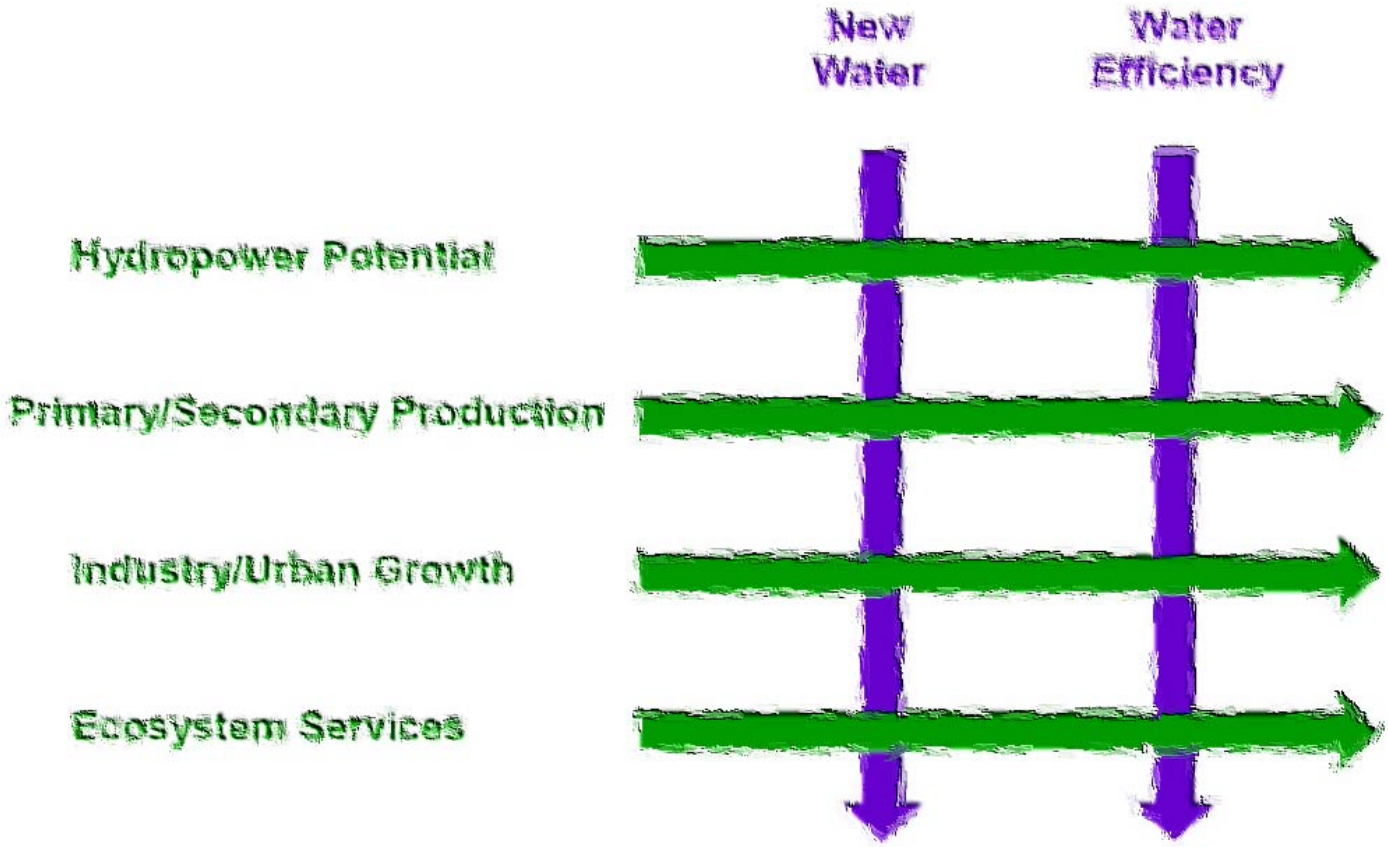
The Trans-boundary Waters Opportunity Analysis as a Tool for RBOs



SOUTHERN AFRICAN DEVELOPMENT COMMUNITY
TOWARDS A COMMON FUTURE

gtz Partner for the Future. Worldwide.

CO-OPERATION
SOUTHERN AFRICAN DEVELOPMENT COMMUNITY
FEDERAL REPUBLIC OF GERMANY

CSIR our future through science

SIWI

The Trans-boundary Waters Opportunity Analysis as a Tool for RBOs

Report prepared by: Phillips Robinson and Associates
P.O. Box 90488, Klein Windhoek, Namibia.
dphillips@iway.na

Report prepared for: SADC Water Division under contract to GTZ
Private Bag X12 (Village), Gaborone, Botswana

Author: DHJ Phillips

GTZ contract - project: 83020708 - 05.2005.6-001.00
CSIR report no.: CSIR/NRE/WR/ER/2009/0124/B

2009

Table of Contents

1 BACKGROUND

As noted elsewhere in this report, RBOs face formidable challenges. Perhaps the key problem faced by RBOs relates to their capacity to fulfil their mandate in relation to attaining the best possible economic improvements within their respective basin, whilst simultaneously respecting issues pertaining to sovereignty. Initiatives to address this problem such the use of Parallel National Action approaches have been covered elsewhere in this report, but the present section concentrates on the potential of a new tool for use by RBOs – the Trans-boundary Waters Opportunity Analysis (TWO Analysis), and how this can assist in defusing sovereignty-related issues, through consensual strategic planning activities.

The TWO Analysis was published in its initial form in late 2008 (Phillips *et al.*, 2008). Its genesis is relevant to this report, as it was designed specifically in response to particular perceived problems that are faced by most or all RBOs:

- most – and perhaps all – trans-boundary basins are known to be managed and utilized in a sub-optimal manner (e.g. see Phillips *et al.*, 2006, 2008);

- realizing improvements in such basins has proven highly challenging, due to a complex mix of technical and political constraints, many of the latter relating to concerns over sovereignty;

- tools such as Cooperative Regional Assessments and Transboundary Diagnostic Analyses are of limited effect, and address mainly technical issues; and

- defusing sovereignty concerns remains a crucial requirement, and none of the previously available tools focuses upon this need.

The following sections discuss the objective of the TWO Analysis; its design and use; a case study involving the utilization of the TWO Analysis on the Nile River; and the potential use of the TWO Analysis by RBOs.

One particular aspect of the use of trans-boundary waters merits emphasis here, this involving Positive-Sum Outcomes (PSOs). A most common problem encountered in negotiations over the use of trans-boundary waters relates to the Zero-Sum Outcome, where water volumes (or benefits) gained by one riparian are lost in equal amount by another. This dynamic exists where the water volumes or benefits are capped, and cannot be enhanced; under such circumstances, simple reallocation must occur, and 'winners' are inevitably balanced by 'losers'. Under such circumstances, negotiations commonly stall, as the probable 'losers' have little incentive to continue the process.

PSOs defuse this *problematique*, as they provide space for all riparians to gain either water volumes or benefits simultaneously over time, with no party experiencing net losses. This is achieved through various methods of 'making the cake bigger', i.e. generating greater water volumes or benefits (or preferably, both) than are available in the *status quo*. The various means by which this can be achieved are explained in later sections of the present text.

2 THE OBJECTIVE OF THE TWO ANALYSIS

As noted in the original publication on the TWO Analysis, the technique can be of use in a range of circumstances:

> *"1 The TWO Analysis can demonstrate possible alternatives for countries sharing trans-boundary water resources, in exploring development opportunities determined to be PSOs. It can be used in both formal negotiations and in training situations.*
>
> *2 The TWO Analysis can act as a 'compass' identifying 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 trans-boundary or intra-State, depending on the circumstance involved."* [Phillips *et al.*, 2008, Section 1.3].

It is clear from this that the TWO Analysis was designed as a tool to be utilized at the strategic level of investigations addressing trans-boundary basins. The general relationship of the TWO Analysis to other forms of study on such basins is shown at Figure 1. This confirms the strategic-level position of the technique, and clarifies its relationship to very broad investigative efforts using the Inter-SEDE Model (see Phillips *et al.*, 2006); to Cooperative Regional Assessments and/or Transboundary Diagnostic Analyses (CRAs and TDAs); and to project-related studies. Hence:

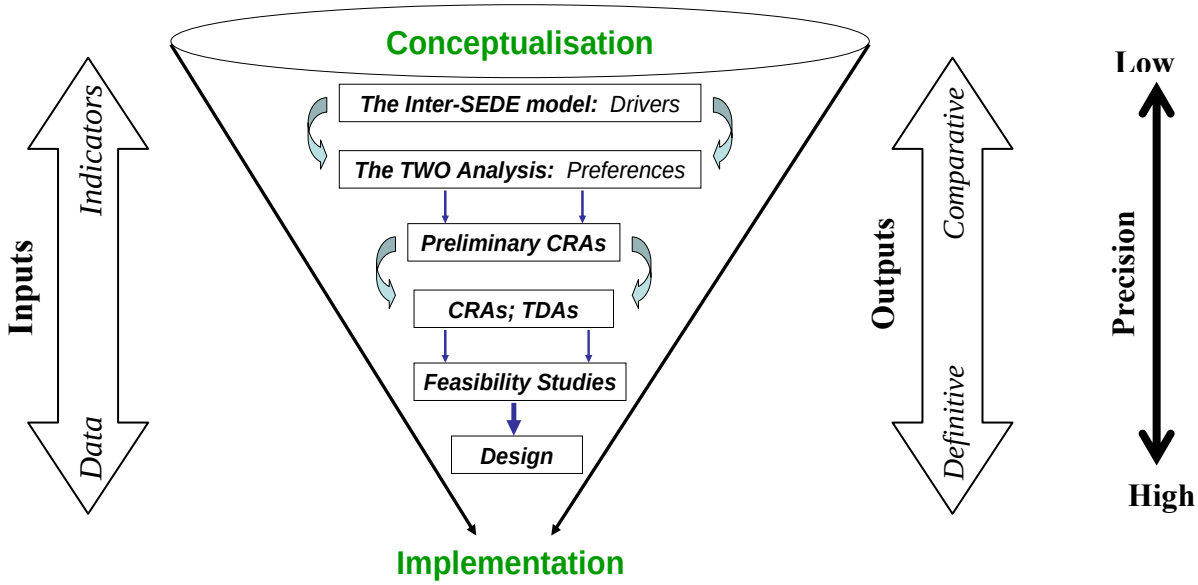
- the Inter-SEDE Model (Phillips *et al.*, 2006) is a comparatively crude tool, and is of utility in defining the relative importance of the key drivers (security, economic development, and environment) in a trans-boundary basin;

- the TWO Analysis generates a high degree of detail at the strategic and holistic level, marrying the use of water resources of all types against possible development options;

- CRAs and TDAs represent detailed technical studies which are best applied to preferred combinations of development options, rather than being used to compare such options; and

- more detailed investigations still (Pre-Feasibility and Feasibility Studies) are required to preface the development interventions themselves, and to underpin specific projects which are intended to contribute to economic development in a trans-boundary basin.

