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Planning and Managing Transboundary River Basins: The Institutionalist Approach

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ABSTRACT

River basins that crosscut political borders can be catalysts for conflict between riparian states (from a neo-realist approach) or cooperation (institutionalist approach). Both approaches believe that states are rationally self-interested. Even though, the institutionalist approach argues that when comparing the long-term costs of conflict over shared waters to the benefits of cooperative management for the whole basin resources, riparians will choose to collaborate and institutionalize their cooperation. Numerous studies have presented various frameworks and tools that assist in exploiting win-win scenarios of cooperative benefit and cost sharing. This paper reviews, from an interdisciplinary perspective, a wide range of the theories and methodologies related to the institutionalist approach of hydropolitics. Four main groups of analytical methods are discussed in the following order: the one-system perception; benefits and costs to be shared; hydropolitical games; and institutional mechanisms. The main aim of this literature review is to pave the way for scholars, concerned with transboundary river basins, to synthesize their own methodologies to fit the case study analysis of their studies.

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KEYWORDS

Transboundary river basins; institutionalist approach; one-system perception; benefit and cost sharing; hydropolitical games; institutional mechanisms

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1. INTRODUCTION

Even 70% of the earth's surface is covered by water (Gleik, 2000, p. 21), less than 2.5% of our water is fresh, less than 33% of freshwater is fluid, and less than 1.7% of fluid water runs in streams (WCD, 2000, p. i). About 60% of accessible freshwater is shared between two or more countries (UN-Water, 2008, p. 3). These shared water resources form 263-plus transboundary[1] lake and river basins, hosting about 40% of the world's population, covering around one-half of the world's land surface, and crosscutting the borders of 145 countries (UN-Water, 2008, p. 3).

Transboundary water governance, in general, is obviously more complicated than that of other natural resources. This is due to the following two main reasons:

- Unlike other scarce resources, water vitally fuels wide range of different sectors, each of which involves various actors. This formulates water governance in a multi-objective and multi-stakeholder framework (Wolf, 2007, p. 3.5).
- Governments usually exploit their natural resources in a unilateral decision-making process, where each defines where, when and how to utilize them. Due to the fact that "nature does not respect national borders", where most of the world's freshwater is shared by two or more sovereign states, the essence of hydropolitics is based on the concept that "unilateralism and water do not mix" (Elhance, 1999, pp. ix, 3).

Two schools arose in the field of hydropolitics: neo-realist and institutionalist approaches (Schmeier, 2010, p. 5). Both are based on the concepts mentioned above: freshwater is fundamental for life and livelihoods; and many of water streams cross manmade-borders. However, the first school argues that managing transboundary water eludes states' sovereignty and trigger conflicts of collective action problems, which may result in 'water wars' (Anisfeld, 2010, p. 266). On the other hand, the second one believes that reality proves the previous thesis wrong[2]: as conflict costs are extraordinarily high, while cooperation brings more benefits, states would go forward to cooperation at the end (Anisfeld, 2010, p. 267). Hence, hydropolitics is defined by Elhance (1999), as "the systematic study of conflict and cooperation between states over water resources that transcend international borders".

Numerous studies have been developing analytical frameworks that enhance the institutional capabilities of offering rational incentives for riparian states to cooperate rather than struggle. After discussing the fundamental theories and arguments over shared waters (section two), this paper reviews those tools and methods of analysis that answer four inter-connected questions about: exploiting the whole basin resources (section three); generating additional benefits with minimum costs (section four); distributing benefits and costs among states (section five); and institutionalizing cooperation (section six).

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[1] Continued debate is tracked in literature around the terminology of 'transboundary' and 'international' river basins, as reviewed by Sadoff & Grey (2002, p. 390). Some argues that the term 'international' describes waters that belong to no specific state, such as 'international seawaters'. Others argue that the term 'transboundary' may be confusing, as there are river channels that their basins cross national borders. Some authors, as well, criticize the term 'watercourses', as it does not inclusively describe the hydrological system of a basin.

[2] The Oregon State University conducted a project entitled "Basins At Risk" (BAR) in the context of the Transboundary Freshwaters Disputes Database (TFDD). The study worked on the water events in international rivers from 1948 to 1999, analyzing the tendency of events to be cooperative or conflictive (based on a point-scale from -7 to +7, ranging from water war to unification into one nation). The project tracked 1831 events, 28% of which were conflictive, 67% were cooperative, and 5% were neutral or not significant, while there were no events recorded for extreme cases on the scale (Yoffe, Wolf, & Giordano, 2003, p. 1112).

2. WHY THE INSTITUTIONALIST APPROACH?

2.1 The Common Waters

One fundamental perception, in planning and managing water resources, is that water should be realized as an economic good[3] (Menzel, 2014). This is because it passes, along its lifecycle, through a group of economic processes: collection and production; drainage and sanitation; in addition to treatment and reuse. These processes require various economic policies, such as: supplies' priorities; pricing and regulation; and controlling expected impacts on both society and environment.

Cornes & Sandler (1986) classified economic goods into four groups, according to the factors[4] of 'exclusion' and 'rivalry': private, public, club and common goods (Table 1). Based on this classification, freshwater (and wastewater[5] as well) can take one of those four forms: a bottle of water in supermarket (private); water pipelines connected by public authorities to houses (public); a well in the desert drilled by a tribe (club); or rivers and lakes (common). The main problematic issues always belong to the last type, the 'commons'[6], for being understood as the 'gift of nature'. While, the other types usually have solid mechanisms of regulation and control. Therefore, common waters challenged, along history, the ability of nations to institutionalize their planning and management of such resources among different national stakeholders and objectives. In other words, it can be said that rivers, in specific, shaped the social and political fabric of nations[7].

While the good water governance[8] in one country requires an ultimate authority of national legislative structure (facing more complications in strong federal nations), governing those transboundary river basins is substantially more sophisticated, where constructing higher supreme organization collides with the principle of state sovereignty (Sadoff & Grey, 2002, p. 390).

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[3] For example, either public authorities or private companies may carry out the mission of collecting, producing and providing drinking water. In each case, service is priced in a different way. In the case of being a private good, the price is regulated by market, according to the real cost and projected profit. While in case of being a public good, government prices the service considering public taxes and other political aspects (as 'mass loyalty'). For deeper discussion, refer to Menzel (2014, pp. 55 - 64).

