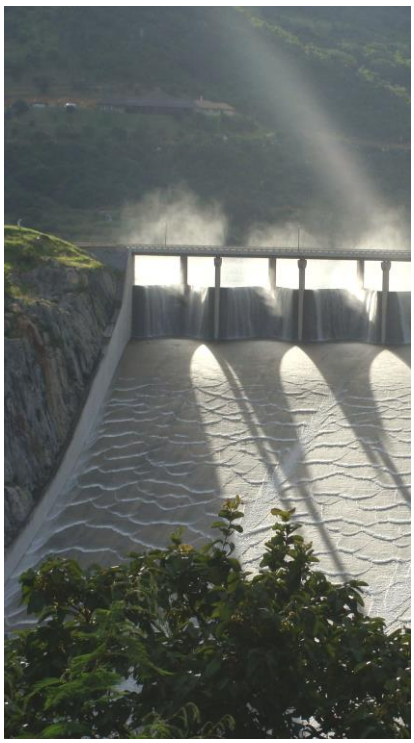


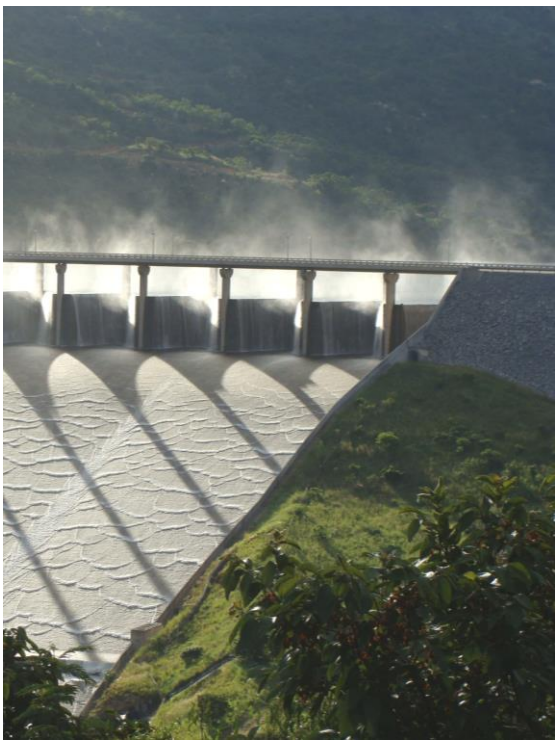


photo: Chris Keevy, 10 February 2009

Maguga dam, 39.438% owned by Swaziland and 60.562% by South Africa

# The management of transboundary water resources

Pieter van der Zaag

UNESCO-IHE Institute for Water Education

March 2017

# The management of transboundary water resources

Pieter van der Zaag

UNESCO-IHE Institute for Water Education

March 2017

**Table of content**

# 1. Transboundary water management

Wherever water crosses a boundary, the challenge of cooperation surfaces and the possibility of conflict looms. Such a boundary could be formed by the plot limits of adjacent irrigation farmers, neighbouring village communities, bordering municipalities, districts, provinces, states or countries. In all these cases the two riparian parties[1] face the dilemma of balancing between absolute sovereignty and basin integrity.

To what extent may individual entities or countries develop and use resources found within their territories, and to what extent do they have to consider interests of other riparian countries, and the 'common interest' of the river basin as a whole?

Upstream parties may emphasise the fact that they exercise 'absolute sovereignty' over their territory when pursuing projects; downstream entities may instead emphasise basin integrity when challenging upstream developments. Water can thus be a cause of conflict, and many authors emphasise this point (much more research papers mention water conflict in their titles then water cooperation, see Gupta and Van der Zaag, 2009). However, water can also be a cause for cooperation.

River basins are characterised by asymmetry, which further complicates matters. The asymmetry, or imbalance, between riparian parties arises simply because water naturally tends to flow in one direction only. This implies that downstream uses hardly impact upstream users, if at all, but upstream uses do cause downstream impacts (Figure 1).[2]

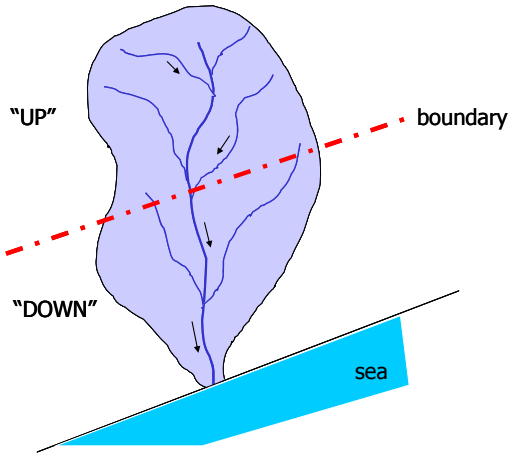



**Figure 1: The asymmetrical situation in a river basin**

[1] Riparian parties are parties that are situated near the same river, and thus inhabit the same drainage basin.

[2] Downstream users may affect upstream users as well, such as through interfering with navigation, or through the construction of reservoirs which may have upstream impacts such as on fish migration, and back water effects that may extent to the territory of an upstream user. However in most cases these impacts are small compared with the impacts that upstream users have on downstream users (Van der Zaag, 2007). Water may also flow in two directions, which occurs in tidal lowlands, but also in river systems such as the Tonlesap lake in the Mekong river in Cambodia.

Normally, this water sharing dilemma is resolved by reference to established rules in society. In many societies, customary arrangements have emerged that deal with this dilemma and ensure a peaceful sharing of water. In most countries rules related to the use of water are enshrined in the national water law. (Sometimes local customary principles are not entirely compatible with principles of statue law.) In case the parties sharing the water resource are nation states, however, most frequently no regional water laws exist that guide, and enforce, the manner in which the water resource should be utilised and shared. Two regions do have such laws: the European Union (Water Framework Directive, in force since 2000) and the Southern African Development Community (SADC) Protocol on Shared Watercourses, in force since 2003; see Van der Zaag, 2009). The UN law deals with this issue (the Convention on the Law of Non-Navigational Uses of International Watercourses, adopted by the United Nations General Assembly in 1997) came into force in 2014.

More than 40 percent of the world population lives in some 270 river basins that are shared by more than one state. Some countries largely depend on water generated in neighbouring states.

Perhaps the biggest problem in sharing water in a transboundary river basin is its sheer scale and the complexity of system interactions over large distances (upstream and downstream). For example, in many cases it is difficult to anticipate and quantify the precise consequences of upstream land use changes on downstream flooding and low flow events. This complexity may also result in unforeseen negative consequences of human interventions, which are difficult to correct and may give rise to tensions between riparian populations and countries sharing the basin.

Fortunately, there is an increasing awareness in the world that appropriate measures need to be taken to ensure the sound and wise management of transboundary water resources. Seen in this light, the general absence of open conflicts about water is a remarkable fact and should be appreciated. We seem to understand that, as much as water may divide groups of people and pit countries against each other, water as the most basic human need appears to mobilise countries towards common thinking.

This common thinking is already materialized in the existence of numerous agreements between riparian countries about water resources, regional treaties, and river basin organizations. One of the essential functions of these international arrangements is reconciling and harmonizing the interests of riparian countries. The main thrust of the management of shared river basins is thus to find ways of turning potential conflicts into constructive cooperation, and to turn what is often perceived as a zero-sum predicament - in which one party's gain is another's loss - into a win-win proposition. Finding such propositions is, however, difficult since water is scarce in the majority of the worlds' transboundary river basins.

To achieve this, there is need to combine technical, institutional and political aspects (Figure 2).

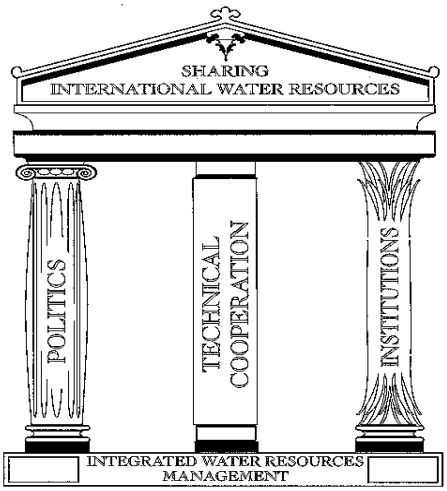



**Figure 2: The classical temple of sharing international water resources**
(Source: Savenije and Van der Zaag, 2000)

**Learning objectives**

The aim of this lecture is that:

1. students get acquainted with current thinking on transboundary water management, and are able to combine general knowledge on water resources and water resources management with specific knowledge on the legal aspects of international environmental and water law;
2. students can reflect critically on this current thinking and on frequently proposed solutions for transboundary water situations;
3. students are aware of their own role as water managers in promoting the peaceful sharing of transboundary water resources.

**Structure**

This lecture note first describes the process towards the UN Watercourses Convention, focusing on the formulation of the principles, and in a following section, on their application of these principles. In a subsequent section, the concept of benefit sharing is introduced. The section that follows forms the heart of this lecture note and attempts to define the transboundary water sharing dilemma, which can be overcome by broadening the scope of negotiations, both in terms of issues (i.e. issue linkage), and in terms of joint infrastructure development. The latter is the subject of the next section. Attention then turns to importance of public involvement in transboundary water management. The last section draws some general conclusions.

Finally, some game theoretical considerations on cost and benefit-sharing are presented in an annex, focusing on a hypothetical transboundary river basin.

# 2. Towards the UN Watercourses Convention

From the early 1950s, international controversies over water affected most regions of the world. Learned international bodies, such as the International Law Association (ILA) began studying the law applicable to these disputes (Wouters, 1997). The ILA developed the Helsinki Rules on the Uses of the Waters of International Rivers (1966). The general principle of the ILA's work on international water law is contained in Article IV of the Helsinki Rules which provides that the principle of equitable utilization governs the use of the waters of international drainage basins.

**Box 1: Article IV of the Helsinki Rules**

> "Each basin State is entitled, within its territory, to a reasonable and equitable share in the beneficial uses of the waters of an international drainage basin."

The Helsinki Rules have played an important role in the codification and progressive development of this branch of international law. States refer to these guidelines to the present day. However, there was insufficient support within the United Nations to adopt the Helsinki Rules as UN law. This was because many countries with well-developed water systems wanted their current water uses explicitly defended (Wouters, 1997).

In the late 1960s, following the failure of the UN General Assembly to have the Helsinki Rules adopted as guidelines governing international water law, the United Nations decided to assign the topic to the International Law Commission (ILC) for detailed study (Wouters 1997). After close to twenty-five years work on the topic, the ILC produced a document that contained thirty-three Draft Articles (1991, revised in 1994) and submitted that to the UN General Assembly with the recommendation that it be adopted as a framework convention. To counter-balance the equity principle, the obligation not to cause significant harm was formulated (Article 7 of the UN Watercourses Convention).

The Sixth Committee of the UN General Assembly was convened as a Working Group of the Whole and met in October 1996 and in March 1997. The meetings were controversial: issues related to transboundary water use that divided States at the beginning of the century resurfaced in the UN debates (Wouters, 1997). At the centre of the discussions were the following issues:

- What limits apply to watercourse States' entitlements to use transboundary waters?
- How are the various factors to be weighed in the overall assessment of an equitable and reasonable use?
- Where a conflict of uses arises, what rule determines which use should prevail?
- What role does "harm" play?