Figure 1. The relationship of the TWO Analysis to other forms of investigations on trans-boundary water resources and development opportunities. CRA: Cooperative Regional Assessment (see Sadoff and Grey, 2002, 2005). TDA: Transboundary Diagnostic Analysis.



In terms of its relationship to other forms of investigation, the TWO Analysis has been designed to be located at the strategic level, as shown in Figure 1 above. The relatively crude Inter-SEDE model developed by Phillips et al. (2006) may be considered to lie more closely to the conceptual end of the spectrum, providing a basic insight into the key drivers in trans-boundary basins. By contrast, the TWO Analysis is designed to generate strategic options and preferences in relation to the optimization of economic development within a trans-boundary basin.

The primary function of the TWO Analysis is therefore to guide riparians towards more optimal and sustainable uses of trans-boundary water resources. More detailed studies would then follow the completion of a TWO Analysis, leading eventually to Feasibility Studies and the implementation of preferred development options.

3 THE TWO ANALYSIS: THE BASIC METHODOLOGY

The basic methodology for the TWO Analysis involves the consideration of all of the existing and potential water resources within a trans-boundary basin, and a range of possible development interventions. These parameters are placed in a matrix, as shown in Table 1. Table 1 is generic in nature, and was produced in this form such that it would be of relevance to essentially all trans-boundary basins world-wide (Phillips *et al.*, 2008). Comment is required here, as to the detail inherent in the vertical and horizontal axes in the matrix.

The vertical columns in Table 1 include all the water resources available, or potentially available, within a trans-boundary basin. Two aspects are of particular importance here:

- The *status quo* is not accepted as the basis for the TWO Analysis, and options that are not currently in use in a trans-boundary basin are brought into the analysis, from the outset. To provide an example, new activities such as desalination may affect the available volume of fresh water within a basin. Desalination technologies have become increasingly affordable during recent decades, and this is altering the views of many nations as to its desirability as one element of the available water resource.[1]

- All possible sources of water are included, in the TWO Analysis. The technique therefore considers not only Blue Water, but also Green Water; all forms of re-usable water; and also Virtual Water, where the latter is of relevance. The inclusion of Green Water is of especial importance, as this component of the hydrological cycle has been largely ignored to date in studies of trans-boundary basins, notwithstanding its great importance volumetrically and in relation to the agricultural sector (see Figure 2 and Rockström, 2001; Falkenmark *et al*., 2005, 2007; Hoff, 2007, 2008; Rost *et al.*, 2008). Virtual Water is also important in strategic-level considerations in many basins, especially where the bulk of the water resource is utilized in supporting agriculture (and where arid conditions predominate; see Allan, 1998, 2001, 2002).

It is instructive here to consider the full range of water resources that may be of relevance in trans-boundary basins, as it is important that each of these is considered. The range as a whole includes the following within the 'New Water' category:

- fresh water developed through desalination;
- the re-use of wastewater to create New Water (this being included in the New Water category rather than under the efficiency of water use);
- the release of higher volumes of Blue Water to downstream riparians, due to improved Green Water/Blue Water management in upstream areas (Hoff, 2007, 2008); and
- water derived from either intra-basin or inter-basin transfers.[2]

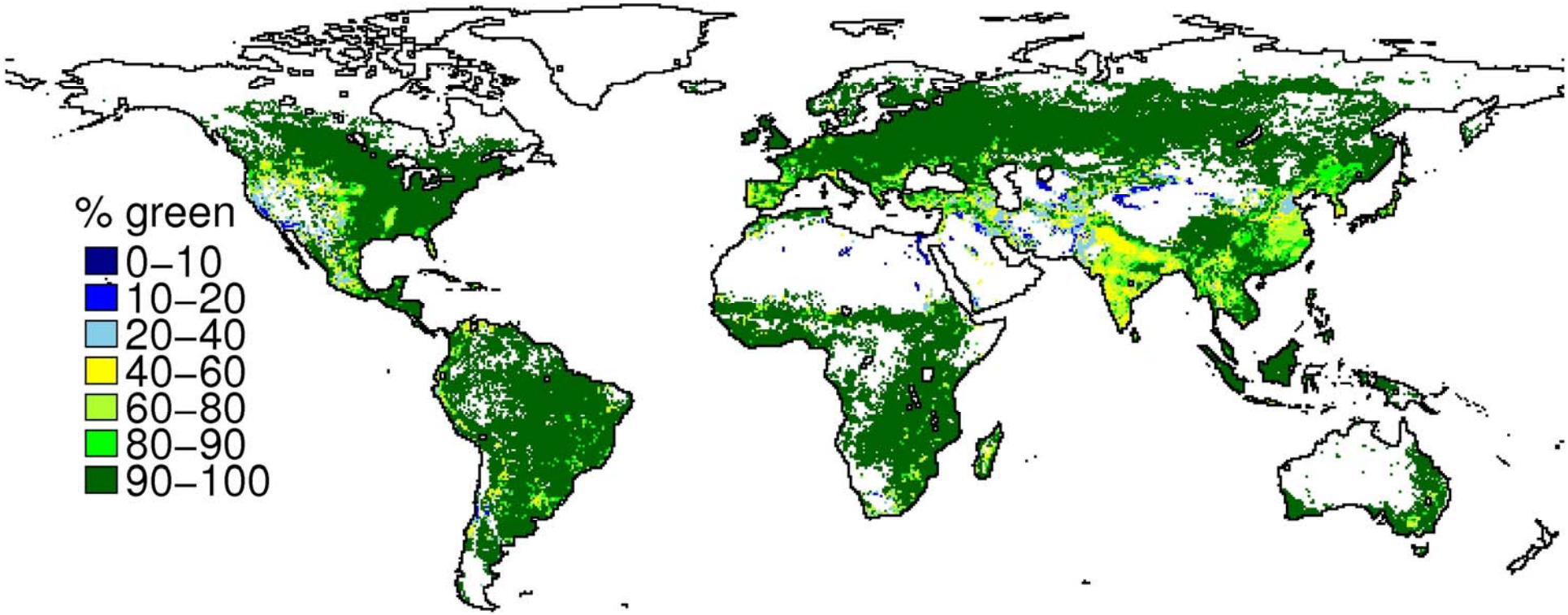
[1] The current costs for desalinating sea water are of the order of US$0.75/m^3. This cost is competitive with development costs for the more expensive natural waters, and is within the range of costs of bankable projects for generating fresh water (Phillips *et al.*, 2006). Water management authorities that are actively introducing high-volume desalination for the first time in response to its increased affordability include those in Algeria, California, Jordan, Namibia, and Spain.

[2] It is obvious that inter-basin transfers affect water availability within the recipient basin. Intra-basin transfers can generate New Water by affecting the existing evaporative characteristics within a basin.

Table 1. The conceptual framework for the TWO Analysis. The text within each box provides examples only of the importance of each node of the matrix, and is not exhaustive in coverage. [After Phillips *et al.*, 2008].

Development Opportunity	***New Water***	***More Efficient Use of Water***	***Other Sources:*** In basins that are not closed, additional water that is not in use may be brought into utilization, to assist in driving any of the four major categories of development opportunity.
Hydropower and Power Trading	New Water can be created by the siting of dams where evaporative losses are minimized. The interplay to Green and Blue Water dynamics should be addressed.	The siting of dams in trans-boundary basins influences the geographical pattern of water availability. This has a profound impact on the net benefits arising from a trans-boundary watercourse.	
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 trans-boundary basins, if this is taken into account.	
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, maximizing the economic returns per unit volume.	
Environment and Ecosystem Services	Enhanced attention to the Green Water-Blue Water interface can improve or guarantee 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 optimizing returns from ecosystem services. Fisheries and tourism are especially important generators of income in such scenarios.	
Others?	Every shared basin is unique, and other types of Positive-Sum Outcomes no doubt exist.		

Figure 2. The proportion of Green Water in total agricultural water fluxes, world-wide. After Rost *et al.* (2008).



In the category relating to the efficiency of water use, the following examples may be provided:

- the use of fresh waters in agricultural activities can be improved markedly by investment in drip irrigation and other techniques, reducing evaporation rates and enhancing yields per unit volume of water utilized;

- economic returns from the agricultural sector can be further enhanced through improved crop selection, reducing requirements for water and where possible also including a greater emphasis on the production of cash crops; and

- the economic returns from water use in the industrial sector can also be improved, e.g. by recycling water and minimizing its use in specific applications; and also by shifting to less water-intensive forms of industry with equal or higher economic returns.

