002) has argued, there are "national determinants of collective action". The difference between the trends driven by these two ways of 'knowing' – that of the scientist outsider; and of water users and guardians of riparian interests – can be illustrated by the ways that these two groups characterise sustainability. In relation to Figure 2:

- The trend in actual water use reflects water management practices and water policies. This trend is regarded as sustainable by those who manage water and protect the interests of an individual riparian in international fora. Emotion provides the basis for this process, rather than reason based on underlying fundamentals, rules, or science.
- The trend in water resource use identified by scientists and economists reflects a level of utilisation that is consistent with: [a] sustained ecological health; [b] the protection of the environmental services of water; and [c] the economically efficient use of water.
- The divergence between these two trends is commonplace – perhaps even universal. Certainly, most

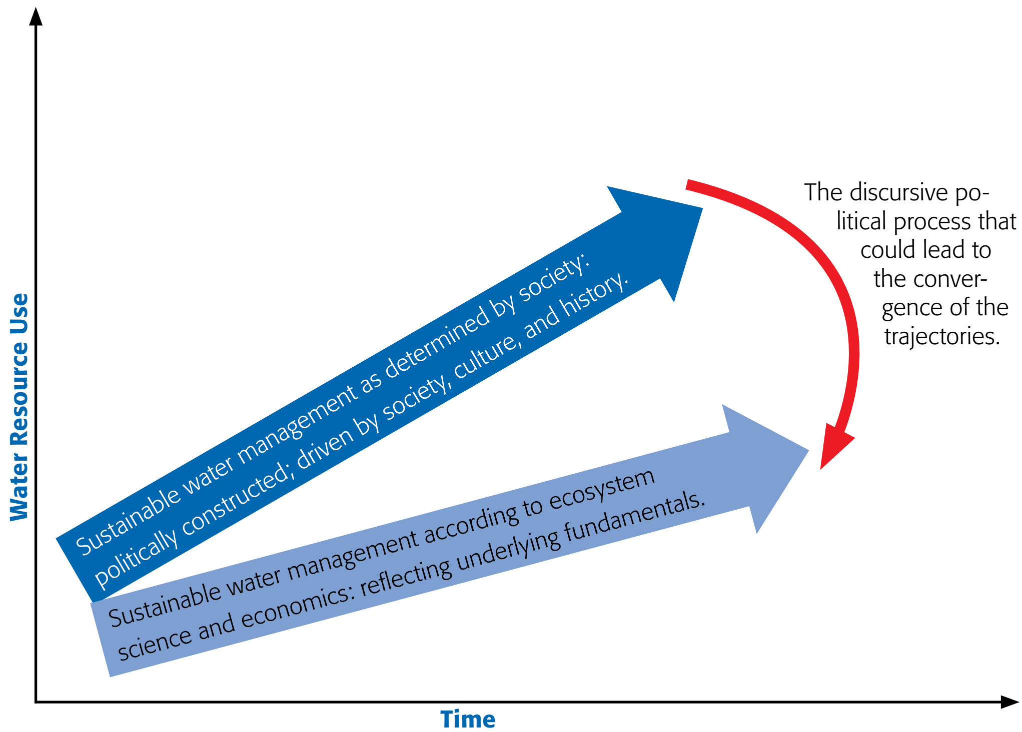

Figure 2. Trends in the use of water resources. After Gywali et al. (2006).

of the national economies worldwide are currently using water resources in ways that are unsustainable, according to the criteria defined by outsider aquatic ecologists and by economists dealing with water resources.

3.4 The reform of water policies, allocation and management

Figure 2 also conceptualises the trend in water use that would be needed to attain convergence between the actual levels of water use, and the sustainable use as defined by the underlying fundamentals advocated by outsider analysts. The actual trend in the utilisation of water resources is driven by the perceived needs of water users and of national officials. It reflects social, economic and national interests – albeit narrowly defined. This trend is constructed as sustainable in the discourses at sub-national levels and at the national level. These constructed beliefs easily overwhelm the observed science of aquatic ecologists and economists. The authors of this report recognise that they are providing knowledge about and indicators of underlying fundamentals and potential options based on ecological and economic principles.

Changing the understanding and activities of water users and of national officials who protect and negotiate on transboundary waters is an intensely political process. Any change would require the adoption of policy reforms, and also the reform of the ways that water is allocated and managed. In other words, changes are required in the approach to the governance of water allocation and management – and this requires reform at both national and international river basin levels.

Integrated Water Resources Management (IWRM) is a widely advocated approach to achieving the sustainable and equitable allocation and management of water resources. IWRM is also a highly political process (Allan, 2006).[4] Unfortunately, its political features

[4] The process of integrating water professionals and scientists is difficult and stressful, and as a consequence is often ineffective. Changes in water management are also very politically charged, as they commonly require the reallocation of water between users (and at the international level, between riparians). Especially politically stressful outcomes result from the changes in the use of land that have to be introduced to modify the levels of water utilisation to meet ecological and economic goals. IWRM should be extended to ILWRAM – Integrated Land and Water Resources Allocation and Management.

are little-recognised by most water professionals. The integration of professional groups is intensely political. The management of water includes its allocation, and the allocation (and mis-allocation) of resources are achieved through political processes. Sometimes these processes are informed by science and an awareness of underlying fundamentals, but this is by no means the norm.

The TWO Analysis provides examples of the underlying fundamentals that will determine long-term outcomes for societies and economies. These are likely to contradict the deeply held assumptions of water-using societies and of certain water professionals. However, the existing use of shared water resources is the result of the capture of those resources by the technically and politically competent, and reflects the asymmetric power relations of the individual river and groundwater basins (Zeitoun and Warner, 2006; Zeitoun, 2008). Communicating the analysis and findings into the long-established asymmetric hydropolitics of the different river basins will require an extensive appreciation of the hydropolitical landscape and an understanding of the ecological and economic situations that underlie each water body. The role of the water scientists and professionals is unavoidably challenging, and easily politicised.