State responses to these issues varied in accordance with:

- their position in international basins: upstream or downstream;
- whether or not they had 'developed' the water resources;

- their (future) relationship with other riparian countries.

The substantive rules contained in Articles 5 and 7 of the Convention and the relationship between these were hotly debated. Box 2 shows the changes in formulations of articles 5 and 7 between the 1991 and 1994 ILC draft texts (ILC, 1994) and the final text of the UN Watercourses Convention of 1997 (http://untreaty.un.org/ilc/texts/instruments/english/conventions/8_3_1997.pdf).

**Box 2: Modifications of the formulations of Articles 5 and 7 of the UN Watercourses Convention**

**Article 5**

*[emphasis added to show additions in the UN Watercourses Convention to the 1994 ILC Draft]*

1. Watercourse States shall in their respective territories utilize an international watercourse in an equitable and reasonable manner. In particular, an international watercourse shall be used and developed by watercourse States with a view to attaining optimal *and sustainable* utilization thereof and benefits therefrom *taking into account the interests of the watercourse States concerned*, consistent with adequate protection of the watercourse.

2. Watercourse States shall participate in the use, development and protection of an international watercourse in an equitable and reasonable manner. Such participation includes both the right to utilize the watercourse and the duty to co-operate in the protection and development thereof, as provided in the present Convention.

**Article 7**

*1991 ILC Draft:*
Watercourse States shall utilize an international watercourse in such a way as not to cause appreciable harm to other watercourse States.

*1994 ILC Draft Articles*:
1. Watercourse States shall exercise due diligence to utilize an international watercourse in such a way as not to cause significant harm to other watercourse States.

2. Where, despite the exercise of due diligence, significant harm is caused to another watercourse State, the State whose use causes the harm shall, in the absence of agreement to such use, consult with the State suffering harm over:

(a) the extent to which such use is equitable and reasonable taking into account the factors listed in article 6;

(b) the question of ad hoc adjustments to its utilization, designed to eliminate or mitigate any such harm caused, and, where appropriate, the question of compensation.

*UN Watercourses Convention of 1997:*
1. Watercourse States shall, in utilizing an international watercourse in their territories, take all appropriate measures to prevent the causing of significant harm to other watercourse States.

2. Where significant harm nevertheless is caused to another watercourse State, the State whose use causes the harm shall, in the absence of agreement to such use, take all appropriate measures, having due regard for the provisions of Articles 5 and 6, in consultation with the affected State, to eliminate or mitigate such harm and, where appropriate, to discuss the question of compensation.

**Box 3: Comparing Article V of the Helsinki Rules with Article 6 of the UN Watercourses Convention**

**Article V of the Helsinki Rules (1966)**

I What is a reasonable and equitable share within the meaning of article IV to be determined in the light of all the relevant factors in each particular case.

II Relevant factors which are to be considered include, but are not limited to:

1. The geography of the basin, including in particular the extent of the drainage area in the territory of each basin State;
2. The hydrology of the basin, including in particular the contribution of water by each basin State;
3. The climate affecting the basin;
4. The past utilization of the waters of the basin, including in particular existing utilization;
5. The economic and social needs of each basin State;
6. The population dependent on the waters of the basin in each basin State;
7. The comparative costs of alternative means of satisfying the economic and social needs of each basin State;
8. The availability of other resources;
9. The avoidance of unnecessary waste in the utilization of waters of the basin;
10. The practicability of compensation to one or more of the co-basin States as a means of adjusting conflicts among uses; and
11. The degree to which the needs of a basin State may be satisfied, without causing substantial injury to a co-basin State.

III The weight to be given to each factor is to be determined by its importance in comparison with that of other relevant factors. In determining what is reasonable and equitable share, all relevant factors are to be considered together and a conclusion reached on the basis of the whole.

**Article 6 of the UN Watercourses Convention (1997)**

1. Utilization of an international watercourse in an equitable and reasonable manner within the meaning of article 5 requires taking into account all relevant factors and circumstances, including:

(a) Geographic, hydrographic, hydrological, climatic, ecological and other factors of a natural character;
(b) The social and economic needs of the watercourse States concerned;
(c) The population dependent on the watercourse in each watercourse State;
(d) The effects of the use or uses of the watercourses in one watercourse State on other watercourse States;
(e) Existing and potential uses of the watercourse;
(f) Conservation, protection, development and economy of use of the water resources of the watercourse and the costs of measures taken to that effect;
(g) The availability of alternatives, of comparable value, to a particular planned or existing use.

2. In the application of article 5 or paragraph 1 of this article, watercourse States concerned shall, when the need arises, enter into consultations in a spirit of cooperation.

3. The weight to be given to each factor is to be determined by its importance in comparison with that of other relevant factors. In determining what is a reasonable and equitable use, all relevant factors are to be considered together and a conclusion reached on the basis of the whole.

The final texts of Articles 5, 6 and 7 (see Box 3 for Article 6, which is compared with Article 5 of the Helsinki Rules) were not accepted by all States. States tended to take positions that favoured their particular interests.

Upstream states supported rules that gave them control of the waters that originated in their territory, appealing to the (non-existing) principle of absolute territorial *sovereignty*. They did not support the inclusion of a new principle (the duty not to cause significant harm) in international water law. They thus supported the status quo. Note that the Helsinki Rules had only enshrined the equity principle.

In contrast, downstream states appealed to the doctrines of prior appropriation ('vested rights') and absolute territorial *integrity*, and embraced an approach that would provide them with the unaltered flow (in terms of quality and quantity) of the waters that entered their territory (Wouters, 1997). These countries favoured the inclusion of the new no-harm principle in international water law.

The fact that the vote on the substantive rules contained in Articles 5 and 7 was closely divided is significant in itself. From such a result it can be deduced that both upstream and downstream States find strengths and weaknesses in the final formulation of the Articles. This could attest to the relative fairness of the compromise finally reached regarding the substantive rules: It favoured neither upstream nor downstream States.

The practical application of the substantive rules of the Convention is achieved under Article 6 which lists the factors which must be taken into account when deciding what an equitable and reasonable use of an international watercourse actually is (Box 3).

In May 1997 the General Assembly of the United Nations finally adopted the Convention on the Law of the Non-Navigational Uses of International Watercourses. by 103 votes in favour to 3 against (Turkey, China, Burundi) with 27 abstentions and 33 countries being absent. Some countries explained their vote (Box 4).

**Box 4: The debate on the UN Watercourses Convention**
(Source: General Assembly Plenary Press Release GA/9248, 21 May 1997)

Riparians located in the upper parts of river basins would have liked the Convention to give primacy to article 5 over article 7. Lower riparians had opposite concerns, but generally appeared to have agreed with the UN Watercourses Convention. The self-declared positions of Turkey, Ethiopia and Egypt were as follows.

**Turkey**, an upper riparian of the Shatt-al-Arab, was one of three countries voting against the UN Watercourses Convention (103 countries voted in favour and 27 abstained), arguing that the 'Convention did not refer to the sovereignty of the watercourse States over the parts of international watercourses located in their territory. The convention should have established the primacy of equitable reasonable utilization over the obligation not to cause significant harm'. Further, that 'it was not appropriate for a framework convention to foresee any compulsory rules regarding the settlement of disputes'. Turkey wishes not to be restrained in its efforts to develop its water resources of the Shatt-al-Arab made up of the Euphrates and the Tigris, through the construction of 33 dams in the giant GAP

project. Syria voted in favour of the Convention.

**Ethiopia**, an upper riparian of the Nile, abstained because 'the text of the Convention was not balanced, particular with respect to safeguarding the interests of upper riparian states. Article 7 (…) (was) of particular concern.' 'The Convention was tilted towards lower riparian States'.

**Egypt**, a lower riparian of the Nile, abstained. Yet Egypt seemed to go along with the Convention, as, in Egypt's reading, the convention 'did not modify customary international law. The Convention did not prejudice the legal weight of international law; its framework should not affect bilateral or regional agreements or established laws.' Obviously, it is in Egypt's interest to defend the status quo, and emphasise the importance of existing agreements. Egypt's bilateral agreement with Sudan, concluded in 1959, in fact claims all Nile waters for both countries, not reserving any water for the upstream riparian countries.

The Watercourses Convention eventually came into force in August 2014, three months after Vietnam had ratified it as the 35th country (Box 5).

**Box 5: Status of the UN Watercourses Convention**

By March 2017, the UN Convention had been ratified, or acceded to, by 36 countries
(countries that did not vote in favour of the UN Watercourses Convention in 1997, yet ratified it in *italics*):

*Benin*, Burkina Faso, *Chad,* Cote d'Ivoire, Denmark, Finland, France, Germany, Greece, *Guinea-Bissau*, Hungary, *Iraq***,** Ireland, Italy, Jordan, *Lebanon*, *Libya,* Luxembourg, Montenegro, Morocco, Namibia, Netherlands, *Niger, Nigeria,* Norway, Palestine, Portugal, Qatar, South Africa, *Spain,* Sweden, Syria, Tunisia, United Kingdom, *Uzbekistan* and Vietnam.

Source: http://treaties.un.org/ Go to: *Status of Treaties (MTDSG)*, *Chapter XXVII Environment,* item 12.

# 3. Applying the principles

In discussing legal and regulatory aspects of the management of international river basins, it is useful to distinguish international from national legal frameworks. Ideally, the country specific laws pertaining to the use of national waters should be consistent with those principles widely accepted to apply to international waters. If not, national water laws and regulations will require to be harmonised between riparian countries. Riparian countries should consider regional and global agreements and common law, but also the principles behind local practices regarding the use and sharing of water resources that have persisted.

Whereas the philosophy behind the 'equitable and reasonable use' and the 'no harm' rules are laudable and widely shared, problems begin when the general principles must be specified for particular situations. In general, problems arise when basin states fail to take the interests of other riparians into account. Upstream basin states may emphasise the fact that they exercise 'absolute *sovereignty*' over their territory when pursuing projects, while downstream countries may emphasise territorial *integrity* when challenging upstream developments. The utilisation of shared water resources, therefore, requires riparian countries to acknowledge the principle of 'limited sovereignty', or, phrased positively, to accept the principle of 'community of interest'.

**Definitions**

In this context it is important to note that whereas in the Helsinki rules the central concept is 'international drainage basin', the UN Watercourses Convention uses the term 'international watercourse' (Box 6).

**Box 6: 'International drainage basin' or 'international watercourse'?**

**Helsinki Rules**: an *international drainage basin* is 'a geographical area extending over two or more States determined by the watershed limits of the system of waters, including surface and underground waters, flowing into a common terminus' (Article II).

**ILC Draft Law** and **UN Watercourses Convention**: a *watercourse* is 'a system of surface waters and groundwaters constituting by virtue of their physical relationship a unitary whole and normally flowing into a common terminus.' An 'international watercourse' then is 'a watercourse, parts of which are situated in different States' (Article 2).

The ILC did not use the concept of "drainage basin" as its object because a drainage basin refers to a "geographic area", implying that a UN law on water would then also extend to territorial issues, which would be potentially very sensitive. Thus the ILC had to invent a new concept that was identical to a drainage basin *minus the land*, i.e. only referring to the water occurring in that drainage basin. They choose to use the word "watercourse" for that.