Virtual Water has recently undergone a renaissance in conceptual understanding, following its initial introduction as a concept more than a decade ago (Allan, 1998). An analysis of Virtual Water flows amongst water-stressed nations reveals a mix of appropriate and grossly inappropriate strategic responses (e.g. see Phillips *et al.*, 2006). Thus, for example, both Egypt and Israel import very large volumes of Virtual Water embedded primarily in agricultural products, and this effectively reserves their available fresh water resources for uses other than growing staple foods. By complete contrast, Syria and certain of the upper riparians of the Nile River export high volumes of Virtual Water in low-cost agricultural products, exacerbating their in-country demands for fresh water supplies. The critical links between fresh water resources and trade are made explicit in such examples, and riparians in water-stressed situations do not always follow coherent policies in this regard.

In relation to development opportunities, the TWO Analysis as originally published included selected options of perceived general importance (Table 1), but noted that each basin is unique (see also Phillips *et al.*, 2006), and the options for each basin should therefore be generated in the specific. This is important, as whilst the generic development categories suggested by Phillips *et al.* (2008) are likely to be of relevance in many (perhaps, all) trans-boundary basins, specific options and sub-options of this type will differ from basin to basin, and the riparians should ensure that these are selected with care. In the Nile River basin, for example, the riparians elected to re-sort the development categories as proposed in the initial TWO Analysis, and to add sub-categories (see Section 7 below and Appendix 1). In relation to the technique, the TWO Analysis permits this without difficulty, and the riparians simply need to ensure that no options of potential significance are omitted, at this early stage of the procedure. The aim here is therefore to be as inclusive as possible, and the later scoping stages will narrow down the options to select those of greatest importance, through a number of steps (see the following text).

It is also important at this early stage of the effort, to clarify which specific potential options are included in each of the broad categories used. The use of sub-categories (as in the Nile River analysis; see Section 7 below) assists in this. Where drivers differ significantly within categories (e.g. for food production and forestry, within the broad primary production category – and also for bio-fuel production), these should be addressed separately, as the subsequent analysis will proceed more smoothly.

Figure 3. A broad classification of river regulation globally. After Nilsson *et al.* (2005) and Nilsson (2006).

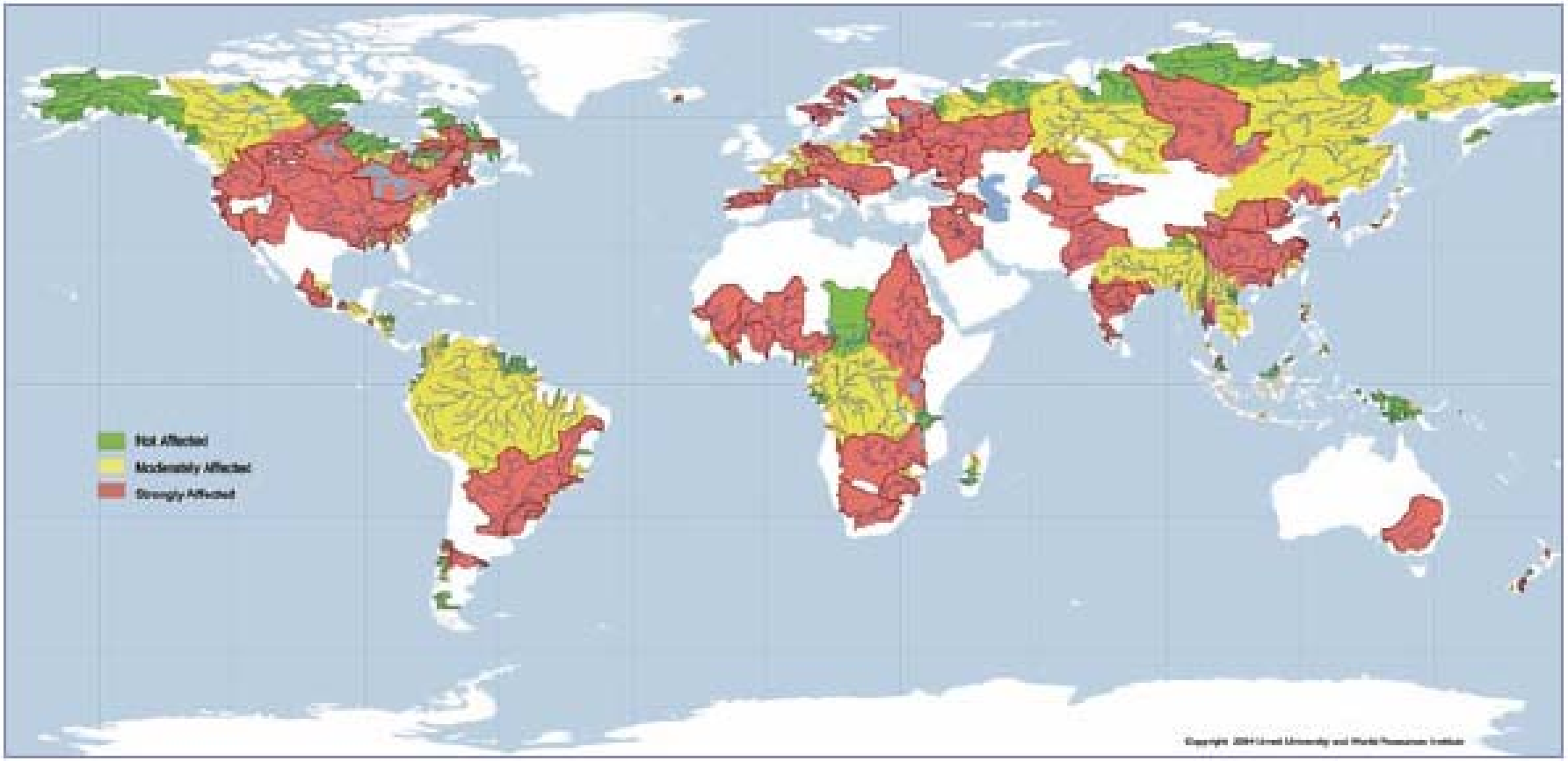
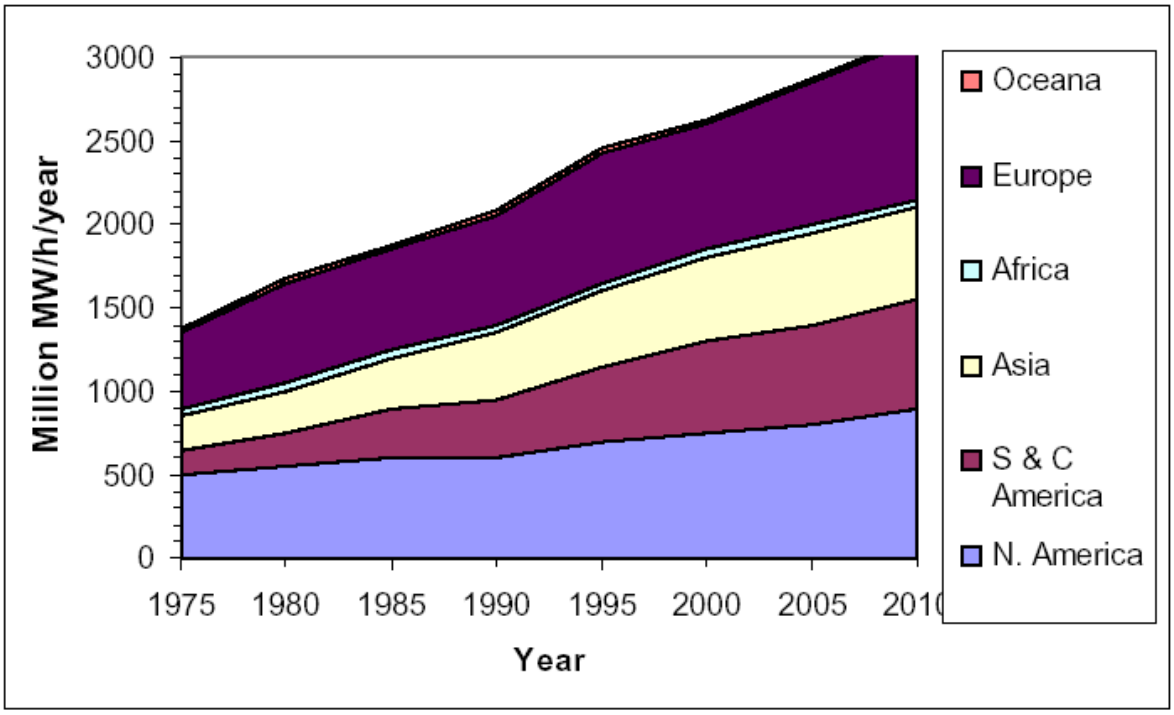


Figure 4. Historical and predicted near-term hydropower production in the world. After White (2000).



The main categories of development options proposed by Phillips *et al*. (2008) were as follows:

- **Hydropower and power trading:** The availability of electrical power is a most important determinant of economic growth, especially amongst developing nations. The scale of river flow regulation to date has been truly massive (Figure 3). Nevertheless, many developing countries in particular possess enormous untapped hydropower resources, for example in the Tigris-Euphrates basin (Kibaroglu, 2007), the Mekong River (MRC, 2003; Phillips *et al.*, 2006), or the Grand Inga scheme on the Congo River with an estimated potential of about 40,000MW (Basson, 2005). Hydropower development in Africa has been especially poor, to date (Figure 4). It is important to note that any development of hydropower has material affects on the Blue Water balance within a basin, and decisions on the preferred location of dams should acknowledge this. This has not always been the case in the past, as evidenced by the huge evaporative loss from Lake Nasser behind the Aswan High Dam on the Nile, for example (see Whittington and McClelland 1992; Whittington *et al*., 1995; Kendie, 1999; Tafese, 2000; Stroh, 2003). The interplay between the positive economic effects of enhanced hydropower availability to riparians and the potentially negative effects of dams on the overall water balance within a basin need to be considered at much greater length, in future studies.

