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Interbasin water transfers and water scarcity in a changing world - a solution or a pipedream?

- A discussion paper for a burning issue -

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Content

Summary

The world is increasingly forced to face the challenge of how to ensure access to adequate water resources for expanding populations and economies, whilst maintaining healthy freshwater ecosystems and the vital services they provide. Now the growing impacts of climate change are exacerbating the problem of water scarcity in key regions of the world. One popular way for governments to distribute water more evenly across the landscape is to transfer it from areas with perceived surpluses, to those with shortages.

While there is a long history of water transfers from ancient times, as many societies reach the limits of locally renewable water supplies increasingly large quantities of water are being moved over long distances, from one river basin to another. Since the beginning of dam building that marked the last half of the 1900s more that 364 large-scale interbasin water transfer schemes (IBTs) have been established that transfer around 400 km³ of water per year (Shiklomanov 1999). IBTs are now widely touted as the quick fix solution to meeting escalating water demands. One estimate suggests that the total number of large-scale water transfer schemes may rise to between 760 and 1 240 by 2020 to transfer up to 800 km³ of water per year (Shiklomanov 1999).

The wide range of IBT projects in place, or proposed, has provoked the preparation of this review, including seven case studies from around the globe. It builds on previous assessments and examines the costs and benefits of large scale IBTs. This report assesses related, emerging issues in sustaining water resources and ecosystems, namely the virtual water trade, expanding use of desalination, and climate change adaptation. It is based on WWF's 2007 publication „Pipedreams? Interbasin water transfers and water shortages“.

The report concludes that while IBTs can potentially solve water supply issues in regions of water shortage – they come with significant costs. Large scale IBTs are typically very high cost, and thus economically risky, and they usually also come with significant social and environmental costs; usually for both the river basin providing and the river basin receiving the water.

From an environmental perspective, IBTs in general interrupt the connectivity of river systems and therefore disrupt fish spawning and migration. They alter natural flow regimes, sometimes with great ecological cost to threatened aquatic species or protected areas, they alter river morphology, and they contribute to salinization, and can also enable the transfer of invasive alien species between river basins. IBTs may facilitate unwise and unsustainable urban and irrigation developments.

What stands out among the IBT case studies outlined in this report (and elsewhere) is the following:

1. Apart from hydropower generation, a common driver of IBTs is a desire to promote irrigated agricultural production in water poor areas. This can see unsustainable and subsidized cropping practices promoted by the IBT;
2. There is typically a failure to examine alternatives to the IBT that may mean delaying, deferring or avoiding the costs (in every sense) of an IBT or examining options of transferring virtual water rather than real water; and
3. There are a range of governance failures ranging from poor to non-existent consultation with affected people, to failing to give sufficient consideration to the environmental, social and cultural impacts of the IBT, in both the donor and recipient basins.

The history of IBTs to date should be sufficient to sound very loud alarm bells for any government contemplating such a development. Despite the lessons from past IBT experiences, many decision makers today continue to see IBTs as a technical solution to restore perceived imbalances in water distribution.

The development of IBTs usually disturbs the finely tuned water balance in both the donating and the receiving river basin. Regularly overlooked in IBT development are the short, medium and longer term impacts of moving water from one community (the donor basin) and providing it to another (the recipient basin).

As noted above, weak governance is also symptomatic of IBT development, with poor to non-existent consultation with affected people commonly being witnessed and a lack of consideration at an appropriate management scale. This failure to look at the impacts of the proposed IBT within a river basin management framework considerably elevates the risks of 'collateral damage' from the IBT. Now, the advent of ongoing, climate-induced changes in hydrology

makes investments in inflexible water infrastructure increasingly risky. Through employing the management model of Integrated River Basin Management governments and civil society will be much better placed to make well informed decisions in relation to IBTs.

WWF recognises that while local IBTs may, under certain circumstances, fulfil an important role (for example in supplying drinking water to population centres) the benefits of many large scale transfer schemes on the drawing board are doubtful. WWF believes that any new interbasin water transfer scheme should be approached in accordance with the principles of sustainability set out by the World Commission on Dams (2000) and most recently addressed by the revised Sustainability Assessment Protocol (HSAF[1] 2009, in preparation). First and foremost this means that any scheme under consideration should be subject to a comprehensive 'needs and options assessment'; detailed cost-benefit and risk analyses that consider the full suite of potential environmental, social and economic risks and impacts.

As advocated in section 6 of this report in examining the alternatives to an IBT, WWF recommends the following step-wise needs assessment, ideally considered at a whole-of-river-basin level, through an integrated planning process. The alternatives should be considered in the following order:

A. Demand Management

1. Reducing water demands;
2. Recycling waste water;
3. Assessing and promoting land use management or industrial development alternatives.

B. Supply Management

4. Trading in virtual water, and only then,
5. Supplementing water supplies locally, and only then,
6. Desalination in water-scarce coastal areas, and only then,
7. Considering an IBT, as a last option.

Through the vehicle of this report, WWF calls on all decision makers to follow the steps outlined above when considering how to meet water needs in areas of scarcity. There is a need to recognise that interbasin water transfer are in most cases a "pipe dream" and that the taking of water from one river to another usually reflects ignorance of the social and environmental costs and a failure to adequately consider better, local alternatives, such a improved management of local demand.

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[1] The Hydropower Sustainability Assessment Forum (HSAF) currently revises the International Hydropower Association's (IHA) Sustainability Assessment Protocol. The HSAF is a collaboration of representatives from different sectors to develop a broadly endorsed sustainability assessment tool to measure and guide performance in the hydropower sector. This Protocol is applicable not only to hydropower schemes, but to water infrastructure projects and plans in general. It will be released in 2009. Further Information: http://www.hydropower.org/sustainable_hydropower/HSAF.html

1 Introduction

As the world faces increasing insecurity about its water supplies – with both droughts and floods on the increase - the world water crisis‘ effects are more and more frequently in the news. Climate change is now beginning to exacerbate water resources vulnerability. The planet urgently needs to face the dilemma of how to secure access to adequate water resources for expanding populations and economies, whilst maintaining healthy freshwater ecosystems and the vital services they provide (WWAP 2009), and in the context of climate change when the nature of water flows can no longer be regarded as stationary (Milly *et al*. 2008).

To those who see the worlds' water balance as a score sheet of shortages and surpluses, one of the obvious solutions to meeting water demands is the transfer of water from areas with perceived surpluses, to those with shortages. While these so named 'interbasin water transfers' (IBTs) can potentially solve water supply issues in regions of water shortage – they come with significant costs.

Large scale IBT schemes are typically very high cost, and thus economically risky, and they usually also come with significant social and environmental costs; usually for both the river basin providing and the river basin receiving the water. Climate-induced changes to hydrology now make these schemes more technically and economically risky.

The wide range of IBT projects in place, or proposed, provoked the preparation of our first review in 2007, that is updated here to consider emerging issues and technologies in the debate on sustaining water resources and ecosystems in the face of climate change. We have looked to many previous assessments, ranging from those that looked upon transfer schemes only as an opportunity (Tecklaff 1967) to reviews that expressed increasing doubt and called for caution (Golubev and Biswas 1979; Biswas *et al*. 1983; USCID 2001; Ghassemi and White 2007), and proposed criteria to assess the merits of proposed projects (Cox 1999; WCD 2000; Gupta and van der Zaag 2008). It examines the costs and benefits of large scale IBTs as a solution to water supply problems in the future, as well as analysing the lessons learnt from some existing schemes.

The report also considers some proposed IBT schemes that have been under consideration for a number of years and that are today in various stages of development. These schemes are examined to establish if they are the best solution for addressing the problems they seek to solve. For each, the economic and environmental risks are identified and alternatives to the construction of the IBT are considered.

The application of the trade in virtual water and also desalination as alternatives to IBTs is assessed. Further, we detail the implications of climate change for water management, and consider the role of water infrastructure in societal responses. This review concludes by setting out (in section 6) a decision-making hierarchy or step-wise process by which any proposed IBTs can be reviewed to determine if they are truly needed, and to ensure that all other feasible alternatives have been considered before moving to the high risk strategy of constructing and operating an IBT scheme.

2 Interbasin water transfers – the context

2.1 The escalating demands for water

Since the launch of the first United Nations World Water Development Report (WWDR) 'Water for People, Water for Life' in 2003 the term 'world water crisis' has frequently made headlines. The report states "*We are in the midst of a water crisis that has many faces. Whether concerning issues of health or sanitation, environment or cities, food, industry or energy production, the twenty-first century is the century in which the overriding problem is one of water quality and management.*" (WWAP 2003).

Freshwater is vital to human survival and in general people have settled in areas with sustainable local water supplies. More than half the world's assessable supplies of water are already diverted for human use (WWAP 2003). Growing populations, increasing urbanisation and intensive agriculture result in over-exploitation of water resources and in many places human water use, domestic, industrial and agricultural, exceeds average annual water supplies. The WWDR notes that "Competition for water exists at all levels and is forecast to increase with demands for water in almost all countries. In 2030, 47% of world population will be living in areas of high water stress" WWAP 2009:150).

Areas of high water overuse tend to occur in regions that are strongly dependent on irrigated agriculture, such as the Indo-Gangetic Plain in South Asia, the North China Plain and the High Plains in North America.

Seventy percent of global freshwater withdrawals are used for agriculture. Irrigation areas have doubled over the last fifty years and are likely to continue increasing (IWMI 2007). Even though agricultural productivity has increased over time („more crop per drop") its development presents a major threat of over-abstraction in many regions and is a major driver for planning and constructing IBTs.

The growing urban concentration of water demand adds a highly localized dimension to these broader geographic trends. Where water use exceeds local supplies, society is often dependent on infrastructure, such as pipelines and canals, to transport water over long distances. In conjunction with this, there is increasing reliance on groundwater extraction.

The consequences of water overuse include:

- (i) diminished river flows;
- (ii) depletion of groundwater reserves triggering wider socio-economic impacts beyond hydrological ones;
- (iii) reduction of environmental flows needed to sustain aquatic ecosystems and the associated services needed by people;
- (iv) diminution and loss of livelihoods for the poorest in many societies;
- (v) societal conflict (e.g. Joy et al. 2007).

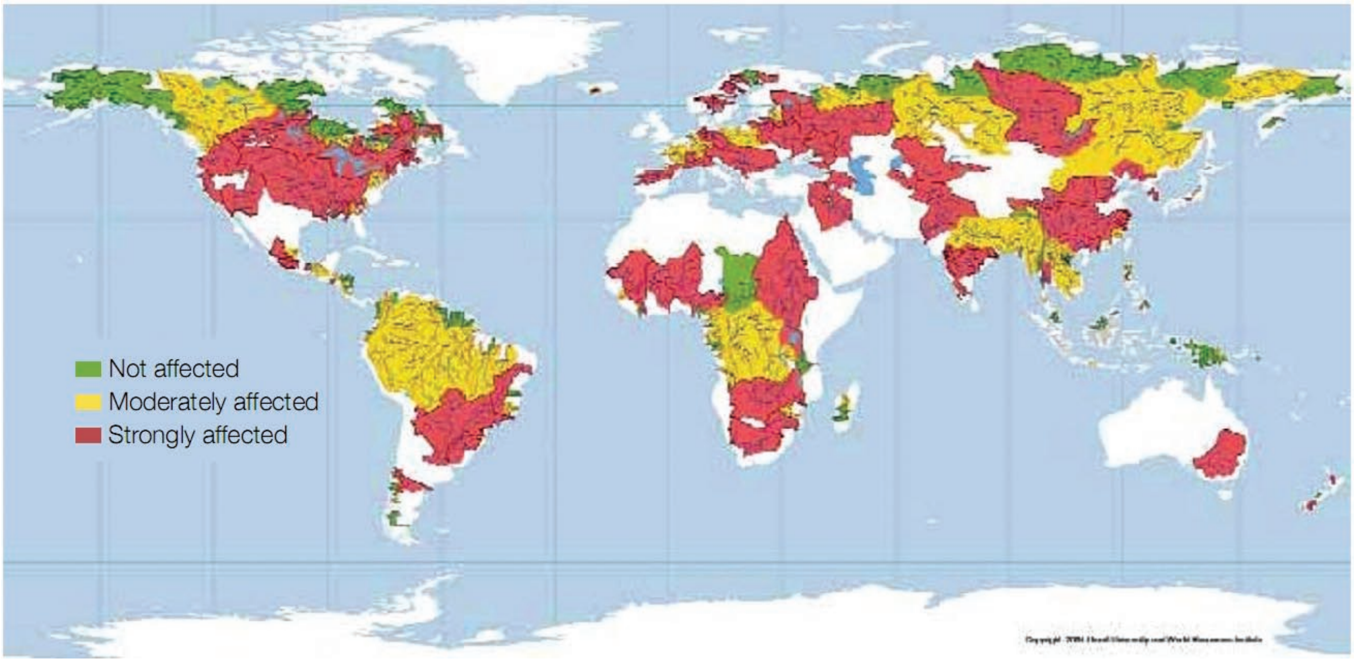
2.2 Impacts on freshwater ecosystems

The measures taken to secure adequate water supplies for human populations inevitably affect freshwater ecosystems. According to the WWF *Living Planet Index* (WWF, 2006a), populations of freshwater species showed a decline of over 30 per cent from 1970 to 2003. This decline in freshwater species is attributed to factors such as (MEA 2005):

- (i) infrastructure development (like dams, inter and intra basin water transfers, canalization, flood-control, river diversions and large-scale irrigation);
- (ii) deforestation;
- (iii) over harvesting;
- (iv) alien invasive species;
- (v) unsustainable agriculture practices (cultivating 'thirsty crops'); and,
- (vi) urban and industrial pollution.

These drivers change the characteristic of river basins and their ecosystems in many ways. For example, dams interrupt the connectivity of river systems and therefore disrupt fish spawning and migration. Water transfers alter natural flow regimes and fluvial morphology, they reduce downstream water availability for agriculture and they contribute to salinization and water table lowering in coastal areas. They can also facilitate the transfer of invasive alien species within or between river basins.

The Millennium Ecosystem Assessment (MEA 2005) states that "dams and other infrastructure fragment 60 per cent of the large river systems in the world". WWF estimates that of the world's 177 large rivers (over 1 000 km long) only 21 remain free flowing from source to sea (WWF, 2006b). Interbasin transfer



Map 1: Fragmentation and flow regulation by Large River System (LRS), (Nilsson *et al*, 2005)

Note: This figure presents the results of the river fragmentation and flow regulation assessment by Nilsson *et al*., (2005). Of 292 of the world's Large River Systems (LRS), 173 are either strongly or moderately affected by dams; while 119 are considered unaffected. In terms of areas, strongly affected systems constitute the majority (52 per cent or about 4 367 km^2) of total LRS catchment areas. The grey colour represents potential LRSs in Indonesia and Malaysia that were not assessed due to lack of data.

schemes have long been recognised as a major threat to river basin integrity and conservation due to (Davies *et al*. 1992), with impacts that include:

- loss of endemic biotas;
- introduction of invasive species;
- genetic intermixing of previously isolated populations;
- water quality degradation;
- drastic alteration of hydrological regimes;
- impacts on estuarine and marine processes;
- reduction in fisheries; and
- spread of disease vectors.

Some of these impacts are assessed further in the case studies in this report.

2.3 Water Footprint and interbasin water transfers

Water footprinting is a key technique that can be used to assess peoples' reliance on distant water resources which are distributed both spatially and temporally. It is a measure of the impact on water resources as a result of our activities. In this report we elaborate on the application of water footprinting as a tool in the context of available alternatives to IBTs. This is a new addition as the concept is recently been developed since previous global assessments of IBTs have been undertaken, and it offers a new approach to managing water scarcity.

Water footprint is measured as the volume of water used in producing goods and services to support our consumption. A detailed water footprint analysis would reveal the complete supply chain of the goods and services and quantifies different kinds of water used e.g. surface or ground water (blue water), effective use of rain (green water) and pollution impact on water resources (grey water) at different temporal and spatial scale. The water footprint shows human appropriation of the world‘s limited freshwater resources and thus provides a basis for assessing the impacts of goods and services on freshwater systems and formulating strategies to reduce those impacts (Hoekstra and Chapagain 2008).

The foundation of water footprint is the concept of virtual water, a term coined by Professor Tony Allan in early 1990s (Allan 1993; 1998) who recognised that importing wheat to the Middle East would be a way to relieve the pressure on scarcely available domestic water resources. The virtual water content of a product is defined as the volume of water required to produce a commodity. When there is a transfer of products or services from one place to another, there is little direct physical transfer of water (except the real water content in the product which is quite insignificant in terms of quantity). There is often, however a significant transfer of virtual water.

The traditional assessment of water demand in a region or a country is expressed as the sum of water withdrawals for different sectors in that region. This is merely a pseudo reflection of the real water demand of the region as the number is influenced by trade of water intensive products. For example, Jordan imports a significant proportion of agricultural products rather than producing domestically using its already scarce water resources. In this case, Jordan is withdrawing less water from within its territory, thus lowering its water demands from traditional point of view. However, the total volume of water used to produce goods and services consumed may not change significantly. In other words, Jordan has, thus, externalised part of its water footprint to the regions from where it imports. Instead of importing water in virtual form, it could have chosen to be self sufficient either by opting for desalination or real water transfers from nearby areas if feasible. This mechanism of re-locating the water footprint of a region to other areas is very relevant in analysing the alternatives to IBT projects.

3 What can we learn from existing interbasin water transfer schemes?

Interbasin water transfer schemes are not a new phenomenon (Shiklomanov 1999). Like the outbreak of dam building that marked the last half of the 1900s, interbasin water transfer are touted as the quick fix solution to meeting escalating demands for water, to stoke the fires of economic development, and to feed rapidly growing human populations. Globally, more that 364 large-scale water transfer schemes have been established that transfer around 400 km³ of water per year and one estimate suggests that the total number of large-scale water transfer schemes may rise to between 760 and 1 240 by 2020 to transfer up to 800 km³ of water per year (Shiklomanov 1999).

Examining the impacts of existing IBTs is quite instructive. It provides significant lessons we should learn as the pace with which new schemes are being formulated and brought forward for consideration quickens.

Interbasin transfers - planned, completed or being conceived - number in the hundreds. No river basin is immune it seems from the easy attraction of becoming a donor or recipient basin. Transfer schemes run the gamut: Japan's Totsukawa to Kinokawa River, Chile's Teno-Chimbarango Canal, France's Durance River project, Morocco's Beri Boussa project and on and on.