The definition of drainage basins or watercourses may be interpreted differently depending on each country's perspective. In large river basins, upstream countries may consider a tributary as a river basin in its own right. It then becomes easy to ignore harmful effects of interventions on

(distant) downstream users. Although such a way of thinking is understandable from the upstream country's point of view, it is certainly not the intention of the principles laid down by ILA, ILC and the UN.

The UN Watercourses Convention's definition of watercourse (being *"a system of surface waters and groundwaters constituting by virtue of their physical relationship a unitary whole"*) is definitive and refers to the largest possible common denominator of a fresh water system. Tributary rivers to a transboundary or international watercourse are therefore integral part of that watercourse and fall under the UN law.

It is important to realise that renewable groundwater resources are integral part of this definition. Only groundwater resources that are unconnected to surface waters fall outside the scope of the UN Watercourses Convention. This logically implies that only fossil groundwaters, i.e. aquifers that have been recharged from surface waters beyond the human time scale, i.e. thousands of years before present, are NOT part of this Convention.

So the concept of "watercourse" does not only refer to water flowing in courses of water (i.e. rivers) but also includes groundwater that is connected to surface water. This raises questions about the status and limits of the *"Draft Articles on the Law of Transboundary Aquifers"*, that were formulated by the ILC in 2008 and adopted by the UN General Assembly in January 2009 (Box 7; see for the full text of the articles: http://untreaty.un.org/ilc/texts/instruments/english/draft%20articles/8_5_2008.pdf).

**Box 7: The Draft articles of the law of transboundary aquifers - inconsistencies with the UN Watercourses Convention** (inspired by Professor Stephen C. McCaffrey's presentation at the UNESCO ISARM Conference, Paris, 8 December 2010; see also McCaffrey, 2011; Dellapenne, 2011; see for a contrasting view: Yamada, 2011)

(1) The draft articles define "Sovereignty of aquifer States" as follows:
"Each aquifer State has sovereignty over the portion of a transboundary aquifer or aquifer system located within its territory. It shall exercise its sovereignty in accordance with international law and the present draft articles."
The UN Watercourses Convention, however, does not recognise the sovereignty principle over international watercourses.

(2) The focus of the draft articles is on aquifers rather than on groundwater
(Note the similarity with drainage basin vs. watercourse concepts.)

(3) The draft articles should focus on groundwaters not covered by the UN Watercourses Convention, i.e. those groundwaters that do not interact with surface waters, i.e. fossil groundwaters. Fossil groundwaters, however, are governed by existing laws that also govern other finite and fossil natural resources, such as oil, petroleum and gas.

Finally, as the object of the UN Convention is the international watercourse, water transfers between such watercourses (better known as inter-basin transfers) are not governed by it (see Gupta and Van der Zaag, 2008).

**Balancing equity with no harm**

The question is frequently asked: which comes first, the right to equitable and reasonable use or the obligation not to cause significant harm? Those riparian states with a stake in the status quo tend to stress the importance of the latter principle (which appears to recognise established uses however inequitable these may be), while those riparians who lagged behind in water development tend to use the former principle to claim waters already used by 'more developed' riparians. The differential application of both principles should, however, be considered a false dilemma. Both principles apply concurrently and represent, as it were, two sides of the same coin (Van der Zaag, 2007). They convey the basic tenet that riparians have rights *and* duties in the uses of water resources, in line with the second principle of the Rio Declaration:

> "States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign *right* to exploit their own resources pursuant to their own environmental and development policies, and the *responsibility* to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction." (UNCED, 1992: 9) *[italics added]*

**Equitable use**

Some authors have argued that the principle of equity is key to water allocation (Wouters, 1997; Wolf, 1999), which was also the premise of the 1966 Helsinki Rules (McCaffrey 1993). The principle of reasonable and equitable use (Article 5 of the UN Watercourses Convention), however, is defined in general terms. To establish what is an 'equitable share', the UN Watercourses Convention in Article 6 directs riparian countries to consider a wide variety of aspects. However, these aspects are prone to subjective interpretations by the riparian states. 'Clearer criteria are needed by which to judge, for instance, what constitutes a reasonable level of per capita water use given the total amount of water available in a river system, and what constitutes a fair apportioning of water among nations sharing common sources' (Postel, 1992: 189).

Van der Zaag et al. (2002) attempt to define measurable criteria on the basis of which water resources can be allocated to the riparian countries in an equitable manner 9see Box 13 below). Such measurable criteria may facilitate negotiations between riparian countries that are in conflict over the issue. Jointly defining such criteria could be a central activity during negotiations. A key parameter for establishing an equitable share is the number of people living in the various parts of a basin. In addition, not only the availability of "blue" water (runoff water feeding into aquifers and rivers) should be considered, but also the availability of "green" water (rainfall water that infiltrates into the unsaturated upper layer of the soil and used directly for biomass production). Two important variables are identified over which the riparian countries should reach consensus:

1. The value of green water relative to blue water;
2. The fraction of reserved water, which is defined as the basic entitlement of each riparian country, and which remains outside the negotiations.

**Some other issues of international rivers** (Gupta, 2004)

*Boundary demarcation*

When a river forms the boundary of two states, the precise nature of the boundary is often in dispute. Where a river crosses a border between two countries, where the water flow is perpendicular to the border, the situation is often beyond dispute. However, where a river forms a boundary between two countries, with one bank being owned by one country and the other by the second country, the boundary demarcation is more complicated. During medieval times the banks were sometimes considered the boundary, with the river being '*res nullius*', i.e. it belonged to nobody. Sometimes the river was considered '*res communis*', belonging to both countries.

Sometimes the more powerful country can gain control over the river up to the other bank. Thus Iraq gained control over the Shatt-al-Arab and had sovereignty over the river up to the river bank in Iran. This was modified by a later agreement of 1975. Similarly, South Africa claimed control over the northern shores of the Orange river in Namibia (after attaining majority rule in 1994, South Africa rectified this historical anomaly).

A common practice is to define as the boundary the *median line*. The median line is the imaginary line equidistant from either river bank, also corresponding with the geometric centre of the river. This creates complications for navigation purposes, as the depth is a more relevant feature than the breadth for navigation. The other practice is the *thalweg line*, which is the deepest part of the river or the median line of the deepest channel. When then river moves because of natural causes, then the general rule is that if it moves suddenly, the boundaries remain as they were, but if it moves gradually, the boundaries would have to follow the shifting line of the water course.

*Navigational uses*

Three principles with respect to the navigational uses have crystallised over time:

a) the principle of freedom of navigation and of commerce for the riparian states;
b) the freedom of commerce, but not of navigation of non-riparian states;
c) the duty to consult and settle all matters concerning navigation by common agreement among riparian states (Congress of Vienna, 1815).

*Appeal and arbitration*

Conventions, such as the convention on the law of non-navigational uses of international watercourses, normally define procedures for settling disputes. The first defined step is to resolve the dispute bilaterally through negotiation. If unsuccessful, the next step is to see whether the disputing parties can agree to submit their dispute for arbitration to the river basin commission (if it exists) or if they can agree to appoint a third party arbiter. If all this is unsuccessful, there is, for the UN law, still the option that the Secretary General of the United Nations appoints a Commission. If this also comes to nought, then the last remaining option for both parties is to submit their dispute to the International Court of Justice (ICJ). If one of the countries, however, also disagrees with this, the dispute cannot be arbitrated by the ICJ.

# 4. Beyond the river: the benefits of cooperation

Reaching agreement over the sharing of transboundary waters resources frequently proves difficult (see e.g. Meissner and Turton, 2003). Negotiations are often complicated by the sovereign sentiments that tend to emerge. During the last few years a solution to this problem has been suggested; namely share benefits derived from water rather than the water itself (Sadoff and Grey, 2002).

Sadoff and Grey (2002) identify four different ways of looking at one and the same river. A river can be seen as the ecological river, the economic river, the political river and the catalytic river. In accordance with these four perspectives, a river can generate four types of benefits, provided its riparians cooperate. These types of benefits include the following:

- *Benefits to the river:* Cooperation between riparian countries allows better management of ecosystems, which will provide benefits to the river, underpinning all other benefits that can be derived.
- *Benefits from the river:* Efficient, cooperative management and development of transboundary rivers can yield real and direct benefits, for example increased food production and energy generation.
- *Reduction of costs because of the river:* Tensions may exist between riparian countries and those tensions will generate costs. Cooperation on transboundary river basin management will reduce those tensions and thus costs.
- *Benefits beyond the river:* Cooperation on rivers may strengthen the cooperation and trade between riparian states and even economic integration, which may yield much greater benefits.

The cooperative river can therefore generate benefits of multiple types (Box 8).

**Box 8: Four perspectives of the cooperative river** (Sadoff and Grey, 2002)

| | Type of benefit | Challenge | Opportunities |
|---|---|---|---|
| The ecological river | Increasing benefits to the river | Degraded water quality, watersheds, wetlands and biodiversity | Improved water quality, soil conservation, biodiversity and overall sustainability |
| The economic river | Increasing benefits from the river | Increasing demands for water, sub-optimal water resources management and development | Improved water resources management for hydropower and agricultural production, flood-drought management, navigation, environmental conservation, water quality and recreation. Share benefits not water |
| The political river | Reducing costs because of the river | Tense regional relations and political economy impacts | Policy shift to cooperation and development, away from dispute/conflict; from foods (and energy) self-sufficiency to food (and energy) security; reduced dispute/conflict risk and military expenditure |
| The catalytic river | Increasing benefits beyond the river | Regional fragmentation | Integration of regional infrastructure, markets and trade. Increasing interdependencies. |

Sadoff and Grey (2002) suggest that when riparian countries negotiate the equitable and reasonable utilisation of a transboundary river basin, they should not solely focus on the allocation of water, but they should also focus on the equitable sharing of the benefits derived from the water. This idea of *benefit sharing* rather than water sharing has become very fashionable.

Benefit sharing is a concept with appeal. The concept of "benefit sharing" appears the obvious, rational and preferred strategy beyond reproach. But there are also some limitations, among them the following (Van der Zaag, 2007):

1. Benefit sharing presupposes a consensus over basic *entitlements*, which is likely to have been a major obstacle in the first instance.
2. Equitable use of transboundary water resources should not only focus on the benefits but also on the *costs*, since nearly any water use or water development is likely to cause some negative impacts somewhere.
3. Due to the interconnectedness of the river basin, the sharing concept should cover the *entire watercourse*, including all costs and benefits and how these are (differentially) distributed.
4. Moreover, the sharing concept seems to suggest that all benefits (and costs) are quantifiable (and commensurable), which is an assumption that may not hold. Will those uses of water whose benefits are difficult to quantify or that are indirect or less tangible be treated on an equal footing? Will the communities that live off environmental resources indeed be included in such benefit sharing arrangements? Will those who bear the costs be compensated?
5. Benefit sharing requires effective institutions and capacity to effectuate and implement the required re-distribution of the benefits over those who bear the costs. This is often most problematic (see e.g. Mokorosi and Van der Zaag, 2007).