[4] The question of 'exclusion' refers to who can get the service, while 'rivalry' asks about the effects of usage by someone on the ability of others to use the service.

[5] According to Menzel (2014, p. 57), wastewater can take one of those four forms of economic goods, as follow: wastewater treated by private company and paid by users (private); wastewater treated by public authority and paid by taxes (public); members in a water association using its reclaimed wastewater (club); or non-reclaimed wastewater disposed in a common river (common).

[6] A common lake shared by a group of fisheries, or a pasture shared by patrons, will witness a tragedy, where each one will act to obtain his own maximum outcome, regardless the sustainability of the resource, resulting in the collective failure of the system. This was firstly introduced by Hardin (1968), as the tragedy of the commons.

[7] Clear examples, proving this argument, are those bureaucratic civilizations of alluvial basins, such as the Nile, Mekong, Euphrates and Indus basins, where strong institutional mechanisms were developed, long centuries ago, in order to manage both vital opportunities (water, food, navigation and trade, then recently industry and energy) and risks (floods and droughts) due to rivers. Moreover, rivers influenced the political transformations in such nations, where those who were able to hydraulically control waterways, possessed power. Other examples are the model of smaller social groups in communities relying on rainfed agriculture or those Bedouins searching for available water resources (wells or seasonal rains). For further discussion, refer to Sadoff & Grey (2002, pp. 391, 392) citing Wittfogel (1957) that introduced the concept of 'hydraulic monopoly'.

[8] According to UN-HABITAT (1999) and World Bank (2013), the term 'governance' usually describes the general process of rule and management, involving authorities, private sector and civil society. However, various normative mechanisms (as rule of law, transparency, accountability and participation) must control the interactions between those three principal groups of actors in order to be described as 'good governance'.

Table 1. Classification of economic goods, adopted by author after Menzel (2014) citing Cornes & Sandler (1986).

Factors		Rivalry	
		Yes	**No**
Exclusion	**Yes**	**Private Goods** Private company (regulated by market: who cannot pay is excluded and the good consumed by one person can no more be consumed by another one)	**Club Goods** Association (regulated by its statute: non-members are excluded and using the facilities of club by one member does not prevent others to use them)
	No	**Common Goods** A gift of nature (regulated by traditions: no one is excluded and the utilization of one person affects others)	**Public Goods** Public authority (regulated by government: no one is excluded and there is no rivalry between consumers)

Yet, the Rhine River provides an example for how cooperation can turn the 'tragedy' of common waters into a story of success, as reviewed by Sadoff & Grey (2002, p. 394). By the 1920s, growing populations and industries led to the complete extinction of salmon in the Rhine, and then the river was known as the 'sewer of Europe' by 1950s. In 1987, the ministers of the Rhine countries agreed on a plan to reduce the chemical contaminants of the river to the level that bring salmon back to life by 2000. The plan, which was named 'Salmon 2000', achieved its goals successfully due to the intensive international cooperation, private investments and public support. More schemes of cooperation take place nowadays in the Rhine for further coordination about flood control and environmental issues.

2.2 Rationality of Institutionalism

According to the implications of Rational Choice Theory (RCT)[9] in the studies of international relations, states (like individuals) are self-interested, where they orient their courses of action to maximize possible national benefits. Both of the well-known hydropolitical approaches, neo-realism and institutionalism[10], consider the rationality of states. However, each approach conceptualizes the whole issue in a different manner, as shown in Table 2 & Figure 1.

Neo-realists argue that conflicts (and perhaps water wars[11]) are more likely to arise between co-basin countries mainly due to the vital essentiality of water as a source of life and development for countries, in addition to the vulnerability of those riparian states dependent on shared resources in facing the threats of water scarcity, food insecurity and severe energy shortages (Schmeier, 2010, p. 5).

On the contrary, the institutionalist branch states that most of basins are cooperative in nature (Yoffe, Wolf, & Giordano, 2003, p. 1112). Where, riparian states, even they were enemies, will conclude at the

[9] According to Elster (1989, p. 22), The essence of RCT is that "when faced with several courses of action, people usually do what they believe is likely to have the best overall outcome", as reviewed in Ward (2002, p. 65).
[10] These two schools of thoughts are considered branches of the classical Neo-Malthusian and Cornucopian theses, which are two opposite arguments about the population growth and available resources on the earth. The first thesis argues that scarcity of resources will limit the growth, while the second believes that human beings are adaptive and innovative enough to manage their resources (Chenoweth & Feitelson, 2005).
[11] In this regards, Dr. Ismail Serageldin (World Bank Vice President) stated, in Stockholm 1995, that: "the wars of this century have been on oil, and the wars of the next century will be on water… unless we change the way we manage water", as reviewed in Anisfeld (2010, p. 266).