- **Primary production:** Most of the Sub-Saharan African nations depend primarily on agriculture as the backbone of their economy. The agricultural sector is always the sector consuming the highest water volumes, generally dwarfing the flows allocated to the domestic or industrial sectors. Improvements that can be attained in water productivity in the agricultural sector have direct impacts on poverty and hunger alleviation. However,

despite the key importance of the agricultural sector in this regard, sub-optimal performance and yields are the norm throughout much of Africa, and huge volumes of water are wasted (e.g. see Rosegrant *et al.*, 2002a, 2002b). The optimization of the Green Water/Blue Water interface is especially critical in this respect (LWRG, 2007; Hoff, 2007, 2008), although other simple and relatively inexpensive technological factors such as the use of drip irrigation techniques are also important.

- **Urban growth and industrial development:** The economic returns from fresh water allocated to the agricultural sector can be increased by two orders of magnitude or more, when flows are allocated to the industrial or services sectors. This implies that countries may climb out of poverty traps by selectively developing their industrial and services sectors, with reallocation of water from the agricultural sector. Whilst it is clear that the socio-economic consequences of moves away from the agricultural sector must be recognized and carefully managed, most of the countries in the transition away from the agricultural sector have experienced relatively few problems in this regard. Examples here include Botswana and Jordan, both of which are currently part-way through the process of a transition away from dependence on agriculture. It is also notable that it is important for countries in arid regions in particular to select their industries with care, as 'thirsty' applications such as textile dyeing are not to be preferred.

- **Environment and ecosystem services:** The original publication on the TWO Analysis (Phillips *et al.*, 2008) focused upon fisheries and tourism in this sector, both of which are capable of producing very high returns for fresh water allocations over time, under the right circumstances. However, it was noted that a range of other types of services exists (see Table 2), and each basin will be unique in the possibilities offered in this sector as a whole.

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

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

The output from the preliminary stage of a TWO Analysis may be displayed in textual form within the nodes of the type of matrix shown in Table 1, but this can also be summarised in colour-coded form, as in the example shown in Figure 5. The latter methodology is especially powerful, as it provides a truly holistic view of strategic development options, at a glance. This technique is used as a base methodology in later sections below, which discuss the flexibility of the TWO Analysis, and its very recent application in the Nile River.

Figure 5. A simplified and highly condensed example of a whole-basin TWO Analysis matrix, showing questions and responses in specific nodes of the matrix, and corresponding colour coding. Note the two-way nature of the interrogation process. NW: New Water. EUW: Efficient Use of Water. VW: Virtual Water. Red: No interaction. Yellow: Some link. Green: Positive interaction.

Questions:

Development opportunity	*Sub-category*	***New Water***	***Efficient Use of Water***	***Virtual Water***
Hydropower	Construction of Dam Xxxx ⟶	Can Dam Xxxx create NW?	Can Dam Xxxx allow more EUW?	Can Dam Xxxx affect VW flows?
	Construction of Dam Xxxx ⟵	Can NW affect Dam Xxxx construction?	Can the EUW affect Dam Xxxx construction?	Can VW flows affect Dam Xxxx construction?
Primary Production	Crop yields ⟶	Can crop yield changes create NW?	Can crop yield changes affect the EUW?	Can crop yield changes affect VW flows?
	Crop yields ⟵	Can NW enhance crop yields?	Can the EUW enhance crop yields?	Can VW flows affect crop yields?
Urban Growth/Industrial Development	Growth of the mining sector ⟶	Can mining growth create NW?	Can mining growth affect the EUW?	Can mining growth affect VW flows?
	Growth of the mining sector ⟵	Can NW enhance mining growth?	Can the EUW enhance mining growth?	Can VW flows affect mining growth?
Environment and Ecosystem Services	Tourism ⟶	Can increased tourism create NW?	Can increased tourism affect the EUW?	Can increased tourism affect VW flows?
	Tourism ⟵	Can NW increase tourism?	Can the EUW increase tourism?	Can VW flows increase tourism?

Responses and Colour Codes:

Development opportunity	*Sub-category*	***New Water***	***Efficient Use of Water***	***Virtual Water***
Hydropower	Construction of Dam Xxxx ⟶	No	Yes, by changing water availability	Not directly
	Construction of Dam Xxxx ⟵	No	Not directly	No
Primary Production	Crop yields ⟶	No	No	Yes; import needs would change
	Crop yields ⟵	Yes, and this is important	Yes, and this is important	Not directly
Urban Growth/Industrial Development	Growth of the mining sector ⟶	No	No	Not directly
	Growth of the mining sector ⟵	Yes, if in the correct location	Yes, if in the correct location	No
Environment and Ecosystem Services	Tourism ⟶	No	Yes, as water could be reallocated	Not significantly
	Tourism ⟵	Yes, and this creates high returns	Not directly	Not directly

4 THE TWO ANALYSIS: FLEXIBILITY

One of the most important attributes of the TWO Analysis relates to its high degree of flexibility. Thus, for example, the various water-related and developmental factors outlined in Section 3 above can be modified to reflect the particular circumstances in each specific basin of interest, and this is of obvious importance where the work of RBOs is concerned. More importantly, however, the TWO Analysis was designed as a tool that can be employed in a very wide range of circumstances:

- to identify preferred development options at a strategic and holistic level in a basin that has been poorly studied to date, but offers a range of potential opportunities;

- to confirm previously selected development preferences, decided upon prior to the creation of the TWO Analysis technique;

- to compare development options and preferences over a range of geographic scales and levels of detail, e.g. through sub-basin and basin-wide analyses;

- to act as the basis for scenario planning, effectively allowing 'what-if' games to be pursued in basins which offer multiple possibilities for future development; and

- to inform the riparians as to changes over time in trans-boundary basins, through the use of the TWO Analysis in relation to the present, and in terms of benchmark dates in the future (given various assumptions as to near-future changes in the basin).

It is especially important to note that the TWO Analysis can be utilised at any desired geographical scale, and this provides most useful nuances to undertakings involving strategic planning in trans-boundary basins. A theoretical example of this is shown at Figure 6, which uses the whole-basin TWO Analysis matrix from Figure 5, and shows possible distinctions between two sub-basins. As this simple example shows, sophisticated strategic planning can be undertaken by preparing matrices arising from the TWO Analysis at several tiered levels of geographical scale, with the matrices 'nested under each other' and the whole basin-matrix being a summation of the matrices relevant to greater levels of sub-basin detail.

One of the great advantages of the TWO Analysis is that it can also be employed as a scenario tool. As noted by Phillips *et al.* (2008):

> *"….the value of modelling often lies more in the ability to consider different possibilities of the future, in the context of distinct choices or uncertainties.… An improved understanding of key drivers and trajectories of change will not only clarify the impact of specific decisions, but also 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, involving 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."* [Phillips *et al.*, 2008, Section 4.5].

Figure 6. An example of theoretical differences between two sub-basins in relation to the TWO Analysis matrix, as compared to the whole-basin matrix shown in Figure 5.

Matrix, Whole Basin:

Development	*Sub-category*	***NW***	***EUW***	***VW***
Hydropower	Dam Construction →			
	Dam Construction ←			
Primary Production	Crop yields →			
	Crop yields ←			
UG/ID	Mining growth →			
	Mining growth ←			
EES	Tourism →			
	Tourism ←			

Matrix, Upstream Sub-basin:

Development	*Sub-category*	***NW***	***EUW***	***VW***
Hydropower	Dam Construction →			
	Dam Construction ←			
Primary Production	Crop yields →			
	Crop yields ←			
UG/ID	Mining growth →			
	Mining growth ←			
EES	Tourism →			
	Tourism ←			

Upstream sub-basin: *Dam construction of relevance in the upstream reaches, but little agriculture present. Mining activities of relevance, but little tourism potential present.*

Downstream sub-basin: *No potential for dam construction, but significant agriculture in this sub-basin. Some mining present, and also significant tourism potential with high value.*

Matrix, Downstream Sub-basin:

Development	*Sub-category*	***NW***	***EUW***	***VW***
Hydropower	Dam Construction →			
	Dam Construction ←			
Primary Production	Crop yields →			
	Crop yields ←			
UG/ID	Mining growth →			
	Mining growth ←			
EES	Tourism →			
	Tourism ←			

This capacity to develop ‘different possible futures’ for a trans-boundary basin is not only powerful in relation to strategic planning; early experience with the use of the TWO Analysis has shown that it also assists markedly in defusing any pre-existing tendencies of riparians in relation to conflict. The scenarios developed from a TWO Analysis are thus generally ‘non-threatening’ to riparians, serving to generate alternative visions of the future for trans-boundary basins. When combined with an analytical approach involving input from all stakeholders of relevance to the basin, this creates a robust platform for truly collaborative and fruitful negotiations.

5 THE TWO ANALYSIS: GENERATING AND USING THE BASKET OF BENEFITS

The preparation of the initial matrices from the TWO Analysis, as described in Section 4 above, is the first step in creating 'the basket of benefits' of relevance to a trans-boundary basin. This concept, first described by Phillips *et al.* (2006), is of great importance in the TWO Analysis which was developed subsequently.