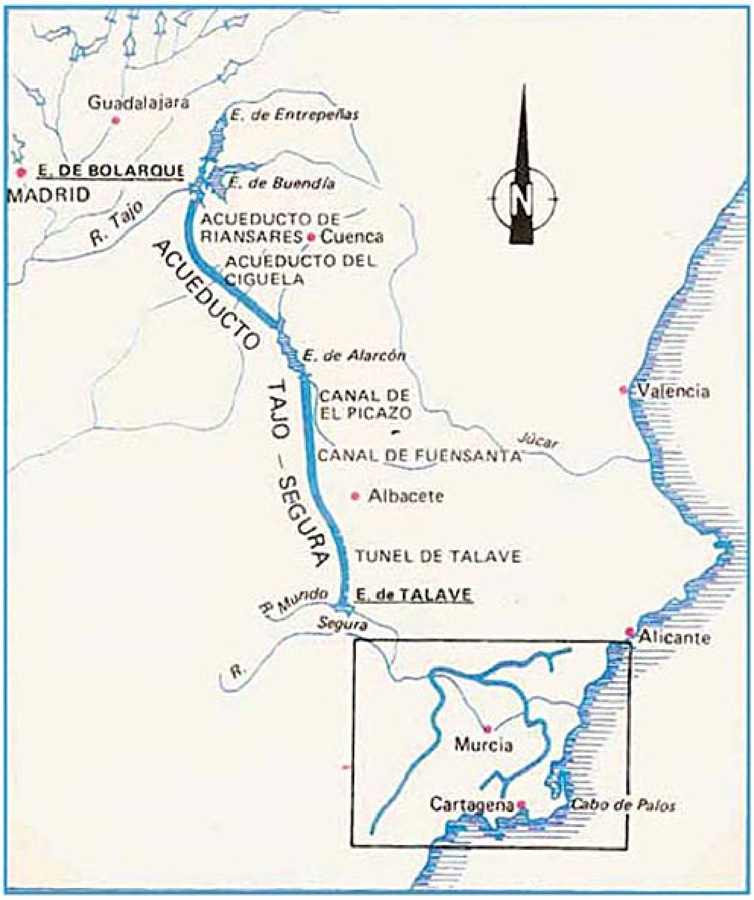
The diversion of the Aral Sea tributaries with a disastrous outcome is one of the best known schemes for all the wrong reasons: salinity, water and fish decline and health problems. Big or small, transfer schemes are often expensive, elaborate, and unsustainable ways that complicate, not solve, water problems. The following pages describe three cases of existing IBTs followed by four cases in the works.

Case study 1: Tagus-Segura Transfer - Spain

About this IBT ?

The Tagus-Segura IBT in Spain is a 286 km long pipeline connecting four different Spanish river basins; the Tagus, Júcar, Segura and Guadiana. It was approved before democratic government with no public discussion of the benefits and impacts of the proposal, and has been operative since 1978.

Its main objective was to solve an estimated water deficit of 0.5 km³/yr in the recipient area of Alicante, Murcia and Almeria provinces, to ensure water supply for 147 000 hectares of irrigation and 76 municipalities in south-east Spain. The pipeline starts at the Entrepenas and Buendia dams in the Upper Tagus, with a storage capacity of approximately 2.4 km³, and facilitates a transfer of 1 km³/yr towards the Talave Dam in the Segura River basin.



Map 2: Schematic representation of the Tagus-Segura IBT
Source: Website of the Segura Basin Management Agency (www.chsegura.es)

The legal approval for the scheme requires that only surplus waters from the Targus River may be transferred (Law 21/1971). Project designers based their calculations in an abnormally humid hydrological period and estimated that 1.4 km^3/yr of water would be available. However, climate and land use changes in the upper Tagus basin have resulted in a reduction of 47% in average streamflow over the past 40 years (Estevan *et al*. 2007). In the initial phase, a maximum transfer of only 0.6 km^3/yr was approved and infrastructures were built to this capacity. Further infrastructure development in the upper Tagus was proposed for an additional 0.4 km^3/yr however actual average streamflows of 0.76 km^3/yr have made the second phase of the project unviable. The actual transfers are variable and are usually only around 0.2-0.4 km^3 per year. On only one occasion (1999-2000 hydrologic year) has the maximum amount of 0.6 km^3 been reached. Transfer volumes are authorized by the Tagus-Segura Transfer Central Management Commission, in response to requests from users. When water storage in the Tagus dams falls below 0.24 km^3, transfers must be approved by the national government through the Council of Ministers.

A total of 9.8 km^3 of water has been transferred in the 30 years the IBT has been operative. Of this, 5.9 km^3 (60%) has been used to complement supply almost 200 000 ha of irrigated agriculture in the Murcia and Alicante provinces; 3.7 km^3 (38%) to complement drinking water supply for over two million people in Murcia, Alicante and Almería; and about 0.2 km^3 has been used to transfer water to the Tablas de Damiel National Park, a wetland ecosystem in the Guadiana River basin.

In addition to the planned water transfers, irrigators in the Segura basin have taken advantage of a 2001 modification of Spanish water law that allows for purchase of water rights. Starting in 2005 they have bought water from irrigators in Aranjuez and Estremera in the Tagus River basin and delivered it via the Tagus-Segura infrastructure. While these transfers have been approved an evaluation of the environmental impacts on the Tagus basin was not incorporated.

In 2008 construction started on a new infrastructure that will take water from the main Tagus-Segura channel to the Mancha plains in the Castilla-La Mancha autonomous region in south-central Spain. The goal is to transfer an additional 0.05 km^3/yr to secure urban water supplies for 58 municipalities. The estimated total cost of the infrastructure is € 270.5 million, largely from EU funds.

Analysis:

The design of the Tagus-Segura IBT was based on a significant overestimation of available water from the donor basin and consequently the scheme has had serious social, economic and environmental consequences in both the donor and the recipient basins.

From an economic standpoint, the Tagus-Segura IBT set a precedent in Spain where beneficiaries were supposed to pay for the infrastructure and operational costs of the transferred waters. Further, part of the income generated from water use fees was to be transferred to donor regions in compensation (Law 52/1980). The user fees have fixed and variable cost components. However, since only the first phase of the project was built the fixed portion of the fee only covers 60% of total construction costs. Additionally, fixed costs are in proportion to the maximum volume that can be transferred (0.6 km^3/yr) and users pay only the portion that they actually receive, which is usually significantly lower. Water losses en route, estimated at about 15%, are subsidized by the state and not paid for by the users. Finally, in times of drought the water users have been repeatedly exempt from payment of fees in order to compensate them for potential economic losses. As a result users have paid for less than 30% of total costs and donor regions have consequently received lower compensations.

In the recipient basin, rather than solving a water shortage, the extensive water infrastructure has become a driver for unsustainable use of water, fostering uncontrolled increases in irrigated areas and urban development on the coast. According to Martínez and Esteve (2002), the original plan was for this IBT to guarantee supply to 90 000 ha existing irrigated agriculture, and convert an additional 50 000 ha to irrigation. However, the expectation of large volumes of transferred water has fostered uncontrolled expansion of irrigation and newly irrigated area has grown to nearly 88 000 ha, despite annual flows from the IBT being around one-third of those projected.

Moreover, the construction of the IBT has fostered a proliferation of illegal boreholes, to manage the fluctuating water supplies from the IBT, contributing to overexploitation of the aquifers. As a result, the IBT has multiplied the initial 'water deficit' that it was supposed to solve and has created a strong dependence of the economy in the recipient region on the IBT.

From an environmental standpoint, although the IBT was based on a supposed water surplus, the Tagus basin has been substantially impacted. Legal minimum stream flow requirements have not been met. The management rules have not been modified in the 30 years the scheme has been operational to reflect current hydrological conditions. As a result, the Entrepeñas and Buendía reservoirs are managed to maximize transfers to the Segura basin and not to provide stream flows or meet other demands in the Tagus basin.

Over the past 30 years up to 70% of the Tagus headwater flows have been transferred to the Segura basin. The reduced stream flows have degraded the ecological status, and affected riparian vegetation along the Tagus River. Lower stream flows have aggravated water quality problems in diminishing the dilution of insufficiently treated effluents from urban centers, particularly from greater Madrid (6 million inhabitants). Further, the lack of access to Tagus headwaters has increased pressure on western Tagus River tributaries, particularly to supply water to Madrid's growing population and economy.

Photo 1: The Tagus in Talavera de la Reina (0 m^3/s) in July 2006, while over 20 m^3/s were being transferred to the Segura basin

The new Tagus River basin management plan currently being developed must balance diminished resources, the impacts of climate change, the need to establish and guarantee an ecologically-sound stream flow regime, as well as meeting priority demands in the Tagus River basin. The pressure of the Tagus-Segura IBT on the Tagus River makes it difficult to achieve good ecological status as required by 2015 by the European Union's Water Framework Directive. In this context, it is questionable whether the plan will be able to justify existence of surplus waters to transfer.

In the recipient basins, the increase in illegal irrigation in expectation of new water supplies has resulted in the occupation and destruction for agriculture of areas of high ecological value. The expansion of irrigated agriculture has created significant eutrophication problems in the Mar Menor Lagoon Ramsar site. The scheme also impacts endemic fish species in the Segura River. For instance, the transfer of species between the basins is threatening through hybridisation the minnow (*Chondrostoma arrigonis*), which is endemic in the Júcar River and listed as a critically endangered species (IUCN Red List 2006).

From a social standpoint, the IBT has become a major catalyst for conflicts between the donor and recipient regions. Improved demand management in the recipient area through the closing down of illegal wells, preventing the creation of new irrigated areas and promoting more sustainable urban land use, would help to reduce these tensions. In a region where 80% of water is used for irrigation the focus should remain on the agricultural sector.

In 2004 the Ministry of the Environment launched an ambitious plan to diversify the sources of water in the Mediterranean regions through increased wastewater treatment and reuse, improved water efficiency in irrigation and urban areas, and the development of desalination plants to increase supply. The A.G.U.A. program, anticipates that in 2015 desalination will provide up to 0.4 km^3/yr in the Segura River basin, which would be sufficient to meet urban water demand in the region. In spite of these initiatives, the draft documents for the Segura basin management plan continue to emphasize transfer and purchase of water.

The reality of diminished river flows in the upper Tagus and the increasing demands for environmental flows are resulting in significant pressure from regional governments and interest groups in recipient regions to maintain the existing scheme and consider a new Tagus-Segura ITB. The new scheme would transfer water from the Medium Tagus in Valdecañas (Extremadura), near Portugal, but the economic, social and environmental viability of this new project is yet to be proven. Authorities in the Murcia region have regularly organized public demonstrations where hundreds of thousands of citizens are called to the streets to defend what they perceive to be their right to Tagus waters (Estevan *et al*. 2007; Fernandez and Selma 2002; Perez 2008).

At the same time, a citizen movement (www.redtajo.es) formed from 2007 in the Tagus basin in Spain and Portugal that advocates more sustainable and rational management of the Tagus River and its tributaries. The drying up of the river in Talavera de la Reina and other major urban centers in the summer of 2006 while over

Photo 2: Public demonstration in defense of the Tagus River in Talavera de la Reina

20 m³/s was being transferred to the Segura basin, the loss of traditional swimming river beaches in Toledo, Aranjuez and Talavera, and the poor water quality along the river were major catalysts for this movement. In June 2009 50 000 people gathered in Talavera de la Reina from all over the Tagus basin to defend their right to clean water and healthy

Summary:

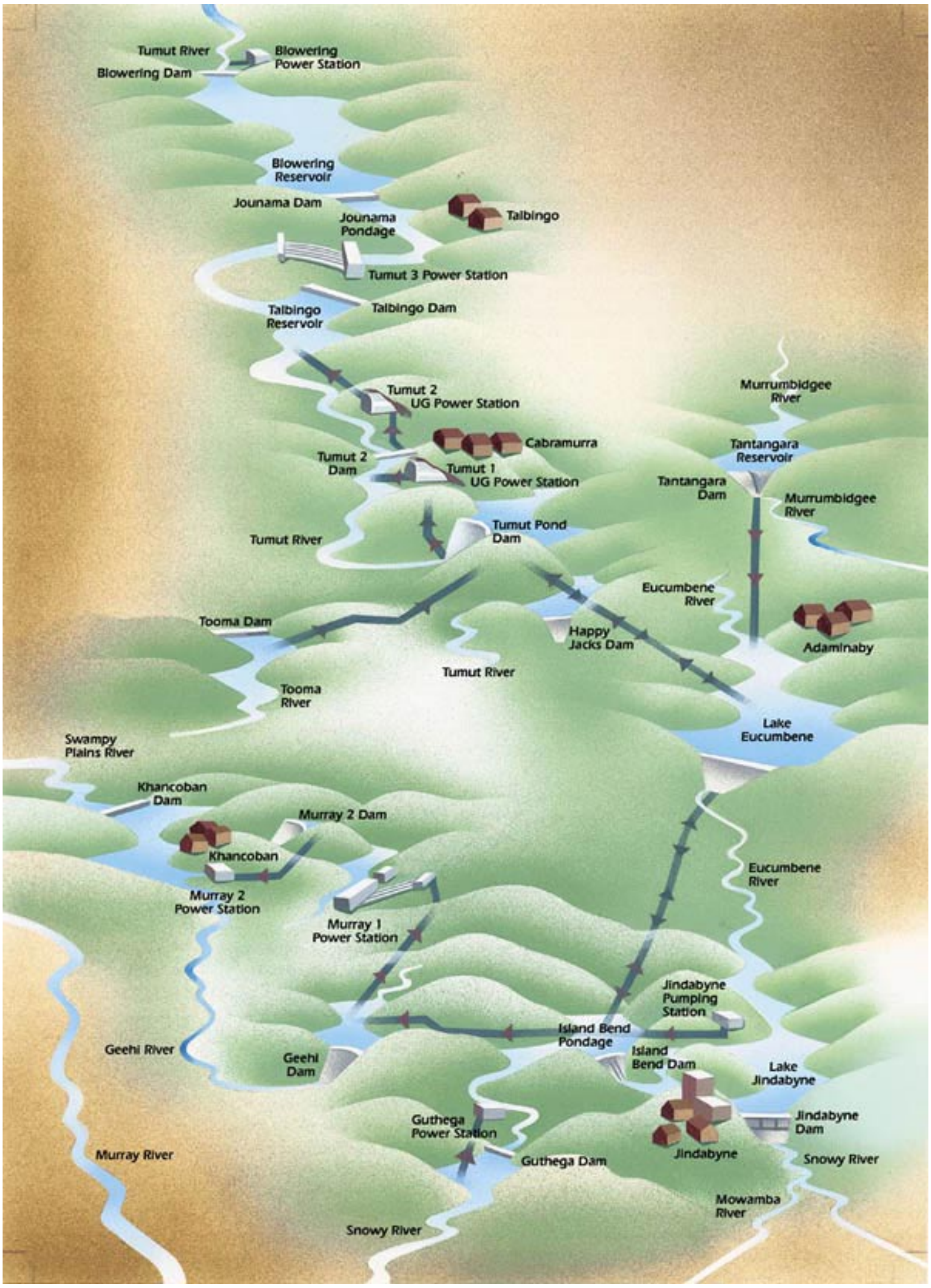
Where	**Tagus – Segura Transfer, Spain**
When	1978 completed
Receiving basin	Segura, Jucar and Guadiana basins
Donating basin	Tagus (upstream)
Distance	286 km main pipe
Volume diverted	0.6 km³/yr
Structures	5 dams, 286 km pipe, network of post-transfer distribution
Cost	Not known
Purposes	Irrigation Urban water supply
Environmental cost/benefits	Reduction in stream flow in donor basin Increased threat level for critically endangered fish species
Social costs/ benefits	Social conflicts Increase of water consumption Increase in agricultural production in the receiving basins
Alternatives?	Close down illegal wells and irrigation Promote sustainable urban land use Increase use of desalinated water Restrict new irrigation development Recycle wastewater
Lessons learnt	Increasing water availability from an IBT can become a driver for unsustainable water use in the receiving area IBTs should be accompanied by strict measures to curb water demand in the receiving area

Case study 2:
Snowy River Scheme - Australia

About this IBT:

The Great Dividing Range in south-eastern Australia is an important source of water, including for the Snowy River, which drains to the south-east. The prospect of damming the Snowy River, and diverting its waters to the western side of the Great Divide into the River Murray basin for the dual purpose of hydropower and irrigation, dates back to 1884.

The scheme was eventually constructed by the national and two state governments (Victoria and New South Wales) at a cost of AUD $ 820 million (US$ 630 million) between 1949 and 1974 and comprises 16 large dams, seven hydropower stations, over 145 km of tunnels and about 80 km of aqueducts, mostly located in Kosciuszko National Park (Wright 1999; Ghassemi and White 2007; Snowy Hydro 2007). The scheme has a total water storage capacity of 7 km^3 and electricity generating capacity of 3 756 MW, 16% of the total capacity in south-east Australia.



Map 3:
The Snowy Mountains Hydro-electric Scheme is an integrated water and hydro-electric power scheme. It collects and stores the water that would normally flow east to the coast and diverts it through trans-mountain tunnels and power stations. The water is then released into the Murray and Murrumbidgee Rivers for irrigation.
Sixteen major dams, seven power stations (two underground), a pumping station, 145 kms of inter-connected trans-mountain tunnels and 80 kms of aqueducts were constructed.

Source: http://www.snowyhydro.com.au/kids_pop.asp

Analysis:
The scheme has yielded substantial economic benefits, as apart from hydropower, in a year with average rainfall it diverts 1.1 km^3/yr of water into the Murray-Darling Basin for irrigation; resulting in an estimated US$ 115 - 145 million per year of value added.

The scheme has also facilitated access for recreation and tourism attractions (3 million visitors per year) by roads servicing the scheme (estimated at about US$ 118 million a year), as well as associated employment opportunities.

However, the environmental impacts on the Snowy River have been severe. It's flow was reduced to 1% of natural; this resulting in a loss of floodplain wetland habitats; silting up of the river channel and invasion by exotic trees, salt water intrusion into the estuary and loss of migratory fish populations. Downstream communities have suffered from a loss of tourism.

When the government owners of the scheme moved to corporatize the Snowy Mountains Hydroelectric Corporation, as a possible prelude to privatization (since abandoned in 2006), residents downstream on the Snowy River demanded that river flows were restored first. They feared that if these flows were proposed after corporatization the compensation payable to the scheme owners for loss of income from electricity generation, sales of water to irrigators and in renovating infra¬structure, would be prohibitive.

The demand to restore the Snowy created conflict with the downstream states and communities along the Murray River, which receives water diverted by the Snowy scheme. The Murray River has 80% of its average annual flow diverted for irrigation. Apart from possible impact on irrigation, any reduction of water threatened to accelerate the environmental collapse of the Murray River and its many services, including Ramsar Convention-listed Wetlands of International Importance.

A vocal community campaign led to a public inquiry. During this, scientists estimated that restoring the Snowy River's flow to 28% was the minimum required to restore the most damaged portion of the river to a more natural condition and re-establish fish populations (SSC 2008). In 2002 the national and state governments signed an agreement to undo part of the water transfers to partly restore flows to the Snowy River and other dammed Alpine streams. The targets for the Snowy River are to return flows to 15% (0.14 km^3/yr) of natural in years 1-7, to 21% (0.21 km^3/yr) in years 7-10, and, under certain conditions, up to 28% (0.29 km^3/yr) after year 10 (The Commonwealth of Australia *et al*. 2002). The governments involved allocated AUD $ 375 million (US$ 289 million) to the 'Water for Rivers' company to secure 0.28 km^3/yr water for environmental releases (0.21 km^3/yr for the Snowy to restore flows to 21%, and 0.07 km^3/yr for the Murray). This is largely being sought through investing in water savings projects to compensate for the reduction of water supply into the Murray-Darling Basin. As of July 2009 0.20 km^3 of annual water entitlements had been secured (Water for Rivers 2009). In practice these 'water savings' are proving difficult to deliver and some repurchase of water entitlements is now being undertaken.

The Jindabyne Dam could not release the increased environmental flow to the Snowy River, and so a new outlet, spillway and hydroelectric plant has been retrofitted to the dam at a cost of AUD $ 90 million (US$ 69 million). For 2009/10 instead of the targeted of 15% annual natural flow, only 4% has been allocated by the New South Wales Government, which the New South Wales Government blames on drought reducing water entitlements (SSC 2008; DWE 2009; SRA 2009). Government delays in implementing key aspects of the agreement, poor governance and the reluctance of Snowy Hydro appear to be contributing to the poor outcomes to date.