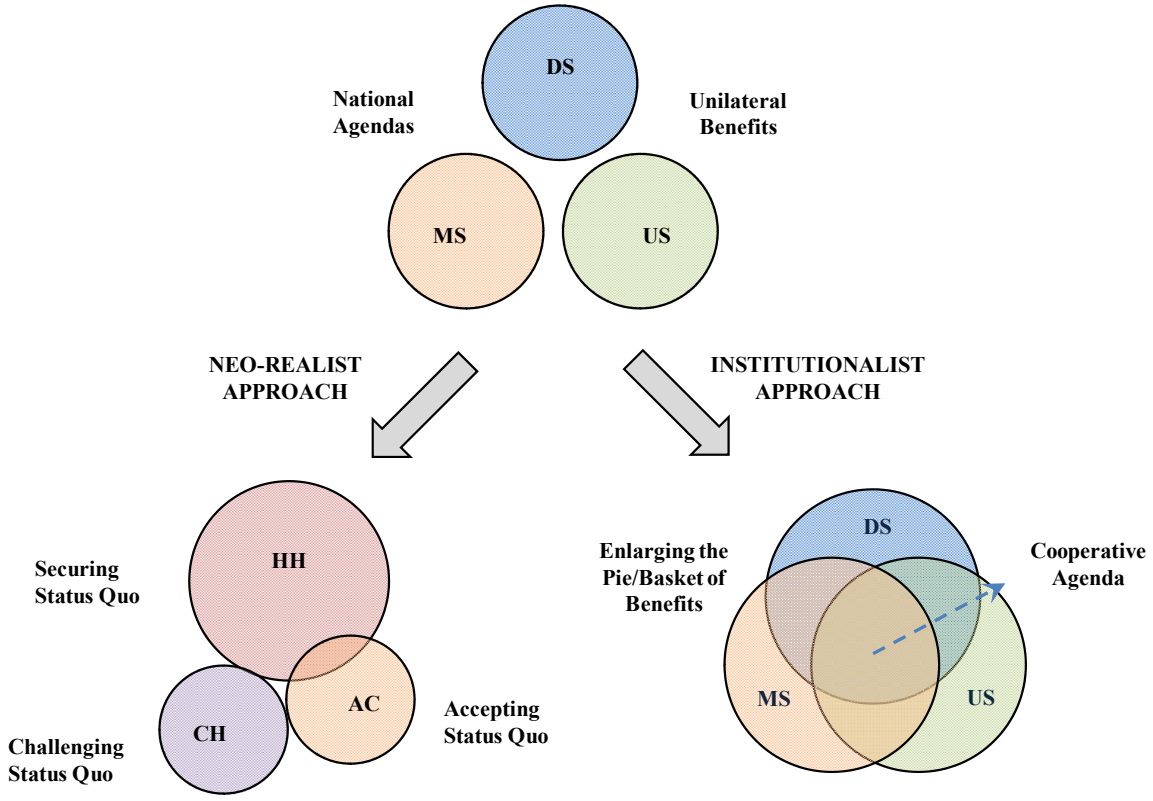
end that it is clearly better to come together agreeing on an international water treaty (ITW) and institutionalizing the basin governance in a river basin organization (RBO) (Schmeier, 2010, p. 6). This is argued to be rational as well, where the extraordinarily expensive costs of conflicts, compared to expected opportunities of cooperation, will induce states to collaborate under one institutionalized umbrella. "Rivers will remain, water needs will grow, non-cooperation will become increasingly threatening, and cooperation will become increasingly important." (Sadoff & Grey, 2005, p. 426)

For instance, the theory of 'hydro-hegemony', introduced by Zeitoun & Warner (2006), argues that as long as various types of asymmetries take place in a transboundary river basin between riparian states, a 'status quo' will be generated, having a hegemon[12] state and other challenger ones. These asymmetries vary based on power measures[13], geographical position, water demands and exploitation potentials. Hydro-hegemony can be either a positive leadership or negative domination,[14] where the hegemon state uses all possible mechanisms for its benefit according to the dynamics of power between riparian states. A counter strategy of 'anti-hegemony'[15] is then used, in different levels, by other states against the hegemon. Other external factors play different roles in this consequence, such as international coalitions, the absence of mandatory international water law, and global market of energy and food.

Table 2. Comparing both neo-realist and institutionalist approaches of hydropolitics, adopted by author after Anisfeld (2010, pp. 266, 267), Schmeier (2010, pp. 5, 6) and Hasenclever, Mayer & Rittberger (2000, p. 11).

	Neo-Realist Approach	Institutionalist Approach
Meta-theoretical Orientation	Rational Choice Theory (RCT)	Rational Choice Theory (RCT)
Branch of	Malthusian thesis	Cornucopian thesis
Drivers	Population growth, vulnerability of water resources and climate change	Conflict is extraordinarily expensive and cooperation is more fruitful
Central Variable	Power	Interest
Behavioral Model	Relative gains seeker (race to the bottom of the barrel)	Absolute gains maximizer (enlarging the pie/basket of benefits)
Outcomes	Zero sum outcomes (win-lose or lose-lose scenarios)	Positive sum outcomes (win-win scenarios)
Expected Scenarios	Disputes and water wars	International water treaties and river basin organizations
General Theme	Conflict	Cooperation

[12] Hegemony is defined by the theory as "the leadership buttressed by authority", whether in positive or negative manner. Compliance mechanisms of such hegemony can be coercive, utilitarian, normative or ideological (Zeitoun & Warner, 2006).
[13] Three forms of power are identified by Zeitoun & Warner (2006, p. 442): hard power (military, political, economic and geographical features); bargaining power (agenda setting); and ideational power (implantation of ideas), as reviewed by Piontek (2010, p. 7).
[14] Zeitoun & Warner (2006, pp. 455, 456) argued the occurrence of varying degrees of negative hydro-hegemony forms in the Nile, Jordan and Euphrates-Tigris river basins.
[15] An example of this conflictive perspective, concerned with the Nile case, can be found in Ibrahim (2011).



Where, DS: Downstream; MS: Midstream; US: Upstream; HH: Hydro-Hegemon; CH: Challenger; and AC: Acceptor.

Figure 1. The conceptualization of both neo-realist and institutionalist approaches, adopted by author after Zeitoun & Warner (2006) and Sadoff & Grey (2005) respectively.

From an institutionalist perspective (Phillips, et al., 2008, pp. 9, 11, 25; 2006, pp. 19, 20, 127), both so-called hegemon and challenger states will not bear paying such enormous cost forever, whether to secure the 'status quo' by one side, or to change it by the other one. While, institutionalized joint-management can bring more benefits for all of them, which is the difference between 'zero sum' or 'positive sum' outcomes.

2.3 Positive Sum Outcomes

When benefits of a transboundary river basin are seen from one narrow perspective, like being only limited to volumetric water allocations, the process will produce 'zero sum' outcomes (win-lose or lose-lose scenarios), where everything gained by one state is a loss for other(s). As a result, dynamics of power will control the whole scene, in which each state seeks for securing its own 'water rights' (Sadoff & Grey, 2002, p. 397):

- A downstream state, on one hand, advocates its right of prior appropriation, usually named "first in time - first in right".
- On the other hand,, an upstream state insists on its right to practice 'absolute sovereignty' in using the water resources running on its lands.

Using the language of the 'hydro-hegemony' theory, the powerful states are those who will be able to impose their interests on ground, where the other weaker states, due to the limitation of benefits, do not have enough attractive options to provide, in order to convince the hegemon to cooperate (Phillips, et al., 2008, p. 25). The lack of information sharing and transparency, because of mutual mistrust in many cases, is the main reason of such limitations.