3.5 Green Water and Blue Water in the transboundary context

As noted by Falkenmark et al. (2007), a shift in conceptual thinking is required if the debate over water utilisation is to reflect the real human need for water. Hitherto, the global debate has been dominated largely by a desire to ensure that access to domestic water supplies is guaranteed for as much of the world's population as possible, and that this is accompanied by adequate levels of sanitation. However, the utilisation of fresh waters for domestic purposes at volumes of perhaps 50 litres per capita/day – increasingly referred to as a human right (Gleick, 1996; United Nations, 2002; Woodhouse, 2004) – is only approximately 1.5 percent of the actual needs. The great bulk of the remaining water is required to produce sufficient food for the global population. Given a human right to basic food supplies, it is clear that a much larger volume of fresh water than that considered presently as a human right must in fact be made available to ensure the health of the global population.

Most of the food in the world is grown through rain-fed agriculture using Green Water, or soil water. This is water derived directly from rainfall, most of which is utilised or evaporates before the residual flows enter underground aquifers or leach into surface waters (Figure 3).

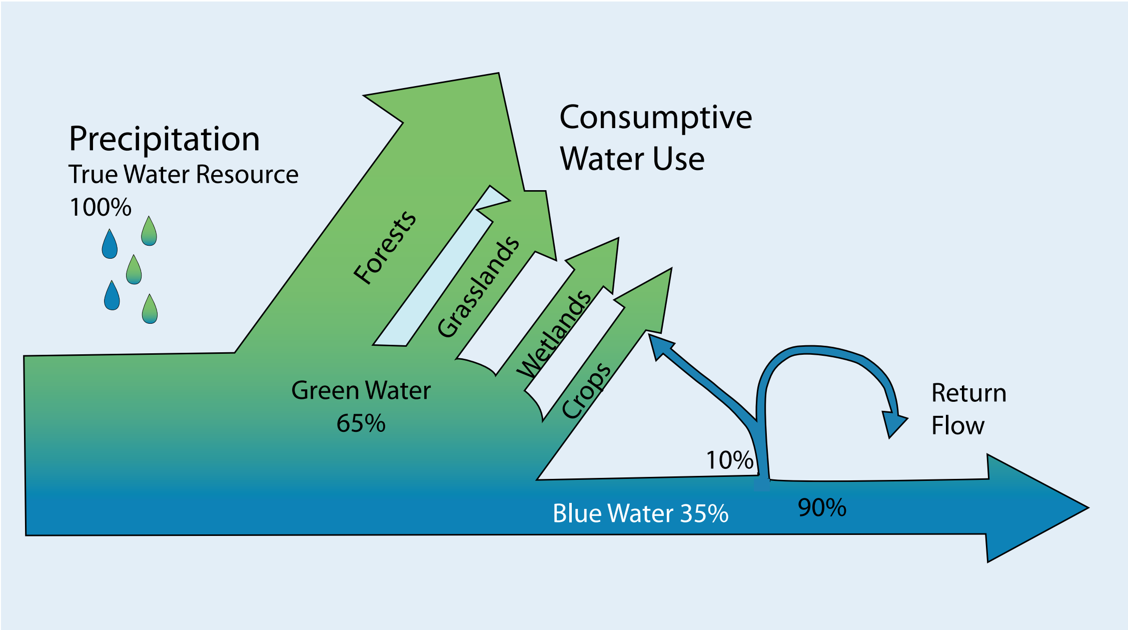

Figure 3. Green Water and Blue Water flow dynamics.

Green Water (the water in rain-fed soil profiles that supports evapo-transpiration and the growth of vegetation and crops) and Blue Water (rivers, lakes and underground aquifers) are slowly becoming distinguished from each other in the international literature. However, they are not altogether discrete. A hydraulic connection exists between them, and is realised through the entry of Green Water by leaching into groundwaters, or its flow directly into surface waters through the soil. Nevertheless, the two forms of fresh water may be addressed separately in analyses, and this is of particular importance in relation to the consideration of agricultural yields.

To date, Green Water has been almost completely ignored by researchers outside the agronomy sector[5] but it is exceptionally important to the overall water balance and agricultural production. Based on datasets from FAO for example, LWRG (2007) have recently shown that the volume of Green Water in the countries of the Nile River basin is approximately double that of Blue Water. Yet, almost all studies to date (and all of the historical agreements between the riparians of the Nile) have addressed the Blue Water component in isolation. This is largely because the Blue Water is the volume that is shared between riparians in transboundary water systems – and most importantly, it is the Blue Water that can be allocated preferentially between the riparians.

The importance of Green Water is shown in global terms in Figure 4. Here it is clearly shown that, in terms of flux, Green Water represents the predominant source of water for agriculture in many areas of the world. Therefore, an important component of the TWO Analysis presented in the current report is to take into account the levels of both Green and Blue Water available to different riparians within the same transboundary basin, as this affects the manner in which the economic outputs from the basin may be optimised.

Optimising agricultural productivity involves the appropriate combination of Green Water and Blue Water use. However, other uses of fresh water apart from agriculture are also significantly affected. The optimisation of the management and use of Green and Blue Water in upstream parts of a transboundary catchment has considerable influence over the Blue Water availability downstream (Dent and Kauffman, 2006; Hoff, 2008), which can have powerful consequences (see Table 3).

In response to these data, it is argued here that no analysis focused on optimising the allocation of Blue Water in transboundary basins can be complete without simultaneously considering Green Water. This is especially the case in arid regions, and many of the examples cited in the present report focus upon arid and semi-arid parts of the world, including the Middle East and much of Africa in particular. Clearly, the optimal use of water is especially important in these areas, as a consequence of their combination of water scarcity and high levels of poverty and hunger.