The future of the Snowy Mountains Scheme is now linked to the impacts of climate change. The Australian Government's climate change advisor has recommended privatising and re-engineering the scheme to store excess wind and solar power for use at peak times. The Garnaut Climate Change Review said (Garnaut 2008:477): "power from intermittent sources at times of low demand and price could be used to pump water into hydroelectric storage for use at times of greater demand and value. Public ownership, and in the case of Snowy Hydro ownership by three governments, has applied constraints on the supply of capital to the optimisation of the value of these major national assets. These constraints have high opportunity costs in the emerging environment. It is important that they be removed." By contrast, the drought that has grown since 2002 has seen the Snowy Hydro Scheme's power generation fall dramatically, so much so that Snowy Hydro has purchased natural gas peaking plants to maintain supplies (Snowy Hydro 2007). The forecast declines in precipitation and runoff in the Australian

Alps, which range from +7 to -24% with a median estimate of -12% (CSIRO 2008), has led many to suggest that the current drought represent a step change in the climate, which may jeopardise the future of the hydro scheme. Headlines in The Canberra Times on 5 and 7 July 2009 concerning the Snowy Scheme stated: "The gold rush that was fed by water is over," "When the rivers don't run," and "Hydro scheme threatened."

Summary:

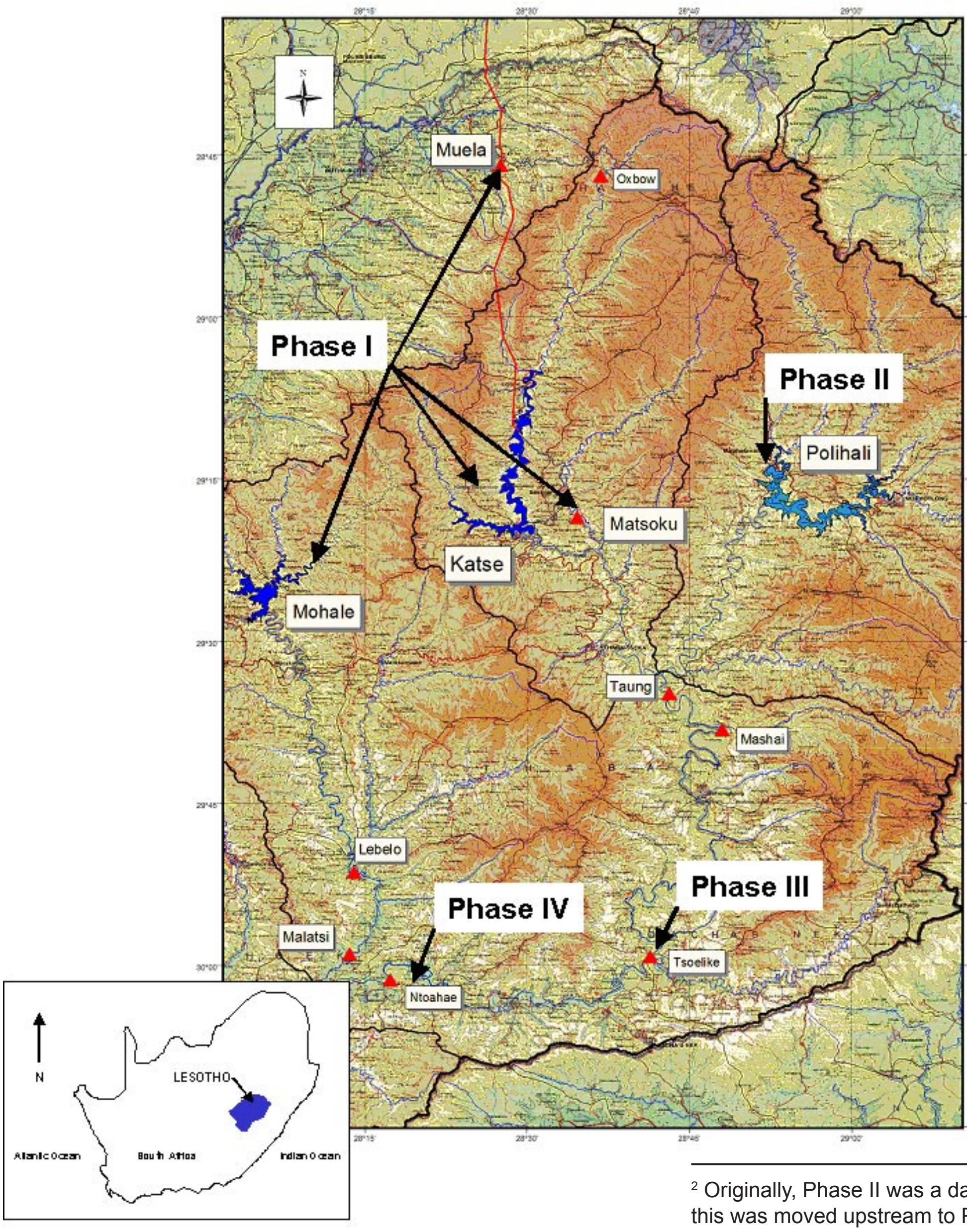
Where	**Snowy River Scheme, Australia**
When	From 1949 until now
Receiving basin	Murray-Darling Basin
Donating basin	Snowy River
Distance	Less than 100 km
Volume diverted	1.1 km^3/yr of water into the Murray-Darling Basin for irrigation
Structures	16 large dams, seven hydropower stations, over 145 km of tunnels and about 80 km of aqueducts
Cost	AUD $ 820 million (US$ 630 million; AUD $ 9 billion in 2002 prices)
Purposes	Hydropower Irrigation
Environmental cost/benefits	Snowy River reduced to 1% of its natural flow, resulting in loss of wetland habitat, silting up of the river channel, invasion by exotic trees, salt water intrusion in the estuary and loss of migratory fish populations. Diverted water has helped (in part) to retain ecological values of Ramsar wetlands and the river channel of the recipient river, the Murray; a grossly over-allocated system.
Social costs/ benefits	For the communities of the Snowy River the costs were loss of income, amenity values and a natural asset. Communities of the recipient River Murray benefited, especially irrigators. The IBT created significant employment locally, was seen as a nation building project, which generates electricity and has opened up the region to tourism
Alternatives?	Electricity generation was possible without the IBT diverting water from the Snowy River, which was seen at that time as expendable in the national interest. More efficient irrigation practices along the recipient river could have allowed an expansion of agriculture without the IBT. Increasing the share virtual water in meeting part of the food demands could have reduced the demand for real water.
Lessons learnt	Projects that don't adequately consider the full costs and benefits, including on natural assets, and their associated communities, cause conflict for decades. Even partial restoration of diverted flows is very expensive. Upfront provision of environmental flows would have significantly reduced the costs. No consideration was given to demand management (improved water use efficiencies) in the recipient basin at the time the IBT was devised. Altered hydrology due to climate change now threatens the delivery of services from the Snowy Mountains Scheme.

Case study 3: Lesotho Highland Water Project - Lesotho and South Africa

About this IBT:

The Lesotho Highlands Water Project (LHWP) is a multi-billion dollar water transfer and hydropower project implemented by the governments of Lesotho and South Africa, and is one of Africa's largest water-resource developments. It is envisaged to eventually comprise six major dams (four phases), and associated infrastructure, on the headwaters of the Senqu River in Lesotho, which becomes the Orange River as it crosses into South Africa (Figure 1). Water is the principal natural resource of Lesotho and its mountains generate nearly 50% of the total run-off of the Orange River, although they constitute only 5% of the total area of the Senqu/Orange Basin.

The LHWP was formalised in 1986 through the signing of 'The Treaty' between Lesotho and South Africa. Construction began on the first of four phases in the early 1990s, and the first dam, Katse Dam (Full Supply Level [FSL] capacity: 1.95 km^3/yr, was completed in 1998 (Phase IA). A second dam, Mohale Dam (FSL capacity: 0.95 km^3/yr), and a diversion weir, Matsoku Weir, followed in 2004 (Phase IB). Muela Hydropower Plant, which was also built as part of Phase I, provides a major part of Lesotho's electricity demands (Tromp 2006). Phase II was approved for construction in 2008 and deliveries of water to South Africa are expected to commence in 2019 or 2020. Phase II comprises a dam at Polihali[2] (FSL capacity: 1.89 km^3/yr) on the upper Senqu River (Tanner *et al*. 2009), with a tunnel to Katse Dam.



Map 4: The location and layout of the Lesotho Highlands Water Project (Odendaal 2007).

[2] Originally, Phase II was a dam on the Senqu River at Mashai but this was moved upstream to Polihali during the pre-feasibility studies in 2007.

In terms of The Treaty, South Africa will buy a stipulated annual supply of water, thereby generating export revenue for Lesotho. Phase I currently transfers 0.60 km^3/yr (www.lhwp.org.ls) to South Africa. Payments for Phase I alone are 14% of Lesotho's Gross Domestic Product for the next 50 years (e.g., 14.7% in 2008; www.lhwp.org.ls). Polihali Dam is expected to double the annual volume transferred to South Africa (1.20 km^3/yr; Tanner *et al*. 2009). If all four of the envisaged phases are developed, the total yield of the LHWP is expected to be in excess of 2.0 km^3/yr (Odendaal 2007), which would generate annual royalty payments to Lesotho of about US$ 100 million.

Estimated costs for Phase I vary between US$ 2.1 billion (Watson 2008) and US$ 3.5 billion (Horta 2007), and were considerably more than originally predicted (Tromp 2006). The expected cost of Phase II is in the region of US$ 1 billion (Tanner *et al*. 2009), and the costs for all phases are expected to be about US$ 8 billion (Gleick 1998); double the original estimates.

Consideration and provisions for mitigation of environmental and social impacts associated with the LHWP were poor in the initial phases of the LHWP. Phase IA, for instance, began before completion of a full environmental Impact assessment report[3], and work on the downstream impacts only started after the completion of Katse Dam. The Lesotho Highlands Development Authority together with the World Bank made a considerable effort to rectify this in subsequent stages of the project, with some success.

Analysis:
From an environmental perspective, Phase I of the LHWP inundated over 100 km of pristine, large, mountain-river habitat, and seriously threatened the reaches downstream. In 2003, following an Environmental Flow (EF) assessment (King *et al*. 2000), an Instream Flow Requirement (IFR) Policy was finalized by LHDA (2003), which specified EF releases, operating rules for the dams and a program to monitor compliance. The operating rules make provision for changes to releases depending on climatic conditions, so that some natural variation is maintained. Treaty provisions for 5% of the natural mean annual runoff to be released as a constant flows from Phase I structures were increased to 10% and 14% from Katse and Mohale Dams, respectively (LHWP 2003). EF were included in the feasibility studies for Phase II and in the yield determination for Polihali Dam (done in 2008), the long term average EF allocations were modelled at 130 million m^3/yr, about 18.7% of the average natural mean annual inflow of 697 million m^3/yr (Tanner *et al*. 2009). Polihali Dam will, however, result in an as-yet-unknown cumulative reduction in flows in the Senqu River, which already has reduced flows as a result of Phase I. The 'target ecological conditions' for the rivers immediately downstream of the dams are thus lower than their pre-dam condition, and despite a commitment to compensation, not all of the losses incurred could be costed or even compensated for (Brown 2008). Downstream, in South Africa, it is likely that harvesting of clean source water will have impacts in the lower Orange River, where water-resource developments and water-quality issues in the Vaal and middle Orange Rivers have already taken their toll (Binedell *et al*. 2005). The condition of the receiving river in South Africa, the Ash River, has also been seriously compromised through erosion and associated river engineering works.

Although there was considerable improvement in the scope and budget for environmental studies, implementation has been inconsistent. Initial problems with EF releases are still being ironed out. The first IFR audit, completed in 2007, found that implementation had been 60% compliant with the IFR Policy and identified issues likely to affect the sustainability of the process (INR 2007). Tardy implementation of, and in some cases disregard for, recommendations was probably responsible for some of the more emotive environmental impacts, such as those to the critically-endangered Maloti minnow (*Pseudobarbus quathlambae*), which are now under threat from smallmouth yellowfish (*Labeobarbus aeneus*) that have been able to access previously inaccessible tributaries via LHWP infrastructure. Although both are indigenous to Lesotho, these two species do not (and quite possibly cannot) coexist naturally (Southern Waters 2006).

From a social perspective, Phase I of the LHWP either directly or indirectly affected some 180 000 people, although the bulk of these people lived along the Senqu River and were not seriously affected by Phase I (King *et al*. 2000). In Phase IA around 30 000 people were directly affected by the construction works and 325 households had to be permanently relocated. About

[3] Although more than 20 social and environmental studies were done (Tromp 2006) most of these post-dated project initiation.

2 300 ha of valuable agricultural land and 3 400 ha of pastures were lost. The numbers were slightly lower in the case of Phase IB, and are likely to be lower still, but by no means insignificant, in Phase II, which is situated in a less-densely populated area of the country. Alteration of flow regimes in the downstream rivers may eventually affect about 150 000 people in Lesotho alone (King *et al*. 2000), although as mentioned, for Phase I the bulk of these impacts are restricted to the Malibamatso and Senqunyane Rivers. (No assessment has been done of the social effects in South Africa).

LHDA has a policy of compensation for loss of arable land and loss of riverine resources. The annual compensation for lost arable land in the form of cash or grain with pulses for 2004 comprised c. US$ 65 000.00, c. 14 000 maize bags and c. 30 000 kg of pulses, which were distributed among c. 3 000 households (LHDA 2005). The first lump sum payments to compensate for predicted downstream losses in river reaches close to Phase I structures (within 60 km; included 6 965 households), which totalled about US$ 27 million, were also paid into community trust accounts in 2004 (LHDA 2005). For the more distal reaches, these payments will be made if monitoring indicated a loss has indeed occurred (LHDA 2003).

The compensation payments notwithstanding, criticism continues to be levelled at the LHDA mainly because many of the concerns related to Phase IA were either not rectified, only rectified after considerable delays (in some cases 10 years) or were repeated in Phase IB (e.g., Thamae and Pottinger 2006), and there have been reports of slow and inadequate compensation. In its initial stages, the project was also plagued by corruption but the authorities have since successfully prosecuted many of the accused. The former Chief Executive of LHDA is in jail, two engineering firms were convicted of bribery (TRC 2005) and the Government has recouped millions of dollars from convicted consulting firms (www.LHWP.org.ls).

Lesotho has gained immense economic benefits from the LHWP with over US$ 300 million in royalties (Jan 1998 - April 2009) since water delivery to South Africa began in 1998 (http://www.lhwp.org.ls/Reports/PDF/Water%20Sales.pdf). The country is also now self-sufficient in power generation. Project-related roads, bridges, power lines and substations, and telecommunications, and ancillary developments (schools, clinics, water supply), have greatly improved access, communications and community infrastructure in the highlands (Tromp 2006). Tourist numbers in the highlands, although still low, have improved noticeably (Tromp 2006). The employment and capacity-building opportunities offered by the project have also been significant, and include employment by LHDA, construction-related employment and consulting opportunities. For instance, Phase IB provided 13 000 person years of employment, of which 40% were from the Highlands, and generated income of c. US$ 25 million in fees to Basotho consultants[4] (Tromp 2006).

There are however concerns that the poorest have not seen the benefits of the project, and the bad press deservedly attracted by the project at its outset lingers on. In particular, this relates to: the investigation of

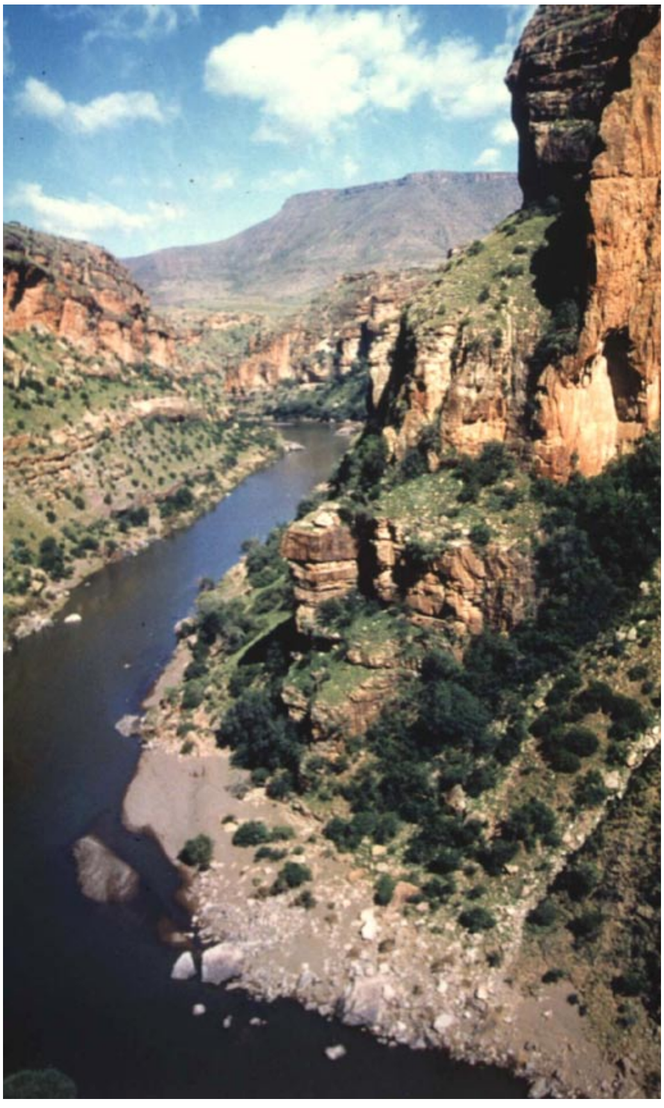


Photo 3: The gorge on the Senqu River downstream of Tsoelike is just one of the reaches that would be inundated by Phase IV of the LHWP. © Cate Brown

[4] As opposed to US$ 18 million in Phase IA.

viable alternatives, resettlement of communities, the compensation for lost assets and governance issues. There are also serious concerns that the LHWP is somewhat of a juggernaut, which will not stop until all four phases[5] have been completed, despite its inevitable and devastating impacts on the long-term sustainability of the Orange River system, or the fact that it would see nearly 80% of the length of Lesotho's major rivers dammed.

Summary:

Where	Lesotho / South Africa: Lesotho Highlands Water Project
When	Conceived in 1950s and formalised in 1986 through the signing of 'The Treaty' between Lesotho and South Africa. Planned as four phases, Phase I was completed in 2003, and Phase II was approved for construction in 2008
Receiving basin	Vaal River, which is part of the Orange River Basin.
Donating basin	Senqu/Orange River.
Distance	c. 200 km of tunnel.
Volume diverted	c. 0.6 km^3/yr (Phase I only).
Cost	Phase I: US$ 2.1-3.5 billion. Phase II: US$ 1 billion. Total: US$ 8 billion.
Purposes	Water supply for South Africa's Gauteng industry region; Electricity, royalties and infrastructure for Lesotho.
Environmental cost/benefits	Reduced, more constant flows and less-frequent floods in the Malibamatso, Senqu and Senqunyane Rivers; Reduction in river ecosystem health; Treat to survival of the critically-endangered Maloti minnow; Excessive erosion in the receiving Ash River in South Africa.
Social costs/ benefits	The project created significant employment locally, and was seen as a nation building project; Lesotho is now self-sufficient in power generation; Significant rise in government revenues, with knock-on benefits linked to social spending; Increased tourism to the highlands; When completed will dispossess more than 30 000 (now about 20 000) rural farmers of cost/benefits assets (including homes, fields, and grazing lands) and deprive many of their livelihoods; The loss of arable and gazing land would increase Lesotho's dependence on foreign food imports.
Alternatives?	The Tugela Water Project in KwaZulu, Natal was investigated as an alternative to Phase II of the LHWP; Water demand management in Gauteng; Water reuse and recycling; Virtual water imports to meet part of the water demands.
Lessons learnt	Failure to investigate and adequately address social and environmental impacts at the outset of a project can lead to prolonged negative impressions of the project; The capital costs for these types of projects are frequently much greater than the proponents first claim, as was the case here (WCD 2000);. Dam costs are often underestimated because they fail to account for all the economic costs of the project (Watson 2008); Poor governance can lead to poor decisions and greater costs, as shown by the allegations of corruption.