Contrariwise, if the sum of benefits is not constant, but positively extendable, 'positive sum' outcomes of win-win scenarios are then possible. This process is widely named in literature as enlarging the 'pie' or 'basket' of benefits[16], through scanning all possible alternatives to maximize the incentives of cooperation. This is the core concept of hydropolitical institutionalism, where all riparians (either relatively strong or weak) rationally compare the reaped benefits and paid costs on the long-term in both cooperative and conflictive scenarios, which is best described by the following statement: “Fostering cooperative regimes is, essentially, a matter of altering perceptions such that the benefits of cooperation are seen to outweigh those of unilateral actions.” (Qaddumi, 2008, p. 13)

Accordingly, sharing benefits can be considered the other side of the 'water rights' coin, providing a broader perspective of equity rather than that of controversial interpretations of rights, as illustrated by Phillips (2005). However, a group of principle complications significantly challenges this cooperative conceptualization about the realization of: bringing more benefits to the system; criteria of benefit and cost sharing; the debate of economic versus ecological priorities; and the enhancement of institutional mechanisms. In other words, even if the pie of benefits was maximized, how can states be satisfied about each one's slice, whether literally or relatively? (Sadoff & Grey, 2005, p. 423)

2.4 International Water Law

The UN Convention on the Law of the Non-Navigational Uses of International Watercourses is considered the main basis for customary international water law. It was based on the Helsinki 1966 Rules[17] and took about three decades to be prepared by the UN International Law Committee (ILC). The convention entered into force on August 17, 2014, after more than 17 years of being opened for signature on May 21, 1997 (UN, 2014).

Although the convention defined a group of principles for good collective governance of shared waters[18], it is criticized for being 'exceedingly vague' in its provisions, providing general 'theoretical principles' with no specific procedures for implementation (Albert, 2000, p. 25). For example, no clear mechanisms are stated for the following: how to utilize shared watercourses 'equitably' and 'reasonably'; what 'significant harms' mean; how to provide 'special regards' for human needs while it is mentioned that no

[16] Further discussions about the use of these terms in the field of international relations, in general, and transboundary river management, in particular, can be found in Tollison & Willett (1979) and McGinnis (1986), as reviewed in Phillips et al. (2006, p. 36) .

[17] Further illustration about the 1966 'Helsinki Rules' on the Uses of the Waters of International Rivers by the International Law Association (ILA), refer to Degefu (2003, pp. 69-73). In addition, the ILA approved in 2004 an update to these principles, known as 'Berlin Rules', which considered sub-national waters, public participation, integrated management and environmental sustainability (Anisfeld, 2010, p. 266).

[18] Most essential ones are: "equitable and reasonable utilization and participation" and "duty to cooperate" (Article 5); prevention of "significant harms" (Article 7); "special regards should be given to the requirements of vital human needs" (Article 10); "balance of uses", considering biophysical constraints, socio-economic needs, population sizes, effects of each use on another uses, current and potential uses, the economic and environmental impact of each use, and the availability of alternatives to a given use (Article 6); and "regular exchange of data" in addition to "notification concerning planned measures with adverse effects" (Anisfeld, 2010, p. 265).

specific use enjoys 'inherent priority'; and what if riparian states did not share information or notify each other (in prior) about their plans of using the watercourse (Anisfeld, 2010, p. 265).

Because these terms are not illustrated in solid executive forms, coming back to negotiations between riparian states would be an inevitable step, even in case of international arbitration, as both sides of dispute must accept going to the International Court of Justice or involving an external state (Degefu, 2003, pp. 69-73). This is obvious through the fact that even more than 400 international treaties apply to different aspects and forms of transboundary waters worldwide (Wouters, 2013, p. 18), in addition to 28 UN agencies, regional commissions and non-UN organizations and programmes working on 13 different overlapping water related programmes, riparian states are always unwilling to internationalize dispute management in most cases (Lele, Klousia-Marquis, & Goswami, 2013).

3. THE ONE-SYSTEM PERCEPTION

The basic lesson learned from the international experience of transboundary river management is that "a river is best managed as a basin unit, as any action in one part of the basin has impacts in another" (Sadoff & Grey, 2002, p. 390). Treating the basin as a 'one-system' optimizes the integrated management and development of shared resources, where the aggregated gains of cooperation can be greater than the sums of individual parts (Sadoff & Grey, 2005, p. 421). This can be clearly seen in comparing both 'basket of benefits' and 'project by project' approaches, where negotiating on the later will "easily result in a stalemate", while the former considers a wide range of alternatives and opportunities to achieve "an acceptable outcome that is agreed by all" (NBI, 2009, p. 10). In large basins, it may be more useful to distinguish a set of 'basin sub-units'[19], analyzing cooperation opportunities in each unit and between all of them.

In order to discuss this 'one-system' perception, the following sub-sections overview the whole hydrologic cycle of a river; the interactions between water, energy and food sectors in a basin; and integrated spatial and river basin planning.

3.1 Hydrologic Cycle

One fundamental mean, to understand a river basin as a 'one-system', is including the whole hydrologic cycle of a watercourse into analysis, tracing a drop of water in its movement from ocean to atmosphere to soil to river and back again, as simplified after Anisfeld (2010, pp. 12-16) in the following components:

- Precipitation, a drop of water falls down from the sky in rain, sleet, hail or snow, due to adiabatic cooling[20]. It is expressed in depth per unit time (e.g. mm/year or mm/month). The drop of water can either fall on a vegetated surface (to flow down through the plant or evaporate from the plant to atmosphere), or on the ground (to run off in stream or infiltrate into the soil). Surface water, running in streams, is named 'blue water', while that stored in soil is 'green water'.
- Evapotranspiration (ET): a drop of water returns to the atmosphere from soil or a water body directly (evaporation), or from soil to plant then out to air (transpiration). It is expressed in the

[19] This is the case in managing the Nile Basin Initiative for example, where two main basin sub-units are defined: the Eastern Nile and Equatorial Lakes (NBI, 2009).