It is notable that the Green Water approach in itself is most unusual, amongst the studies on transboundary waters that have been completed to date. Almost all such investigations concentrate primarily (or only) on Blue Water. As noted by Falkenmark et al. (2007) and others (e.g. see Rockström, 2001; Rosegrant et al., 2002a, 2002b; Falkenmark and Lannerstad, 2005; Hoff, 2007, 2008), this is a fundamental weakness of most of the studies completed to date, which have ignored the bulk of the available fresh water resources. In addition to Green Water and Blue Water, it is important to include re-usable wastewater (sometimes referred to as either 'Grey Water' or 'Black Water'), which is of importance in the agricultural sector in particular.

3.6 Water resources, the Zero-Sum dilemma, and Positive-Sum Outcomes

Zero-Sum dilemmas arise when riparians sharing a given transboundary watercourse perceive that a) their options are limited to the status quo, b) the available fresh water resources (or the benefits arising from these) are capped and/or c) no extension of such resources or benefits are possible. Under such circumstances, the reallocation of either the water itself or the benefits arising from the fresh water resources would imply that the gains enjoyed by one riparian are lost in equal measure by one or more other States sharing the watercourse.

Phillips et al. (2006) argued that in many transboundary watercourses, the status quo is not an appropriate starting-point for negotiations on sharing water, essentially because basin hegemons have already

5 As stated by Dent and Kaufmann (2006), Green Water is ignored "by engineers because they cannot pipe it or pump it, by economists because they cannot price it, and by governments because they cannot tax it".

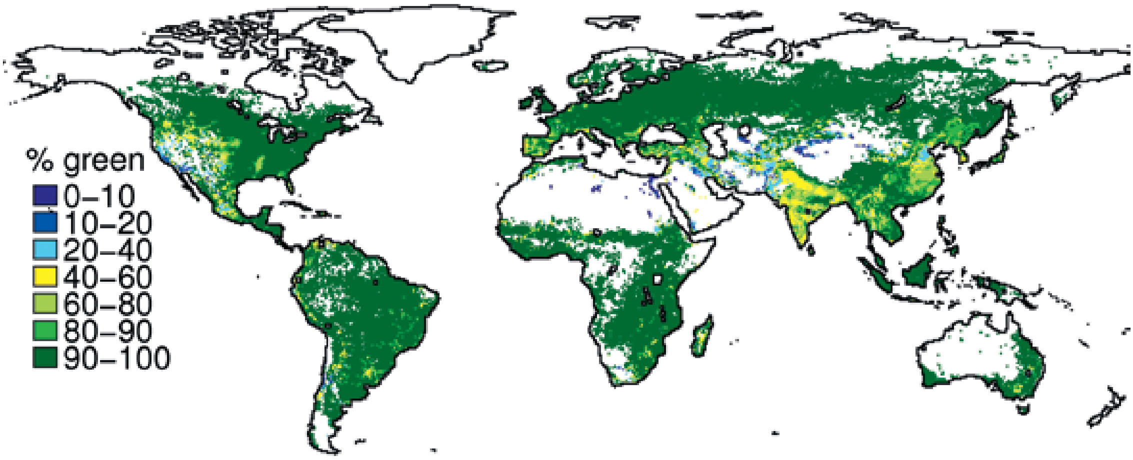

Figure 4. The proportion of Green Water in total agricultural water fluxes, worldwide. After Rost and Gerten (2008).

Upstream Consequences	Downstream Consequences
• Less Green Water for crops, exacerbating the effects of droughts, resulting in yield losses, food insecurity, and loss of livelihoods	• Food insecurity
• Flash floods • Damage to local infrastructure • Soil erosion	• Floods • Damage to infrastructure • Siltation of channels and reservoirs
• Lowering of water tables; failure of wells • Failure of springs; reduced base flow in rivers	• Uncontrolled river flow; high peak flows and reduced or no dry-season flow • Less hydropower and damage to turbines • Less and less reliable urban water supply • Less water available for irrigation • Less water for natural ecosystems, especially in the dry season

Table 3. The upstream and downstream consequences of poor rainwater and soil management. After Dent and Kauffman (2006).

'cornered the resource' (or the benefits arising from the water). This position is supported by Conca (2006), but using a different logic. Conca argues that the negotiated international regime is an inappropriate foundation for inter-State agreements. The concept of hydro-hegemony has been developed by Zeitoun and co-workers in recent years (Zeitoun and Warner, 2006; Zeitoun, 2008) to explain why the allocations of fresh water – or of benefits – in certain transboundary basins have become grossly asymmetrical and inequitable, and how any change to this is resisted by the hegemon. Under circumstances of 'coercive or dominant hydro-hegemony', the more powerful riparians are most unwilling to 'give up' the water allocations and/or benefits they have so assiduously gained, and the weaker riparians are generally at a loss as to how this may be achieved – or even how to bring the hegemon to the negotiating table.

PSOs are the key to addressing this problematique because they ensure that the weaker riparian States can offer the hegemon a further benefit, which encourages them to engage in negotiations. Equitable shares of the resource can then be approached or attained without any party becoming disadvantaged over time. This is especially powerful when the transition between the status quo and the eventual outcome is designed in detail (Phillips et al., 2006, 2007, in press; Turton, 2008a). PSOs can also provide powerful solutions where no strong hegemon exists, as all co-riparians benefit simultaneously from the introduction of improved practices in water management and/or utilisation.

3.7 Climate change

According to the Intergovernmental Panel on Climate Change (IPCC, 2007), current trends could lead to an average global temperature rise of 2-3°C within approximately the next 50 years. The IPCC (2007) also suggests that a temperature increase of 2°C could lead to a 20-30 percent reduction in water availability in some vulnerable regions, such as Southern Africa and certain areas surrounding the Mediterranean Sea.[6] It is clear that such regions face significant challenges in the sustainable supply of water to support national and regional economic growth and population growth, an improved quality of life, and regional equity.