[5] A fifth phase, comprising a dam on the lower Senqunyane River, has also been proposed.

Conclusions – lessons learnt

The preceding case studies describing IBT schemes from three different parts of the World illustrate well a number of the common, negative impacts of these schemes. The table below summarises these.

Negative impacts of IBT	Case study 1. Tagus-Segura Transfer, Spain	2. Snowy River, Australia	3. Lesotho Highlands Water Project, Lesotho and South Africa
Demand management in recipient basin not serious part of pre-planning for IBT, leading to on-going water wastage	✓	✓	✓
IBT became driver for unsustainable water use in recipient basin– irrigation and urban	✓	✓	-
Created strong dependence on IBT in recipient community	✓	✓	✓
IBT now seen as inadequate and other water supplementation required (groundwater, desalinisation, recycling etc)	✓	✓	-
Saw proliferation of boreholes to access groundwater – leading to over-exploitation of this resource too	✓	-	-
Donor basin experienced serious environmental impacts through reduced flows especially	✓	✓	✓
IBT created or escalated threats to critically endangered, threatened species etc	✓	-	✓
Scheme saw economic benefits in recipient basin at the cost of communities in the donor basin	✓	✓	✓
IBT catalyst for social conflict between donor and recipient basins or with government	✓	✓	-
IBT has not helped the situation of the poor affected or displaced by it	-	-	✓
Post IBT mitigation costs very high, either environmentally or socially	✓	✓	✓
Governance arrangements for IBT weak, resulting in budget blow-out or corruption	-	-	✓

From the above there are several key lessons that can be learned, as follows:

1. Before progressing to commission an IBT, there should be a comprehensive assessment of the alternatives available for providing the water needed in the proposed recipient basin. Can this water be provided through demand management, water recycling, water harvesting etc, before considering a major infrastructure investment with its inevitable environmental and social impacts? Or, is there an alternative to meet the demands by re-distributing the water footprints to regions with water surpluses (transferring virtual water rather than real water across river basins)?

2. Undertake a cost-benefit analysis of the likely impacts of the IBT on both the donor and recipient basins, considering the full range of environmental, social and economic implications.

3. Ensure risks associated with the proposed IBT - environmental, social and economic - are clearly understood, and if the project proceeds, governance arrangements are adequate to manage and minimise these risks.

4. Undertake consultations with the likely directly and indirectly affected people, before a decision is taken regarding the possible IBT (and certainly before it becomes fait accompli) ensuring they understand and have the opportunity to voice views on likely cost, benefits and risks.

Note that such approach is advocated as a 'needs and options' assessment in the report of the WCD (2000) and is addressed in the Section I of the Sustainability Assessment Protocol (HSAF 2009).

4 In the pipeline – interbasin water transfers in the future

Despite numerous less than positive experiences with large scale interbasin water transfers, many decision makers are today still looking toward them as a solution to water supply problems within their country.

Many ambitious projects are under consideration at present. This includes a number of schemes that will transfer water over thousands of kilometres, as well as many other schemes that are less grand in scale.

Globally there is no single, reliable source of information on the numbers and kinds of IBTs that are planned; most schemes being developed within countries. The major sources of information on proposed large IBTs assembled for this report include UNESCO (Cox 1999), academic assessments (Shiklomanov 1999; Lasserre, 2005; Ghassemi and White 2007; Gupta and van der Zaag 2008) and the International Commission on Irrigation and Drainage (ICID 2006).

In some countries plans exist to not just transfer water from one basin to another, but to transfer water across many river basins. Plans for IBTs are also not limited to countries that as yet have no negative experiences with them. Proponents in Australia for example, despite the vast amounts of money being spent on restoring some of the flows in the Snowy River system (see case study 2 in section 3), still have plans for large water supply schemes (Ghassemi and White 2007).

This report examines this issue further through the following four case studies of proposed transfer schemes from all over the world.

Case study 4: Acheloos Diversion, Greece

Why an IBT ?

The 220 km long Acheloos River originates in the Pindos mountain range and runs southwards through Western Greece to the Ionian Sea. The upper reaches of the river are developed for hydro-electricity at the Kastraki and Kremasta dams, but there are plans to divert its waters eastwards to the Thessaly plains, an important agricultural region.

The diversion plans date back to the 1930s, but concrete proposals were not developed until the 1980s, when the Greek government expressed its intention to implement the Upper Acheloos Diversion Project, designed to transfer up to 0.6 km^3 of water per year to Thessaly.

The government's vision is to bring together two of Greece's most important natural resources - the Acheloos River and the Thessaly plain - for the benefit of the national economy.

In particular, the plan is to divert water from the Upper Acheloos River to the Pinios River in Thessaly, at the position Drakotripa on the other side of the Pindos mountain range, and from there to the arable land of Thessaly. However, there is no provision for the transfer of water from the outlet of the diversion to the non-existent irrigation network of Thessaly.

Decisions by the Council of State (Greece's Supreme Court) in the 1990s and in 2005 declared the project illegal, on the grounds that it violated Greek and EU

Photo 4: Traditional wooden bridge at upper Acheloos River, Greece © WWF / V. Psihogiou

legislation on water management, Greek legislation on EIA and international legislation on the preservation of cultural heritage. Nevertheless, the diversion is still on the Greek political agenda today and support remains strong. In July 2006 the project was declared a plan of "national importance", thus bypassing the legal obstacle of the Supreme Court ruling.

Expected environmental and social impacts:
The project is expected to cause irreversible damage to ecosystems of exceptional ecological value and could bring about local extinctions of several populations of endangered and internationally protected species, including otter (*Lutra lutra*), trout (*Salmo trutta*) and dipper (*Cinclus cinclus*).

Populations of other species such as grey wolf (*Canis lupus*), wildcat (*Felis silvestris*) and roe deer (*Capreolus capreolus*) are expected to be seriously disturbed both during and after construction by alterations to the landscape. The pristine forest ecosystems of the area will be seriously damaged through the opening of roads during the construction and operational phases of the dams.

The riverine habitats of the Southern Pindos face the prospect of permanent alterations, due to the construction of deep reservoirs. Further downstream, the wetlands of the Messolongi Lagoons Complex (one of the 10 Ramsar wetlands in Greece), a site of global ornithological significance, are expected to suffer from serious reduction in freshwater input. It is also worth noting that the flow of the Acheloos River has been reduced by 12% between 1980 and 2006 (Skoulikidis 2009). The Acheloos Valley and Delta have also been included in the national Natura 2000 list.

Photo 5: Mouth of Acheloos River in Central Greece
© WWF / D. Vasiliadis

The construction works in fragile mountain ecosystems are also likely to exacerbate soil erosion and landslides and large tracts of land will be inundated by the main reservoirs. The diversion project is also expected to have serious socio-economic and cultural impacts. These include destruction of important cultural monuments such the 11th century monastery of St George of Myrophyllo, and a number of stone bridges which will be inundated.

The project is also linked to the restoration of Lake Karla in Thessaly, which was drained in order to gain arable land in 1962. In 1995, it was decided to re-establish the lake. Most of the water (60%) to the Lake Karla will flow from Pinios River, which, in turn, will receive the water from Acheloos diversion. The reconstitution of Lake Karla highlights the problem of the continuous (mis)management of water resources.

Analysis:
Economically, the sustainability of this IBT project is questionable. A cost-benefit analysis done in 1988, on behalf of the Ministry of National Economy, concluded that even if the construction and operational timetables were met, the project was only marginally in the 'black' financially.

The project is driven by the wish to increase agricultural output in Thessaly, but water supply problems in that region can be largely attributed to the mismanagement of its water resources for irrigation, and the widespread cultivation of cotton, a water intensive ('thirsty') crop. In fact, the economic viability of the project is dependent on cotton farming, which is at present heavily subsidised; these subsidies per kilogram of crop being close to the world market price. Cotton subsidies are being phased out under the framework of the reformed EU Common Agricultural Policy and are expected to be completely discontinued after 2013. However, Greece continues to support intensive cotton production and seems unwilling to plan for a smooth shift towards the cultivation of less "thirsty" crops.

Thessaly is a region naturally rich in water (e.g. Pinios River, Lake Karla, Pamisos River). However, the use of inefficient irrigation methods has wasted large quantities, leading to serious water supply problems. Unregulated bore drilling for irrigation has caused depletion and increased salinity of the groundwater, leading to salinization of the soil, a situation further exacerbated by wasteful irrigation methods.

Rather than a large scale IBT, the construction of a series of small reservoirs in the rivers of Thessaly, coupled with efficient irrigation methods, would guarantee better distribution of irrigation water and also be more cost effective.

Summary:

Where	**Upper Acheloos Diversion Project - Greece**
When	Original plan dates to 1930s Designed in 1980s – currently on hold, but possibility of revival of plans
Receiving basin	Plain of Thessaly
Donating basin	Acheloos
Distance	174 km
Volume diverted	0.6 km^3/yr
Structures	Mesochora mega dam (150 m high) and Mesochora reservoir (228 m^3 volume) Mesochora – Glystra tunnel (7.5 km long) Sykia mega dam (150 m high) and Sykia reservoir Sykia diversion channel to Thessaly (17 400 m long) Mouzaki major dam (135 m high) and Mouzaki reservoir Pyli dam (90 m high) and Pyli reservoir Pyli – Mouzaki tunnel (8 km)
Cost	Not known. Construction cost estimated at € 720 million (US$ 971 million). However total cost including necessary adaptations of irrigation networks, complementary infrastructures, maintenance and management have never been estimated. In 1996 the total cost was estimated at € 2.9-4.4 billion (US$ 3.9-5.9 billion)
Purposes	Provision of irrigation water for 240 000 ha of land in Thessaly
Environmental cost	Serious impacts on rare riverine and forest habitats and landscapes of South Pindos Destruction of Greece's most important habitat for the trout Impacts on downstream freshwater habitats, including Ramsar and Natura 2000-listed areas, due to reduced flow Extensive disruption of fragile mountain landscapes
Social costs	Loss of cultural heritage Disruption of Southern Pindos communities Use of large amounts of national funding to support unsustainable agricultural practices
Alternatives?	Address mismanagement of water in Thessaly region Apply demand management practices Construction of smaller reservoirs in rivers of Thessaly Reduce production of 'thirsty' crops (cotton in this case), consider relocation of the water footprint of cotton production to other regions where the impacts are minimal Improve irrigation efficiency Take measures to counteract falls in groundwater tables and soil salinization

Case study 5: São Francisco Basin Interlinking Project, Brazil

Why an IBT ?
The São Francisco Basin Interlinking Project is designed to supply water to 12 million people in the semi-arid region of Pernambuco Agreste and the metropolitan area of Fortaleza in north-east Brazil by collecting water from the São Francisco Basin between Sobradinho and Itaparica dams in the state of Pernambuco.

This project involves the construction of canals, water pumping stations, small reservoirs and hydroelectric plants and is part of the Program for Sustainable Development of the Semi-arid and São Francisco River Basin. Two main axes of development are proposed, centred on major canals: Eixo Norte and Exio Leste. Costs are expected to be at least US$ 2.38 billion and up to 1 million jobs may be generated.

Designed in 2000, the Federal Government modified and released the proposal in 2004 and states that the project will benefit 12 million people, irrigate 300 000 hectares, contribute to one million jobs and provide a solution to drought. The São Francisco River Basin Committee, represented by eight states, agrees that supply is important but publicly expressed concern about the approach proposed.

Although the São Francisco River Basin Committee did not approve the project, the National Water Resources Council did in February 2006.

The National Water Agency issued a 20-year authorization for water use to the National Integration Ministry, on September 22nd in 2005, and also issued the Certificate of Sustainability Evaluation for Water Engineering for the project. Construction has commenced on over one hundred kilometres of canals on both axes, although there are more than ten court challenges to the project approvals before the Federal Supreme Court.

Expected environmental and social impacts:
According to the National Integration Ministry, environmental impacts will be minimal as the amount of water diverted is as little as 1.4% of average flows, which is disputed by opponents who calculated that 25-47% of such flows may be diverted.

Despite this view, the project has caused controversy, as opponents (including state government institutions of the proposed donor basins, technical councils, and churches) claimed the main use for the water would be for irrigation, neglecting other uses. Other criticisms cover technical and operational feasibility, national priorities, economics, justice and social value, environmental aspects and legal support, as follows:

- A continuing focus on large, expensive water engineering projects which overlook impacts on freshwater ecosystems and the use of alternative, environmentally friendly and lower cost interventions;
- As this is a region forecast to suffer greater water scarcity with climate change, the medium to long term viability of the new infrastructure is questioned;

Map 5: Project for Interlinking São Francisco Basin to the North-eastern Basins
Source: National Integration Ministry, Brazil

- Only 4% of the diverted water will benefit the dispersed population, 26% will be for urban and industrial use and 80% for irrigation;
- Temporary loss of jobs and incomes due to land appropriations;
- A continuation of what is in effect subsidized agriculture without full consideration of the social, economic and environmental costs
- Lack of investments, training and modernization of water management entities;
- Risks of conflict during the construction works.

Specific environmental costs will derive from biodiversity loss, fragmentation of native vegetation, risk of introduced non-native species potentially harmful to people, disrupted fishing due to more dams, siltation, and water loss due to evaporation as the water cycle is altered. The Exio Leste canal has been constructed up to either side of the Serra Negra Biological Reserve, Brazil's first nature reserve. Further construction would bisect and damage this critical remnant of the Atlantic Forest, which is the territory of the Pipipa and Kambiowa indigenous peoples.

The Union's Counting Court (TCU, in Portuguese) concluded that the benefits of the IBT are overestimated and the costs are underestimated. The TCU pointed out that the project's effectiveness depends on the capability of the Federal Government to manage and distribute water to the population on completion of the link. The TCU's audit also recommended that the Federal Government proceed to a full evaluation of the project and requested a plan to show the interlinking processes that will integrate all the actions.

The proposed project presents a very complex situation, with many concerns that go beyond the physical construction issues. There are political rivalries between the State of Bahia (against the construction) and the State of Ceará (in favour); the perception being that the IBT would give the latter more influence.

WWF Brazil has stated that all possible alternatives to the IBT should be taken into account before a decision is taken to construct such enormous hydrological infrastructure.

Analysis:
Critics contend that there is already adequate water in north east Brazil to meet the needs of the residents if only it were managed more efficiently. The possible alternatives were not adequately indicated by the EIR such as, for example:

1. Demand management, including more efficient use of water with resultant reduction of losses and re-location of the water footprint to the regions where the impacts would be minimal (i.e. transfer of virtual water to meet the food demand rather than to import real water to grow food in the regions itself);
2. Greater reliance on small-scale and decentralised systems, such as rainwater harvesting;
3. Revision of water licences in line with water actually used and needed;
4. Federal Government priority in implementing the São Francisco Basin and Brazilian Semi-Arid Integrated Sustainable Development Program, including:
   - Rehabilitation of vulnerable and environmentally degraded basins with a view to improving sanitation services and water supply, recovery of riparian forest, soil conservation and solid waste management;
   - National Action of Desertification Combat and Droughts Effects Mitigation Programme (PAN-Brazil) including plan to reduce expansion of semi-arid areas;
   - Strengthening capacity building with local institutions;
   - Federal partnerships with states and municipalities, as well as building partnerships with civil society – NGOs and the regional productive sectors;
   - Expand regional partnerships – structuring actions like the one with Northeast Bank (Banco do Nordeste, in Portuguese);
   - Implement better Integrated River Basin Management;
   - Provide water security for the dispersed population;
   - Develop regional economies to allow better quality of life for the river dwelling people; Groundwater program;
   - Conclusion of unfinished water development projects.

Summary:

Where	Brazil: Rio Sao Francisco Project
When	This project started during colonial period. It was taken up again by President Lula de Silva in 2000.
Receiving basin	A number of smaller catchments in the states of Ceara, Rio Grande do Norte, Pernambuco and Paraíba.
Donating basin	San Francisco, from the states of Minas Gerais, Goiás, Distrito Federal, Bahia, Sergipe, Alagoas.
Distance	The river is 2 700km long. The two canals total 720km.
Structures	Public supply and multiple uses, mainly for irrigation. Northern axis: 4 pumping stations, 22 canals, 6 tunnels, 26 small reservoirs, 2 hydroelectric plants of 40 megawatt and 12 megawatt capacity; Eastern axis: 5 pumping stations; 2 tunnels and 9 reservoirs.
Cost	US$ 2.38 billion.
Purposes	Irrigation of about 330 000 ha. Bring 2 092 km of dry riverbeds back to life. Discharge of 26-127 m^3/s. Average is 53 m^3/sec.
Environmental cost	Reduction in biodiversity of native aquatic communities in receiving basins. Loss and fragmentation of areas with native vegetation. Uncertainty about the adequacy of stream regimen determined.
Social costs	Reducing the hydroelectric capacity in the donating basin. Only large landowners and big businesses will benefit from the 3.9% increase in water availability in the receiving states.
Alternatives?	Demand management. Re-location of part of its water footprint to other more resilient regions by virtual water transfers rather than real water. Revision of water licences. Small scale and decentralized infrastructure based on technologies such as rainwater harvesting and sustainable groundwater use. Implementation of the São Francisco Basin and Brazilian Semi-Arid Integrated Sustainable Development Program. Rehabilitation and revitalization of the São Francisco River Basin. Strengthen negotiations with river basin committees (RBC) – as in case of RBC for the Prircicaba, Capivari and Jundiai Rivers, establishing new rules that reduce volume of water to be transferred in the dry season.

Case study 6: Olmos Transfer Project, Peru

Why an IBT ?

The prospect of deriving water from the Huancabamba River in the Amazon basin to irrigate the pampas of Olmos was first proposed in 1924. The pampas of Olmos lie on the coastal strip of northern Peru and are extensive, flat, sparsely populated areas with very little rainfall. The vegetation varies from desert to dry forests.

After numerous delays, a private-public partnership was signed between the regional government of Lambayeque and ProInversion for the Olmos Tinajones Special Project (or PEOT), and in late 2005 drilling commenced on the 19.3 km long tunnel through the Andes mountains to irrigate 150 000 ha of land. In mid 2009, the 44 million m^3 Limon Reservoir was practically finished and most of the trans-Andean tunnel had been drilled. The project's first phase is scheduled to conclude in 2010.

The second phase comprises the diversion of waters from the Manchara and Tabaconas rivers to the Huancabamba. The Manchara River originates in the rural community of San Miguel de Tabaconas, while the Tabaconas River originates in the Tabaconas Namballe National Sanctuary; a protected area established in 1980 for the conservation of the paramo ecosystem, cloud forest and endangered species like spectacle bear (*Tremarctos ornatus*) and montane tapir (*Tapirus pinchaque*). The third phase consists of an irrigation system which will irrigate 150 000 ha of land. Two hydroelectric power stations are also part of the project with a planned output of 4 000 GWh.