[20] Adiabatic cooling is a process in which "an air mass rises, expands, and cools", where "cool air can hold less water than warm air". As a result, cooled air mass can be supersaturated with water vapor, forming clouds and drops of condensed water that fall on the ground, as reviewed in Anisfeld (2010, p. 12).

same unit as precipitation, though in reversed direction. Due to practical complications of measuring the ET rate in real world (being controlled by temperature, humidity, wind, solar radiation and type of vegetation), potential evapotranspiration (PET) is hypothetically calculated, which is always less than real value of ET.

- Percolation: a drop of water, which does not evaporate to atmosphere, may percolate downward to reach the groundwater zone. According to the physical characteristics of underground layers[21], groundwater is formed in aquitards and aquicludes (found in layers of silt and clay), or aquifers (sand and gravel), where it is relatively easy to pump out water. Groundwater may be linked with surface water in different means, where the former may discharge to the later and vice versa. Otherwise, in case of much deeper water table, where groundwater is not recharged, the resource is considered 'non-renewable' or 'fossil' that was formed in past times and/or under different climatic conditions.
- Stream flow (blue water): drops of water run in stream, because of precipitation and groundwater discharge. It is expressed in water volume (carried by stream) in unit time. Pathways and flows of a stream are shaped due to several complex factors, such as precipitation rate, duration of rainfalls, evapotranspiration, groundwater linkage, topography, and geology. The ultimate destination of most rivers is to discharge into the oceans. However, some streams discharge into inland areas, from which water evaporates (e.g. the Aral Sea).

The comprehensive understanding, of the hydrologic cycle of a river and its components, is considered the first step towards optimized management of shared resources, realizing the concept of 'national water security', which basically incorporates "freshwater endowments and quality, rainfed and irrigated agricultural practices, soil water availability, variability and changes in precipitation and humidity rates" (Zeitoun, Alan, & Mohieldeen, 2010, p. 240).

3.2 Integrated Water Resources Management

Not limited to blue water, the integrated water resources management (IWRM)[22] promotes the full realization and utilization of the water resources available in a basin, involving green water, groundwater, reclaimed wastewater and desalinated seawater. The application of this integrated concept faces real political and technical obstacles in transboundary basins.

In particular, green water is not clearly addressed in transboundary water agreements or international water law, despite the fact that green water represents the bulk of water resources in a basin and supplies most of the world's food production through rainfed agriculture (Phillips, et al., 2008, pp. 19, 23). Dent & Kaufmann (2006), reviewed in Phillips et al. (2008, p. 24), refer the main reason of this issue to the fact that "green water is ignored by engineers because they cannot pipe it or pump it, by economists because they cannot price it, and by governments because they cannot tax it". However, significant efforts were made by several studies to highlight the economic and technical problems of green water utilization for its crucial role in facing the challenges of blue water shortages, population growth and climate change, such

[21] Most important characteristics, to know about underground layers, are: 'porosity', which is the amount of water that is contained in soil; 'hydraulic conductivity', the ease with which that water will move; and 'water table', the top of groundwater zone, as reviewed in Anisfeld (2010, p. 14).

[22] The IWRM is "a process which promotes the coordinated development and management of water, land and related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (GWP, 2010).

as Falkenmark (1989) and Rockstroem et al. (2009). Van der Zaag, Seyam & Savenije (2002) used the concept of green water in finding equitable allocations of water resources in transboundary river basins. Taylor (2009) called for counting soil water in any basin water balance. Furthermore, Zeitoun, Alan & Mohieldeen (2010) included both green and blue water in the analysis of 'virtual water flows', studying the water trade within a basin and internationally.

Inclusion of groundwater, in the agreements of transboundary basins, is greatly difficult as well, due to technical problems of mapping and quantification (Anisfeld, 2010, p. 264). In addition, Eckstein & Eckstein (2005) argued that policymakers' limited understanding of hydrogeology makes it even more complicated.

3.3 Basin Synergies and Tradeoffs

Basins' dynamics are very complicated, where they comprises various inter-dependent aspects. Thus, every action in one sector causes impacts on other sectors, whether positively (considered synergies) or negatively (tradeoffs). When these impacts are transboundary (across national borders), those dynamics become more sophisticated. Watershed management and dam construction are two clear examples that can reflect these complexities as follow:

- More often, poor rural settlements reside in the watersheds (water catchments), which may carry several actions that have severe impacts on downstream, such as cutting down forests, causing water flows to be flashy and increasing risks of droughts and floods, the two issues that obviously threat downstream communities (Sadoff & Grey, 2002, pp. 394, 395). While forests in uplands play an essential role in holding blue water within the landscape, large schemes of afforestation (planting new trees) or re-afforstation (replanting trees that were cut down) reduce runoffs of blue water, due to the high evapotranspiration losses of the new landcover (Hoff, 2008, pp. 169, 170).
- Dam construction comprises more complex synergies and tradeoffs, as deeply investigated by WCD (2000, p. 9). On one hand, dams can create multiple opportunities: hydropower generation, water storage, agricultural and fishery activities, flood control, runoffs regulation, and others. While on the other hand, various social and environmental negative impacts may take place: displacement of indigenous people, release of greenhouse gases due to submerged vegetation-cover under dam reservoir, alteration of river flows in quantity and quality, threatening natural habitats and fish species, in addition to erosion of banks and coasts.

The above two examples clarify the vital role of cooperation between upstream and downstream states in managing transboundary river basins. For instance, massive efforts should be made for financing programs of rural development in uplands and coordinating dam construction to jointly share benefits and mitigate costs.

3.4 The Security Nexus

The concepts of water[23], energy[24] and food[25] security are interrelated in the way that requires an interactive nexus approach (WEF, 2011), optimizing the efficiency of production and consumption for all

[23] Water security is defined by Global Water Partnership as "ensuring the availability of adequate and reliable water resources of acceptable quality, to underpin water service provision for all social and economic activities in a manner that is environmentally sustainable; mitigating water-related risks, such as floods, droughts and pollution;

of these sectors (Hoff, 2011). This nexus comprises a group of overlapping interconnections (Baziliana, et al., 2011), some examples of which are as follow:

- Food production processes require substantial amounts of water and energy;
- Essential fertilizers and pesticides for agriculture consume energy in production and farm operation phases, in addition to contaminating water resources;
- Exploiting and utilizing water resources requires energy;
- Producing electricity requires water, not only in hydropower generation, but also in thermal and nuclear plants, even in manufacturing photovoltaic systems; and
- Biofuel, another source of electricity generation, relies on food production.