Many examples have been given in support of the benefit-sharing concept. A recent example is the proposed dam development on the Blue Nile (Box 9). In Africa the following four examples of successful benefit-sharing are frequently mentioned:

- Kariba reservoir (on the Zambezi river),
- Manantali dam in Mali (on the Senegal river),
- the Lesotho Highlands Development Project (Senqu-Orange-Gariep), and
- Maguga dam in Swaziland (on the Incomati river; see Box 11 below).

It should be realised, however, that in these four examples the cost and benefit sharing arrangements are problematic. This is because they all involve only a part of these watercourses and some riparian countries do not take part in them. This raises the question whether in these and other cases indeed all the costs and all the benefits are shared equitably. Indeed in most of these examples some of the negative externalities have been borne by parties that were not part of the benefit-sharing arrangement.

**Box 9: A potential triple win on the Blue Nile through transboundary cooperation on infrastructure development** (Goor et al., 2010)

The Upper Blue Nile River Basin in Ethiopia has huge potential for hydropower generation and irrigated agriculture. Controversies exist as to whether the numerous infrastructural development projects that are on the drawing board in Ethiopia will generate positive or negative externalities downstream in Sudan and Egypt. In order to examine the economic benefits and costs of developing reservoirs on the Blue Nile for Ethiopia, Sudan and Egypt, Goor et al. (2010) developed a basin-wide integrated hydro-economic model. The model integrates essential hydrologic, economic and institutional components of the river basin in order to explore both the hydrologic and economic consequences of various policy options and planned infrastructural projects. Unlike most of the deterministic economic-hydrologic models reported in the literature, a stochastic programming formulation has been adopted in order to:

i) understand the effect of the hydrologic uncertainty on management decisions,
ii) determine allocation policies that naturally hedge against the hydrological risk, and
iii) assess the relevant risk indicators.

The study reveals that the development of four mega dams in the upper part of the Blue Nile Basin would change the drawdown refill cycle of the High Aswan Dam. Should the operation of the reservoirs be coordinated, they would enable an average saving for Egypt of at least 2.5 x $10^9$ $m^3a^{-1}$ through reduced evaporation losses from Lake Nasser.

Moreover, the new reservoirs (Karadobi, Beko-Abo, Mandaya and Border) in Ethiopia would have significant positive impacts on hydropower generation and irrigation in Ethiopia and Sudan: at the basin scale, the annual energy generation is boosted by 38.5 TWh $a^{-1}$ of which 14.2 TWh $a^{-1}$ due to storage. Moreover, the regulation capacity of the above mentioned reservoirs would enable an increase of the Sudanese irrigated area by 5.5%.

Sediment fluxes poses another important dimension to these development plans, which were not considered in this study.

# 5. The transboundary water sharing dilemma

The asymmetry that obtains in river basins (see above) implies that downstream uses hardly impact upstream users, if at all, but upstream uses do cause downstream impacts (Figure 2, above). If we combine this "natural" asymmetry with the two principles enshrined in the UN Watercourses Convention (equity and no harm), one conclusion may de deduced: transboundary water sharing between upstream and downstream users implies that upstream users have to forego some of the potential water benefits (Van der Zaag, 2007). This is so because if upstream riparians ignore the needs of the downstream countries inequitable water allocation may result, and/or significant harm may be caused.

Annex 2 provides a hypothetical example of how the costs and benefits of water resources development in a transboundary basin can be shared in different ways between upstream and downstream parties:

- downstream parties could compensate upstream parties for limiting their developments;
- upstream parties could compensate downstream parties for the negative impacts caused by their water developments;
- both parties could opt for limiting their developments, obviating the need for compensation.

The example is based on game theoretic considerations and illustrates the water sharing dilemma.

The transboundary water sharing dilemma can be summarised by the following question:

> Would it be rational for an upstream sovereign state to voluntarily collaborate on the management of transboundary waters, take into account the needs of downstream riparians, and as a consequence be willing to forego some immediate water benefits?

This question, which seems to refer to the (ill-defined) concepts of "hydrosolidarity" (Falkenmark and Lundqvist, 1999; Falkenmark and Folke, 2002) can only be responded affirmatively if dependencies exist between the riparian countries concerned that point in the opposite direction compared to the water dependency.

If in such situations water users acknowledge that they depend on each other, not only in terms of water but also in other ways, and not only now but also in future, it may be rational for them to cooperate and forego some immediate benefits. This may be considered a form of *"water rationality"*, as suggested by Alam (1998).

Situations of interdependence, fortunately, frequently occur. This is because riparian countries are neighbours, and neighbours tend to develop relationships that encompass a variety of dimensions and sectors – logistics and transport, trade, energy, other types of market linkages, joint infrastructure development, cultural links, historical ties, etc.

In such a context it would be foolish and short-sighted for a riparian country to focus on short-term gains that could damage the bilateral relationship, and thus in the long run would turn out costly. It is only in situations where countries cannot afford to adopt a longer term perspective that opting for the immediate benefits is understandable. In such cases a strategy could be to "bribe" poor countries into cooperation. But this strategy would only work if within a reasonable time period they would be able to adopt a cooperation strategy at their own accord.

Within river basins or watersheds large (power) differences between actors/entities may exist. It is often suggested that social homogeneity facilitates collective action (see e.g. Turton and Henwood, 2002). Interestingly, Baland and Platteau (1999) have shown that cooperation may prevail even in cases with large power differences, or perhaps even because of these differences. Those who have a larger stake also have a large interest in the common good and its orderly use. Moreover, even powerful actors depend on their less powerful neighbours.

The recognition by those in a more advantageous position of their dependence on the cooperation of those in a less advantageous position finds expression in the former's willingness to forego immediate and short-term benefits; and this in turn may trigger the latter's willingness to compromise. This delicate dynamic may lead to long-enduring water institutions This dynamic may possibly explain effective locally developed water-sharing arrangements in Eastern and Southern Africa (Fleuret, 1985; Grove, 1993; Adams et al. 1994; Potkanski and Adams, 1998; Van der Zaag, 1999; Mohamed-Katerere and Van der Zaag, 2003; Komakech et al., 2012) and elsewhere (e.g. Martin and Yoder, 1988; Boelens and Davila, 1998).

Transboundary water sharing may thus be more likely where greater and more intensive interdependencies exist, since this would increase the likelihood of a balanced relationship. Such interdependent situations, however, will often be accompanied by continued negotiations, and collaborative actions that are interspersed with frequent periods of tensions. In fact, cooperation does not often occur without conflict, and vice versa (Box 10).

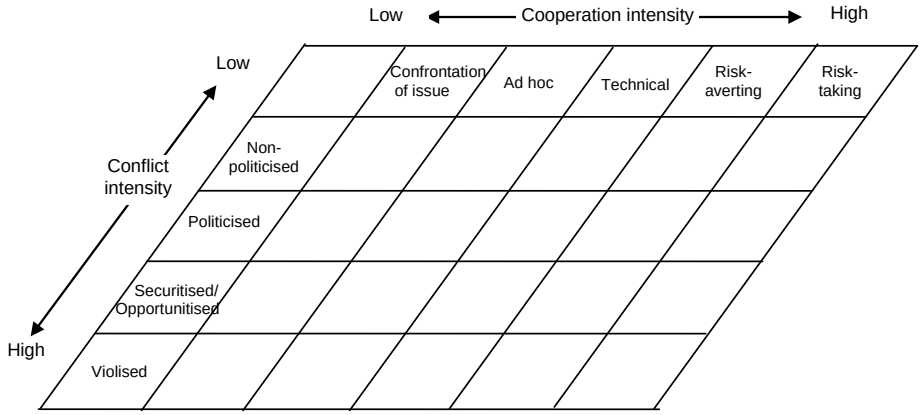
We now can hypothesise that consciously promoting links between riparian countries may facilitate and sustain water sharing. This could be achieved in a variety of ways, including:

- water-related (e.g. joint infrastructure development and management);
- beyond water (e.g. through trade, transport, cultural links, scientific collaboration).

We may conclude that the sharing of transboundary water resources represents a delicate balancing act. If there might be any difference in weight between the right of equitable use and the obligation not to cause harm, then it must result from the following truism: a water sharing agreement that is not perceived as equitable and reasonable by all the parties is unlikely to last and be sustained over time. It is therefore that some experts argue that the principle of equitable utilization is key to water allocation (Wouters, 1997; Wolf, 1999), which was also the premise of the 1966 Helsinki Rules (McCaffrey, 1993).

**Box 10: Conflict and cooperation co-exist**

Most work on transboundary waters situates water conflict and cooperation at opposing ends of a continuum. Examining a transboundary water situation from this "either or" perspective is unhelpful as it ignores that very often cooperation and conflict co-exist, and that transboundary relations evolve over time, whereby the levels of conflict and cooperation change over time. In the words of Mirumachi and Allan (2007), "dynamic transboundary relations are characterized by varying intensities of co-existing conflict and cooperation. Once the co-existence of conflict and cooperation is recognized, it is possible to escape the misleading assumption that transboundary water relations exist on a single axis from undesirable conflict to desirable cooperation." The latter assumption inevitably leads to the assumption that any conflict is 'bad', and that all forms of cooperation are 'good' (Zeitoun and Mirumachi, 2008).




**The matrix of conflict and cooperation, as proposed by Mirumachi and Allan (2007)**

Water sharing can succeed and be sustained over time in case multiple dependencies exist between riparian countries. In such situations short term gains, accrued through selfish behaviour, may prove self-destructive in the long run. This may explain why, despite the frequent rhetoric of water wars, cooperative deals occur much more frequently than expected.

Interdependencies between riparians should therefore not be viewed as a weakness but rather be celebrated. Through finding creative deals they offer potential opportunities. Interdependencies can be (a) actively acknowledged by bringing them unto the negotiation table, for example through issue linkage (see below), and (b) actively promoted by means of shared infrastructure development (see next section), or through institutionalising upstream-downstream linkages, for example in the form of payment for environmental services arrangements. A question is whether water engineers and water managers are sufficiently equipped to identify such opportunities.

## Issue linking

When negotiations between riparians (be they countries, communities or individual water users) prove to be difficult or stall, it may help to introduce completely new issues to the table. These may relate to issues in adjacent river basins, or may be entirely unrelated to water, such as trade, access to ports, to energy, to markets etc. When searching for additional issues to be brought to

the negotiation table, what is in fact happening is the search for other interdependencies that exist between the riparians and that counterbalance and reciprocate the inherently one-sided upstream-downstream relationship (Van der Zaag, 2007). An issue linkage can be understood as an exchange of concessions in fields of relative strength (Dombrowsky, 2010). Two examples are briefly mentioned to illustrate this point.

The deadlock that existed in the negotiations between Swaziland, South Africa and Mozambique on a water sharing agreement over the Incomati river basin could only be broken when the adjacent Maputo river basin was included in the negotiations. This was because the interests that the three riparian countries had in both basins differed and, to some extent, could be traded (Van der Zaag and Carmo Vaz, 2003).