The linkages between society and water resources can be viewed in terms of a cyclical progression, often referred to as the "Driver-Pressure-State-Impact-Response (DPSIR) model, as shown in Figure 5.

Pressures exerted by external drivers of change (such as global warming, urbanisation, and population increases) shape the condition or state of the water resources (Q1). In turn, the state of the water resources influences the ways in which society uses these resources, exerting a variety of impacts on both society and the resources themselves (Q2). The responses of society can be directed at one or more points in the cyclical progression to achieve desirable outcomes (Q3). Responses that target the driving forces (i.e. those seeking mitigation) include the reduction of carbon emissions and the capture and storage of carbon dioxide. Interventions aimed at the state of resources or the impacts on resources and society (involving adaptation) include modified patterns of water use, as well as the implementation of effective water conservation measures and water demand management approaches.

First-order impacts of climate change (such as atmospheric temperature and water availability) are often the focus of discussion on mitigation measures and adaptation strategies. However, it is very likely that secondary ('knock-on') effects could be much more significant. The following are examples of such effects that could be considered:

- While the total amount of water available in a region may be reduced, the effects of increases in the spatial and temporal variability of water (more floods and droughts, and greater regional disparity) may be more important.
- Altered patterns of weathering and rainfall intensity may lead to increased sediment and chemical loads in run-off, affecting the suitability of water for use,

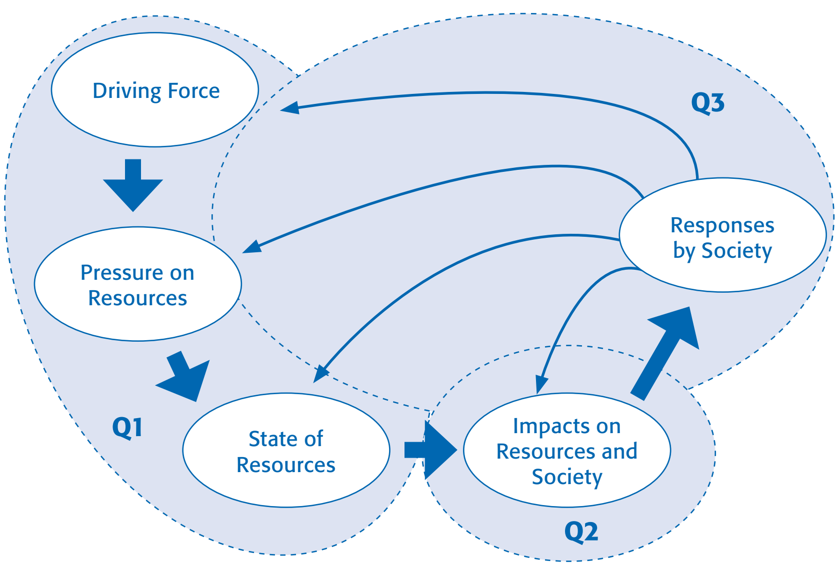

Figure 5. The links between society and water resources.

[6] The project team notes that significant uncertainty remains, connected to modelling outputs pertaining to regional changes in climate. This generates difficulties for governmental bodies attempting to generate policies to address the effects of climate change. Such policies should be of a flexible nature, able to be modified as time passes and the precise regional changes in climate become more apparent.

the storage capacity of dams, the generation of hydroelectricity, and the costs of water treatment.
- Changes in water temperature will affect evaporation rates, the solubility of salts and gases (notably of oxygen), species distribution, and eutrophication.
- The distribution of disease vectors and prevalence of diseases (such as malaria, bilharzia and cholera) are likely to change substantially with alterations in climate.
- Sea level rise will not only affect coastal infrastructure, but will change the hydrodynamics of coastal aquifers and estuaries (that support coastal ecosystems, biodiversity and productivity).
- The potential impact of climate change on groundwater is very poorly understood. This is particularly worrying, since many communities in rural areas of developing countries such as those in southern Africa rely almost exclusively on groundwater for their livelihoods. The underground storage of water (e.g. through groundwater recharge) may be more efficient in some circumstances in the future, than the use of surface impoundments.

The range of potential impacts and consequences described above will require new management approaches (Turton, 2007). Certain factors require close consideration:

- It is clear that we can no longer rely solely on data from the last 50 years, to plan for the next 50 years. Dynamic predictive models are needed (Milly et al., 2008).
- The present management paradigm that does not accommodate change should make way for a more adaptive approach to management. A specific example involves the conservation of biodiversity, where the ecosystems that need protection may move physically over time.
- Mitigation measures should also be carefully evaluated in the future, in the context of sustainability. Short-term gains should not be traded for long-term liabilities. In this context, much greater understanding is needed of the opportunities and costs related to mitigation measures. This includes the production of biofuels (Gerbens-Leenes et al., 2008), the capture and sequestration of carbon, and the use of various forms of alternative energy.

Possible options for effective action include the following:

- the development of a water sector strategy linked to climate change;
- the development of decision-support systems to provide decision-makers with useful information, in a usable form, when they need it;
- the identification of the areas likely to face the greatest risk of water shortages, and the development of plans to remedy this situation.

Several authors have noted that the countries exhibiting high levels of poverty are especially vulnerable to the effects of climate change due to their low adaptive capacity (e.g. see Boko et al., 2007). Of the 50 countries classified as vulnerable to climate change, 33 are located in sub-Saharan Africa. This vulnerability to climate change effects is coupled to the abundance of transboundary basins in the African continent, and makes the need to optimise the economic benefits from the utilisation of water in such basins is all the more urgent.