The security nexus approach significantly contributes to studying cooperation opportunities in transboundary river basins. The second phase of the Global Catchments Initiative (GCI-II), run under the Global Water System Project (GWSP) at University of Bonn, surveyed experts' opinions around the relations between the security Nexus and transboundary governance in a group of river basins (Lawford, et al., 2013, p. 610). The specific stresses on basins that experts ranked were: climate change, political and economic change, regional and economic development, demographics, urbanization, land use change, and basin infrastructure. These factors affect the Nexus in different manners according to the basin characteristics and effectiveness of governance (Lawford, et al., 2013, p. 612). Other studies added to the nexus a fourth dimension, beside water, energy and food areas, such as land resources (Ringler, Bhaduri, & Lawford, 2013), or climate (WEF, 2011).

3.5 Territorial Cohesion and Transboundary Rivers

The European Union (EU), founded in 1993 and referred as one of the main examples of international cooperation, has provided a special concern to water management issues, through the establishment of the Water Framework Directive (WFD) in 2000 and Floods Directive (FD) in 2007 (EC, 2015). Among the activities held by the WFD, the EU members were asked to prepare 'River Basin Management Plans' (RBMPs) to be submitted in two rounds for 2003-2009 and 2009-2015 (EEA, 2012, p. 6). The scope of these RBMPs involves the transboundary river basins in the EU, which covers 60% of its territory area. The essential challenge of preparing the RBMPs, was the conflict arose between different administrative and legal systems of countries (and even federal states), of which the natural borders of a transboundary river basin crosscut. The submitted drafts of 2009 showed another challenging problem, which is the gap between both river basin and spatial planning in scopes and time schedules. Simply, spatial planning assigns a function for every place, and then mutual interactions are generated between that function and the river basin management, whether for water needs, wastewater disposal, or even risks of floods and droughts (EEA, 2012, pp. 22-39). For example, the identification of urban and rural expansions relies on the freshwater resources available to fuel all their social and economic needs, in addition to flood plains

addressing the conflicts that may arise from disputes over shared waters, especially in situations of growing stress, and turning them into win-win solutions" (GWP, 2012).

[24] Energy security is viewed by the International Energy Agency, since its establishment in 1974, in terms of "the uninterrupted availability of energy sources at affordable prices" (IEA, 2013).

[25] Food security is assured "when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life." (World Food Summit, 1996).

and their characteristics. Navigational uses of a river, as well, should be linked directly to the spatial planning of roads.

Accordingly, the European Environmental Agency (EEA) introduced an integrated 'place-based' approach (Figure 2) to develop the RBMPs in its second round to enhance the coordination mechanisms in both vertical and horizontal dimensions: linking local, regional, national and transnational administrations vertically; and various spatial and water sectors horizontally (EEA, 2012, pp. 63-65). The EU Cohesion Funds, as well, financed transnational cooperation projects integrating territorial cohesion[26] and water management issues.

Another integrated framework is the 'One Bio-Region - One Health' (OBROH), introduced by Pezzoli et al. (2014), which is emerged from the transboundary place-based approach as well. The OBROH framework focuses on the health of those regions that are conductive in ecological, social and economic characteristics, even if they cross borders.

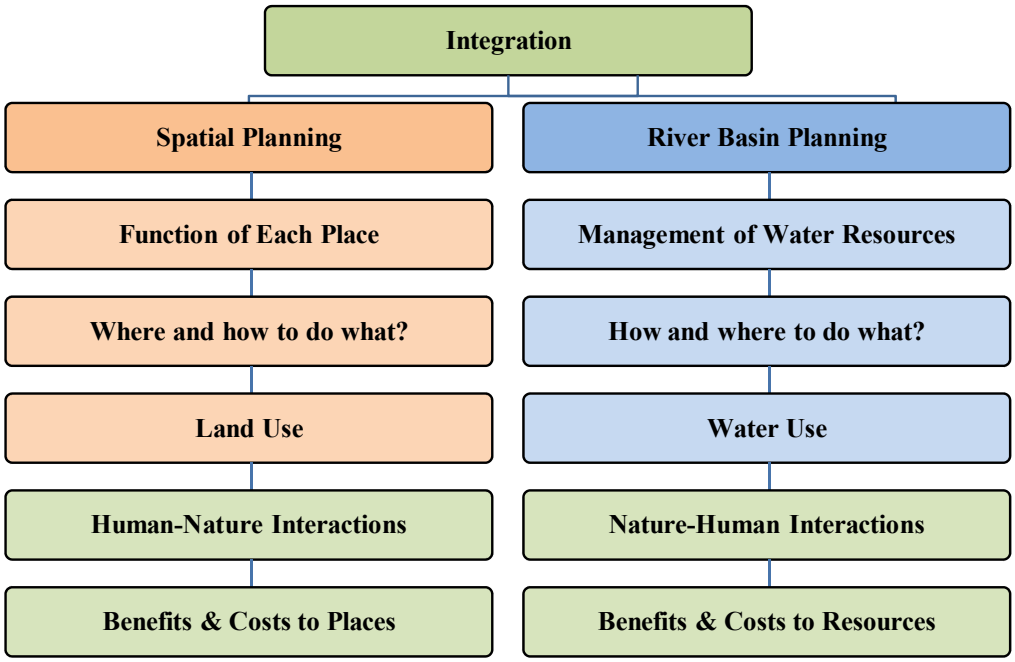


Figure 2. The integrated spatial and river basin planning, adopted by author after EEA (2012).

4. BENEFITS AND COSTS TO BE SHARED

Cooperative management of the river basin as one-system generates additional benefits and costs to be shared between riparian states. Comprehensive classification of such benefits and costs is essential in order to compare the different alternatives and scenarios. Various methodologies of categorization are discussed below. In general, they mostly involve the three pillars of sustainable management: society, environment and economy, in addition to political aspects (Table 3).