Expected environmental and social impacts:

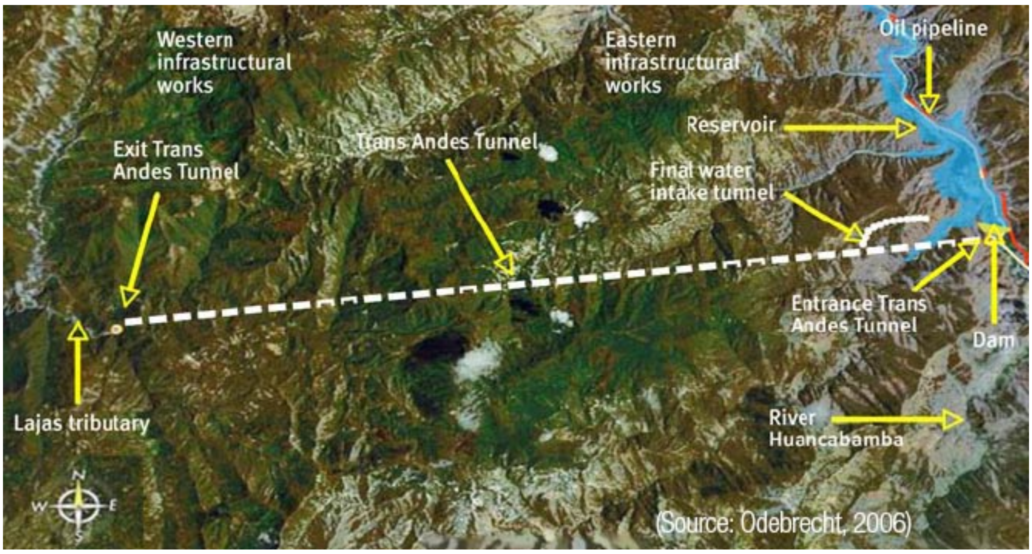
The estimated cost of this IBT is US$ 185 million, however no estimates of the potential benefits are known.

The environmental and social damage however is likely to be substantial. The Environmental Impact Assessment only addresses the first phase and as such does not address impacts of the second and third phase in the Manchara, Tabaconas and Olmos regions.

During the dry months (July-September) there is usually very little supply flow available. At this time no IBT water should be taken. A resolution was passed in May 2006 to maintain discharge at 1.7 km^3/yr. It is debatable whether this is a sufficient environmental flow.

According to Zegarra *et al* (2006), no measures have been taken so far to avoid the inevitable logging of the valuable dry forest. No less than 66 000 ha of these forests are going to be converted into irrigated fields.

A critical aspect of the Olmos Transfer Project is the status of the lands that will be converted to irrigation. To make the project attractive for private investors the government claimed a certain area of land. This was done in the 1990s. The state reserved 110 000 ha; 80 000 ha of the Santo Domingo de Olmos community and 30 000 ha of the Mórrope community. The expropriation of these areas from the community of Santo Domingo de Olmos was done without consultation, and has been disputed by the community (Zegarra *et al* 2006).



Map 6: Olmos Project Plan, first phase
Source: Odebrecht, 2006

Photo 6: Start Trans Andes Tunnel © Credit: WWF / W.Nagel

A key question is who are the buyers of the new lands suitable for irrigation? People from outside the region, who have sufficient resources to buy the land and the water? What will they produce? High quality products for export to the capital Lima or abroad? If so, this is likely to create social conflicts between locals and the new inhabitants. This is a very real risk, as nearly 50 percent of the 218 social conflicts recorded by the national ombudsman's office as of February 2009 were triggered by socio-environmental problems, many of them related to water management issues (Rosales 2009).

The future of the local carob tree forest is also crucial. This forest type is valuable for the local people and their way of living. They use it as food for their livestock, for apiculture, to produce carob and ultimately they use the wood to make charcoal (Zegarra *et al* 2006).

An additional social impact of this proposal will be the forced re-location of the village of Pedregal, with its 200 inhabitants, in the Huancabamba River basin. While compensation has been given for this relocation, no information is available on how this has affected the ways of life of these people.

Photo 7:Rice paddies near the river Huancabamba
© Credit: WWF / W.Nagel

Analysis:
While this first phase of the project is nearly complete, the second and third phases in their early stages, meaning that there may still be time to apply adjustments and avoid environmental and social impacts. The development of an independent, integrated and comprehensive environmental impact assessment (EIA) study should be a priority. This assessment should consider the likely impacts of climate change and response options. In the headwaters, poor landholders could benefit from a payment for watershed services scheme to manage the river basins well to sustain PEOT's sources of water. To solve the social conflict relating to communal lands and the absence of land titles, a social impact assessment should also be done.

If there is to be conversion of some lands to irrigated fields, as per the proposal, then this should avoid areas with valuable dry forest. In this way the local community members will retain their forests and so at least a part of their communal grounds will be safe (Zegarra *et al* 2006).

Given the climate and landscape, a preferable alternative to total reliance on irrigated cropping may be to blend this with cattle breeding. By promoting irrigated agriculture through the IBT it is potentially making the agricultural sector very vulnerable. Irrigation is also likely to see trees removed, high rates of evaporative water loss, and possibly salinization problems. PEOT directors have expressed an intention to reforest some areas of dry forests to compensate for the areas that will be lost.

The implication of climate change on the viability of the scheme is unknown, but the loss of more than 20% of the area covered by glaciers in Peru is certain to change the hydrology of rivers (Rosales 2009) and operations of water infrastructure schemes. The National Center for Atmospheric Research will conduct a study on the impact of climate change on the PEOT with Inter-American Development Bank funds.

Summary:

Where	Peru: Olmos Transfer Project (PEOT)
When	July 2004 contract was signed.
Receiving basin	Olmos
Donating basin	Huancabamba
Distance	19.3 km long tunnel.
Structures	2 tunnels , 1 dam of 43 m (phase 1), 2 hydropower plants and 1 dam (phase 2), irrigation system (phase 3).
Cost	US$ 185 million (phase 1)
Purposes	Irrigation Energy supply
Environmental cost	Logging of dry forest in favour of new irrigation grounds. Deterioration of ecosystems in the donating basin. Changed river flows.
Social costs	Loss of communal grounds and no recognition of the communal land rights of the farmers. Relocation of 200 people in donating basin.
Alternatives?	Apply demand management instruments to reduce water demands. Introducing water saving methods. Change from ‚thirsty‘ export products to rain-fed crops. Save the carob dry forest by avoiding conversion of these lands to irrigation. Blending irrigated cropping with stock breeding.

Case study 7:
The South-North Transfer, PR of China

Why an IBT ?
The ongoing water shortage in north China – especially in the agricultural and industrial areas of the densely populated north China plain – is by any measure, very severe. Always fairly arid, the region's water resources have been heavily drained by intensive agriculture, rapid population growth, and an expanding industrial sector.

As incomes rise, China's per person water demand for residential use is also increasing. Northern China is characterized with inefficient irrigation water use, declining water quality and rapidly growing non-agricultural water demands. The region is experiencing growing pressure to divert water from the agricultural sector to the municipal and industrial sectors.

With only 10% of China's water resouces, North China has about 40% of China's cultivated area and produces 31% of its gross indusctrial outputs. On the top of that the spatial distribution of China's water resources is quite uneven. The result is falling water tables, pollution and dry rivers in the North China Plain. Since the late 1970s, the annual water withdrawals in the North China Plain have exceeded the limits of the annual renewable supplies. The over extraction of groundwater has caused depletion of rivers and aquifers at an alarming rate (Shi 1997) and as a result ecosystems and the environment have been severely degraded.

In every year of the 1990s, the Yellow River, China's second largest river, experienced periods when there was no run-off to the sea. The worst case happened in 1997, when there was no runoff to the sea for 226 days. When there is no surface water available, the demands are met by over-drafting the groundwater, and in the North China Plain this exceeds 90 km^3 in a year (Yang and Zehnder 2005).

While China's government cannot be criticised for providing its citizens with water in deficit areas, critics believe alternatives to the South-North Transfer Project, with better socio-economic outcomes and lower environmental impacts, were not adequately considered before the project was approved (Sharma 2005).

The studies on the South-to-North Water Transfers started in the 1950s and resulted in three water transfer projects; the Western Route Project (WRP), the Middle Route Project (MRP) and the Eastern Route Project (ERP) being proposed.

The project will take water from the Yangtze basin and transfer it more than 1 000 kilometres to the Yellow River, Huai River and Hai River basins in the north (Government China, www.nsbd.gov.cn). China's Ministry of Environmental Protection (formerly State Environment Protection Administration - SEPA) has completed EIAs of the Eastern and Middle Routes of the SNWT Project, and has approved the projects for construction. The Western Route is currently being assessed.

Expected environmental and social impacts:
Eastern Route Project
The main challenge associated with the Eastern Route Project is environmental cleanup, rather than to address negative impact. Agricultural run-off, sewage, factory waste, river transport pollution, and intensive aquaculture already heavily pollute the existing waterways along the route. Pulp and paper factories are the biggest point source polluters, but agricultural

Map 7: Sketch Map of The Scheme of Eastern Route Project.
Source: http://www.nsbd.gov.cn/zx/english/erp.htm

run-off is also quite severe. The water quality meets only the minimum requirement for drinking at the point of diversion. That too deteriorates rapidly as we move further north as a result of the influx of the untreated wastewater from agricultural run-off, sewage, factory waste, river transport pollution, and intensive aquaculture along the route.

The Eastern Route Project will mainly refurbish, expand and upgrade the already existing infrastructure, including the old Grand Canal thus improving the environmental conditions on already deteriorated route. For these reasons the Eastern Route Project may have some substantial environmental benefits.

Middle Route Project

The main concern with the Middle Route Project is twofold. First is the major social problem as it displaces nearly 330 000 people due to the need to raise the Danjiangkou Dam on the Han River, a tributary of the Yangtze. Second is related to the impacts on environment and ecosystem due to the reduced flow along the middle and lower reaches of the Han River, between the Route intake and Wuhan (where the Han River flows into the Yangtze). The average annual surface runoff of the Han River is only around 39 km^3/yr and that drops considerably during dry years up to 19 km^3/yr. Thus, a diversion of nearly half of the annual flow during dry years would have a major impact on aquatic ecosystem and the environment downstream of the diversion point.

Map 8: Sketch Map of The Scheme of the Middle Route Project.
Source: http://www.nsbd.gov.cn/zx/english/mrp.htm

According to experts the short-term strategy for dealing with the drain on the Han River is to seasonally adjust the volume of water diverted. The long-term solution being discussed is to extend the diversion to the Three Gorges Reservoir farther south.

Western Route Project

For the Western Route Project, work is scheduled to begin in 2010 to 2015. The Western Route Project is planned to divert water from three tributaries of the Yangtze River to the Yellow River. It passes through remote regions where economic development is relatively very small compared to the burgeoning developments in the east.

Here, the upper stretches of the Yangtze and the Yellow River will be linked through more than 300 km of tunnels built in remote and mountainous terrain with an altitude of 4 000 metres. As the main part of the route is located around 4 000 metres above sea level, and with geological difficulties at the construction route, the cost is bound to be significantly higher.

Three dams are needed in the Yalong River (175 m), Tongtian River (302 m) and the Dadu River (296 m). There will be geological difficulties with regional earthquake levels of about 6-7 even 8-9 locally.

Because the elevation of the bed of the Yellow River is higher than that of the corresponding section of the Yangtze (by 80-450 meters), pumping stations will be necessary to move the water into the Yellow River. This infrastructural work is estimated to cost US$ 37.5 billion for a supply of about 20 km^3/yr. The total water needed for the whole of north China is 52 km^3/yr.

While the Eastern and Middle Routes are aimed directly at supporting China's burgeoning and prospering eastern cities, the Western Route would direct very expensive resources to further subsidizing with cheap water the grain farmers of China's middle west. Farmers in that region already draw large volumes of low-cost water from the Yellow River in Gansu, Ningxia, Inner Mongolia and Shaanxi, in producing low-value crops.

Pressure to promote economic development in China's poorer western provinces appears to be compelling middle planners to promise the construction of the Western Route Project.

Cumulatively, the three water diversions may impact on the environment and livelihoods of people living downstream along the Yangtze. Some forecast problems include declines in fisheries, coastal erosion, and ingress of seawater further up the Yangtze channel that may jeopardize Shanghai's water supply (Biswas *et al*. 1983; Ghassemi and White 2007). Consequently, Shanghai Municipal Government is investing 17 billion CNY ~ 2.5 billion US$ to build a drinking water storage reservoir on the Qingcao Island.

Analysis:
China needs a change of water management philosophy and this is already happening through improved water laws and policies adopted in recent years.

The South-North Water Transfer scheme is expensive and with fewer benefits compared to the alternatives. At an estimated cost of over US$ 59.9 billion it is not only costly to taxpayers, but also to the environment, especially for the Western and the Middle Routes.

There are alternatives at hand for saving water without damaging the environment, such as:

- Re-locating the water footprints of the North to appropriate regions in the South.
- Increasing system efficiency such as by enhancing distribution efficiency by reducing transmission losses.
- Improving water use efficiency, particularly in agriculture, by reducing subsidies for agricultural water use.;
- Increasing water reuse, including better pollution prevention and control and large-scale investment in water treatment facilities; and
- Recharging groundwater reserves and help in conserving water that can be later used in drought conditions.

Summary:

Where	**China: Eastern route (Lower reaches of Yangtze river)**
When	Started in December 2002, building on some existing projects. Planned completion in 2016.
Receiving basin	Yellow River Basin, Hai River Basin
Donating basin	Lower reaches of Yangtze
Distance	1 156 km (main route), discharge of 14.8 km^3/yr
Structures	Canal, tunnel, pumping stations
Cost	US$ 8.2 billion
Purposes	Irrigation Municipal and industrial water supply Ecological water for over-exploited northern rivers
Environmental cost	Sediment loss affecting riparian and coastal maintenance. Less dilution of pollutants. Invasive biota and chemicals in the passing lakes (Hongze, Luoma, Nansi, Dongping). Change of river patterns and in natural flow cycles of the rivers, disturbing the wildlife and ecosystems.
Social costs	About 72 000 people displaced.
Alternatives?	Improving water distribution efficiency. Re-location of the water footprints by virtual water transfers. Improving water distribution efficiency. Increase of water use efficiency and reduction of subsidies for agriculture water use. Recharging groundwater reserves and conserving water that can be later used in drought conditions.

Where	China: Middle route (middle reaches of Yangtze river)
When	Started in 2003. Completion is due by 2012
Receiving basin	Yellow River Basin, Hai River Basin: Beijing and Tianjin Municipalities and Hebei, Henan and Hubei provinces
Donating basin	Middle reaches of Yangtze (from Danjiangkou Reservoir of the Han River, a tributary of the Yangtze)
Distance	1 427 km (main route)
Structures	Canal, aqueduct, tunnel
Cost	US$ 14.7 billion
Purposes	Municipal and industrial water supply Irrigation
Environmental cost	Reducing water flow of donating basins
Social costs	Relocation of 330 000 inhabitants due to increase in size of Danjiangkou Reservoir and along the route itself.
Alternatives?	Improving water distribution efficiency. Re-location of the water footprints by virtual water transfers. Improving water distribution efficiency. Increase of water use efficiency and reduction of subsidies for agriculture water use. Recharging groundwater reserves and conserving water that can be later used in drought conditions.

Where	China: Western route (upper reaches of Yangtze river)
When	Still doing preliminary studies because of complex area
Receiving basin	Yellow River; Qinghai, Gansu, Shaanxi, Shanxi Provinces, the Ningxia Hui Autonomous Region and Inner Mongolia.
Donating basin	Tongtian River - the Upper reaches of Yangtze; Yalong and Dadu Rivers - the tributaries of the Yangtze.
Distance	450 km of tunnels, 20 km^3/yr may be the discharge.
Structures	Dams, tunnels, pumping stations.
Cost	37 billion US$ (only preliminary costs).
Purposes	Municipal and industrial water supply Irrigation Ecological water for northern rivers
Environmental cost	Vulnerable and fragile area Part of Tibetan mountainous ecoregion Water availability is not inexhaustible, especially in light of climate change with glaciers receding Real danger of earthquakes and landslides during construction
Social costs	Relocation of people, including minorities.
Alternatives?	Improving water distribution efficiency. Re-location of the water footprints by virtual water transfers. Improving water distribution efficiency. Increase of water use efficiency and reduction of subsidies for agriculture water use. Recharging groundwater reserves and conserving water that can be later used in drought conditions.

Conclusions - summary of lessons learnt

As was the case with the long established IBTs considered in Section 3, there are many common themes running through the four case studies of prospective transfer schemes reviewed here. The table below lists 11 so-named 'Process weaknesses or expected negative impacts from the IBT' these are also common to those identified as real negative impacts in Section 3 relating to the long-established IBTs.

In the following section, a step-wise approach to avoid these oft-repeated errors is presented and then illustrated with examples and tools that can be used to defer, delay or even totally avoid the need for an IBT.

It seems that despite the well-documented problems associated with the earliest IBTs, the lessons have not yet been learned and that decision makers continue to repeat the same errors when contemplating and then moving forward to initiate new schemes.

Needless to say, these interbasin transfer schemes that have been planned for decades have not incorporated emerging issues that are critical in justifying this investment, such as the alternative offered by trade in virtual water, nor threats to this inflexible infrastructure from the impacts of climate change.

Process weaknesses or expected negative impacts of IBT	**Case study**			
	4. Acheloos Diversion, Greece	**5. São Francisco Basin Interlinking Project, Brazil**	**6. Olmos Transfer Project, Peru**	**7. South-North Transfer, PR of China**
Demand management in recipient basin not serious part of pre-planning for IBT, potentially supporting on-going water wastage	✓	✓	✓	✓
IBT expected to become driver for unsustainable water use in recipient basin– irrigation and urban	✓	✓	✓	✓
Will create strong dependence on IBT in recipient community	✓	✓	✓	✓
Donor basin likely to experience serious environmental impacts through reduced flows especially	✓	-	✓	✓
IBT expected to create or escalate threats to critically endangered, threatened species, Ramsar sites, Natura 2000 sites etc	✓	-	✓	-
Scheme likely to see economic benefits in the recipient basin at the cost of communities in the donor basin	✓	✓	✓	✓
Inadequate consultations with those likely to be affected either directly or indirectly	✓	✓	✓	✓
IBT may become catalyst for social conflict between donor and recipient basins or with government	✓	✓	✓	✓
IBT is not expected to help the situation of the poor affected or displaced by it	-	✓	✓	✓
Post IBT mitigation costs expected to be very high, either environmentally or socially	✓	✓	✓	✓
Governance arrangements for IBT appear weak	-	✓	✓	-

5 Climate change

Supply side responses

Climate change will be felt first by most people in changes in water availability. Traditionally the water sector has assumed that water flows, while varying within a certain range from season to season and year to year, were predictable and thus 'stable'. These average flows are the basis for water infrastructure designs and investments. However the changes in precipitation and evapotranspiration are changing river inflows. Many regions, where a lot of people live, are expected to become drier, while other areas may become wetter. More frequent extreme events are expected: storms, floods and droughts. Melting glaciers may deprive many rivers of consistent seasonal flows. As a result more erratic and diminished water flows are anticipated in many rivers prompting proponents of supply side solutions call for accelerated investments in interbasin water transfer schemes and more water storage.