Another example is the negotiations between the Belgium and The Netherlands, where the key issue of Belgium concerned the Scheldt river basin (namely securing access to the port of Antwerp by large vessels through the Scheldt estuary located in Dutch territory) whereas the main concern of the Dutch was related to the Meuse river basin (reducing pollution of the upper parts of the river Meuse). Only when these issues were linked was a creative deal possible: whereas the Dutch were “downstream” with respect to the Meuse issue, they were “upstream” with respect to the Scheldt issue (Meijerink, 2008). This notwithstanding, cooperation between the Flemish (Belgian) and the Dutch on the Scheldt have remained highly problematic and still is contentious. This means that even the strategy of issue linkage has its limitations and should be examined with critical eyes.

# 6. Joint infrastructure development

An intensive form of collaboration evolves when riparian countries decide to jointly develop hydraulic infrastructure. To jointly develop infrastructure can make much sense. Here we mention five possible reasons:

1. The multi-purpose nature of large dams/reservoirs often implies that the benefits are not limited to one country. If this is the case, excluding the other countries could make such a development uneconomic and unfeasible.
2. In case of multi-purpose dams, the various sectoral benefits (i.e. from flood mitigation, hydropower production and irrigation) may be distributed unevenly over the various countries involved, creating complex demands and conditions that can only be resolved through joint operation.
3. In general one can observe that the development of large hydraulic infrastructures in one riparian country typically causes (positive or negative) externalities in other riparian countries. The other countries should at least be informed, and their no-objection may only be achieved if their specific needs and interests are taken into account.
4. In case a river forms the boundary of two riparian countries, the construction of a reservoir on that river presupposes collaboration.
5. In case of infrastructure for early warning of floods (requiring sets of rainfall stations, gauging stations, real-time transmission infrastructure, agreed numerical models, etc.), a riparian country may only fully benefit if parts of this infrastructure is located in upstream countries, creating a willingness of the downstream country to engage with one or more upstream countries.

To jointly develop infrastructure (both hardware and software) requires a good insight into all the (social and economic and environmental) costs and benefits involved, and how these will be distributed over the various participating parties. This not only requires a good understanding of the hydrological system, and what the biophysical impacts will be of the proposed intervention, but also of the socio-economic consequences of the proposed intervention.

Ideally, we need to combine the hydrological knowledge with socio-economic information, through e.g. the development of integrated hydro-economic models. Such models allow us to compare the costs and benefits of alternative interventions, as well as to optimise the design of a proposed intervention, and to estimate realistic and fair compensation arrangements.

The development of jointly owned hydraulic infrastructural works such as reservoirs can be based on, and facilitated by, the capacity sharing concept (Dudley and Musgrave, 1988; Dudley, 1990). In capacity sharing one reservoir has multiple owners, each having a precisely defined share in the capacity of that reservoir to store water. By carefully accounting for all in- and outflows (including releases, net evaporation and seepage losses), the different users can manage their part of the storage capacity according to their own preference and risk profile. Therefore, the capacity sharing method can also be used in reservoirs with multiple uses, such as instream uses, urban uses, and

irrigation, which typically have different levels of supply assurance (see also Symphorian et al., 2003).

An example of a jointly owned reservoir is Maguga dam on the Komati river. Although this reservoir is located in Swaziland, it is jointly owned and operated by Swaziland and neighbouring South Africa. In this benefit sharing scheme the benefits (entitlements to secure water from storage) as well as the costs of investments, have been defined in much detail (Box 11). Note that the full agreement is even more complex, whereby also different levels of assurance of supply are defined and "commensurated" (see Swaziland and South Africa, 1992).

**Box 11: Summary of a benefit sharing arrangement between South Africa and Swaziland on the Komati river.**

Source: Treaty on the development and utilisation of the water resources of the Komati river basin between Swaziland and South Africa, signed on 13 March 1992; Annex 2 (Apportionment of capital cost)

| | | | |
|---|---|---|---|
| Total Cost of Driekoppies Dam | $T_D$ | = | 104.7 × $10^6$ Rand |
| Total Cost of Maguga Dam | $T_M$ | = | 138.3 × $10^6$ Rand |
| Hence: Total Cost | $T$ | = | 243.0 × $10^6$ Rand |
| South Africa: incremental water allocation | $i_r$ | = | 111.0 × $10^6$ $m^3$/year |
| Swaziland: incremental water allocation | $i_s$ | = | 72.6 × $10^6$ $m^3$/year |
| Hence: Total incremental water allocation | $i_t$ | = | 183.6 × $10^6$ $m^3$/year |

The Basic Cost is apportioned to Swaziland and South Africa in proportion to the mean basic water shortages experienced by each of the respective states in 1981, i.e. 0.11 and 0.89 respectively. The Basic Cost shall be fixed as 0.599 times the Total Cost. The Incremental Cost is apportioned to Swaziland and South Africa in proportion to the incremental water allocations expressed as equivalent High Assurance water.

Hence Swaziland's share of the Total Cost expressed as proportion of the cost of Maguga Dam is given by:

$$S_s = \frac{T}{T_M} \times \left( 0.599 \times 0.11 + 0.401 \times \frac{i_s}{i_t} \right)$$

$$= (243.0/138.3) \times ( 0.06589 + 0.401 \times (72.6/183.6) )$$

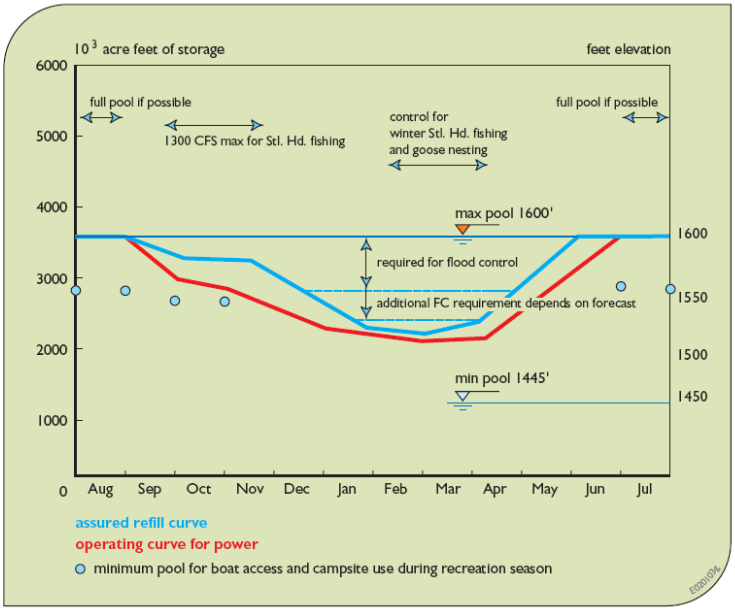
$$= 0.39438$$

Accordingly South Africa's share of the Total Cost of Maguga Dam (1-$S_s$) equals 0.60562.

**Operation rules of multi-purpose reservoirs**

Large multi-purpose reservoirs have complex rules that inform dam operation. These rules embody the various functions of the reservoir and the priorities attached to those functions (Figure 3). Different functions have different preferred operating rules, as is indicated in Box 12.

**Figure 3: An example reservoir rule curve for a single reservoir on the Columbia River in the USA, specifying the storage targets and some of the release constraints, given the particular current storage volume and time of year.** The release constraints also include the minimum and maximum release rates and the maximum downstream channel flow and depth changes that can occur in each month. (Source: Loucks and Van Beek, 2005, figure 4.16, page 102).




**Box 12: Reservoir operating rules for different functions**

| Purpose or function | Rule | | Comment |
|---|---|---|---|
| | high flow season | low flow season | |
| Hydropower generation | *keep water levels high* | *keep water levels high* | produces most power (assuming constant electricity price throughout year) |
| Water for irrigation | *fill completely* | *empty (completely)* | uses (most) water during the dry irrigation season |
| Flood mitigation | *do not entirely fill* | - | keeps capacity to store a flood wave and reduces flood levels downstream |
| Environmental releases | *release a minimum high season flow* | *release a flow not smaller than the minimum* and *not larger than the maximum low season flow* | maintains a certain degree of the natural flow regime downstream |
| Political/ statutory releases | *minimum and/or maximum cross border release* | *minimum and/or maximum cross border release* | satisfies bilateral or multilateral agreements or treaties |

Note also that some rules may overlap. The challenge is to develop a coherent set of rules that reflects the preferences of a society for the different functions of the reservoir, and of the importance of the various sectors involved. This inevitable implies a careful weighing of these functions and their preferences.

These preferences can sometimes be expressed in economic value terms. Sometimes that is not possible, or not expedient: certain functions may have such a high priority that they overrule others. In such cases the relevant rules serve as constraints.

Since large dams often have a transboundary dimension or impact, or are even jointly owned by different countries, the establishment of the operating rules of such dams also have to be agreed with the riparian countries potentially affected or involved.

**What do water experts need to know to promote peaceful water sharing?**

The previous sections show that transboundary water management is data, and knowledge, intensive. This section therefore addresses the following question: What do water engineers and water managers need to know to promote the peaceful sharing of transboundary waters? If water experts are to contribute anything in this field, they need to understand, and be able to assess, and quantify and measure, normative concepts such as "equity" and "benefit sharing".

As an exercise, let us briefly attempt to inventorise the data needs to assess whether a certain water allocation arrangement could be considered "equitable". We base ourselves on equations developed by Van der Zaag et al. (2002), reproduced in Box 13.

**Box 13: Equations defining the equitable sharing of transboundary water resources.**
Source: Van der Zaag et al. (2002)

$$Q_b = C \; A \; MAX\,[\,P - I\,,\,0\,] \qquad \text{(eq. 1)}$$

$$Q_g = (1\text{-}C) \; A \; MAX\,[\,P - I\,,\,0\,] \qquad \text{(eq. 2)}$$

$$Q_{r,i} = \left( Q_{t,i-1} + W_g \sum_i^n Q_g + (1 - R_b) \sum_i^n Q_b \right) \cdot \frac{N_i}{\sum_i^n N} \qquad \text{(eq. 3)}$$

$$Q_{t,i} = MIN\left[ Q_{t,i-1} + W_g Q_{g,i} + (1 - R_b) Q_{b,i} - Q_{r,i}\,,\; Q_{t,i-1} + (1 - R_b) Q_{b,i} \right] \qquad \text{(eq. 4)}$$

where
- $A_i$ = basin area occupied by country $i$ ($10^9$ m$^2$)
- $C$ = net runoff coefficient (-)
- $I$ = average annual interception (m yr$^{-1}$)
- $i$ = prefix for the riparian countries involved, with $i$=1 for the upper most basin country and $i$=$n$ for the most downstream
- $n$ = total number of basin countries
- $N_i$ = the population living in that part of the river basin occupied by country $i$
- $P$ = average annual precipitation (m yr$^{-1}$)
- $Q_{b,i}$ = blue water generated in country $i$ ($10^9$ m$^3$ yr$^{-1}$)
- $Q_{g,i}$ = green water generated in country $i$ ($10^9$ m$^3$ yr$^{-1}$)
- $Q_{r,i}$ = right to blue water of country $i$ over and above the reserved blue water ($10^9$ m$^3$ yr$^{-1}$)
- $Q_{t,i}$ = surplus blue water to be transferred to downstream countries ($10^9$ m$^3$ yr$^{-1}$)
- $R_b$ = fraction of blue water reserved for each riparian country (-)
- $W_g$ = weight of green water relative to blue water (-)

From Box 13 it is clear that *hydrological data* are needed. We need to be able to assess water availability, and we need to know this in a spatially explicit manner, with sufficient temporal resolution (i.e. at least monthly, preferably daily). The following are the specific data requirements:

- precipitation, non-productive interception, and hence effective precipitation;
- the amount of water infiltrating into the soil, stored as soil moisture in the unsaturated zone and used (in the form of transpiration) for biomass production (green water);
- the balance of effective precipitation minus green water, i.e. the remaining blue water resources, in the form of river flow, and surface and aquifer storage.