[26] The concept of 'territorial cohesion' "builds bridges between economic effectiveness, social cohesion and ecological balance, putting sustainable development at the heart of policy design" (EC, 2008, p. 3) .

Table 3. A summary of various categorization methods for benefits and costs of cooperation.

Methods of Analysis	Classification of Benefits and Costs			
	Environmental	**Social**	**Economic**	**Political**
CRA Framework by Sadoff & Grey (2002; 2005)	To the River	From the River (Direct) & Beyond the River (Indirect)		Because of the River
Inter-SEDE Model by Phillips et al. **(2006)**	Environmental	Economic		Security
TWO Analysis by Phillips et al. (2008)	Ecosystem Services	Hydropower, Primary Production, and Industrial & Urban Growth		
IDAM Tool by Brown et al. (2009)	Biophysical	Socio-Economic		Geopolitical
SWOT Analysis by ISU (2006)	Strengths, Weaknesses, Opportunities, and Threats			

4.1 Cooperative Regional Assessment

Cooperative Regional Assessment (CRA) is a practical tool for achieving cooperation in transboundary river basins, developed by Sadoff & Grey (2005). CRA provides a three-step analysis for converging isolated national agendas of riparian states into an optimized cooperative agenda. These three steps are as follow:

- Transboundary analysis, providing a 'basin-wide' vision of all potential benefits of cooperation, in the way that maximizes the net gains of managing and developing the whole basins;
- Distributive analysis, assessing different alternatives of sharing benefits and costs among riparians in an equitable and fair manner, in which each state accepts its net gains; and
- Institutional analysis, defining required institutional mechanisms of implementation, monitoring and evaluation.

In a preceding study of Sadoff & Grey (2002), ecological, economic and political benefits of cooperation in international rivers were categorized in four groups: benefits to the river (ecological); benefits from the river (direct economic); reducing costs because of the river (political); and benefits beyond the river (indirect economic). While, costs were not limited to financial, ecological and relational aspects only, but also extended to forgone-benefits of one state due to unilateral actions of others (Sadoff & Grey, 2005, p. 425).

4.2 Transboundary Waters Opportunity Analysis

As an extension of Sadoff & Grey (2002) categorization of benefits, Phillips et al. (2006) , a research group of the Stockholm International Water Institute (SIWI) developed a first analytical model 'Inter-SEDE', then followed by the 'TWO' analysis by Phillips et al. (2008).

The 'Inter-SEDE' model analyzes the key-drivers of conflict and cooperation potentials in a transboundary river basin, grouping the input factors into three packages of indicators: security (S); economic development (ED); and environment (E). These indicators cover a wide range of aspects related to military expenditures, water resources, social and economic challenges, and environmental risks. The outputs of the model explore the expected benefits of cooperation on the global, regional, national, sub-national, and household levels. Phillips et al. (2006, pp. 122-169) used the case studies of Jordan, Mekong, and Kagera Basins to test the applicability of the 'Inter-SEDE' model.

The second tool is the Transboundary Waters Opportunity (TWO) analysis, which builds a matrix of the opportunities of development (hydropower, primary and food production, industry and urban growth, in addition to environmental and ecosystem services) versus water resources (new water and efficient use of existing water). Each pair of both sets define the potential benefits of cooperation according to the river basin characteristics, such as: siting dams for less evaporation losses; the use of reclaimed wastewater, green water and groundwater in agriculture; shifting from agriculture-based economy; maximizing economic returns of water use; and water purification of wetlands (Phillips, et al., 2008, pp. 7, 12).

Furthermore, the Socio-Economic Development Project of the Nile Basin Initiative (NBI) published a manual to introduce the Benefit Sharing Framework (BSF), adopting the 'TWO' analysis to be used in the Nile case (NBI, 2009). The 'BSF' defines three stages for implementation: establishing a common understanding of used terms and existing settings; identifying the significance of benefit sharing under various scenarios; and determining the magnitude of proposed baskets of benefits.

4.3 Integrative Dam Assessment Modeling

Brown et al. (2009), a multi-disciplinary research team, developed the Integrative Dam Assessment Modeling IDAM tool to be used by decision-makers for conducting multi-objective analysis of costs and benefits of both dam construction and removal processes. The tool combines the biophysical, socio-economic and geopolitical perspectives[27] in its evaluation, in which nine impacts of each area[28] (27 in total) are assessed, both objectively (metric magnitude) and subjectively (valuation), and produced in two circle diagrams, one for costs and another for benefits. The main scope of this tool is to transform the decision-making process about dams to be transparent, inclusive, and participatory.

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[27] The 1992 United Nations Conference on Environment and Development defined three primary areas for environmental and social sustainability in development, which are biophysics, socio-economics, and geopolitics (UN Committee on Economic Development, 1993), as reviewed in Brown et al. (2009).

[28] The nine impacts of the biophysical area are: water retention time; natural value; downstream tributaries; biodiversity; distance of river left dry downstream of dam; CO_2 equivalent to coal; flood protection; site stability; and reservoir surface. The socio-economic impacts are: social cohesion; cultural change; non-agricultural economic activity; health; agriculture economic activity; displacement; hydropower/infrastructure; housing values; and transportation. The geopolitical impacts are: downstream riparian population; downstream irrigation; political boundaries; existing dams; agreements/institutions; political participation; historical stability/tensions; domestic governance; and socio-economic impacts for non-constituents. Further illustration of applications can be reviewed in Brown et al. (2009).

4.4 Strengths-Weaknesses-Opportunities-Threats Analysis

The SWOT analysis[29] is a classical method used to assess plans and projects. It is a matrix analysis of the strengths, weaknesses, opportunities and threats of the issue under study. Bhagria (2010) analyzed the Nile Basin Iniative (NBI) activities and projects using the SWOT method. Samaan (2014) used the SWOT analysis, as well, to study the strengths and weaknesses of the Blue Nile Basin, then the opportunities and threats of constructing hydrological projects on the Blue Nile, providing special focus on the Grand Ethiopian Renaissance Dam.