Unsurprisingly, industry proponents like the International Commission on Large Dams stridently propose more infrastructure investment: „An adequate and safe water supply is an essential component to our health, environment, communities and economy. But two major factors will increase the stakes: the incoming climate change, making the water resources more irregular, with drying trends necessitating more water storage; and the world population growth, increasing the demand for domestic, agricultural and industrial water with emphasis on irrigation for food production. Therefore, the crucial role dams played throughout human history will continue during the 21st century" (ICOLD 2007:5). Some academic assessments more cautiously support such measures, such as (Kabat and Schaik 2003:75) to say "Increased storage is a logical option to cope with changing hydrological parameters." The WWDR comments (WWAP 2009:81): "Today, in parts of many countries demand exceeds available runoff. These countries depend on dams and water harvesting systems to control irregular storm runoff. The situation is particularly acute in arid and semi-arid areas [...]. Increasingly, it will be impossible to do without some form of water storage, either surface (reservoirs or water-harvesting systems) or underground (cisterns and aquifers). Global changes, in particular the impacts of climate change, elevate the need for water storage to a higher priority". They qualify this by saying "Investments in physical infrastructure must be accompanied by investments in 'soft' infrastructure [...] However, while there is a strong relation between water investment and growth, the relation between the quantity of water used and a country's level of development is inconclusive [...] Many water-poor economies have developed, while the ratio of water use to GDP in many developed countries has been declining" (WWAP 2009:83). Many of these proponents are vague on the extent to which they propose to rely on less-contentious water storage via natural wetlands, rainwater harvesting and better groundwater management, versus more dams and IBTs. The Intergovernmental Panel on Climate Change (IPCC) is even more cautious is stating "With increased temporal runoff variability due to climate change, increased water storage behind dams may be beneficial, especially where annual runoff does not decrease significantly" (Bates *et al*. 2008:12).

A number of governments are now using climate change to justify more water infrastructure. The "Water guide" prepared for the 2009 5th World Water Forum's ministerial declaration, while making reference to "non-structural adaptation measures," claims that: "National and sub-national strategies need to be developed for adaptation to climate change/variability [...] Assessments of needed infrastructure for adaptation should be carried out and then required infrastructure planned and financed. [...] Hydropower development and inland navigation needs to be revisited and developed as an adaptation measure." It goes onto call on decision makers to "Invest in sustainable and socially responsible hydropower and water storage [...] as hydropower is an effective adaptation measure in the context of climate change" and "Enhance inland waterborne transport." (MFAT and WWC 2009:4-5).

Individual governments have included interbasin water transfer schemes in their climate change policies. For instance, China's national plan in relation to water and adaptation lists a number of ecosystem bases actions but goes onto promise: "Strengthen infrastructure planning and construction. Speed up building of the Project of South-to-North Water Diversion [case study above], and gradually generate the new pattern of optimized water resources allocation by three water diversion lines linking the Yangtze River, Yellow River, Huaihe River, and Haihe River, characterized by "four horizontal and three vertical lines". Enhance the construction and improvement of key water control projects (reservoirs, etc) and infrastructures in irrigation areas. Continue the construction of regional water storage and water diversion projects" (NDRC 2007:50-51). Similarly the Indian Government's plan commits to "augment storage capacity" (PMCCC 2008:31).

Water grids
A number of jurisdictions have proposed "water grids" as a solution, namely networks of interbasin water infrastructure that may enable water to be moved in any direction to where it is required. The ideological underpinnings of this approach can be grasped in the words of Reynolds, an early proponent, who purported to assess „Phases in the history of the development and use of water resources" to define water grids as "A possible ultimate pattern of such development" (Reynolds 1979:147). As drought, or the first step changes in climate began to threaten the water supplies of a number of eastern Australian cities this decade, their state governments responded in hastily prepared plans to invest heavily in establishing such water grids.

The Queensland Government is spending AUD $ 9 billion (~ US$ 7.4 billion) on a South East Queensland Water Grid that they describe as the "largest urban drought response in Australia". The project involves more than 450 kilometres of pipeline, two new dams, a desalination plant and three advanced water treatment plants to deliver around 350 million $m^3$of additional water a year (QWC 2008). The plans have many sensible elements, like a greater reliance on recycled water, but also include questionable elements, such as a proposed interbasin transfer from a new and shallow dam at Traveston Crossing on the ecologically sensitive Mary River.

Two of five key strategies in the Victorian Government's plan (DSE 2007) involve creating a water grid in that state, with six links under construction and investigation into the feasibility of a seventh project. These links include some sensible elements, such as replacing thousands of kilometres of leaky open channels with a more water efficient pipeline system in the Wimmera-Mallee region. Other transfers make little sense, such as the Sugarloaf Interconnector that would take water to Melbourne from the Goulburn River a major tributary of the water-stressed River Murray. Prepared with little apparent assessment of the likely climate change impacts, in theory government investment in greater water efficiency (to save an estimate 225 million m^3 in the first stage) in a major irrigation district will allow a third of the saved water to be allocated to environmental flows, a third to expanding irrigation, and a third for export to the city. However a subsequent climate change assessment suggested that the Goulburn River is among the most over-allocated catchments and among the tributaries likely to be most heavily impacted by reduced inflows resulting from climate change (-14% in the 2030 median forecast; CSIRO 2008:33-35). Even worse, eight years of the current drought (or climate change) in south eastern Australia has reduced River Murray inflows by 70% compared to long term average levels, much lower than those estimated for 2030 (MDBA 2009). Thus even if the water efficiency saving are achieved in the irrigation district, it is highly unlikely that there will be any water to transfer to Melbourne in dry times when it is needed.

What is apparent is that these Australian states are also responding to water scarcity with demand management measures and by diversifying their water sources, and there is considerable scope to expand these options. New government proposals to secure water in south east Queensland include reducing per capita water consumption by 24% over the next 50 years, and sourcing 30% of supplies from recycled water and desalination (QWC 2008). For instance Melbourne has reduced its water use by 22%, use of recycled water has increased from 2 to 14% from 1999 to 2007, and the government plans to produce 100 million m^3 of high-quality recycled water by 2012 (DSE 2007).

Risks from supply side responses and alternatives
In contrast to the proponents of more large-scale water infrastructure, a growing number of assessments have focussed instead on the risks in making large investments in inflexible infrastructure when climate change means that hydrology is no longer stationary. Instead they consider the need for "no and low regrets" water management measures to adapt to climate change that can be scaled up quickly as required.

Frederick (1997:141) was early in recognising the inherent risks in relying on supply-side solutions, declaring "Although new infrastructure may be an appropriate response to climate-induced shifts in hydrologic regimes and water demands, it is difficult to plan for and justify expensive new projects when the magnitude, timing, and even the direction of the changes are unknown." Instead, to adapt water management to climate change Frederick promotes: integrated river basin management; demand management; greater reliance on markets and prices to allocate supplies and introduce incentives to conserve; and better planning.

The IPCC also considers the issue, stating that: "The consequences of climate change may alter the reliability of current water management systems and water-related infrastructure". It goes onto conclude: "Adaptation options designed to ensure water supply during average and drought conditions require integrated demand-side as well as supply-side strategies. The former improve water-use efficiency, e.g. by recycling water. Expanded use of economic incentives, including metering and pricing to encourage water conservation and development of water markets and implementation of virtual water trade, holds considerable promise for water savings and reallocation of water to highly valued uses. Supply-side strategies generally involve increases in storage capacity, abstraction from water courses, and water transfers. Integrated water resources management provides an important framework to achieve adaptation measures across socio-economic, environmental and administrative systems. To be effective, integrated approaches must occur at the appropriate scale or scales needed to facilitate effective actions for specific outcomes" (Bates *et al*. 2008:5-6).

The Dialogue on Water and Climate through a series of thematic and geographic case studies and global discussion examined how water managers cope with today's climate variability and future climate change. In addition to building capacity they identified an extensive array of adaptation options that were categorised as: policy instruments; technological and structural instruments; risk sharing and spreading (insurance and finance); and change of use, activity or location (Kabat and Schaik 2003:61). Interbasin transfers were not explicitly proposed as an option but use of surface and ground water storage were identified as possible coping measures.

Moench and Stapleton (2007) assessed priorities for action in climate risk management based largely on their work in developing countries. In emphasizing the complementary nature of investment in infrastructure and "living with water", they conclude that climate-water risk management decisions need to be specific to locations and context, and that training a new generation of specialists to apply the concepts and tools is required. They identify four techniques that need to be developed for better climate water risk reduction, namely: spatial planning to reduce vulnerability; financial mechanisms, particularly insurance; economic diversification, including the use of virtual water and strategy shifting; and living with water (Moench and Stapleton 2007:71-73).

Hallegatte (2009) reviewed strategies to adapt water management to climate change, emphasizing that "new infrastructure will have to be able to cope with a large range of changing climatic conditions", and that uncertainty on climate impacts makes it impractical to use climate forecasts for infrastructure design, adding that "there are good reasons to think that the needed climate information will not be available soon." Instead, Hallegatte (2009:240) recommends more robust, risk management approaches, namely:

i) Selecting "no-regrets" strategies that yield benefits even in the absence of climate change;
ii) Favouring reversible and flexible options;
iii) Buying "safety margins" in new investments;
iv) Promoting soft adaption strategies; and
v) Reducing decision time horizons.

These more considered assessments on how to sustain water supplies and freshwater ecosystems in the face of climate change highlight the risks that more surface water storage and transfer infrastructure could prove: redundant as hydrology changes; more costly than a range of alternatives that are available; and prop up unsustainable practices rather than facilitating change to more robust livelihoods. These assessments emphasise the large role of non-infrastructural interventions, such as insurance, and of robust measures like conjunctive groundwater use as more flexible adaptation to climate change.

6 Alternatives to Interbasin Water Transfers

The preceding sections have focussed on established or proposed interbasin water transfers and strongly illustrate the case that in most instances these water infrastructure proposals come with a range of generally unacceptable or unnecessary social, economic and environmental costs.

To reiterate, established IBTs are typically characterised by the following negative attributes:

- Demand management in the recipient basin was not a serious part of pre-planning for IBT, leading to on-going water wastage there;
- The IBT became a driver for unsustainable irrigation or urban water use in the recipient basin;
- The scheme created strong dependence on the IBT in the recipient community, thus promoting unsustainable activities, and removing the need to improve water use efficiencies or find alternative water sources/supplies;
- The IBT is now seen as inadequate and other water supplementation approaches have been required such groundwater extraction, desalinisation, recycling etc;
- The donor basin experiences serious environmental impacts through reduced flows especially;
- The IBT created or escalated threats to critically endangered, threatened species, Ramsar listed wetlands, protected areas sites etc;
- The transfer scheme saw economic benefits in recipient basin at the cost of communities in the donor basin;
- The IBT served as a catalyst for social conflict between the donor and recipient basins or with government;
- The IBT has not helped the situation of the poor affected or displaced by it;
- Post IBT mitigation costs have proven very high, either environmentally or socially;
- Governance arrangements for some IBT's are weak, resulting in budget blow-outs or corruption (in some cases): and,
- Climate change impacts have generally not been considered in planning these IBTs increasing the risk that these large, inflexible investments may become largely redundant.

In section 3 it was noted that the lessons we can learn from existing IBTs are as follows:

1. Before progressing to commission an IBT, there should be a comprehensive assessment of the alternatives available for providing the water needed in the proposed recipient basin. Can this water be provided through demand management, water recycling, water harvesting, virtual water trades etc, before considering a major infrastructure investment with its possible environmental and social impacts? Or is there an alternative to meet this demand by importing water intensive products from water rich regions, thus promoting virtual water transfer rather than to rely on real water transfers?
2. Undertake a cost-benefit analysis of the likely impacts of the IBT on both the donor and recipient basins, considering the full range of environmental, social and economic implications.
3. Ensure risks associated with the proposed IBT; environmental (including climatic), social and economic are clearly understood, and if the project proceeds, governance arrangements are adequate to manage and minimise these risks.
4. Undertake consultations with the likely directly and indirectly affected people, before a decision is taken regarding the possible IBT (and certainly before it becomes fait accompli) ensuring they understand and have the opportunity to voice views on likely cost, benefits and risks.

Addressing the key weaknesses in IBT planning

What stands out among the IBT case studies documented in this report, and elsewhere, are the following:

1. Apart from hydropower generation, a common driver of IBTs is a desire to promote agricultural production in water poor areas, and, in particular irrigated agriculture. This can see unsustainable cropping practices promoted by the IBT when perhaps this was unwise;
2. There is typically a failure to examine alternatives to the IBT that may mean delaying, deferring or avoiding the costs of an IBT; and
3. There are a range of governance failures ranging from poor to non-existent consultation with affected people, to failing to give sufficient consideration or weight to the environmental, social and cultural impacts of the IBT, in both the donor and recipient basins.

In the following section each of these is examined more closely.

6.1 IBTs promoting agricultural production in water poor areas

Globally agriculture consumes around 70% of the water diverted for human use, and most of this water does not reach the plants it was intended to sustain. A massive growth in demand for agricultural expansion, driven by growing wealth in many countries, poverty reduction programs and increasingly the growth of crops for biofuels, threatens to consume even more water. International Water Management Institute & Stockholm International Water Institutes forecast that eradicating malnutrition by 2025, with current productivity, requires additional diversions "*close to all the water withdrawals at present*" (IWMI & SIWI 2004). As key rivers, ranging from the Rio Grande/Bravo, to the Nile and the Indus, increasingly fail to reach the sea, this poor water management is a source of tension between countries.

With many IBTs being driven by agricultural water demands, it is important to assess the economic viability of agricultural practices in the proposed recipient basin. As several of the case studies documented here reveal, the creation of an IBT can (or will) stimulate expansion of agricultural activities, especially irrigation, in areas that may not be suited to this climatically or otherwise. It can also foster the establishment of such agricultural activities with a reliance on under-priced (meaning subsidised) IBT-sourced water; such a reliance not being sustainable in the long-term.

As seen in the situation of the Upper Acheloos Diversion project in Greece (see case study 4 in section 4), the IBT is justified (in large part) on the premise that it will sustain the agricultural industry, and in particular the cotton production in the Thessaly plains. It is however highly questionable whether cotton production here would be economically viable without the large subsidies it receives. Within the EU, only Spain and Greece have sizeable cotton production and in 2001 together they accounted for 2.5% of cotton production and 6% of world exports in cotton. At the same time they received 16% of world cotton subsidies. In 2002/03 it is estimated that under the EU's common agricultural policy (CAP), subsidies exceeded US$ 900 million (Gillson *et al* 2004).

6.2 IBTs that fail to examine alternatives

Examining the alternatives to IBTs should be considered before embarking on engineering-based solutions to regional water shortages. Such alternatives may reveal that the development of an IBT can be delayed, deferred for several years, or perhaps avoided altogether. Global experiences show that all too often the decision is taken to proceed with an IBT before these alternatives are fully considered. While these alternatives may take longer to analyse, and even implement, if they avoid the environmental, social and economic costs of the typical IBT then they are clearly worth the investment.

In a major assessment of IBTs, Ghassemi and White (2007:24) declare that "policy makers and water resources managers of basins with apparent water shortages should firstly exhaust all possibilities for better management of their own water by:

1) Eliminating losses in their current water supply network;
2) Increase water use efficiencies;
3) Conjunctive use of water and ground water resources;
4) Increasing water prices to promote water use efficiency and shift water use from low value to higher value production systems;
5) Reclamation of wastewater in municipal areas; reviewing policy and regulations; and improving monitoring.'

Ghassemi and White (2007:354) go onto describe "Water conservation measures that can be used as a substitute for interbasin water transfer projects and new sources of water supply include the following" and go onto detail:

- Increasing water use efficiency;
- Water trading;
- Wastewater reclamation;
- Conjunctive use of surface and groundwater;
- Water metering and pricing;
- Cloud seeding;
- Water desalination; and
- Building new dams.

In moving to examine the alternatives to an IBT, WWF recommends the following systematic and step-wise approach. As considered further in sections 5.3 and 7, ideally these options are considered at a whole-of-river-basin level, through an integrated planning process.

The alternatives should be considered in the following order:

A. Demand Management

1. Reducing water demands;
2. Recycling waste water;
3. Assessing and promoting land use management or industrial development alternatives.

B. Supply Management

4. Trading in virtual water, and only then,
5. Supplementing water supplies locally, and only then,
6. Desalination in water-scarce coastal areas, and only then,
7. Considering an IBT, as a last option.

Below, each of these options are examined more closely and in many cases illustrated with real life examples or tools that can be used to see them applied.

6.2.1 Reducing water demands

Demand management simply means manipulating or adjusting water demands so they don't exceed supplies. Demand management is fundamentally about finding water use efficiencies wherever they are available across the many ways that society uses water. Demand management is, to use financial terms, 'living within ones means', or 'not overspending the budget'. Such water efficiencies exist in almost every facet of water use and the task is to identify them, raise awareness on them of them, and find ways, means and incentives to see these water savings achieved.

Here, WWF outlines some of these demand management options in more detail:

Domestic and urban water users

Globally, households use only about 10% of water diverted (Turton & Henwood 2002), and some of the water saving practices available in the home include:

- Reducing water application on the garden (for example, through planting species that require less water, mulching around plants, using 'grey water', installing more efficient watering systems etc);
- Closing taps while brushing teeth;
- Installing low-flush-toilets;
- Repairing leaking taps;
- Washing the car, motorbike or bike with a bucket instead of a garden hose;
- Washing dishes in a tub instead of under running water; and
- Installing low-flow shower heads.

An example of where these types of measures have been promoted successfully is in south-east Queensland on the eastern seaboard of Australia (see box below).

In another example, the Environment Agency of England and Wales has recently identified metering water use, from 33% of households today, and charging for water use by volume as having the greatest potential to reduce emissions associated with water supply through improved household water efficiency.

Education programs - a key tool in demand management

To create a better understanding of water issues and help resolve water resource problems, educational programs are highly recommended. Community, industry and school education programs raise awareness about the need to conserve water and to bring about long term changes in water consumption behaviour. This is only possible if the targeted community is able to obtain the necessary knowledge and gain understanding of water management that can then be adapted to their own needs and local circumstances (AWA 2005).

Most successful are education programs that are providing practical solutions. Water education programs for primary and secondary schools are encouraged so as to promote awareness in the next generation of decision makers.

Important aspects of such programs are that they provide the person with some real life examples to point him/her in the right direction; that include simple water saving ideas which do not change their way of living and that are geographically relevant at local, regional and national levels.

In general, water costs are not well reflected in the price of products due to the subsidies in the water sector, particularly for agricultural users. The general public is, although often aware of energy requirements, much less aware of the water requirements in producing their goods and services (Chapagain & Hoekstra 2004). This presents an opportunity to change water use-related purchasing behaviour through education.

Box: Household water efficiency measures promoted in a region of Australia

South East Queensland (Australia):
Water demand management is in part about increasing public awareness of water issues and encouraging more efficient use of water, without diminishing quality of life. Society needs to treat water as a valuable resource.

There needs to be a focus on educating the community so that they are able to gain an understanding of the economic and ecological benefits of reducing water consumption.

An example of such management is in south-east Queensland where there has been a reduction of water demand by up to 18% in some local government areas (AWA 2005).

Examples of some of the initiatives used include:

- User-pays pricing and universal water metering;
- Encouragement of the installation of water efficient devices using rebates/discounts, for example, dual flush toilets and low flow shower heads;
- Routine restrictions on garden watering;
- Incentives for plumbing efficiency 'check-ups';
- Educational campaigns; and
- Lowering water pressure in districts where this is feasible.

Agricultural water users
Currently, 16% of global cropland is irrigated, producing 40% of all food. This makes irrigated agriculture about 3.6 times more productive per unit-area than non-irrigated agriculture (Chapagain Orr 2008).