In addition to the above biophysical data, we also need other types of data, such as the number of people living in the various parts of the river basin. A more sophisticated equation would require specific information on water abstractions by the various sectors of society, as well as return flows (and their quality). We also need *economic and political information*, i.e. what is the value of green water relative to blue water; and which part of the blue water resources generated within our territory belongs to ourselves and may thus be kept outside the water sharing negotiations?

We may conclude that operationalising the equity concept is data and knowledge intensive. The knowledge requirements for developing "benefit sharing" schemes are arguably even greater. This is because this concept does not only involve a good understanding of the available water resources (and their reliabilities) and water needs, but also an understanding of how costs and benefits between the parties will be apportioned (Box 11).

In river basins where all of the water resources are already committed and used, water use may lead to tensions, especially in the face of climate variability and uncertainties with respect to the actual water availability and use. New arrangements and agreements may need to be reached. However, such difficult zero-sum allocation decisions need legitimacy, both scientifically and politically. The former requires reliable data, sound interpretation of these data and trusted algorithms and models, which demands multidisciplinary expertise; the latter requires an inclusive approach whereby those affected by the decision are part and parcel of the process, and are fairly represented, and whereby the different stakeholder representatives can hire there own experts to ensure that models and modelling results can be trusted. This lesson is well illustrated by the case of the Lerma-Chapala Basin in Mexico, which is shared by several different federal states (Box 14).

In conclusion, questions of transboundary water management can thus only be addressed if we have a good qualitative and a reasonable quantitative understanding of the hydrological processes within the river basin at hand. In addition also a good understanding of the uses of water by human intervention is required. It is ironic that often data on (human) water use are more uncertain and scarcer than data on (natural) water availability. Once we are able to quantify water availability and use, we can do many more things. We can attempt to quantify the economic value of the water use, and from there calculate the productivity of water as well as estimate its economic value. Based on this information tools can be developed that may assist decision-makers (for planning purposes) and managers/operators (for operational management). Alternative water allocation scenarios can be developed and compared; alternative policies and investment plans considered, as well as scenarios that focus on the uncertainty of future water availability and

future demand. For all these purposes regular monitoring of rainfall, river flows, water abstractions as well as production figures (e.g. crop yields) is important. Novel observation technologies based on remote sensing techniques provide new opportunities to significantly improve monitoring, and complement conventional sources of information. Rainfall, cloud cover, surface albedo, temperature, actual evaporation, crop yields, surface area of dams and changes in groundwater volumes can all be measured from space, which in itself may be a positive factor helping the sharing of data between riparians!

**Box 14: Re-allocation of water requires legitimate data and models – the case of the Lerma-Chapala Basin in Mexico** (Source: Wester et al., 2008)

The Lerma-Chapala Basin provides surface water and groundwater for nearly 900,000 ha of irrigation farms, supplements the water needs of Mexico's two major cities, Mexico City and Guadalajara, and hosts the touristic Chapala Lake at its downstream end. The closure of the Lerma-Chapala Basin is a result of increasing human pressures on water. The resulting levels of blue water depletion have made the basin very sensitive to climatic fluctuations.

The lack of accurate water accounting in the basin, and the relatively wet period in the 1960s and 1970s, resulted in an overestimation of water availability by decision makers and the "overbuilding" of the basin. Consequently, water levels in Lake Chapala dropped precipitously between 1994 and 2002, from 68% to 14% of maximum storage (about 7,000 Mm3).

Between 1999 and 2004, political conflicts and negotiation processes surrounding the allocation of surface water dominated the Lerma-Chapala River Basin Council.

In 1999 the members of the Council decided to revise the agreement as it was clear that it was not rescuing Lake Chapala. This was attributed to weaknesses in the old allocation agreement, including an overestimation of water availability in the basin, an underestimation of the area under small-scale irrigation and the lack of mechanisms to control the clandestine use of water.

New studies were conducted, more sophisticated numerical models were developed, longer time series were considered, and new environmental economic techniques were used in order to come up with a more refined water allocation agreement. User representatives of the various sectors and the state representatives consulted hydrological, environmental, economic and social experts. After many negotiation rounds the so-called "joint political optimum" scenario for water allocation was defined. This allocation algorithm formed the basis of a non-binding voluntary agreement that was adopted by the Council and converted into a legally binding treaty. Meanwhile the lake level has largely recuperated, mainly due to abundant rainfall and exceptionally large inflows in 2003 (Mollard and Vargas Velazquez, 2004)

## 7. Public participation

Integrated management of water resources requires strengthening capacities at the highest *and* lowest levels within a basin. This insight calls for commitment at the highest political levels, as well as for the active participation of stakeholders and the general public in the process of international river basin management. The participation of stakeholders will assist in elaborating solutions that are sustainable and equitable, and may help to make national laws compatible with traditional norms and customs found at the local level (Savenije and Van der Zaag, 2000).

Box 15 gives an example of how stakeholders can have a very constructive impact on the process of developing international agreements. With the benefit of hindsight, one can say that in Europe environmental pressure groups have played an important role in bringing sustainability considerations higher on the political agenda and in enhancing a positive policy environment for international negotiations and cooperation.

**Box 15: Legal action by private bodies against polluters of Rhine water** (Adapted from Lammers, 1989)

A number of Dutch private persons, water companies and lower administrative bodies, dissatisfied with the increasing pollution of the Rhine, initiated legal proceedings because they claimed to sustain damage.

In 1974 a Dutch lobby group of environmentalists and a few Dutch farmers brought an action before the District Court of Rotterdam in the Netherlands against a French potash mine, the greatest salt polluter of the Rhine. The Court declared the discharge of the waste salts by the mine unlawful under Dutch law and ordered the mine to pay compensation.

Private legal action was also taken before the courts in France. In 1981 ten Dutch complainants, among whom the province of North Holland, started proceedings before a French court objecting against licenses issued by French local government to the mine, allowing it to dispose waste salts in the Rhine. The French court annulled these licenses.

Legal proceedings instituted by (potential) victims before national courts against major individual polluters of the Rhine appeared to be an interesting supplementary means to abate the pollution of the Rhine. The legal principles developed by those courts are of a much wider scope and will be helpful in respect of other damages done to water quality and quantity in the Rhine, and possibly also in other basins.

**Box 16: The principle of non-discrimination in the UN Watercourses Convention** (Source: UN, 1997)

**Article 32: Non-discrimination**

Unless the Watercourse States concerned have agreed otherwise for the protection of the interests of persons, natural or juridical, who have suffered or are under a serious threat of suffering significant transboundary harm as a result of activities related to a shared watercourse, a Watercourse State shall not discriminate on the basis of nationality or residence or place where the injury occurred, in granting to such persons, in accordance with its legal system, access to judicial or other procedures, or a right to claim compensation or other relief in respect of significant harm caused by such activities carried on in its territory.

**Box 17: From Potential Conflict to Cooperation Potential**

*"Since wars begin in the minds of men, it is in the minds of men that the defences of peace must be constructed"* (UNESCO Constitution, November 1945)

The Hague Ministerial Declaration, signed in March 2000, identified the key challenges to achieving water security. These challenges provide the context for the World Water Assessment Programme. Within this UN-wide initiative, UNESCO has launched "From Potential Conflict to Co-operation Potential" (PCCP). The PCCP initiative addresses the challenge of sharing water resources primarily from the point of view of governments, and develops decision-making and conflict prevention tools for the future. PCCP is guided by UNESCO's paramount mandate to nurture the idea of peace in human minds.

PCCP aims to foster co-operation between stakeholders in the management of shared water resources, while helping to ensure that potential conflicts do not turn into real ones. It focuses on the development of tools for the anticipation, prevention and resolution of water conflicts.

One critical aim of water management is to continually reconcile the opposing interests of all water users - be they individuals, enterprises, corporations, interest groups, administrative or sovereign entities. The management of water conflicts, confrontations, competitions and co-operation are thus a part of water resources management in its broadest sense. Negative interactions (such as competition, confrontations etc...) over scarce water resources can lead to tension and - in extreme situations - even conflict, should they remain unattended.

PCCP was conceived with the idea that, although shared water resources can be a source of conflict, their joint management should be strengthened and facilitated as a means of co-operation between various water users. Thus PCCP aims to demonstrate that a situation with undeniable potential for conflict can be transformed into a situation where co-operation potential can emerge. PCCP's thematic focus is on this very transition - from PC to CP.

The PCCP programme has developed thematic papers, case studies and educational materials, which are all available from the web: http://www.unesco.org/water/wwap/pccp/index.shtml

***Water and Conflict Resolution Series***

- Water and Peace for the People (by Jon Martin Trondalen)
- Transboundary Water Management - Principles and Practice (edited by Anton Earle, Anders Jägerskog and Joakim Öjendal)
- Managing and Transforming Water Conflicts ( by Jerome Delli Priscoli and Aaron T. Wolf)

***Disciplinary studies***

- History and Future of Shared Water Resources
- Institutions for International Freshwater Management
- Transforming Potential Conflict into Cooperation Potential: The Role of International Water Law
- State-of-the-Art Report on Systems Analysis Methods for Resolution of Conflicts in Water Resources Management
- Alternative Dispute Resolution Approaches and their Application
- Negotiation in the Context of International Water-Related Agreements
- Etc.

***Case studies***

Aral Sea; Columbia; Incomati; Jordan; Mekong; Nile; Rhine; Upper Lempa; Lake Titicaca.

***Training course materials***

The UN Watercourses Convention contains a non-discrimination article, which gives stakeholders suffering transboundary damages access to the judicial system of the country where the damages originated (Box 16).

One strategy to promote public participation is to invest in research and education on transboundary issues. UNESCO's "From Potential Conflict to Cooperation Potential" programme wants to achieve this (Box 17).

## 8. Conclusions

In this lecture note it has been argued that water tends to build asymmetrical relationships between people, communities and nations; because of the simple fact that water flows downhill. The action of the upstream riparian impacts on the downstream riparian and not vice versa. We all tend to emphasise that we are at the receiving end, living downstream, and that somebody else upstream constrains our options. Claims to water therefore travel upstream; but do water users also consider the impact of their own actions further downstream? One's vision and understanding of particular water situations is therefore often partial and biased. It could be hypothesised that the more downstream one is located, the more complete one's view of the basin is likely to be!

The partial and biased vision easily may cause misunderstandings, tensions and ultimately conflicts. Conflicts do indeed occur. But cooperative deals are being brokered more often than one would expect. This is so because neighbours, be they persons, neighbouring villages or riparian countries, seem to understand that they are doomed to live together in future; and realise that short term gains, accrued through selfish behaviour, in the long run will prove self-destructive.