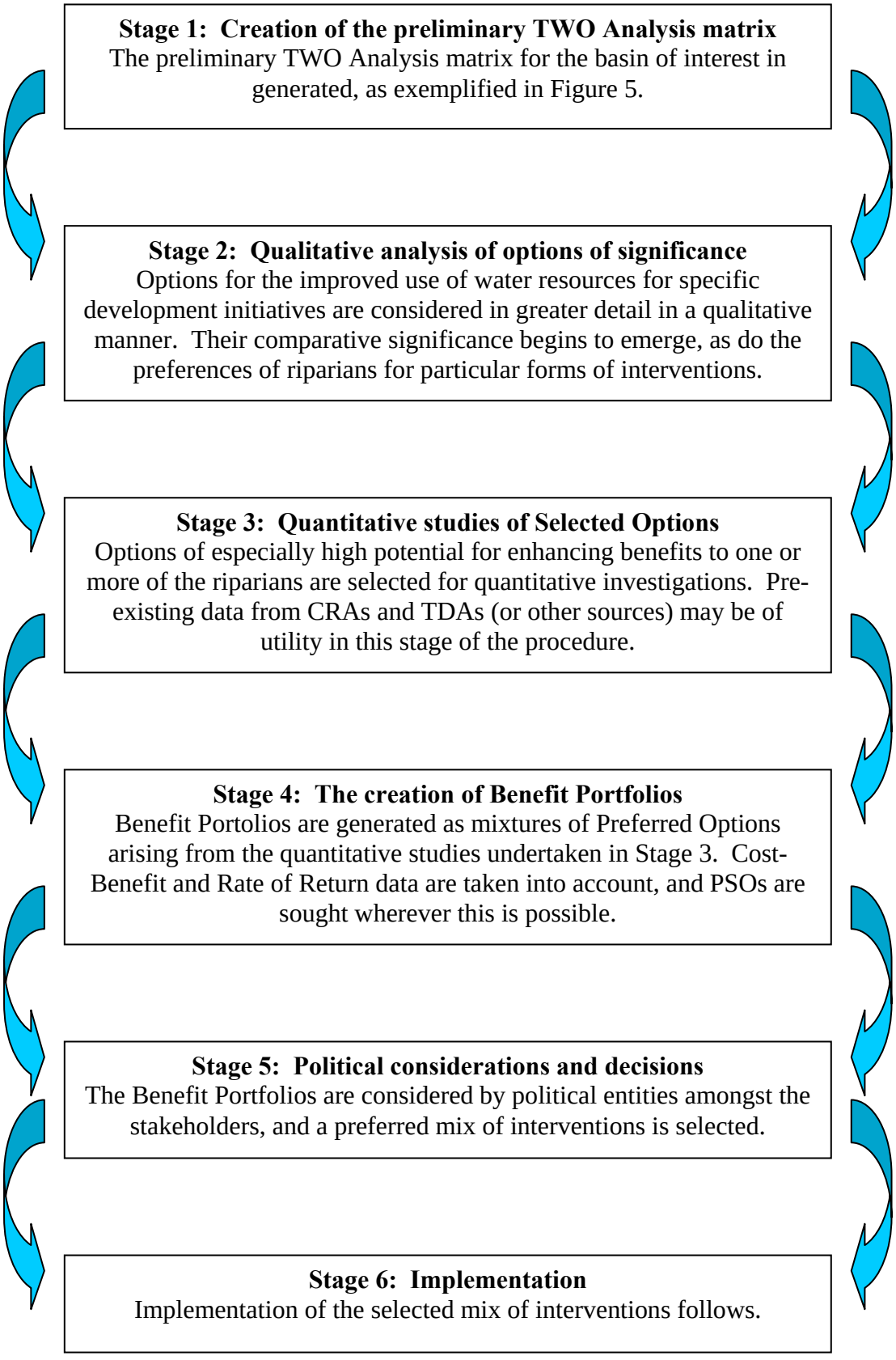
The primary drive when creating the basket of benefits is to use as broad an approach as possible, and this requires that: [a] the whole basin should be addressed, initially; and [b] all potential benefits should be included. At the initial stage, broad scoping (only) should occur, through the use of the colour-coding system that has previously been described. Thereafter, additional stages of scoping should be employed to narrow down the choice of benefits of useful value to the riparians, and the present section describes this process in general terms.

Several sequential stages are recommended, following the completion of the preliminary TWO matrix for a trans-boundary basin as a whole (see Figure 7). It is important to note that the degree to which technocrats and politocrats become involved in these stages will differ, according to the basin concerned (and especially its degree of securitization; see Turton, 2003). Most of the early stages of the process are essentially technically-driven, but there will nevertheless be merit in political interests being brought into the process, even at this phase of the work. This is because political interests in trans-boundary basins do not always respond to basin optimization as perceived from a technical or economic standpoint, and the process as a whole should be consensual in nature, if it is to be successful. A 'resonance' should therefore be sought between the technical and political aspects of the process, and RBOs will be important facilitators of such a process, as is discussed further at Section 8 below.

The stage after the completion of the preliminary TWO matrix involves a more detailed and mainly qualitative analysis of the items that have been included in the basket of benefits (i.e. the interfaces colour-coded green in the preliminary TWO matrix, as exemplified by Figure 5). In this stage, the specific nature of the link between the various available water resources and the development option should be described, and a view formed as to its likely significance by comparison to other potential benefits. This level of significance is generally characterised by the degree of economic improvement or 'uplift' that can be created by the benefit involved, i.e. by the quantum economic improvement, compared to the *status quo*.

Experience reveals that this stage of the process can be undertaken relatively simply and rapidly with assistance from senior water managers familiar with the basin of interest, without requiring access to detailed numerical or other data of relevance to the basin or its component parts (see also Section 7 below). An early view is therefore generated of the relative significance and value of each of the items in the basket of benefits.

Figure 7. The general stages of the TWO Analysis, and their respective outputs.



Importantly, if this process involves representatives of all of the riparians (and both the technical and political spheres of interest), the participants begin to discern differences between the individual riparians as to their perceived importance of the various potential benefits. This starts to feed a dynamic leading eventually to negotiations on benefit-sharing (see below).

This qualitative stage in scoping the basket of benefits should give rise to a list of potential benefits which all the riparians consider to be worthy of additional consideration. Once such an agreement has been reached, the subsequent stage of the analysis should be triggered, and this addresses each of the potential benefits in a quantitative fashion, generating a Cost-Benefit Analysis and data on Rates of Return for each of these. Studies of this nature are commonly components of a CRA or TDA, and where such studies have already been undertaken on basins or sub-basins, the data arising from them are of direct utility in the quantitative studies supporting the TWO Analysis.

The output from this quantitative stage of the effort will comprise a range of potential benefits, each accompanied by Cost-Benefit and Rate of Return data (Stage 3 in Figure 7). The riparians should then consider this information, and prepare options to be fed into the following stage of the procedure. This involves the preparation of Benefit Portfolios, which will comprise a range of individual items from the basket of benefits, in specific (and differing) admixtures. Several issues represent key considerations at this stage of the effort:

- The Cost-Benefit and Rate of Return data are important parameters when developing Benefit Portfolios, as in most or all cases, front-end costs will be involved in realizing benefits, and the available finance will be somewhat limited.

- Benefit Portfolios should also be prepared whilst taking account of the need wherever possible to create Positive-Sum Outcomes. This implies that the Benefit Portfolios should include specific items that create improvements for all the riparians of a trans-boundary basin, and not merely for a select few (and certainly not favouring the basin hegemon; see Zeitoun and Warner, 2006; Zeitoun, 2008). If this is not respected, riparians who will experience no net benefits will be hesitant to proceed. This may require a degree of sophisticated negotiation, in certain circumstances.

- The initial mix of benefits can be tailored to optimise short-term returns; to provide optimum benefits over a longer period; or some mix of these, with the costs and rate of economic improvements being distinct for each riparian. This is important, as each of the riparians will have a unique preference for investment schedules and rates of economic return. The different Benefit Portfolios will each display a specific mix, in terms of these parameters.

The Benefit Portfolios may then be provided to the political entities representing the riparians, with a view to negotiating and finalizing the preferred mix of interventions. At this stage of the effort (Stage 5 in Figure 7), it is obvious that Benefit Portfolios which contain Positive-Sum Outcomes will have a much better chance of being selected for implementation, as all the riparians will benefit simultaneously in these instances. Negotiations at Stage 5 of the procedure may be accompanied by a degree of mixing-and-matching of specific benefits from distinct Benefit Portfolios, this being essentially a form of 'horse trading' by the parties involved. Once the riparians have agreed upon the preferred mix of interventions, the implementation phase may proceed.

6 THE TWO ANALYSIS: STAKEHOLDER INVOLVEMENT AND THE PREFERRED ROLE OF RBOS

The TWO Analysis as described above follows a logical and step-wise progression, and several factors are of key importance in guaranteeing a successful conclusion. Two of the most important of these relate to stakeholder involvement, and the need for a specific entity to drive the process as a whole, keeping the technical and political interests engaged.

In terms of stakeholder involvement, the TWO Analysis is a relatively simple procedure, and this allows stakeholders of all types to contribute to the distinct stages of the process. Obviously, certain steps in the procedure require a reasonably intimate understanding of the technical issues involved, but non-technical stakeholders (including politicians) can be brought along in this process, and this is a desirable element of the decision-making procedure as a whole. The all-pervasive effects of decisions on water resource use in trans-boundary basins imply that stakeholder involvement in the distinct stages of the TWO Analysis should be as broad as possible, rendering final decisions as transparent and consensual as possible.

The need for a specific entity to drive the process as a whole is of exceptional importance. Clearly, no individual riparian should be entrusted with this task, as this would give rise to accusations of favouritism and other forms of conflict. RBOs are the perfect driver of the TWO Analysis, as they are supra-national in nature, and should hold balanced views of preferred outcomes, defusing tendencies for hegemony. At the all-important phase where Benefit Portfolios are prepared and presented to the political arena, RBOs would be the perfect driver and facilitator, as they should be perceived as being independent, but eager to fulfil their key mandate, i.e. the optimisation of economic returns from the basin as a whole.

7 A CASE STUDY: THE NILE RIVER BASIN

The TWO Analysis was published in its final form only in November 2008, and it is therefore a new tool for use in trans-boundary basins. However, previous studies completed in parallel to the development of the TWO Analysis (Phillips, unpublished) have shown that its use can generate new insights to water management in trans-boundary basins, even where these have been subjected to very considerable previous study. This is the case for the Jordan River basin, work on which is still in progress.

In early 2009, the TWO Analysis was employed to investigate the potential for benefit sharing in the Nile River basin. This work is also ongoing, but the findings to date are discussed here, providing a case study that assists in confirming the strong utility of the technique.