3.8 The role of regional economic frameworks

The regional integration of markets in a transboundary basin represents a longer-term strategy to ensure that the benefits generated from the implementation of preferred development opportunities are distributed appropriately amongst the riparian states. A practical example involves the inter-connection of electricity transmission networks and the development of power pools for energy markets. A second example involves the construction of inter-basin transfers to meet the demand for fresh water in areas experiencing water scarcity. Such practical ways of distributing benefits through market mechanisms may lead to improved livelihoods for citizens and communities beyond the involved transboundary basin. In this context, Regional Economic Cooperation frameworks such as those of the Southern Africa Development Community or the European Union are critically important to ensure the integration of markets and the free movement of goods, services and labour. Where such a framework exists, a TWO Analysis can be designed to meet the strategic objectives of the regional community, as well as simply addressing the riparians of the transboundary basin under consideration.

Photo: Jakob Granit, SIWI

4. Conclusions and Next Steps

4.1 The use of the TWO Analysis

It is proposed that the four factors relating to development opportunities enumerated in this analysis (hydropower production and power trading; primary production; urban and industrial development; and environment and ecosystem services) and the two main factors addressing water resources (New Water; the efficient use and management of water), should be developed further through the use of quantitative indicators. Both New Water and the efficient use and management of water can then be addressed individually or sometimes together in relation to each of the four development options. This type of multi-criteria analysis could involve both quantitative and qualitative indicators, as long as the method used is clear. This process will provide a new strategic tool to determine the preferred or optimal use of the water resources in transboundary basins. It will also point to how basin States may best cooperate to attain PSOs where all parties benefit from the enhanced management of shared watercourses. The collective judgment of the users will always determine the final outcome, but the TWO Analysis may shift the thinking towards PSOs that may not have been explored before.

Later studies to be undertaken will provide further development of the quantitative aspects of the approach and strengthen the usefulness and power of the methodology. We believe that the TWO Analysis can be utilised for a wide range of distinct purposes by different parties. In general terms, the following may be noted:

- At the political level, the conceptual framework underlying the TWO Analysis provides deep insights into the preferred strategic stance of the riparians within a transboundary basin. Such strategic-level planning is presently absent from almost all basins of this type. In addition, the TWO Analysis should assist measurably in driving cooperation between co-riparians, especially where PSOs can be identified.
- Amongst the donor community and the International Financial Institutions, the TWO Analysis

provides a starting point for support to preferred and/or optimal development options in transboundary basins that can assist measurably in focusing international aid and finance. Where such programmes are specifically focused upon the alleviation of poverty and hunger, the TWO Analysis provides preferred routes for both improving the intra-sectoral use of fresh waters (usually in developing countries, and in the agricultural sector), and the inter-sectoral reallocation of flows.

- At the managerial level, the TWO Analysis can provide a blueprint for the preferred sectoral allocation of fresh waters, and the desired changes in such allocation over time. This is extremely valuable in determining major infrastructural requirements (e.g. basin storage requirements, hydropower, desalination, wastewater treatment and re-use, and inter-basin transfers).
- In relation to potential investors, the strategic and holistic dimensions of the TWO Analysis provide important information on investment requirements, including the preferred chronological sequence for making these investments. This information will be of great utility to investors for all sources of finance (International Financial Institutions, public sector, private sector, or a mix of these).

4.2 Limitations of the TWO Analysis

Certain limitations of the TWO Analysis have been identified, these being primarily related to the scale of the analytical methodology. Scale is important, since conclusions can be erroneous if inputs are taken from specific temporal or spatial scales and assumptions of linearity are made when interpolating or extrapolating the results. For example, in many cases, country-wide data do not reflect basin-level data, and cannot therefore be used directly as a proxy to describe a specific basin.

4.3 Using the TWO Analysis for endogenous basins

The process inherent in the proposed TWO Analysis does not rely on the basin being transboundary in nature. In fact, the presence of multiple riparian states is ignored in certain elements of the methodology. There is considerable potential (and a range of ways) for the use of the methodology in endogenous basins that follow the same objective to optimise the economic development potential of the basins involved in a sustainable fashion.

4.4 Access to (pre)investment capital

The TWO Analysis is designed to generate the initial framework of a consensual strategy for economic development of the riparians of any given transboundary basin. Assistance from aid organisations will be especially important in this initial step in the process. Once such a strategy has been agreed upon, access to (pre) investment capital is a critical requirement. The larger infrastructure projects will commonly rely on public sector finance, often through loans from International Financial Institutions. Private sector finance is critical for the medium and smaller project elements. Further, the scope for expanding the use of public-private sector partnerships in certain areas is wide. Such partnerships are naturally complementary under certain circumstances. The private investor's focus on the short-term financial viability of the investment coupled with the public sector wider and longer-term view and objectives (e.g. the attainment of the Millennium Development Goals relating to poverty and hunger) can be beneficial to successful projects and initiatives.

4.5 Scenario planning using the TWO Analysis

In connection to climate change effects, Boko et al. (2007) have noted "the need for a learning tool that is interactive and can be run in intervals and be revisited as part of a multi-country and multi-sector process that encourages and facilitates interdisciplinary analyses". Decision support tools such as the TWO Analysis are often seen as absolute predictive models that are based on one set of inputs and an absolute output. However, the value of modelling often lies more in the ability to consider different possibilities of the future, to illustrate the potential impacts and uncertainties of different choices and decisions. Such analyses involve scenario planning.

Scenarios are used to characterise the future (or to describe multiple plausible futures). The utility of both the process and the products are vested in the present, since knowledge about key drivers and uncertainties of the future can provide information contributing towards better decisions. An improved understanding of key drivers and trajectories of change will not only clarify the impact of specific decisions, but also


Photo: Jakob Granit, SIWI

allow the active countering of undesirable trajectories of change. Strategies and decisions can be played out in 'different futures' to secure the most beneficial outcome through the most robust approaches that involve the least risk. This knowledge will not only benefit resource managers and decision-makers, but will also empower all the role players in the water sector to engage in cooperative governance.