The following are some of the lessons that have been drawn from the previous studies (Van der Zaag and Savenije, 2000):

1. Integrated management of shared water resources requires *triggers* and *opportunities*. In addition, political change, or the dissipation of international tension (e.g. the termination of Apartheid and the 'Fall of the Berlin Wall') can offer excellent opportunities to break a deadlock and establish joint management arrangements.

2. A system of *technical communication and cooperation* is extremely important to support joint management of water resources. Particularly where the political environment is not favourable, technical cooperation is the most important instrument to maintain minimum levels of communication and to prevent conflicts to escalate *(Track-Two)*. Through technical cooperation mutual trust and understanding is built up.

3. *The playing field needs to be level*, implying that all countries should have adequate capacities to analyse and develop their negotiating position. Staff from riparian countries should have the same level of knowledge and speak the same "technical language". Joint capacity building efforts can be, and are, instrumental to facilitate communication and cooperation.

4. *Free access to hydrological information* (and information on water use) is essential to maintain mutual trust and technical cooperation. In many regions international organisations (such as UNESCO, WMO, UNEP, WWF, IUCN) have played very important roles in this regard. Publicly available data, for example data derived from remotely sensed sources such as satellite images, provide new opportunities to ensure or promote collaboration.

5. Besides the positive influence that *economic cooperation* has on the political environment, a system of open economic cooperation and a free access to markets is instrumental in facilitating the trade of 'virtual water'.

6. To reach agreements on sharing international water, and acknowledging the interdependencies between riparians, *the playing field needs to be broadened*. Issue linking, involving other sectors than directly related to the water sector (e.g. transport), can open-up new imaginative win-win propositions.

7. Often the *downstream country should take the initiative* in this process.

8. At the grassroots level *all the users of water*, including rainfed farmers and shrimp fishermen, *should have access to sufficient information* concerning the decisions taken about their water resource, and, through appropriate basin organisations, the right to *participate* in the decision-making process.

## References


Adams, W.M., T. Potkanski and J.E.G. Sutton, 1994. Indigenous farmer-managed irrigation in Sonjo, Tanzania. *Geographical Journal* 160(1): 17-32.

Alam, Undala Z., 1998. Water rationality - Mediating the Indus Waters Treaty. PhD Thesis. Geography Department, University of Durham.

Baland, J.-M., and Platteau, J.-P., 1999. The ambiguous impact of inequality on local resource management. *World Development* 27(5): 773-788.

Boelens, R., and G. Davila (eds.), 1998. *Searching for equity; conceptions of justice and equity in peasant irrigation.* Van Gorcum, Assen.

Dellapenna, J.W., 2011. The customary law applicable to internationally shared groundwater. *Water International* 36(5): 584-594.

Dombrowsky, I., 2009. Revisiting the potential for benefit sharing in the management of transboundary rivers. *Water Policy* 11: 125-140.

Dombrowsky, I., 2010. The role of intra-water sector issue linkage in the resolution of transboundary water conflicts. *Water International* 35(2): 132-149.

Dudley, N., 1990. Urban capacity sharing - an innovative property right for maturing water economies. *Natural Resources Journal* 30: 381-402.

Dudley, N, and F. Musgrave, 1988. Capacity sharing of water reservoirs. *Water Resources Research* 24: 649-658.

Falkenmark, M., and C. Folke, 2002. The ethics of socio-ecohydrological catchment management: towards hydrosolidarity. *Hydrology and Earth System Sciences* 6(1): 1-9.

Falkenmark, M., and J. Lundqvist, 1999. Towards upstream/downstream hydrosolidarity; introduction. In: Towards upstream/downstream hydrosolidarity; proceedings of the SIWI/IWRA Seminar; Stockholm, 14 August; pp. 11-15.

Fleuret, P., 1985. The social organization of water control in the Taita Hills, Kenya. *American Ethnologist* 12(1): 103-118.

Goor, Q.,C. Halleux, Y. Mohamed and A. Tilmant, 2010. Optimal operation of a multipurpose multireservoir system in the Eastern Nile River Basin. *Hydrol. Earth Syst. Sci.* 14: 1895–1908.

Grove, A., 1993. Water use by the Chagga on Kilimanjaro. *African Affairs* 92: 431-448.

Gupta J. 2004. International Water Law, IHE Lecture Note. IHE, Delft.

Gupta, J., and P. van der Zaag, 2008. Interbasin water transfers and integrated water resources management: Where engineering, science and politics interlock. *Physics and Chemistry of the Earth* 33: 28-40.

Gupta, J., and P. van der Zaag, 2009. The politics of water science: On unresolved water problems and biased research agendas. *Global Environmental Politics* 9(2): 14-24.

ILA, 1966. Helsinki rules on the uses of the waters of international rivers, adopted by the International Law Association at the 52nd conference, Helsinki, 20th August 1966. The International Law Association, London.

ILC, 1994. The law of non-navigational uses of international watercourses - extracts from the report of the International Law Commission. *Environm. Policy and Law* 24/6; pp. 335-368.

Komakech, H.C., P. van der Zaag and B. van Koppen, 2012. The dynamics between water asymmetry, inequality and heterogeneity sustaining canal institutions in Makanya catchment, Tanzania. *Water Policy* 14(5): 800–820.

Lammers, J.G., 1989. The Rhine: legal aspects of the management of a transboundary river. In: W.D. Verwey, *Nature management and sustainable development*. IOS, Amsterdam; pp. 440-457.

Loucks, D.P. and E. Van Beek, 2005. *Water resources systems planning and management – an introduction to methods, models and applications.* UNESCO, Paris.

Martin, E.D., and R. Yoder, 1988. A comparative description of two farmer-managed irrigation systems in

Nepal. *Irrigation and Drainage Systems* 2(2): 147-172.

McCaffrey, S.C., 1993. Water, politics and international law. Chapter 8 in: P.H. Gleick, *Water in crisis; guide to the world's water resources*. Oxford University Press, Oxford.

McCaffrey, S.C., 2011. The International Law Commission's flawed Draft Articles on the Law of Transboundary Aquifers: the way forward. *Water International* 36(5): 566-572.

Mirumachi, N., and J.A. Allan, 2007. Revisiting transboundary water governance: Power, conflict cooperation and the political economy. Proceedings from CAIWA International Conference on Adaptive and Integrated Water Management: Coping with Scarcity. Basel, Switzerland, 12–15 November 2007.

Meijerink, S., 2008. Explaining continuity and change in international policies: issue linkage, venue change, and learning on policies for the river Scheldt estuary 1967-2005. *Environment and Planning A* 40: 848-866.

Meissner, R., and A.R. Turton, 2003. The hydrosocial contract theory and the Lesotho Highlands Water Project. *Water Policy* 5(2): 115-126.

Mohamed-Katerere, J., and P. van der Zaag, 2003. Untying the "Knot of Silence"; making water policy and law responsive to local normative systems. In: F.A. Hassan et al. (eds.), History and Future of Shared Water Resources. *IHP Technical Documents - PCCP series No. 6.* UNESCO, Paris [http://www.unesco.org/water/wwap/pccp/pubs/disciplinary_studies.shtml]

Mokorosi, P.S., and P. van der Zaag, 2007. Can local people also gain from benefit sharing in water resources development? Experiences from dam development in the Orange-Senqu river basin. *Physics and Chemistry of the Earth* 32: 1322-1329.

Mollard, E. and S. Vargas Velazquez, 2004. "Liable but not guilty": the political use of circumstances in a river basin council (Mexico). Proceedings of the workshop on Water and Politics – Understanding the Role of Politics in Water Management; Marseille, 26-27 February 2004. World Water Council, Marseille; pp. 39-50

Postel, Sandra, 1992. *Last oasis, facing water scarcity*. W.W. Norton, New York.

Potkanski, T., and W.M. Adams, 1998. Water scarcity, property regimes and irrigation management in Sonjo, Tanzania. *Journal of Development Studies* 34(4): 86-116.

SADC, 2000. Protocol on shared watercourses in the Southern African Development Community (SADC) Region. Signed in Windhoek on 7 August 2000. SADC, Gaborone.

Sadoff, C.W., and D. Grey, 2002. Beyond the river: the benefits of cooperation on international rivers. *Water Policy* 4: 389-403.

Savenije, H.H.G., and P. van der Zaag, 2000. Conceptual framework for the management of shared river basins, with special reference to the SADC and EU. *Water Policy* **2**(1-2): 9-45.

Symphorian, G.R., E. Madamombe and P. van der Zaag, 2003. Dam operation for environmental water releases; the case of Osborne dam, Save Catchment, Zimbabwe. *Physics and Chemistry of the Earth* 28: 985-993.

Turton, A.R., and R. Henwood (eds.), 2002. Hydropolitics in the Developing World: A Southern African Perspective. AWIRU. University of Pretoria, Pretoria.

UN, 1997. Convention on the Law of the Non-Navigational Uses of International Watercourses. Adopted by the United Nationals General Assembly in resolution 51/229 of 21 May 1997. New York, United Nations.

UNCED, 1992. Rio Declaration on Environment and Development. The final text of agreements negotiated by Governments at the UN Conference of Environment and Development, 3-14 June 1992, Rio de Janeiro.

Van der Zaag, P., 1999. Water allocation principles in catchment areas: some notes on constraints and opportunities. In: E. Manzungu, A. Senzanje and P. van der Zaag (eds.), *Water for agriculture in Zimbabwe: policy and management options for the smallholder sector.* University of Zimbabwe Publications, Harare; pp. 168-178.

Van der Zaag, P., 2004. Game theory and its relevance for shared river basins. In: WaterNet, CCR, ISRI, Catalic, UNESCO-IHE Delft, UZ (eds.), Conflict Prevention and Cooperation in International Water Resources – Course Book. *IHP Technical Documents in Hydrology - PCCP series* No. 25. UNESCO, Paris; pp. 2-29 - 2-39.

Van der Zaag, P., 2007. Asymmetry and equity in water resources management; critical governance issues for Southern Africa. *Water Resources Management* 21 (12): 1993-2004.

Van der Zaag, P., 2009. Southern Africa: Evolving regional water law and politics. Chapter 15 in: J.W. Dellapenna and J. Gupta (eds.), *The Evolution of the Law and Politics of Water.* Springer, Berlin; pp.245-261.

Van der Zaag, P., and Á Carmo Vaz, 2003. Sharing the Incomati waters: cooperation and competition in the balance. *Water Policy* 5: 349-368.

Van der Zaag, P., and H.H.G. Savenije, 2000. Towards improved management of shared river basins: lessons from the Maseru conference. *Water Policy* **2** (1-2): 47-63.

Van der Zaag, P., I.M. Seyam and H.H.G. Savenije, 2002. Towards measurable criteria for the equitable sharing of international water resources. *Water Policy* **4**(1): 19-32.

Wester, P., S. Vargas, E. Mollard, and P. Silva, 2008. Negotiating surface water allocations to achieve a soft landing in the closed Lerma-Chapala Basin, Mexico. *International Journal of Water Resource Development* 24(2): 275-288.

Wolf, A.T., 1999. Criteria for equitable allocations: the heart of international water conflict. *Natural Resources Forum* 23: 3-30.

Wouters, Patricia, 1997. Present Status of International Water Law. In: *International Water Law; Selected Writings of Professor Charles B. Bourne.* Kluwer Law International, London.