The work to date on the Nile River basin has involved the preparation of a preliminary TWO Analysis matrix for the basin as a whole, and this is shown at Appendix 1 to the present report. The process by which the preliminary TWO Analysis matrix was prepared for the Nile River is of relevance to the present report, as this contextualises the level of effort needed to generate specific outcomes from the TWO Analysis. The core of the preliminary matrix as shown at Appendix 1 was generated collaboratively by a group of some 35 individuals representing all of the Nile River riparians. The following comments are of relevance to the process involved:

- The general shape of the preliminary TWO Analysis matrix for the Nile River was decided by the riparians themselves. It will be noted that the principal development categories employed (the horizontal rows in the matrix at Appendix 1) are somewhat distinct from those in the TWO Analysis as originally published (Phillips *et al.*, 2008). However, the items included in the TWO Analysis as originally published are all present in the preliminary matrix for the Nile River, albeit in slightly distinct groups of categories (compare Appendix 1 to Table 1 in this section of the present report). This reveals that all trans-boundary basins are unique, and riparians will have established views as to the more important drivers within specific basins. The TWO Analysis was designed specifically to accommodate this, and no problems arise from tailoring the technique to the specific desires of the riparians.

- The matrix as shown in Appendix 1 was created over a three-day workshop, with additional effort over about a week thereafter by the two facilitators, to finalise the product. It is clear from this that massive levels of effort are not required to address at least the initial step in the TWO Analysis. The most time-intensive stage in the TWO Analysis process is Stage 3 as shown in Figure 7, which requires the generation of quantitative data on options which appear to have particular merit as interventions. However, even this stage of the procedure will not be deeply time-intensive for most trans-boundary basins, and many of the input data are often already available for well-studied basins.

- The capacity of the procedure inherent in the TWO Analysis to defuse conflict was most notable, during the workshop that created the core of the preliminary TWO matrix shown at Appendix 1. At the time of the workshop, the riparians were locked into a challenging

process involving the consideration of the draft Cooperative Framework Agreement for the Nile, with outstanding disagreements over the wording of the draft agreement in respect to Article 14. This relates to the core of the discord between the riparians in terms of the historical volumetric agreements from 1929 and 1959, and the opposing Nyerere Doctrine (see Okoth-Owiro, 2004; Phillips *et al.*, 2006). Despite this source of conflict and securitisation (Turton, 2003), the representatives at the workshop collaborated without difficulty on the task of preparing the TWO Analysis matrix. This emphasizes the 'non-threatening' nature of the TWO Analysis procedure as a whole.

Clearly, the preliminary TWO Analysis matrix as shown at Appendix 1 to this document represents only the start of the TWO Analysis as a whole, in relation to the Nile River basin. However, even this step has created a collaborative dynamic amongst the riparians, and has revealed important aspects of the basin that were not hitherto appreciated, in full. One of the most important of the latter is that the Nile River basin is managed sub-optimally at the present time, and quantum improvements in economic returns from the river are possible. This conclusion was supported by all participants at the workshop in early 2009, and shows that the initial belief that the TWO Analysis can give rise to quantum improvements in trans-boundary basins is fully justified.

8 RBOs AND THE TWO ANALYSIS

As noted in the first section above related to the TWO Analysis (Section 1 above), RBOs face specific difficulties in optimising the economic returns from trans-boundary basins, whilst taking account of issues pertaining to sovereignty. This remains a key problem faced by many RBOs, and no truly effective remedies have been identified, to date.

It is argued here that the TWO Analysis will assist RBOs materially in this effort. This is primarily due to the fact that the TWO Analysis facilitates the creation of a 'shared vision' for the future development of a trans-boundary basin, and the process involved is of a generally non-threatening nature. In circumstances where individual riparians display a degree of nervousness over the process, the use of the TWO Analysis as a scenario testing tool can be relied upon. The non-threatening nature of the process is a primary key to creating collaboration between the riparians.

The TWO Analysis is also a phased tool, in relation to the predominant types of inputs (and expertise) required to undertake its separate (but linked) stages. The early stages in the TWO Analysis should be driven primarily by technical experts, with economists being introduced at the quantitative analytical phase (Stage 3 in Figure 7), and with political entities being engaged as may best ensure a smooth flow of the process. Political entities become of primary importance at the later stages of the effort, when the Benefit Portfolios have been developed and negotiations are required to determine preferred mixes of interventions. By this stage of the effort as a whole, a fully collaborative dynamic will have developed amongst the technocrats (at least), and all data required to support political decisions will have been amassed.

As alluded to in Section 6 above, it is envisaged that RBOs are the perfect facilitators in the completion of a TWO Analysis. This is because RBOs represent all the riparians within a trans-boundary basin – by definition – and should hold balanced views of the preferred outcomes in terms of optimising benefits for all parties. RBOs also typically include a mix of technocrats and politocrats, and this allows them to 'bridge the gap' between these two communities and their often distinct views of optimal basin development.

Whether RBOs should attempt to complete TWO Analyses in-house is another matter, however. Most RBOs are unlikely to possess the full range of technical expertise (or the capacity) required to achieve this, and in any event, broad stakeholder participation is certainly preferred, as has already been stated. Some parties have also suggested that even RBOs are not sufficiently independent to generate proposals for the key development initiatives in trans-boundary basins, and there is merit in using external consultants for such a task (COWI Uganda, 2008). In any event, it is undeniable that RBOs are perfectly placed to take a coordinating role in the use of the TWO Analysis in trans-boundary basins, and hence in identifying and triggering the implementation of key development initiatives.

9 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.

Basson, G. (2005, on-line). Hydropower dams and fluvial morphological impacts - an African perspective. http://www.un.org/esa/sustdev/sdissues/energy/op/hydro_basson_paper.pdf

COWI Uganda (2008). *Development of a Kagera River Basin Transboundary Cooperative Framework and Management Strategy in the Four Riparian Countries of Burundi, Rwanda, Tanzania and Uganda.* Final Report to the Nile Basin Initiative, November 2008.

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.

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.

Kendie, D. (1999). Egypt and the hydro-politics of the Blue Nile River. *Northeast African Studies*, 6 (1-2), 141-169.

Kibaroglu, A. (2007). Turkey's water policy and the Euphrates-Tigris Rivers system. Presentation at the MENA training Course on Trans-boundary Waters, Amman, Jordan, 14 November 2007.

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.

Okoth-Owiro, A. (2004). *The Nile Treaty: State Succession and International Treaty Commitments: A Case Study of the Nile Water Treaties*. Konrad Adenauer Foundation, Nairobi, Kenya.

MRC (2003). *State of the Basin Report*. The Mekong River Commission, Phnom Penh.

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.

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

Phillips, D.J.H., Allan, J.A., Claassen, M., Granit, J., Jägerskog, A., Kistin, E., Patrick, M. and Turton, A. (2008). *The Transcend-TB3 Project: A Methodology for the Trans-*

boundary Waters Opportunity Analysis (the TWO Analysis). Prepared for the Ministry of Foreign Affairs, Sweden.

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 Scarcity.* 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., Gerten, D., Bondeau, A., Lucht, W., Rohwer, J. and Schaphoff, S. (2008). Agricultural green and blue water consumption and its influence on the global water system. *Water Resources Research,* 44, W09405, doi:10.1029/2007WR006331.

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.

Stroh, K. (2003). Water: An advocate for reason. Win-win solutions for the Nile basin. *International Politics and Society*, 4, 1-14.

Tafesse, T. (2000). The hydropolitical perspective of the Nile question. Proceedings of the VIII Nile 2002 Conference, 26-29 June, Addis Ababa.

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.

White, R. (2000). World stock of reservoirs; reservoir sedimentation. Seminar presentation, HR Wallingford, England.

Whittington, D. and McClelland, E. (1992). Opportunities for regional and international cooperation in the Nile Basin. *Water International*, 17 (3), 144-154.

Whittington, D., Waterbury, J. and McClelland, E. (1995). Toward a new Nile water agreement. In: *Water Quantity/Quality Management and Conflict Resolution: Institutions, Processes, and Economic Analyses* (Dinar, A. and Loehman, E.T., Eds.), pp. 167-178. Praeger, Amsterdam.

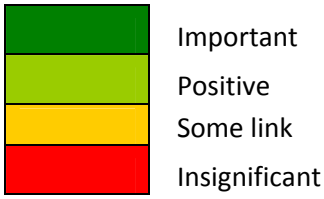
Zeitoun, M. (2008). *Power and Water in the Middle East: The Hidden Politics of the Palestinian-Israeli Water Conflict.* London: I.B. Taurus.

Zeitoun, M. and Warner, J. (2006). Hydro-hegemony: A framework for analysis of trans-boundary water conflicts. *Water Policy*, 8, 435-460.

Appendix 1. The preliminary TWO Analysis matrix for the Nile River basin.

The preliminary TWO Analysis matrix for the Nile River basin is shown on the following twelve pages. Four generic development categories were selected by the riparians for inclusion in the TWO Analysis, together with three generic forms of water resources. In all cases, the analysis was developed as a two-way interface between the water resources and the development opportunities, and the matrices show this by means of arrows denoting the direction of the interfaces involved.

The matrix as a whole is provided here as sequential colour-coded summary sheets; questions raised in the Analysis; and answers to the questions as raised. The colour coding used is shown below.