In the context of the TWO Analysis, scenario planning is useful from the input, process and output perspectives:

- Input: The exclusive use of currently available data on the biophysical environment, political processes, social development, demographic status and economic development ignores the impacts both of expected changes (such as political transformation, population growth, potential climate change and trade agreements) and unexpected changes (such as conflict, or future technological innovation). This implies that derived recommendations would only apply in cases where these inputs do not change over time.
- Process: The process of identifying future trends allows participants to engage on important issues without (immediately) focusing on current disputes, borders or conflicts. Once there is some agreement on the future desired status, it is easier to translate current realities and options into choices that would bring about the desired status. This process often tests assumptions of cause and effect, and allows participants to reassess positions that may previously have been considered to be non-negotiable.
- Output: A better understanding of 'potential futures' and the consequences of different present-day choices in those distinct futures will contribute to a shared understanding of options, and more transparent decision-making. This will also significantly contribute to the effective communication of options and choices.

The conceptual framework for the TWO Analysis provides a starting point for a better understanding of key drivers, opportunities and trade-offs to promote value-added outcomes in the provision of environmental goods and services to meet social and economic development.

5. Acronyms

CSIR	Council for Scientific and Industrial Research (South Africa)
FAO	Food and Agriculture Organization
GEF	Global Environment Facility
GDP	Gross Domestic Product
HIV-AIDS	Human Immunodeficiency Virus-Acquired Immune Deficiency Syndrome
ILWRAM	Integrated Land and Water Resources Allocation and Management
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
km	Kilometres
LWRG	London Water Research Group
m^3	Cubic metre
PSO	Positive-Sum Outcome
SADC	Southern African Development Community
SIDA	Swedish International Development Cooperation Agency
SIWI	Stockholm International Water Institute
SMFA	Swedish Ministry for Foreign Affairs, Stockholm
TWO	Transboundary Waters Opportunity [Analysis]
UN-HABITAT	United Nations Human Settlements Programme
UNEP	United Nations Environment Programme
US	United States [of America]
USD	United States Dollars
WCD	World Commission on Dams
WRI	World Resources Institute

6. References

Allan, J.A. (1998) Virtual water: A strategic resource. Global solutions to regional deficits. Groundwater, 36 (4), 545-546.

Allan, J.A. (2001) The Middle East Water Question: Hydropolitics and the Global Economy. I.B. Tauris, London.

Allan, J.A. (2002) Water resources in semi-arid regions: Real deficits and economically invisible and politically silent solutions. In: Hydropolitics in the Developing World: A Southern African Perspective (Turton, A.R. and Henwood, R., Eds.), pp. 23-36. African Water Issues Research Unit, Pretoria.

Allan, J.A. (2003) Virtual water eliminates water wars? A case study from the Middle East. In: Virtual Water Trade: Proceedings of the International Expert Meeting on Virtual Water Trade (Hoekstra, A.Y., Ed.), pp. 137-145. Value of Water Research Report Series No. 12, November 2003, IHE Delft, the Netherlands.

Allan, J. A. (2006) IWRM/IWRAM [Integrated water resources allocation and management]: A new sanctioned discourse? In Integrated Water Resource Management in South Asia: Global Theory, Emerging Practice and Local Needs (Mollinga, P.P., Dixit, A. and Athukorala, K., eds). Hyderabad: SaciWATERs.

Ashton, P.J. and Turton, A.R. (2008) Water and security in sub-Saharan Africa: Emerging concepts and their implications for effective water resource management in the southern African region. In: Brauch, H.-G., Grin, J., Mesjasz, C., Krummenacher, H., Behera, N.C., Chourou, B., Spring, U.O., Liotta, P.H. and Kameri-Mbote, P. (Eds), Facing Global Environmental Change: Environmental, Human, Energy, Food, Health and Water Security Concepts – Volume IV. Berlin: Springer-Verlag, pp. 665–678.

Benvenisti, R. (2004) Addressing the Dead Sea basin water issues. 2nd Israeli-Palestinian International Conference on Water for Life in the Middle East, Antalya, Turkey, 10-14 October 2004. Israel/Palestine Center for Research and Information, Jerusalem.

Boko, M., Niang, I., Nyong, A., Vogel, C., Githeko, A., Medany, M., Osman-Elasha, B., Tabo, R. and Yanda, P. (2007) Africa. In: Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J. and Hanson, C.E., Eds. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, pp. 433-467. Cambridge: Cambridge University Press.

Chossudovsky, M. (2006) The militarization of the Eastern Mediterranean: Israel's stake in the Baku-Tbilisi-Ceyhan pipeline. Global Research, 23 May 2006. See <www.globalresearch.ca>.

Conca, K. (2006) Governing Water: Contentious Transnational Politics and Global Institution Building Cambridge, MA.: MIT Press.

Conrady, R. and Buck, M. (2007) Trends and Issues in Global Tourism, 2007. Berlin: Springer.

Cowx, I.G., Almeida, O., Bene, C., Brummett, R., Bush, S., Darwall, W., Pittock, J. and van Brakel, M. (2004) Value of river fisheries. In: Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries Volume I, pp. 1-20. Welcomme R. and Petr, T., Eds. FAO Regional Office for Asia and the Pacific, Bangkok. RAP Publication 2004/16.

Davies, B.R. & Day, J. (1998) Vanishing Waters. Cape Town: University of Cape Town Press.

Dent, D. and Kauffman, S. (2006) Green Water credits for rainwater management by farmers. Global Water News, 4, 4-5. See www.saciwaters.org/

Falkenmark, M. and Lannerstad, M. (2005) Consumptive water use to feed humanity: Curing a blindspot. Hydrology and Earth Sciences, 15-28.