Yamada, C., 2011. Codification of the Law of Transboundary Aquifers (Groundwaters) by the United Nations. *Water International* 36(5): 557-565.

Zeitoun, M., and N. Mirumachi, 2008. Transboundary water interaction I: reconsidering conflict and cooperation. *International Environmental Agreements* 8: 297–316.

# Annex

## Benefit- and cost-sharing – a game theoretic application to a hypothetical transboundary river basin (Source: Van der Zaag, 2004)

Let us reflect on how cost-sharing can be helpful to come to an agreement between riparian countries whereby all the parties could possibly benefit.

Consider a non-existent, hypothetical river basin called Mvula shared by two countries. One country (UP) is situated upstream of the other, downstream, country (DOWN). Given that water flows downhill, water use in DOWN does not affect water availability in UP, but consumptive water use in UP does diminish water availability in DOWN.

### Initial situation

Consider the starting situation. Both countries are not very developed, and both derive some benefits from utilising the water resources of this basin, including the important services that the riverine ecosystems produce. Let us assume that in this starting situation the countries derive the following net benefits from their uses of the basin's water resources; these we will call *primary benefits*:

*Primary benefits*

| | |
|---|---|
| UP | 20 M/a |
| DOWN | 40 M/a |

DOWN derives more benefits from the river's resources because it has more water (thanks to water generated in UP that flows into DOWN), and richer water-based ecosystems, especially Mvula's estuary, that produce important goods such as fisheries.

### Development options

Both countries now want to develop economically and further utilise the water resources of the basin. Each country has three development options:
1. No development
2. Medium development
3. Full development.

The full development option means that a maximum amount of the water available in either UP or DOWN is consumptively used. Medium means that only a portion (say 50%) of all water resources available in both countries is consumptively used. No development means that the starting situation is maintained. It is further assumed that medium development is the maximum allowable development level so as not to harm the primary benefits derived from the river; whereas the full development scenario reduces those primary benefits to nil.

The potential direct economic benefits (i.e. assuming that sufficient water is available) of the medium and full development scenarios are for both countries identical.

*Potential direct economic benefits from development scenarios*

| | |
|---|---|
| NO | 0 M/a |
| MEDIUM | 50 M/a |
| FULL | 100 M/a |

**Resulting benefits for UP**

The total benefits that result for the various development scenarios are clear for country UP, since its water availability does not depend on what country DOWN will choose to do. UP will derive its highest benefit when choosing the full development scenario.

*Total benefits for UP*

| development scenario | primary benefits | development benefits | total benefits |
|---|---|---|---|
| 1. NO | 20 | 0 | 20 |
| 2. MEDIUM | 20 | 50 | 70 |
| 3. FULL | 0 | 100 | 100 |

**Resulting benefits for DOWN**

The benefits for DOWN depend on which development scenario UP chooses. If UP decides not to develop, sufficient water is available for DOWN's medium development plan, and some water stress for primary benefits would occur for the full development scenario.

*Total benefits for DOWN if UP chooses NO development*

| development scenario | primary benefits | development benefits | total benefits |
|---|---|---|---|
| 1. NO | 40 | 0 | 40 |
| 2. MEDIUM | 40 | 50 | 90 |
| 3. FULL | 10 | 100 | 110 |

If UP chooses full development, however, no water generated in UP will reach DOWN. DOWN will have to make do with the relatively small amounts of internally generated water resources, hampering its development.

*Total benefits for DOWN if UP chooses FULL development*

| development scenario | primary benefits | development benefits | total benefits |
|---|---|---|---|
| 1. NO | 20 | 0 | 20 |
| 2. MEDIUM | 10 | 20 | 30 |
| 3. FULL | 0 | 30 | 30 |

If UP chooses its medium development scenario, water sufficient to sustain the ecosystem in DOWN is released from UP; but any additional water use by DOWN would affect primary benefits.

*Total benefits for DOWN if UP chooses MEDIUM development*

| development scenario | primary benefits | development benefits | total benefits |
|---|---|---|---|
| 1. NO | 40 | 0 | 40 |
| 2. MEDIUM | 20 | 50 | 70 |
| 3. FULL | 5 | 75 | 80 |

**Comparing outcomes**

The above results can be summarised in a so-called pay-off table as follows:

| | | DOWN | | |
|---|---|---|---|---|
| | | NO dev. | MEDIUM dev. | FULL dev. |
| **UP** | NO dev. | 20 , 40 | 20 , 90 | 20 , 110 |
| | MEDIUM dev. | 70 , 40 | 70 , 70 | 70 , 80 |
| | FULL dev. | 100 , 20 | 100 , 30 | 100 , 30 |

*(NB: The first figure in each cell gives the total benefits for UP, the second that for DOWN)*

The highest total benefits that can be derived from the Mvula water resources amounts to 150 M/a (70 + 80), namely when UP chooses the Medium development scenario, and DOWN the Full development scenario. Any other combination of scenarios yields less total benefits.

Nevertheless, for UP it is always better to choose the full development scenario. It is therefore most likely that UP chooses the full development option; severely restricting the development options for DOWN. In that situation DOWN sees very little added benefit of choosing the Medium development scenarios, compared with no further developments (only 10 M/a additional benefit). The Full development scenario yields no additional benefits at all.

As a result, a sub-optimal outcome may be expected, with a highly inequitable water utilisation in favour of UP, while the total benefits only amount to 130 M/a.

**Side-payments**

The observed asymmetrical outcome could, in principle, be solved by means of side payments. Two theoretical possibilities exist:
(a) UP pays DOWN, namely for the impact caused by implementing its full development scenario;
(b) DOWN pays UP, namely for UP settling for the medium development scenario.

**UP pays DOWN**

UP could compensate DOWN if it implements the full development scenario, because this would impact directly on water availability and thus restrict DOWN's development options. UP would cause significant harm to DOWN. The financial impact on DOWN is clear: at least 40 M/a (70-30) and at most 50 M/a (80-30). The table below calculates the final benefits if UP would pay DOWN 40 M/a.

*Benefits if UP goes for Full Development, and pays DOWN 40 M/a*

| development scenario | primary benefits | development benefits | side payment | total benefits |
|---|---|---|---|---|
| UP - full | 0 | 100 | - 40 | 60 |
| DOWN - medium | 10 | 20 | +40 | 70 |

But why would UP accept to pay DOWN? UP may not be signatory to a convention that compels it to compensate for transboundary harm. UP may simply consider the water available from the Mvula basin inside its territory as its own property ("absolute territorial sovereignty").

**DOWN pays UP**

Alternatively, DOWN could offer UP a payment for foregoing the FULL development option and settle for Medium development. It would have to pay at least 30 M/a (100-70) to satisfy UP, which DOWN may be willing to pay, since its added benefit would be at least 40 M/a (70-30) and at most 50 M/a (80-30).

*Benefits if UP settles for Medium Development, being paid 30 M/a by DOWN*

| development scenario | primary benefits | development benefits | side payment | total benefits |
|---|---|---|---|---|
| UP - medium | 20 | 50 | +30 | 100 |
| DOWN - full | 5 | 75 | - 30 | 50 |

Yet the total benefits to UP (100) are now twice as big as that for DOWN (50). It is doubtful whether DOWN would find this a fair deal, even if it is for DOWN the most rational choice to make.

**An equitable outcome**

The UN Watercourses Convention (UN, 1997) states that each country sharing an international river:

(a) should utilise it in an equitable and reasonable manner; and
(b) prevent the causing of significant harm to other countries.

Applying these rules to the Mvula example, the situation whereby both UP and DOWN choose the medium development option adheres closest to the letter and spirit of the UN Watercourses Convention: transboundary impact would be minimised, while allowing both countries a reasonable and equitable share of Mvula's water resources. Both countries would derive comparable benefits (70 M/a each). But the total benefits are less than the optimal possible.

*Benefits if both countries settle for Medium Development*

| development scenario | primary benefits | development benefits | total benefits |
|---|---|---|---|
| UP - medium | 20 | 50 | 70 |
| DOWN - medium | 20 | 50 | 70 |

In this reading, neither of the two countries could claim compensation for settling for the medium development option, since it would be conceived as their duty to do so.

If, however, one country would defect and proceed with full development, a new situation would result which would conflict with international rules. The issue of compensation could become a subject of negotiation.

Defecting would, in fact, be tempting for both countries. UP would gain 30 M/a if it proceeded with full development. If DOWN would unilaterally proceed with full development, it could gain 10 M/a of additional benefits; however UP might retaliate by also opting for full development, leading to a severe loss for DOWN.

## Learning

We can learn from the above type of reasoning, which is informed by Game Theory. It shows how countries can achieve the highest benefits in negotiating shared water resources. Such reasoning relies on us being able to precisely quantify all types of positive benefits and negative impacts in monetary values, and add them up. It opens ways to come to a compromise solution. Such compromises have been informed by generally accepted rules with respect to transboundary waters. However, in the absence of a central authority that stands over and above the riparian states, such compromises cannot be imposed.

## Conclusion

The above example is highly simplified and only considers the consumptive use of water (e.g. for irrigation). In such cases the impact (externality) is always negative.

A more realistic situation would consider not only consumptive but also (largely) non-consumptive uses of water, such as hydropower, fisheries, flood control, maintaining ecological flows. In such cases win-win solutions between upstream and downstream countries may be available. This is because some of the upstream uses (e.g. of hydropower) may have a (potential) positive impact (externality) downstream (see e.g. Dombrowsky, 2009).

## Exercise

- Form two groups of two people each.
- One group represents the country UP, the other group the country DOWN.
- One member of the delegation represents the ministry of foreign affairs, and the other the ministry of economic development.
- Negotiate an agreement between UP and DOWN on the Mvula river (see next page) which has to be signed by all four delegates.

AGREEMENT
ON THE COOPERATION FOR THE SUSTAINABLE DEVELOPMENT
OF THE MVULA RIVER BASIN

The Governments of UP and DOWN have resolved to conclude this Agreement, and have appointed as their respective representatives:

| UP: | DOWN: |
|---|---|
| . . . . . | . . . . . |
| Minister of Foreign Affairs | Minister of Foreign Affairs |
| And | |
| . . . . . | . . . . . |
| Minister of Economic Planning | Minister of Economic Planning |

Who have agreed to the following:

1) The following development levels will be allowed:

a) In UP: . . . . . *(fill in either NONE, or MEDIUM, or FULL)*

b) in DOWN: . . . . . *(fill in either NONE, or MEDIUM, or FULL)*

2) The following cost sharing arrangements have been agreed

. . . . . *(fill in either UP or DOWN)*

will pay the other party an amount of

. . . . . Million per year

3) The final benefits that will accrue to both countries as a result of the above will be the following:

| country | primary benefits | development benefits | side payment | total benefits |
|---|---|---|---|---|
| UP | . . . . . | . . . . . | . . . . . | . . . . . |
| DOWN | . . . . . | . . . . . | . . . . . | . . . . . |

IN WITNESS WHEREOF, the undersigned, duly authorized by their respective governments have signed this Agreement.

DONE this …. day of the month …….. in the year ……, at ……

| | |
|---|---|
| . . . . . | . . . . . |
| . . . . . | . . . . . |