Economic Development – Colour-Coded Matrix

Category	Sub-category and Direction	New Water	Efficiency of Water Use	Virtual Water
Economic	Hydropower: Construction >			
Development	Hydropower: Construction <			
	Hydropower: Distribution →			
	Hydropower: Distribution ←			
	Agriculture →			
	Agriculture ←			
	Agricultural processing →			
	Agricultural processing ←			
	Livestock →			
	Livestock ←			
	Industry →			
	Industry ←			
	Navigation →			
	Navigation ←			
	Fisheries →			
	Fisheries ←			
	Tourism →			
	Tourism ←			
	Urban development →			
	Urban development ←			
	Transport Infrastructure →			
	Transport Infrastructure ←			
	Trade →			
	Trade ←			
	Technology transfer →			
	Technology transfer ←			
	Climate →			
	Climate ←			

Economic Development – Questions Matrix

Category	Sub-category and direction	New Water	Efficiency of Water Use (EWU)	Virtual Water
ECONOMIC DEVELOPMENT - QUESTIONS	Hydropower: Construction →	Can new H:C create New Water?	Can H:C affect the EWU?	Is there a coherent link between VW and this sub-category?
	Hydropower: Construction ←	Can New Water affect hydropower construction?	Can the EWU affect hydropower construction?	
	Hydropower: Distribution →	Can improved H:D create New Water?	Can H:D improve the EWU?	
	Hydropower: Distribution ←	Can New Water affect hydropower distribution?	Can the EWU affect hydropower distribution?	
	Agriculture →	Can altered agricultural practices create New Water?	Can altered agricultural practices improve the EWU?	
	Agriculture ←	Can New Water enhance agricultural returns?	Can the EWU be increased in agriculture?	
	Agricultural processing →	Can altered agricultural processing create New water?	Can agricultural processing affect the EWU?	
	Agricultural processing ←	Can New Water improve agricultural processing?	Can changes to the EWU improve agricultural processing?	
	Livestock →	Can changes to livestock production create New Water?	Can changes to livestock production improve the EWU?	
	Livestock ←	Can New Water improve livestock production?	Can changes to the EWU improve livestock production?	
	Industry →	Can changes to industrial practices create New Water?	Can changes to industrial practices improve the EWU?	
	Industry ←	Can New Water enhance industrial production?	Can changes to the EWU enhance industrial production?	
	Navigation →	Can navigation issues create New Water?	Can changes to navigation improve the EWU?	
	Navigation ←	Does New Water affect navigation?	Can changes to the EWU enhance navigation?	
	Fisheries →	Can changes to fisheries create New Water?	Can changes to fisheries improve the EWU?	
	Fisheries ←	Can New Water enhance fisheries production?	Can higher EWU enhance fisheries production?	
	Tourism →	Can changes to tourism create New Water?	Can changes to tourism improve the EWU?	
	Tourism ←	Can New Water enhance income from tourism?	Can the EWU be improved to enhance tourism?	
	Urban development →	Can changes to urban development create New Water?	Can changes to urban development improve the EWU?	
	Urban development ←	Can New Water enhance urban development?	Can higher EWU enhance urban development?	
	Transport Infrastructure →	Can changes to the transport infrastructure create New Water?	Can changes to the transport infrastructure improve the EWU?	
	Transport Infrastructure ←	Is New Water important for transport infrastructure development?	Is the EWU important in transport infrastructure development?	
	Trade →	Can changes to trade patterns create New Water?	Can changes to trade patterns improve the EWU?	
	Trade ←	Can New Water enhance profits from trade?	Can higher EWU improve profits from trade?	
	Technology transfer →	Is technology transfer important in generating New Water?	Is technology transfer important in improving the EWU?	
	Technology transfer ←	Is New Water relevant to technology transfer?	Is the EWU relevant to technology transfer?	
	Climate →	Can changes to climate create New Water?	Can climate change affect the EWU?	
	Climate ←	Can New Water affect the climate?	Can changes to the EWU affect the climate?	

Economic Development – Answers Matrix

Category	Sub-category and direction	New Water	Efficiency of Water Use	Virtual Water
ECONOMIC DEVELOPMENT - ANSWERS	Hydropower: Construction →	Not in isolation	Yes, due to Blue Water loss by evaporation from impounded dams	No
	Hydropower: Construction ←	Not in isolation	No	No
	Hydropower: Distribution →	Yes (e.g. pumping previously unused groundwater; desalination)	Yes, because some applications require pumping	No
	Hydropower: Distribution ←	Yes, as HP distribution is needed to areas where New Water can be created	Yes, as HP distribution is needed to areas where the EWU can be improved	No
	Agriculture →	Yes, by improving Blue Water flows downstream	Yes, by improving Blue Water flows downstream	Yes, because agricultural products include VW
	Agriculture ←	Yes, e.g. through wastewater re-use or use of freed-up Blue Water	Yes, e.g. through drip irrigation techniques	Yes, because agricultural products include VW
	Agricultural processing →	No	Not directly	Yes, because changes to food imports affect processing needs
	Agricultural processing ←	No	No	Yes, because changes to food imports affect processing needs
	Livestock →	No	Yes; decreases in livestock production improve the EWU	Yes, because livestock include large VW volumes
	Livestock ←	Yes, but this use is not generally desirable	Yes, but this use is not generally desirable	Yes, because livestock include large VW volumes
	Industry →	Not directly	Yes, by minimizing water use through recycling, although volumes are minor	Not significant
	Industry ←	Yes, and this use of New Water is of high added value	Yes; inter-sectoral reallocation from agriculture greatly enhances returns	Not significant
	Navigation →	No	No	No
	Navigation ←	Only tangentially by changing flow dynamics in the river	Only tangentially by changing flow dynamics in the river	No
	Fisheries →	No	No	Not significant
	Fisheries ←	Possibly, by changing flow dynamics in the river	Possibly, by changing flow dynamics in the river	Not significant
	Tourism →	No	Yes; tourism generates very high value returns from water	Not major
	Tourism ←	Yes, and this provides very high value returns from water	Yes, through reallocation of water from other lower-value uses	Not major
	Urban development →	No	A tangential link exists	No
	Urban development ←	A tangential link exists	A tangential link exists	No
	Transport Infrastructure →	No	A tangential link exists	Yes, because virtual water imports rely on transport infrastructure
	Transport Infrastructure ←	A tangential link exists	A tangential link exists	Yes, because virtual water imports rely on transport infrastructure
	Trade →	Yes, because of the link to Virtual Water	Yes, because of the link to Virtual Water	Yes
	Trade ←	Yes, because of the link to Virtual Water	Yes, because of the link to Virtual Water	Yes
	Technology transfer →	Yes, e.g. through wastewater re-use; desalination	Yes, e.g. through crop selection; drip irrigation; industrial applications	No
	Technology transfer ←	No	No	No
	Climate →	Yes, as volumes in the basin will change	Yes, because of the Green/Blue Water linkage	Yes, as trade will change in response to climate change
	Climate ←	Only tangentially and probably not in a major fashion	Only tangentially and probably not in a major fashion	Yes, as trade will change in response to climate change

Environmental Benefits – Colour-Coded Matrix

Category	Sub-category	New Water	Efficiency of Water Use	Virtual Water
Environmental				
	Wetland conservation →			
	Wetland conservation ←			
	Soil erosion →			
	Soil erosion ←			
	Water flow regulation →			
	Water flow regulation ←			
	Forestry →			
	Forestry ←			
	Water quality →			
	Water quality ←			
	Biodiversity →			
	Biodiversity ←			
	Watershed management →			
	Watershed management ←			
	Air quality →			
	Air quality ←			
	Climate →			
	Climate ←			

Environmental Benefits – Questions Matrix

Category	Sub-category and direction	New Water	Efficiency of Water Use (EWU)	Virtual Water
Environmental Questions	Wetland conservation →	Can changes in wetland conservation create New Water?	Can changes in wetland conservation enhance the EWU?	Is there a coherent link between VW and this sub-category?
	Wetland conservation ←	Is New Water important for wetland conservation?	Can changes in the EWU affect wetland conservation?	
	Soil erosion →	Can changes in soil erosion create New Water?	Can changes in soil erosion affect the EWU?	
	Soil erosion ←	Can New Water affect soil erosion rates?	Can the EWU affect soil erosion rates?	
	Water flow regulation →	Can water flow regulation create New Water?	Can water flow regulation affect the EWU?	
	Water flow regulation ←	Can New Water affect water flow regulation?	Can the EWU affect water flow regulation?	
	Forestry →	Does forest extent and cover affect New Water?	Does forest extent and cover affect the EWU?	
	Forestry ←	Can New Water affect forest extent and cover?	Can the EWU affect forest extent and cover?	
	Water quality →	Is the quality of New Water critical?	Are water quality concerns connected to the EWU?	
	Water quality ←	Can New Water affect water quality in the basin?	Can the EWU affect water quality in the basin?	
	Biodiversity →	Can changes in biodiversity create New Water?	Can changes in biodiversity affect the EWU?	
	Biodiversity ←	Is biodiversity affected by New Water?	Is biodiversity affected by the EWU?	
	Watershed management →	Can watershed management changes create New Water?	Can watershed management changes affect the EWU?	
	Watershed management ←	Is watershed management inflenced by New Water?	Does the EWU affect watershed management?	
	Air quality →	Can changes in air quality create New Water?	Can changes in air quality affect the EWU?	
	Air quality ←	Can New Water affect air quality?	Can the EWU affect air quality?	
	Climate →	Can climate change create New water?	Can climate change affect the EWU?	
	Climate ←	Can New Water affect climate change?	Can the EWU affect climate change?	