The *Comprehensive Assessment of Water Management in Agriculture* (CAoWMiA 2007:2-14) recently assessed the options for meeting the world's need for agricultural produce with available water supplies. They warn that "Without further improvements in water productivity or major shifts in production patterns, the amount of water consumed by evapotranspiration in agriculture will increase by 70%–90% by 2050. The total amount of water evaporated in crop production would amount to 12 000–13 500 cubic kilometers, almost doubling the 7 130 cubic kilometers of today. […] On top of this is the amount of water needed to produce fiber and biomass for energy". The assessment goes onto highlight that: "75% of the additional food we need over the next decades could be met by bringing the production levels of the world's low-yield farmers up to 80% of what high-yield farmers get from comparable land. […] the greatest potential increases in yields are in rainfed areas, where many of the world's poorest rural people live and where managing water is the key to such increases. […] while there will probably be some need to expand the amount of land we irrigate to feed 8–9 billion people […] there is real scope to improve production on many existing irrigated lands." They note that: "A 35% increase in water productivity could reduce additional crop water consumption from 80% to 20%." The assessment concludes by recommending eight policy actions to:

1) Change the way we think about water and agriculture.
2) Fight poverty by improving access to agricultural water and its use.
3) Manage agriculture to enhance ecosystem services.
4) Increase the productivity of water.
5) Upgrade rainfed systems—a little water can go a long way.
6) Adapt yesterday's irrigation to tomorrow's needs.
7) Reform the reform process—targeting state institutions.
8) Deal with tradeoffs and make difficult choices.

Implementing measures for conserving and making more efficient use of the water already allocated to agriculture is a most appealing first option. This is especially so given that current overall water-use efficiency is low: only an estimated 37% per cent of diverted waters is effectively consumed by the crops for which they are intended (WWAP 2009:115). The many opportunities that exist for improving water efficiency, in both irrigated and rain-fed agriculture, mean that more food could be grown without increasing existing levels of water use. There are two basic means by which water-use efficiency can be improved:

(a) increasing the share of the water actually taken up by plants, and
(b) producing more crop per unit of water (WWF 2003a).

Water-saving practices in agriculture include (WWF 2003a):

- Broad bed cultivation is a useful method, particularly in irrigated wheat;
- Alternate furrow cultivation of beans and maize is an alternative to save water (up to 50% in Pakistan);
- Cultivation of aerobic rice varieties;
- Drip and sprinkler irrigation for sugarcane, cotton and wheat;
- Use of the no-tillage approach;
- Growing different crops that require less water; and
- Change to organically grown crops.

To further improve water use efficiency within the production of crops the accurate measurement of water use on a crop and farm scale is the first step.

6.2.2 Recycling waste waters

To some water management practitioners, recycling waste or used water falls within the realm of demand management. Here it is considered separately to draw attention to the potential that it offers as part of the alternatives to the construction of an IBT scheme.

Treatment and then reuse of water from irrigation and stormwater drainage, sewage and other effluents, industry and utilities can greatly supplement local water supplies. The annual reclaimed water volumes total about 2.2 billion m^3, based on 2000 and 2001 figures from the World Bank (WWAP 2006). On a global scale, non-potable water reuse is currently the dominant means of supplementing supplies for irrigation, industrial cooling, river flows and other applications. Due to increases in potable water consumption, the total volume of these recycled resources is likely to increase by 3-5% per year based on current water use patterns (UNDP 2004).

Yet in some cultures, reuse of water has not yet been publicly accepted. According to surveys, the best water reuse projects in terms of economic viability and public acceptance are those that substitute reclaimed water in lieu of potable water for use in irrigation, environmental restoration, cleaning, toilet flushing and industrial uses.

The volume of water available for reuse is considerable, with the advantage being that there is a guaranteed supply, which is not dependant on weather patterns. Some forms (and mechanisms) of water reuse include (AWA 2005; Shelef 2001):

- Indirect reuse via river or water storage;
- Aquifer storage and recovery of reused water or stormwater. Recharge of groundwater to create a barrier to seawater intrusion;
- Industrial reuse;
- Dual reticulation supply of reused water;
- Grey water reuse (for example, toilet flushing in hotels, office buildings and high-rise buildings, using dual water distribution systems);
- Augmentation of recreational bodies of water;
- Irrigation of public parks, sport fields, etc.;
- Street washing;
- Car and train washing; and
- Water for fire hydrants.

6.2.3 Virtual water trade

Another way to consider the merit of IBTs for promoting agriculture is through the concept of ‚virtual water‘. Term is used to describe the amount of water used in the production process of goods (Hoekstra and Chapagain 2008). For example, the production of 1 kg of beef requires 16 000 litres of water, though we should be careful when and where this water is being used in the process. As goods are traded across the globe, or between regions within countries, virtual water is transferred. According to Hoekstra and Chapagain, this virtual water trade can be an important instrument in achieving water security and efficient use of water, and they argue that virtual water trade between or within nations can be a feasible alternative to the actual transport of water through interbasin transfer schemes. Global virtual water flows during the period 1997-2001 added up to 1 625 km^3/yr (compared to an estimated 400 km^3/yr in interbasin water transfers; Shiklomanov 1999), with the major share (61%) of the virtual water flows between countries is related to international trade in crops and crop products, 17% is related to the trade in livestock products and the rest is related to the industrial products (Chapagain

Box: Examples of where ‘virtual water’ is a factor in IBT-related decision making

Southern Africa:
The trade in virtual water can potentially offer an alternative to expensive water transfer schemes in Southern Africa. Earle and Turton (2003) pose that there are a number of states in the Southern Africa Development Community, such as Angola, DR of Congo, Zambia and Mozambique, that are well suited for grain production and have the potential to become surplus producers. These surpluses could then be exported to the richer, water stressed nations within the region, such as South Africa, thus reducing the need for physical transfers of water there. To achieve this would require substantial investments in agriculture and grain transfer systems, but this could well be both more economically, as well as environmentally sustainable, particularly if productivity of existing crop lands can be enhanced.

Morocco and Europe:
WWF undertook an assessment on virtual water transfers from water scarce Morocco in July 2006.

Morocco’s horticulture sector has established links to European markets because of its favourable location, growing climate and francophone history. Tomato farms in Souss Massa boast a modernised industry with a high degree of technical expertise and tools. Technology transfer occurs in this sector with workers and business people travelling between Spain and Morocco, returning and applying the latest advances in crop production techniques. If EU quotas are eventually lifted, then Morocco will take advantage of much lower labour costs to concentrate on more high-value products.

Economic development in Morocco has been stimulated in part by the rise of export intensive irrigated agriculture and is seen as a vital employment sector for the country’s future. Currently agriculture represents 80% of rural employment and more than 40% of national employment. Intensive export-led agriculture has increased pressures on the environment and the natural resource base, but most profoundly on freshwater. If current water use patterns were to remain constant, water availability per capita would be halved by 2020. Trade restrictions, tax exemptions, price support and water subsidies are designed to protect the cereal-dominated agricultural sector, which uses huge amounts of scarce water resources inefficiently.

Virtual water experts point out that this problem could be averted by relying on cereal crops from international markets, produced in areas with favourable growing conditions for wheat. However, a national desire for food self sufficiency often over-rides rational discussion as to the optimal allocation of water.

Irrigated agriculture currently uses 83% of all diverted water in Morocco, where recent droughts have aggravated water shortages. This highlights the need for new approaches in national and local water management. This would require a more balanced distribution of water use, including adequate pricing measures, to ensure long term sustainability.

Spain and the UK
A study by Chapagain and Orr on virtual water shows that the EU consumes 957 000 tons of Spanish fresh tomatoes annually, which evaporates 71 million m^3/yr of water and would require 7 million m^3/yr of water to dilute leached nitrates in Spain. In Spain, tomato production alone evaporates 297 million m^3/yr and pollutes 29 million m^3/yr of freshwater. Depending upon the local agro-climatic character, status of water resources, total tomato production volumes and production system, the impact of EU consumption of fresh tomatoes on Spanish fresh water is very location specific. They further argue that unlike the emission of gases and their global mixing effect, polluted water is more localised in its impact, while the consequence of having a larger or smaller water footprint created by an individual or a nation can be felt directly at locations from where those imports originate.

Hence, re-locating the water footprints by virtual water transfers also needs to be critically examined as the consequences sometimes might be counter productive. Chapagain and Orr (2008) suggest that the technical solutions to improve the impacts of a water footprint could involve buying and sourcing products from regions of higher water abundance or from areas of higher water efficiency. Similarly, sourcing from areas where the virtual water content of the products is made-up with a majority of green water (effective use of rain water) use of could reduce the need to mobilise water from fresh water bodies. An understanding of water impacts is one criterion among many when making decisions, but is a crucial element in determining how we can adapt to the challenges of facing growing populations’ demand on limited water resources.

and Hoekstra (2009). They calculated that 16% of the global water use is not meant for domestic consumption but for export. A recent study by WWF-UK shows that UK relies nearly 62% on external water resources for the goods and services consumed internally (Chapagain and Orr 2008). A similar study by WWF-Germany shows that Germany is 50% dependent on external water resources to meet its water demands (Sonnenberg *et al*. 2009). These studies clearly show that how pivotal trade can be in mitigating water demands.

Before progressing to commission an IBT, there should be a comprehensive assessment of the alternatives available for providing the water needed in the proposed recipient basin. Can this water be provided through demand management, water recycling, water harvesting etc, before considering a major (and usually high cost) infrastructure investment with its possible environmental and social impacts? Or, is there an alternative to meet the demands by re-distributing the water footprints to regions with water surpluses (transferring virtual water rather than real water across river basins)?

A review of food flows, and subsequently virtual water trade, in China (Ma *et al*., 2006) found that there is a food surplus in north China, and a food deficit in south China, which is balanced on a national scale through import of agricultural products from the north to the south. In 1999, south China imported (amongst other commodities) 17 million tons of grain, 23 million tons of vegetables and 2.4 million tons of dairy products from north China. Together with imports of eggs, meat and fruit this represented a virtual water import of nearly 52 km^3/yr. In comparison, the maximum amount of water transferred under the three routes of the South-North transfer (see case study 7 in section 4) is in the order of 38-43 km^3/yr. These figures raise the question whether the physical transfer of water from south to north over such long distances, and at such expense makes economic sense, when even larger amounts of virtual water are transported back from north to south. Other examples of ‘virtual water’ as a consideration in IBT development are given in the box below.

There are no easy answers to these questions, but it does indicate the need for more research into whether some of the water shortages in north China can be addressed otherwise than through IBT.

6.2.4 Supplementing water supplies locally

Rainwater harvesting

Rainwater management, also known as harvesting, is receiving renewed attention as an alternative to, or a means of, augmenting water supplies.

Intercepting and collecting rainwater where it falls is a practice that extends back to pre-biblical times. It was used 4 000 years ago in Palestine and Greece and in South Asia over the last 8 000 years. In ancient Rome, paved courtyards captured rain that supplemented the city’s supply from aqueducts and as early as 3000 BC, in Baluchistan, farming communities impounded rainwater for irrigation.

Recently in India, harvesting has been used extensively to directly recharge groundwater at rates exceeding natural recharge conditions. Reports from other international organizations focusing on this area indicate that eleven recent projects across Delhi resulted in groundwater level increases of from 5 to 10 metres in just two years. In fact, the application of rainwater management in India is likely to be one of the most modern in the world.

The site www.rainwaterharvesting.org provides links to cases where rainwater management has been successfully applied in different nations in both urban and rural settings.

An advantage of rainwater harvesting is that its costs are relatively modest and that individual or community programs can locally develop and manage the required infrastructures (collection devices, basins, storage tanks, surface or below-ground recharge structures or wells).

Larger scale rainwater harvesting schemes, which intercept runoff using low-height berms or spreading dikes to increase infiltration, have also been introduced in upstream catchments where deforestation has decreased water availability (WWAP, 2006). A word of caution is warranted here however, as in some parts of Australia (for example) the large scale interception of overland run-off flows to support irrigated ‘thirsty crop’ agriculture in arid and semi-arid areas has denied this water from other downstream users, notably graziers. Large, shallow impoundments are used to store this water, from which evaporation rates are very high.

Downstream rivers are suffering, including significant wetlands areas. Rainwater harvesting such as this is highly inefficient and not in the best interests of the majority of those downstream within the basin.

Restoring traditional water management structures
The restoration of traditional water harvesting technologies is proving to be a beneficial means of improving modern water supplies in some countries. An example, are the traditional water storage systems, known as tanks, found in the mid-Godavari basin of India. These tanks have a history of 1 500 years with some of the systems built in 1100 AD perfectly functioning even today in the Warangal district.

These systems were designed and built to meet several social, economic and ecological functions. Primarily they store monsoon rain to meet the agricultural, fisheries, religious, grazing, groundwater recharge, washing and drinking water needs of the people as well for livestock water supplies. Every village in the southern parts of India and Sri Lanka has more than one traditional tank.

Photo 8: Restored village water tanks near Wrangal, India. There are around 209 000 such tanks in India that could be part of an alternative to IBTs. © J. Pittock

Using GIS techniques within the Maner sub-basin (an area of 13 033 km^2) of the Godavari River of India, WWF recently identified 6 234 traditional water tanks, covering an area of 58 870 ha or about 5% of the region. Of these, 57 tanks are more than 100 ha in area. If restored to 3 metres average depth, these 6 234 tanks could hold about 1.74 billion m^3 of water, by just capturing 15-20% of the rainfall (Gujja *et al.* in press).

The restoration of these tanks has three major benefits:

a) the silt and clay removed from the tanks can be spread on fields to improve the fertility and water holding capacity of farm soils, reducing the need for artificial fertilisers, improving crop productivity immediately, and recovering the costs;
b) most of the restoration work can be done by the community, thus generating local employment; and
c) restoration will recharge the extensive areas of depleted groundwater aquifers, restoring use of many existing wells that have dried up.

In this way the water needs of some of the poorest rural communities across an extensive region of the Deccan Plateau can be met without resorting to expensive water infrastructure. Presently the irrigated area in the Maner sub-basin is around 400 000 ha. Through renovating the traditional tanks this irrigated area can be provided with more assured water and also support an increase in area for irrigated crops of another 200,000 ha. An estimate of the finances required to renovate all the tanks to 3 m depth is in the order of US$ 635 million over five years. This is much cheaper than construction of large dams and transfers to serve the same purpose. For example, the 2.13 billion m^3 dam proposed on the Godavari River at Polavaram to divert 8.13 billion m^3 of water per year to the coastal plains (Gujja *et al.* 2006) – part of the Indian Government's proposed interlinking of rivers scheme - is expected to irrigate only 290 000 ha and has a cost of ~US$ 4 billion. The dam will also remove more than 250 000 people from their traditional homes and submerge more than 60 000 ha of productive land and forest.

6.2.5 Desalination

Use of desalinisation is increasing, especially in water-scarce coastal areas, including the USA, Mediterranean basin and the Middle East, India, China, Australia and small island states. There is also a desalinisation proposal for London.

Criticised as 'bottled energy', desalination could provide a reliable source of potable water without being reliant on rainfall. However, desalinisation is an 'energy hungry' process and critics point to this as a negative of this option when it relies on energy derived from fossil fuels. Environmental problems associated with desalinisation include disposal of the waste brine solution and biocides used to wash the plant membranes. In spite of major advances in energy efficiency, these major problems remain an obstacle to the wider use of desalinisation technologies (AWA 2005).

WWF assessed this technology (Dickie 2007) and proposed a framework for making economically and environmentally sound decisions on large scale projects. In WWF's view supply-side investments in desalination plants raise some similar questions as for interbasin transfer scheme. WWF recommends considering desalination and in particular seawater desalination as an option only:

- after integrated water resource management plans are in place at the catchment and local levels and these demonstrate a need to augment water supplies;
- for seawater desalination, after relevant marine protection plans are in place;
- where robust land use planning schemes that give adequate weight to environmental constraints exist and are enforced. These may include provisions to manage demand through the exclusion of thirsty developments such as irrigated agriculture or golf courses from water scarce districts;
- after all no regrets conservation and efficiency measures have already been undertaken or allowed for in the assessment of water needs in the proposed area of supply. Implementation plans backed by adequate resourcing should exist for medium and longer term water conservation and efficiency measures;
- where water, including agricultural water, is appropriately priced to reflect the full costs of supply. Where social reasons exist for reducing the real cost of water, the subsidies should be directed specifically to the target group, should be transparent and should not be applied to the water price;
- where the capital expenditure devoted to desalination plants could not be more productively or cost-effectively be devoted to:
    - demand management as an alternative to additional supply
    - using related technologies to recycle water;
    - using related technologies to treat "impaired water" resulting from prior poor environmental practice;
    - restoring the functioning of damaged natural water supply systems.

Like interbasin transfer schemes, desalination plants can use a lot of energy, especially in pumping. WWF recommends that such plants should be made climate neutral. Accordingly plant promoters and approval agencies need to ensure that plants are:

- designed to use the most energy efficient technologies
- developed in stages to take advantage of improving energy efficiency.
- sited with due regard to the need to protect sensitive areas and minimise the energy required to pump water to consumers
- powered through renewable energy, purchase green energy or use "Gold Standard" offsets for all their emissions.

WWF's policy on desalination plants further emphasizes the need to ensure desalination plants are not subsidized, that their deployment is not driven by nor supports water-inefficient downstream impacts, and that there is further research on the environmental impacts.

6.2.6 Consider IBTs as a last option

Any proposal for an IBT should be placed under the decision making microscope before a decision is taken to proceed. Too often the very viable alternatives to an IBT are not given sufficient attention in such decisions. The evidence is clear that these schemes can offer solutions to water shortage problems that are less costly, less damaging to the environment and less disruptive and divisive in society. Frequent environmental omissions in the pre-planning and execution of IBTs are the provision of adequate environmental flows within the donor basin, and the management of invasive species transferred with the water between basins. Decision makers owe it to their constituents to undertake comprehensive cost-benefit and risk assessments as part of reaching a decision in relation to any proposed IBT, as proposed by the WCD (2000) and is addressed in the Section I of the Sustainability Assessment Protocol (HSAF 2009).

6.3 Governance failures in river basin level planning

It was noted in the introduction to this section that one of the attributes evident in the IBT case studies documented in this report (and elsewhere also) is the failure of governance arrangements to ensure that comprehensive cost-benefit and risk assessments form part of IBT-related decision making. Molle (2008) in an incisive assessment of the societal determinants of river basin closure identifies eight main drivers for over-committing water resources and 'over-building' water infrastructure that are equally applicable to interbasin transfer schemes:

1) The political economy (benefits) of river basin development;
2) Ideology and state building;
3) Fuzziness of water rights and double accounting;
4) The malleability of cost-benefit analysis;
5) Regional politics – equity and/or the "grab it first" strategy;
6) Low risk and high subsidies as a result of public funding;
7) The push factor of agrarian pressure and shock events; and
8) Lopsided governance and weak public participation.

Weak governance is also indicated by the commonly witnessed poor to non-existent consultation with affected people resulting in insufficient consideration or weight being afforded to the environmental, social and cultural impacts of the IBT, in both the donor and recipient basins.

Yet another signal of poor governance is the lack of consideration at an appropriate management scale, meaning failure to look at the impacts of the proposed IBT within a river basin management framework. Without this, the risks of 'collateral damage' from the IBT are very much higher. Through employing the management model of Integrated River Basin Management (IRBM) governments and civil society will be much better placed to make well informed decisions in relation to IBTs.

A report prepared in October 2004 for the IRBM Task Force of the China Council on International Cooperation for Environment and Development, proposed a way forward for China to move in establishing an IRBM framework for the management of its extensive river systems. Some extracts from that report (below) help explain the concept of IRBM and the rationale behind it (report at www.harbour.sfu.ca/dlam/04riverbasin%20rpt.htm).