Falkenmark, M., Berntell, A., Jägerskog, A., Lundqvist, J., Matz, M. and Tropp, H. (2007) On the Verge of a New Water Scarcity: A Call for Good Governance and Human Ingenuity. SIWI Policy Brief. Stockholm: Stockholm International Water Institute.

FAO (1995) Effects of Riverine Inputs on Coastal Ecosystems and Fisheries Resources. Rome: Food and Agriculture Organization.

FAO (2004) Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries. Rome: Food and Agriculture Organization.

Fox, C. and Sneddon, C. (2005) Flood Pulses, International Watercourse Law, and Common Pool Resources: A Case Study of the Mekong Lowlands. Research Paper 2005/22, Expert Group on Development Issues, United Nations University and World Institute for Development Economics Research.

Gerbens-Leenes, P.W. Hoekstra, A.Y. and ven der Meer, Th. T. (2008) The Water Footprint of Bio-energy: Global Water Use for Bio-ethanol, Bio-diesel, Heat and Electricity. Value of Water Research Report Series No. 34. Delft: UNESCO-IHE Institute for Water Education.

Gleick, P.H. (1996) Basic water requirements for human activities. Meeting basic needs. Water International, 21, 83-92.

Gleick, P.H. (2006) The World's Water 2006-2007: The Biennial Report on Freshwater Resources. Washington D.C.: Island Press.

Gywali, D., Allan, J. A., Antunes, P., Dudeen, A., Fernandez, C. S., Monteiro, P. M., Nguyen, H. K., Novacek, P. and Pahl-Wostl, C. (2006) EU-INCO Water Research from FP4-FP6 (1994-2006): A Critical Review. A report for the EU Water Initiative, Brussels: EU Directorate General for Research, International Scientific Cooperation, EUR 22017.

Hoff, H. (2007) Green Water in the global water system. Global Water News, No. 5/6, 4-7. See <www.saciwaters.org/>

Hoff, H. (2008) Challenges in upland watershed management: The Green-Blue Water approach. Manuscript as yet unpublished, Professor Holger Hoff, Stockholm Environment Institute, Sweden.

Honey, M.H. and Krantz, D. (2007) Global Trends in Coastal Tourism. Washington D.C.: Center on Ecotourism and Sustainable Development.

IPCC (2007) Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

Jägerskog, A., Granit, J., Risberg, A. and Yu, W. (2007) Transboundary Water Management as a Regional Public Good. Financing Development – An Example from the Nile Basin. Report Number 20. Stockholm: Stockholm International water Institute.

Kalikawe, M.C. (2001) Botswana: Integrating biodiversity into the tourism sector. A presentation made to the UNEP International Workshop on Best Practices and Country Case Studies, Mexico City, 29–31 March 2001.

LWRG (2007) Virtual Water 'Flows' of the Nile River Basin. Evaluating Current and Future Crop and Livestock Trade between Nile Riparians and Globally – A First Approximation. London Water Research Group, July 2007.

Milly, P.C.D., Betancourt, J., Falkenmark, M., Hirsch, R.M., Kundzewicz, Z.W., Lettenmaier, D.P. and Stouffer, R.J. (2008) Stationarity is dead: Whither water management? Science, 319, 573-574.

Monteiro, P.M.S. and Matthews, S. (2003) Catchment2Coast: Making the link between coastal resource variability and river input. South African Journal of Science, 99, 299-301.

Monteiro, P.M.S. and Marchand, M. (2008) Catchment2Coast: A Systems Approach to Coupled River-Coastal Ecosystem Science and Management. IHP Technical Documents in Hydrology, in press. Paris: UNESCO.

Nilsson, C. (2006) A world dominated by fragmented rivers. Global Water News, No. 4, 1-3.

Nilsson, C., Reidy, C.A., Dynesius, M. and Revenga, C. (2005) Fragmentation and flow regulation of the world's largest river systems. Science, 308, 405-408.

Nixon, S.W. Olsen, S.B., Buckely, E. and Fulweiler, R. (2004) Lost to the Tide: The Importance of Freshwater Flow to Estuaries. Final Report submitted to the URI Coastal Resources Center, Narragansett, Rhode Island.

Oberholster, P.J. and Ashton, P.J. (2008) State of the Nation Report: An Overview of the Current Status of Water Quality and Eutrophication in South African Rivers and Reservoirs. Parliamentary Grant Deliverable. Pretoria: Council for Scientific and Industrial Research (CSIR).

Oberholster, P.J., Botha, A-M. and Grobbelaar, J.U. (2004) Microcystis aeruginosa: Source of toxic microcystins in drinking water. Africa Journal of Biotechnology 3, 159-168.

Oberholster, P.J., Botha, A-M. and Cloete, T.E. (2005) An overview of toxic freshwater cyanobacteria in South Africa with special reference to risk, impact and detection by molecular marker tools. Biokem 17, 57-71.

Oberholster, P.J., Cloete, T.E., van Ginkel, C., Botha, A-M. and Ashton, P.J. (2008) The use of remote sensing and molecular markers as early warning indicators of the development of cyanobacterial hyperscum crust and microcystin-producing genotypes in the hypertrophic Lake Hartebeespoort, South Africa. Pretoria: Council for Scientific and Industrial Research (CSIR).

Phillips, D.J.H., Daoudy, M., Öjendal, J., Turton, A. and McCaffrey, S. (2006) Transboundary Water Cooperation as a Tool for Conflict Prevention and for Broader Benefit-sharing. Ministry for Foreign Affairs, Stockholm, Sweden.

Phillips, D.J.H., Attili, S., McCaffrey, S. and Murray, J.S. (2007) The Jordan River basin: 2. Potential future allocations to the co-riparians. Water International, 32 (1), 39-62.