Environmental Benefits – Answers Matrix

Category	Sub-category and direction	New Water	Efficiency of Water Use (EWU)	Virtual Water
Environmental - Answers	Wetland conservation →	No	No	No
	Wetland conservation ←	Not significantly	Yes, as water must be reserved for wetland conservation	No
	Soil erosion →	No	Yes, as turbidity affects the economic returns from water	No
	Soil erosion ←	Tangentially, through changes in flow patterns	Tangentially, through changes in flow patterns	No
	Water flow regulation →	Yes, for example by ensuring Blue Water flows downstream	Yes, as the water balance in the basin changes	Changes to trade patterns could affect water flows
	Water flow regulation ←	Yes, as the water balance in the basin changes	Yes, as the water balance in the basin changes	Changes to trade patterns could affect water flows
	Forestry →	Yes, because of the Green/Blue Water interface	Yes, as the water balance in the basin changes	No
	Forestry ←	Only tangentially and not significantly	Yes, because of the Green/Blue Water interface	
	Water quality →	Water quality constraints exist, according to end use	Water quality constraints exist, according to end use	No
	Water quality ←	Only tangentially and not significantly	Yes, as upstream changes in the EWU affect downstream reaches	
	Biodiversity →	Yes, to the extent that the basin water balance changes (e.g. draining the Sudd)	Yes, to the extent that the basin water balance changes	No
	Biodiversity ←	Yes, to the extent that the basin water balance changes	Yes, to the extent that the basin water balance changes	
	Watershed management →	Yes, especially through the Green/Blue Water interface in upstream reaches	Yes, especially through the Green/Blue Water interface in upstream reaches	Changes to trade patterns could affect watershed management
	Watershed management ←	Yes, to the extent that the basin water balance changes	Yes, to the extent that the basin water balance changes	Changes to trade patterns could affect watershed management
	Air quality →	No	Yes, e.g. such changes affect agricultural yields	Yes, because greenhouse gases affect plant growth
	Air quality ←	Not substantively	Somewhat, as forest cover etc. affects carbon dioxide concentrations	Yes, because greenhouse gases affect plant growth
	Climate →	Yes; current evidence suggests parts of the basin will get wetter	Yes, as agricultural yields will be affected	Yes, as trade will change in response to climate change
	Climate ←	Yes, as a secondary effect of e.g. land cover	Yes, as a secondary effect of e.g. land cover	Yes, as trade will change in response to climate change

Political Benefits – Colour-Coded Matrix

Category	Sub-category	New Water	Efficiency of Water Use	Virtual Water
Political	Legal instruments/mechanisms →			
	Legal instruments/mechanisms ←			
	Political stability/cohesion →			
	Political stability/cohesion ←			
	Basin-wide institutions →			
	Basin-wide institutions ←			
	Rural water supply →			
	Rural water supply ←			

Political Benefits – Questions Matrix

Cat.	Sub-category and direction	New Water	Efficiency of Water Use (EWU)	Virtual Water
Political - Questions	Legal instruments/ mechanisms →	Can LI/M assist in creating New Water?	Can LI/M assist in enhancing the EWU?	Is there a coherent link between VW and this sub-category?
	LMI ←	Can New Water affect LI/M?	Can the EWU affect LI/M?	
	Political stability/cohesion →	Does political stability/cohesion help to create New Water?	Does political stability/cohesion help to improve the EUW?	
	Political stability/cohesion ←	Does New Water affect political stability/cohesion?	Does the EWU affect political stability/cohesion?	
	Basin-wide institutions →	Are basin-wide institutions needed to create New Water?	Are basin-wide institutions needed to optimise the EWU?	
	Basin-wide institutions ←	Does New Water affect the need for basin-wide institutions?	Does enhancing the EWU affect the need for basin-wide institutions?	
	Rural water supply →	Does improved RWS depend on New Water?	Does improved RWS depend on enhanced EWU?	
	Rural water supply ←	Is New Water relevant to a political objective to improve RWS?	Is the EWU relevant to a political objective to improve RWS?	
Social Capital- Questions	Technology transfer →	Is technology transfer important in generating New Water?	Is technology transfer important in improving the EWU?	Is there a coherent link between VW and this sub-category?
	Technology transfer ←	Is New Water relevant to technology transfer?	Is the EWU relevant to technology transfer?	
	Knowledge transfer →	Is knowledge transfer needed to enhance New Water volumes?	Is knowledge transfer needed to enhance the EWU?	
	Knowledge transfer ←	Does New Water influence knowledge transfer?	Does the EWU influence knowledge transfer?	
	Skill resources/mobility →	Are skill resources/mobility of relevance to New Water?	Are skill resources/mobility of relevance to the EWU?	
	Skill resources/mobility ←	Does New Water influence skill resources/mobility?	Does the EWU influence skill resources /mobility?	
	Education →	Is education relevant to the enhancement of New Water volumes?	Is education relevant to improvements in the EWU?	
	Education ←	Does New Water affect education?	Does the EWU affect education?	
	Indigenous knowledge →	Is indigenous knowledge relevant to New Water?	Is indigenous knowledge relevant to the EWU?	
	Indigenous knowledge ←	Is New Water relevant to indigenous knowledge?	Is the EWU relevant to indigenous knowledge?	
	Employment →	Can employment levels affect New Water?	Can employment levels affect the EWU?	
	Employment ←	Does New Water increase employment levels?	Do improvements in the EWU improve employment levels?	
	Health →	Can health affect the creation of New Water?	Can health affect the EWU?	
	Health ←	Would New Water improve general basin health levels?	Would improvements in the EWU improve basin health levels?	
	Language →	Are language barriers important in relation to New Water?	Are language barriers important in relation to the EWU?	
	Language ←	Does New Water affect language?	Does the EWU affect language?	

Political Benefits – Answers Matrix

Category	Sub-category and direction	New Water	Efficiency of Water Use (EWU)	Virtual Water
Political- Answers	Legal instruments/mechanisms →	Aligned basin-wide legislation would assist, but is not essential	Aligned basin-wide legislation would assist, but is not essential	No, although policy alignment would be preferred
	Legal instruments/mechanisms ←	Not particularly, although alignment would be preferred	Not particularly, although alignment would be preferred	No, although policy alignment would be preferred
	Political stability/cohesion →	It is not essential, but assists	It is not essential, but assists	A basin-wide approach to virtual water would be best
	Political stability/cohesion ←	To some degree, through 'spillover' from water cooperation to High Politics	To some degree, through 'spillover' from water cooperation to High Politics	A basin-wide approach to virtual water would be best
	Basin-wide institutions →	No, although they might assist in creating an aligned approach	No, although they might assist in creating an aligned approach	A basin-wide institution could assist in delineating a policy
	Basin-wide institutions ←	No, although they might assist in creating an aligned approach	No, although they might assist in creating an aligned approach	A basin-wide institution could assist in delineating a policy
	Rural water supply →	A tangential link exists	A tangential link exists	Yes, as shortages in RWS could be balanced by VW
	Rural water supply ←	A tangential link exists	A tangential link exists	Yes, as shortages in RWS could be balanced by VW

Social Capital Benefits – Colour-Coded Matrix

Category	Sub-category	New Water	Efficiency of Water Use	Virtual Water
Social Capital	Technology transfer →			
	Technology transfer ←			
	Knowledge transfer →			
	Knowledge transfer ←			
	Skill resources/mobility →			
	Skill resources/mobility ←			
	Education →			
	Education ←			
	Indigenous knowledge →			
	Indigenous knowledge ←			
	Employment →			
	Employment ←			
	Health →			
	Health ←			
	Language →			
	Language ←			

Social Capital Benefits – Questions Matrix

Cat.	Sub-category and direction	New Water	Efficiency of Water Use (EWU)	Virtual Water
Social Capital- Questions	Technology transfer →	Is technology transfer important in generating New Water?	Is technology transfer important in improving the EWU?	Is there a coherent link between VW and this sub-category?
	Technology transfer ←	Is New Water relevant to technology transfer?	Is the EWU relevant to technology transfer?	
	Knowledge transfer →	Is knowledge transfer needed to enhance New Water volumes?	Is knowledge transfer needed to enhance the EWU?	
	Knowledge transfer ←	Does New Water influence knowledge transfer?	Does the EWU influence knowledge transfer?	
	Skill resources/mobility →	Are skill resources/mobility of relevance to New Water?	Are skill resources/mobility of relevance to the EWU?	
	Skill resources/mobility ←	Does New Water influence skill resources/mobility?	Does the EWU influence skill resources /mobility?	
	Education →	Is education relevant to the enhancement of New Water volumes?	Is education relevant to improvements in the EWU?	
	Education ←	Does New Water affect education?	Does the EWU affect education?	
	Indigenous knowledge →	Is indigenous knowledge relevant to New Water?	Is indigenous knowledge relevant to the EWU?	
	Indigenous knowledge ←	Is New Water relevant to indigenous knowledge?	Is the EWU relevant to indigenous knowledge?	
	Employment →	Can employment levels affect New Water?	Can employment levels affect the EWU?	
	Employment ←	Does New Water increase employment levels?	Do improvements in the EWU improve employment levels?	
	Health →	Can health affect the creation of New Water?	Can health affect the EWU?	
	Health ←	Would New Water improve general basin health levels?	Would improvements in the EWU improve basin health levels?	
	Language →	Are language barriers important in relation to New Water?	Are language barriers important in relation to the EWU?	
	Language ←	Does New Water affect language?	Does the EWU affect language?	

Social Capital Benefits – Answers Matrix

Category	Sub-category and direction	New Water	Efficiency of Water Use (EWU)	Virtual Water
Social Capital- Answers	Technology transfer →	Yes, e.g. through wastewater re-use; desalination	Yes, e.g. through crop selection; drip irrigation; industrial applications	No
	Technology transfer ←	No	No	No
	Knowledge transfer →	Yes, for various forms of New Water	Yes, e.g. in crop selection	Yes, as higher in-basin production reduces VW imports
	Knowledge transfer ←	No	No	Yes, as higher in-basin production reduces VW imports
	Skill resources/mobility →	Yes, for various forms of New Water	Yes, e.g. in crop selection	No
	Skill resources/mobility ←	Only marginally	Only marginally	No
	Education →	Yes, for various forms of New Water	Yes, e.g. in crop selection	Yes, as a consensual basin-wide strategy is needed
	Education ←	Only marginally	Only marginally	Yes, as a consensual basin-wide strategy is needed
	Indigenous knowledge →	No	Only in a few instances	No
	Indigenous knowledge ←	No	No	No
	Employment →	No	No	Not significantly
	Employment ←	Only slightly	Only slightly	Not significantly
	Health →	No	No	Yes, through nutrition in imported foods
	Health ←	Yes, by improving nutrition	Yes, by improving nutrition	Yes, through nutrition in imported foods
	Language →	Only slightly	Only slightly	No
	Language ←	No	No	No