"A key factor that undermines efforts to deliver sustainability outcomes is sector-based governance; the organization of public administration that segregates, rather than integrates, economic, social and environmental policy, laws and administration. With pressure on water resources intensifying in all parts of the world, integrated river basin management (IRBM) is rapidly being introduced in many countries as a management framework that can help draw together economic, social and environmental aspirations.

IRBM is a process of coordinating the management and development of the water, land, biological and related resources within a river basin, so as to maximize the economic and social benefits in an equitable way while at the same time conserving freshwater ecosystems and species.

IRBM is also a participatory mechanism for solving conflicts and allocating water among competing users, while recognizing that natural ecosystems are in part the suppliers of that resource and the fundamental 'natural infrastructure' that delivers it to human users. Natural ecosystems are also key providers of a range of ecosystems services (flood mitigation, water quality improvement and fish production for example) which previously were overlooked in water resource management."

"Many of the problems with river and water resource management being encountered by China …today are also found in other countries. In many of these, IRBM is being applied as the administrative framework to see enhanced integration of economic development, community well-being and environmental sustainability into decision-making. Table 1 below summarises both the key problems that other countries how encountered with managing rivers and water resources and how IRBM offers solutions to these problems."

Where it is being applied, IRBM differs markedly from basin to basin and is strongly dependent on the complexity of the basin's socio-economic and political environment. Most basins face similar hurdles, such as:

- Gaining political agreement between governments (on provincial, national and international level);

- Bringing together competing stakeholders to share their knowledge, learn, appreciate new perspectives and reach agreements on sustainable solutions;
- Overcoming the perspective that water and aquatic biodiversity are a common resource that can be used without limit;
- Gathering high quality, up-to-date data;
- Getting proper assessment of ‚needs and options‘ for development proposals;
- Providing incentives for more efficient use of diverted waters;
- Planning for the exploitation of a Basin‘s resources without undermining their sustainability; and
- Ensuring safety for populations from recurring floods and their relationships with land use change in the basin (watershed and floodplain especially).

An IRBM plan can focus on various topics, but a basin organisation is necessary to coordinate, integrate, promote and/or even enforce decisions regarding the use and management of natural resources on a basin-wide scale. By undertaking options and needs assessments, possible alternatives to develop the basin in a more sustainable way will be identified. Tools for better water management that may be applied include payments for environmental services (see box below) and mimicking natural water flows as far as possible - environmental flows (Tilders 2002).

To better integrate water use and conservation in river basin management, appropriate water laws are needed. To maximise conservation and socio-economic outcomes, these laws should:

- Define the water basins or the transboundary water basins the law is designed for;
- Ensure water dependent environmental values are identified and adequate water flows are allocated for their conservation;
- Define water rights and apportion the available water resource;
- Define and install a method to make users pay for their water use;
- Treat water rights separately from land titles; and
- Enable water rights to be traded, so more efficient water users can buy water and produce more, and employ more people, by purchasing water rights from less efficient users.

To be effective, IRBM also requires strong legal mechanisms to provide the management and enforcement framework, but also to clarify roles and responsibilities. As indicated above, ideally, IRBM

Table 1: Summary of international experiences in relation to river basin management and how IRBM offers solutions to these problems

The problems	The solutions IRBM offers
Institutions and legislation	
Sector-based approaches Historically governments and societies have failed to appreciate the intrinsic linkages between economic growth, societal wellbeing and environmental sustainability, and have established decision-making, legal and administrative systems that serve to isolate, rather than integrate these pillars of sustainable development.	IRBM fosters a change in the way governments do business; moving away from sector- based institutions, policies and laws, to more integrated approaches.
Institutional weaknesses and lack of integration and coordination Sector-based management and decision-making is a product of sector-based institutions, policies and laws. Without addressing these fundamentals, the implementation of IRBM cannot succeed. Poor coordination among Ministries is a strong signal of this form of institutional failure. Allied to this are laws and policies that promote sector-based management.	IRBM is as much about social and economic policy reform as it is about moving to manage the environment for long-term sustainability. For this reason the implementation of IRBM must be mandated by the highest level of Government and be supported by appropriate legal and administrative coordination tools.

The problems	The solutions IRBM offers
Inappropriate management scale River basins provide a convenient and appropriate management scale; yet historically management has been allowed to operate at small scale without due consideration for downstream and broader impacts.	The paradigm shift to IRBM needs to draw into river basin level planning and management ALL government Ministries and stakeholders, at all levels; national, provincial and local. Decentralisation of management responsibility to river basin commissions, provincial and local governments is the key to successful IRBM.
Stakeholder and public participation	
Unsustainable land and water uses fostered by ignorance Unless the principles of IRBM and sustainability are understood by both the government sector and civil society, and then applied at the local, provincial and river basin levels, the capacity of ecosystems to support livelihoods will continue to decline.	Stakeholder and public participation can enhance the quality of IRBM decisions and help implementation by reducing costs and delays. In order to empower local stakeholders it is necessary to invest in education and public awareness programs and activities that target all sectors of society.
Lack of transparency and consultation in decision making The failure of governments to inform and consult local people about development and river/water resource management proposals that may impact on them is strongly counter-productive to the ethos of IRBM, breeding conflict and resentment among stakeholders.	Opportunities to participate in decision-making and providing access to management-related data are key aspects of gaining the support, involvement and commitment of stakeholders for implementing IRBM.
Economic measures and financial incentives	
Failure to consider all costs (economic, environmental and social) of development activities Where economic cost and benefits are the primary consideration of impact assessment processes, then unsustainable land and water use practices are promoted when external costs – both environmental and social – are excluded from resource allocation decisions.	The global trend in impact assessment is to consider the full range of environmental, social and economic cost and benefits, and this is now supported by robust methods for valuing the services provided by ecosystems within these assessment processes.
Failure to provide economic incentives and remove disincentives to sustainability Not valuing the full range of services provided by ecosystems has contributed strongly to their widespread degradation. Unsustainable land and water management practices have unwittingly been encouraged and even subsidized by governments, both through their ignorance of the broader social and environmental costs , and through the promotion of an economic development agenda as a priority.	There is now a vast array of economic measures and financial incentive options being applied in China and internationally that are proving highly successful in transforming land and water management into sustainable development enterprises. Two of several keys to their successful application in a Chinese context are to tailor the measures to fit local situations and to combine measures together in creative ways.
Applying IRBM-related technologies:	
River management problems not being addressed through available technologies Typical river management problems are flooding, pollution, water scarcity and loss of biodiversity. Associated with these are escalating human health costs, damage to urban, rural and industrial infrastructure, food and water shortages, and lost opportunities for economic development and poverty reduction.	An IRBM approach helps to mobilize these technologies in a strategic and carefully planned way. This leads to a reduction in these impacts, while not compromising development and social betterment aspirations.

Box: Payments for environmental services (PES) – an incentives tool that aligns with IRBM

It is now widely recognised that natural ecosystems produce a wide range of environmental services. These include carbon sequestration of forests, regulation of water quality and quantity, scenic beauty, climate regulation, ecosystem goods (e.g. fisheries) and biodiversity conservation. Proponents of payments for ecosystems services argue that the failure of society to compensate land managers for these services is a key contributory factor to the rapid and negative changes in land-use that is being witnessed globally.

PES mechanisms are market-based instruments that arose as a response to remedy market failures associated with environmental services. The basic principle of PES is that those who provide environmental services should be rewarded for doing so. This means mechanisms are put in place that transfer rewards from those who benefit from the environmental service to those who manage it. For example, land managers have the choice to sustainably manage the natural resources on their land that provide environmental services, or to allocate their land and natural resources to other alternative uses such as agriculture. In many cases, however, the services provided by natural resources are not restricted and the benefits they provide accrue beyond the people who manage them. For example, upstream watershed protection services typically benefit downstream stakeholders, including drinking water companies, bottling companies and hydroelectric companies. In most cases, however, these beneficiaries have not compensated upstream land managers for the provision of these services, and the result is that beneficiaries have been "free-riding" - deriving benefits at someone else's expense.

PES aims to change the incentives for land use in order to maintain or restore the desired environmental service. Payment mechanisms assume that decisions on land use and land use change are largely based on the net economic benefits that accrue to the land manager. Maintaining land in its natural state that provides environmental services is seldom a more attractive option than its conversion. The main reason for this is that benefits of environmental services often accrue to stakeholders other than the land manager, ranging from downstream stakeholders in the case of the regulation of quality and quantity of water of upstream forests and wetlands, to international stakeholders in the case of carbon sequestration of forests. To be effective, the payment to the land manager must effectively change the net benefits, making the maintenance of the natural resources and the environmental services derived thereof greater than alternative land uses (WWF, CARE and IIED, 2005).

within each basin is guided by an organisational body or commission, which also has its roles and responsibilities specified in law. A key role of such commission's is to plan for sustainability and to do this in consultation with stakeholders. In this way, quick fix decisions, such as those relating to IBTs can be avoided and be replaced with more considered, consultative and balanced decision making.

Transboundary watersheds or basins

IRBM, and its associated legal instruments, also has a key role with the management, regulation and conservation of transboundary watersheds or basins. Within countries there are often disputes between sub-national governments over transfers of water across provincial and other boundaries (eg. Joy *et al*. 2007) highlighting the need for better governance. Globally there are 263 transnational rivers that drain 45% of the Earth's surface, are home to 40% of the world's people and contain 60% of global runoff. Unilateral action by one country in a basin, such as withdrawing too much water through an IBT, can seriously impact on other countries and the environment of the basin. Multi-national river basin management agreements and institutions are needed for sustainable management of these rivers. Two treaties provide a framework for such agreements and WWF advocates that all relevant countries support their implementation.

a) The 1997 UN Convention on the Law of Non-Navigational Uses of International Watercourses provides a global framework for the sustainable, cooperative and equitable management of shared rivers. WWF urges governments to ratify this Convention as 17 more ratification are required for the treaty to enter into force.

b) The 1992 Convention of the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) within the United Nations Economic Commission for Europe (UN/ECE) has more effective provisions and is intended to strengthen national measures for the protection and ecologically sound management of transboundary surface waters and groundwater. The Convention obliges parties to prevent, control and reduce water pollution from point and non-point sources. The Convention also includes provisions for monitoring and research and development (UN/ECE, 1992). WWF urges UN ECE countries to complete ratification of the 2003 amendment to the convention that would enable non-European countries to join this treaty.

In addition, WWF is urging national governments to complete negotiations in the United Nations General Assembly for adoption of the draft articles on the law of transboundary aquifers as a protocol to the 1997 UN Watercourses Convention in order to promote sustainable management of shared groundwater systems.

7 Assessment of interbasin water transfers

It is only comparatively recently as conflicts over water infrastructure developments have increased that thought has gone into assessment criteria for proposed new IBTs. Cox summarized and extended a lot of existing thought under the auspices of UNESCO in 1999 (Cox 1999), and his criteria were generally supported at a session of the 3rd World Water Forum in 2001 (Bruk 2001). Cox proposed that a proposed interbasin water transfer is justified, if it satisfies the following criteria:

a) Economic productivity impacts

Criterion 1: The area of delivery must face a substantial deficit in meeting present or projected future water demands after consideration is given to alternative water supply sources and all reasonable measures for reducing water demand.

Criterion 2: The future development of the area of origin must not be substantially constrained by water scarcity; however, consideration to transfer that constrains future development of an area of origin may be appropriate if the area of delivery compensates the area of origin for productivity losses.

b) Environmental quality impacts

Criterion 3: A comprehensive environmental impact assessment must indicate a reasonable degree of certainty that it will not substantially degrade environmental quality within the area of origin or area of delivery; however, transfer may be justified where compensation to offset environmental injury is provided.

c) Socio-cultural impacts

Criterion 4: A comprehensive assessment of socio-cultural impacts must indicate a reasonable degree of certainty that it will not cause substantial socio-cultural disruption in the area of origin or area of water delivery: however, transfer may be justified where compensation to offset potential socio-cultural losses is provided.

d) Benefit distribution considerations

Criterion 5: The net benefits from transfer must be shared equitably between the area of transfer origin and the area of water delivery.

These criteria have much merit but to are also circular. Any IBT is likely to substantially degrade environmental quality as the river ecosystems have evolved to depend on all the natural flows (criterion 3), as have the livelihoods of the people who live in these basin and depend on freshwater ecosystem services (criterion 2). Further, these criteria were developed before the full implications of new approaches, such as virtual water, and the uncertainty induced by climate change brings to freshwater infrastructure projects.

In relation to dams but applicable to IBT's, the World Commission on Dams (WCD 2000) identified seven strategic priorities for improved decision making, namely:

1. Gaining public acceptance;
2. Comprehensive options assessment;
3. Addressing existing dams;
4. Sustaining rivers and livelihoods;
5. Recognising entitlements and sharing benefits;
6. Ensuring compliance;
7. Sharing rivers for peace, development and security.

These WCD criteria are more comprehensive and focussed on institutional processes, and are supported by WWF, yet suffer from challenges in interpretation at the project scale. WWF is currently participating in the "Hydropower Sustainability Assessment Forum" with industry, governments and other non-government organizations in an attempt to seek agreement on how to more practically implement these strategic priorities (HSAF 2009).

The Interbasin Water Transfer Africa Workshop 2006 in Ghana formulated guidelines to assist African policy makers in making informed and comprehensive choices from the political, economic, social, environmental and technical perspectives of interbasin water transfer projects.

More recently, Gupta and van der Zaag (2008) have argued that "grand scale engineering works, such as interbasin transfers, are only justified after all (smaller scale) alternatives have been exhausted, and only if these works are meant to satisfy, in intention and in implementation, vital human needs. We would further argue that […] five criteria […] needs to be satisfied, namely:

1. Real surplus and deficit: there is a real surplus in the donor basin and a real deficit in the recipient basin.
2. Sustainability: the transfer scheme is sustainable in terms of economic, social and environmental aspects.
3. Good governance: the scheme is developed through a process of good governance (including participatory decision-making, transparency, accountability, the rule of law, etc.).
4. Balance existing rights with needs: the scheme respects existing rights; if necessary adequate compensation measures are agreed. No person will be worse off because of the scheme, and there are no negative extra-territorial effects.
5. Sound science: the scheme is based on sound science, it adequately identifies uncertainty and risk and gaps in knowledge. All possible alternatives have been considered.

Again, while these criteria have much to commend them, they also suffer from similar gaps to Cox in terms of meaningless terms like "surplus" and "sustainable" in relation to IBTs.

The WWDR assesses water access as concludes that: The global distribution of freshwater must be considered together with its accessibility. With about 75% of total annual runoff accessible to humans [...] and with slightly more than 80% of the world's population (4.9 billion people) served by renewable and accessible water, almost 20% of people are unserved by naturally occurring renewable resources and must take their supply from ancient aquifers (aquifer mining), interbasin transfers and desalinized seawater" (WWDR 2009:170). While this narrow assessment (excluding such options as great use of virtual water trades, for instance) identifies a portion of the world's people that may require IBTs to meet their basic water requirements, it also implies that better governance is key to meeting the water needs of most people, not more interbasin transfers.

In the interim, WWF believes a simple set of measures should be used to measure needs and options in relation to proposed IBT projects. Having assessed the growing impacts of climate change, emerging approaches for meeting water needs and alternatives to an IBT, WWF recommends the following systematic and step-wise approach to identifying how the water needs of people may best be met while minimal reliance on IBTs. These options are best considered at a whole-of-river-basin level, through an integrated planning process. The alternatives should be considered in the following order:

A. Demand Management

1. Reducing water demands;
2. Recycling waste water;
3. Assessing and promoting land use management or industrial development alternatives.

B. Supply Management

4. Trading in virtual water, and only then,
5. Supplementing water supplies locally, and only then,
6. Desalination in water-scarce coastal areas, and only then,
7. Considering an IBT, as a last option.

8 Conclusions and recommendations

The history of interbasin water transfers (IBTs) to date should be sufficient to sound very loud alarm bells for any government contemplating such a development. However, despite the many lessons we should have learnt from past IBT experiences, many decision makers today continue to see IBTs as a technical solution to restore perceived imbalances in water distribution. To illustrate this point, an article in the Hydrological Sciences Journal of 2005 states that "*interbasin* transfer of water in India is a long-term option to correct the spatial and temporal mismatch of water availability and demand, largely owing to the monsoon climate" (Jain *et al*, 2005).

This is a simplistic point of view based on the false notion that moving water from places regarded as having 'water surpluses', to water scarce areas, can be undertaken without significant social and environmental impacts. This is the "pipe dream" that this publication seeks to illuminate.

The development of IBTs, rather than restoring a perceived water imbalance, usually disturbs the finely tuned water balance in both the donating and the receiving river basin. Regularly overlooked in IBT development are the short, medium and longer term impacts of moving water from one community (the donor basin) and providing it to another (the recipient basin).

There is no escaping the fact that for large parts of the human population, water scarcity is a serious problem and this is increasingly exacerbated by a changing climate. Water shortages can be a product of a range of factors apart from drought. These include overpopulation of naturally water-poor areas, over-exploitation of local water resources, inappropriate agricultural practices, water wastage etc. Thus, the question of how to meet the demand for water in water-stressed areas remains an urgent one to be answered.

WWF recognises that while local interbasin transfer schemes may, under certain circumstances, fulfil an important role, for example in supplying drinking water to population centres, the benefits of many large scale transfer schemes that are still on the drawing board are doubtful. In the past many IBTs have caused a disproportioned amount of damage to freshwater ecosystems in relation to the schemes' benefits thus leading to significant losses of ecosystem goods and services and unacceptable social and economic impacts both in the donor and the recipient basin.

The size of many schemes has meant that a large-scale IBT is rarely the most cost effective way of meeting water demands. Now, the growing impacts of climate change in altering hydrology makes large investments in inflexible water infrastructure even more risky. Concerning too is that in many cases the introduction of an IBT does not encourage users to use the water more effectively, continuing wasteful practices.

WWF believes that any new interbasin water transfer scheme should be approached in accordance with sustainability principles set out by the World Commission on Dams and addressed by the HSAF revised IHA Sustainability Assessment Protocol (HSAF 2009). First and foremost this means that any scheme under consideration should be subject to a comprehensive needs and options assessment; detailed cost-benefit and risk analyses that consider the full suite of potential environmental, social and economic impacts.

For those IBT where agriculture is the major driver for its construction, land use managegement alternatives need to be carefully assessed, including considering producing in other regions with higher overall water availability and less water stress, or even replacing own production by imports of products and stimulating less water intensive industry development to generate income opportunities for the local population.

As advocated in section 6 of this report, in moving to examine the alternatives to an IBT, WWF recommends the following step-wise approach, ideally considered at a whole-of-river-basin level, through an integrated planning process. The alternatives should be considered in the following order:

A. Demand Management

1. Reducing water demands;
2. Recycling waste water;
3. Assessing and promoting land use management or industrial development alternatives.

B. Supply Management

4. Trading in virtual water, and only then,
5. Supplementing water supplies locally, and only then,
6. Desalination in water-scarce coastal areas, and only then,
7. Considering an IBT, as a last option.

WWF believes that in many cases the above steps will be sufficient to ensure water security within a river basin.

In conclusion, WWF calls on all decision makers to follow the steps outlined above when considering how to meet water needs in areas of scarcity. There is a need to recognise that interbasin water transfer are in most cases a “pipe dream” and that the taking of water from one river to another usually reflects ignorance of the social and environmental costs and failure to adequately consider better, local alternatives, such a improved management of local demand.

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