Phillips, D.J.H., Daoudy, M., Jägerskog, A. and Turton, A. (in press) The Jordan River basin: 3. Options for satisfying the current and future water demand of the five riparians. Water International, in press.

Puckridge, J.T., Sheldon, F., Boulton, A.J. & Walker, K.F. (1993) The Flood Pulse Concept applied to Rivers with Variable Flow Regimes. In Davies, et al., 1993. A Synthesis of the Ecological Functioning, Conservation and Management of South African River Ecosystems. Water Research Commission Report No. TT 62/93. Pretoria: Water Research Commission.

Rockström, J. (2001) Green water security for the food makers of tomorrow: Windows of opportunity in drought-prone savannas. In: Water Security for the 21st Century – Innovative Approaches. Stockholm Water Symposium, 2000. Water Science and Technology, 43, 71-78.

Rosegrant, M.W., Cai, X. and Cline, S.A. (2002a) World Water and Food to 2025: Dealing with Scar-

city. International Food Policy Research Institute, Washington D.C.
Rosegrant, M.V., Cai, X., Cline, S.A. and Nakagawa, N. (2002b) The Role of Rainfed Agriculture in the Future of Global Food Production. Discussion Paper 90, International Food Policy Research Institute, Washington D.C.
Rost, S. and Gerten, D. (2008) Global water use in rainfed and irrigated agriculture. Water Resources Research, in press.
Sadoff, C.W. and Grey, D. (2002) Beyond the river: the benefits of cooperation on international rivers. Water Policy, 4, 389-403.
Sadoff, C.W. and Grey, D. (2005) Cooperation on international rivers. A continuum for securing and sharing benefits. Water International, 30 (4), 1-8.
Snaddon, C.D., Davies, B.R., Wishart, M.J., Meador, M.E. and Thoms, M.C. (1999) A global overview of inter-basin water transfer schemes, with an appraisal of their ecological, socio-economic and socio-political implications, and recommendations for their management. Water Research Commission, Pretoria.
Turpie, J. (2006) The existence value of biodiversity in South Africa: How interest, experience, knowledge, income and perceived level of threat influence local willingness to pay. Ecological Economics, 46 (2), 199-216.
Turton, A.R. (2000) Precipitation, people, pipelines and power: Towards a political ecology discourse of water in Southern Africa. In Political Ecology: Science, Myth and Power (Stott, P. and Sullivan, S., Eds.). Edward Arnold, London.
Turton, A.R. (2003) The political aspects of institutional development in the water sector: South Africa and its international river basins. D.Phil. thesis. Department of Political Science, University of Pretoria.
Turton, A.R. (2007) Can we solve Tomorrow's Problems with Yesterday's Experiences and Today's Science? Des Midgley Memorial Lecture presented at the 13th SANCIAHS Symposium, 6 September 2007, Cape Town.
Turton, A.R. (2008a) A South African perspective on a possible benefit-sharing approach for transboundary waters in the SADC region. In Water Alternatives. Volume 1. Number 2, pp. 1–21. Paper originally presented at the First African Water Week, Tunis, 26-28 March 2008.
Turton, A.R. (2008b) Three Strategic Water Quality Challenges that Decision-Makers Need to Know About and How the CSIR Should Respond. CSIR Report No. CSIR/NRE/WR/EXP/2008/0160/A. Keynote address, A Clean South Africa, presented at the CSIR Conference "Science Real and Relevant", 18 November 2008. Pretoria: Council for Scientific and Industrial Research (CSIR).
Turton, A.R. and Ashton, P.J. (2008) Basin closure and issues of scale: The southern African hydropolitical complex. International Journal of Water Resources Development, 24 (2), 305-318.
UN-HABITAT (2006) State of the World's Cities 2006/7. United Nations Human Settlements Programme (UN-HABITAT), Nairobi.
UNEP (2005) Making Tourism More Sustainable: A Guide for Policy Makers. United Nations Environment Programme, Nairobi.
United Nations (2002) General Comment No 15 of the Committee on Economic, Social and Cultural Rights entitled The right to water (arts. 11 and 12 of the International Covenant on Economic, Social and Cultural Rights). UN Document E/C.12/2002/11, 26 November 2002.
Waterbury, J. (2002) The Nile Basin: National Determinants of Collective Action. New Haven: Yale University Press.
WCD (2000) Dams and Development: A New Framework for Decision-making. World Commission on Dams. London: Earthscan Publishing.
Woodhouse, M. (2004) Threshold, reporting and accountability for a Right to Water under international law. Water Law Review, 8 (1), 1-29.
Zeitoun, M. (2008) Power and Water in the Middle East: The Hidden Politics of the Palestinian-Israeli Water Conflict. London: I.B. Taurus.
Zeitoun, M. and Warner, J. (2006) Hydro-hegemony: A framework for analysis of transboundary water conflicts. Water Policy, 8, 435-460.

7. Annex

Categories: Sources / Factors: Development	a) New Water	b) Efficient use of water	c) Other sources in basins that are not closed
1. Hydropower and power trading			
2. Primary production			
3. Urban growth and industrial development			
4. Environment and ecosystem services			
5. Others (every basin is unique and other opportunites may exist)			

Table ES.1. The conceptual framework for the TWO Analysis.

The TWO Analysis – Introducing a Methodology for the Transboundary Waters Opportunity Analysis

This report presents a conceptual framework that can be used by stakeholders concerned by the development and management of shared freshwater resources. The objective is to promote the sustainable and equitable use of transboundary water resources, and to clarify trade-offs relating to development.

The report outlines a concept for analysing potential benefits in a transboundary river basin to optimise economic growth, political stability and regional integration. The conceptual framework is intended to be used by basin State Governments, Regional Economic Communities, and financing entities.

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