5. HYDROPOLITICAL GAMES

The hydropolitical interactions in a shared basin are usually modeled using the 'Game Theory' (GT)[30], where the riparian states are considered a group of players, each of which believes that straight-forward maximization of utility is not a rational choice, as the consequences of one's course of action partly depends on the decisions of others (Chwaszcza, 2008, pp. 140, 144). Accordingly, the criterion for rational choice in GT is to aim at an 'equilibrium point', which is essentially challenged by 'mutual dependency' of choices, resulting in 'infinite regress' or "circular expectations about expectations"[31]. The most widely accepted understanding of the 'equilibrium point' is that of John Nash's concept, which models rational interaction as a 'mixed-motives' game[32]. Nash's concept states, "one should choose the best counter-strategy to what one expects the other person(s)' choice will be" (Chwaszcza, 2008, p. 145).

There are two main types of hydropolitical games: non-cooperative and cooperative games. The main factor, distinguishing both, is the assumption of whether riparian states accept to co-manage their shared resources or not. In addition, a multi-level game takes into consideration the sub-national and international factors, beside national ones.

5.1 Non-Cooperative Games

According to Anisfeld (2010, p. 273), well-known examples of non-cooperative games are the Prisoner Dilemma (PD)[33] and Chicken[34] games, which can model some specific situations between riparian states in transboundary river basins, as follow:

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[29] The SWOT analysis was developed at Stanford Research Institute (SRI) by Robert Stewarts and Albert Humphrey in the 1960s through the project of Fortune 500 companies to address their effectiveness. The method exceeded the limit of utilization in economy, but has been widely used in planning and reformation programs of projects, plans and institutions (ISU, 2006).

[30] The GT is one branch of the rational choice theory (RCT). GT deals with "situations where others' choice of strategy affects your best choice and vice versa" (Ward, 2002, p. 66).

[31] For more about the game theory and equilibrium points, refer to Chwaszcza (2008, p. 144) and Ward (2002, pp. 66, 69).

[32] In contrast to 'constant-sum' game, 'mixed-motives' game is that one where the gains of one player do not equal the losses of another, where both can win and both can lose (Chwaszcza, 2008, p. 145).

[33] "Prisoner Dilemma" is the story of two members in a criminal gang whom police arrested. The investigator is sure that both are guilty but has no clear evidence. He gives an offer for each to think about individually in their solitary custody. The offer is as follows: if both do not confess, he will give them a minor punishment; if both confess, he will recommend less than the most severe sentence for both; and if one confess and the other does not, the confessor will get the lenient treatment, while the other get the book slapped at him, as illustrated by Hargreaves Heap et al. (1992) reviewed in Chwaszcza (2008, pp. 145, 146).

- The two players in the first game of PD are more likely expected to choose "not to cooperate", although the best scenario for both of them takes place in case of cooperation. Their decision is based on the mutual mistrust, each one to the other, as if one chooses to cooperate while the other defects, the former will get the maximum loss and the later will get the maximum benefit.
- In the second game, the two players are confronting each other on the common path. At the end, if both players kept moving in their directions, they will clash, resulting in a 'lose-lose' scenario, while the other option is that one of them chickens out, having a 'win-lose' scenario.

Therefore, non-cooperative games are those models where each player does not have complete information on the other players' capabilities and preferences (interests), and then mutual probabilistic decision-making controls the outcomes. Nevertheless, if the game is repeated for enough times[35], a strategy of reciprocity, 'tit for tat', is then generated, where each player exploits the other's strategy, acting in the following turns based on the cumulative experience. Although the equilibrium of unconditional defection is more likely to occur in games like the PD, Axelrod (1984) showed that there exist cooperative equilibria in 'open' or 'iterated' games, but only if cooperation is reciprocated and defection is punished. This is what happens in hydropolitical games, when riparian states, after several turns of interactions, find that, on long-term means, conflict is more expensive while cooperation is fruitful (Anisfeld, 2010, p. 273). However, such n-person games become more complicated as much as the number of players increases and relative power of each varies (Chwaszcza, 2008, p. 156). Different examples in literature, for modeling non-cooperative hydropolitical games, are listed in Table 4.

5.2 Cooperative Games

On the other hand, cooperative games[36] are based on the possibility that players can come together in one binding agreement, the case in which each player will get more benefits than acting unilaterally. Hence, this type of games relies on a group of fundamental principles, which are completely on the contrary to the other non-cooperative type. These are: transparency and information sharing; targeting 'positive sum' outcomes; and fair distribution of benefits and costs.

Most studies of this type of games rely on comparing a base case (usually the status quo) to the various options of cooperation (all possible partial groups and grand basin-wide coalition), analyzing different distributional methods and equilibrium concepts. Thus, the main questions of computation focus on the rational allocation of those surplus generated benefits of cooperation, and what incentives make a state be willing to act multi-laterally (join the grand coalition). In this regards, Dinar & Nigatu (2013, pp. 8, 9) illustrate two levels of rationality: the condition that the benefits allocated to any state, if joined the grand coalition, will exceed those ones in case of acting unilaterally (individual rationality); and that the benefits of acting multi-laterally will exceed those of joining partial coalitions (group rationality). Wu & Whittington (2006, pp. 8-12) explain three well-known methods of distribution of cooperative game studies, as follow:

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[34] 'Chicken' game tells about: "Two adolescents decide to resolve a dispute by riding towards each other down the middle of a road. The first to turn away loses. If both continue straight ahead, they will crash and risk serious injury", as illustrated by Hargreaves Heap et al. (1992) reviewed in Chwaszcza (2008, p. 160).

[35] This is known in literature as the 'challenge of free riding' or 'iterated games'. For further illustration, refer to Chwaszcza (2008, pp. 155, 156).

[36] Further comparison between both cooperative and non-cooperative games can be found in Kilgour & Wolinsky-Nahmias (2004).

- The 'Core', which is the set of all possible benefits' allocations that fulfill both individual and group rationalities for all states, in the way that there will be a lower and upper bounds[37] for each player. The range size of allocation, for each state within these bounds, defines its bargaining power, where if it is large, more-negotiable options will be available for it and vice versa.
- The 'Nucleolus', which is a focal point that for sure lies in the core, identifying the small payoff area that minimizes the maximum objection of all possible coalitions, and maximizes the net benefits[38] to be obtained from the worst possible outcome (Rawls's notion of 'veil of ignorance'[39]). Thus, this concept best satisfies the interests of most disadvantage parties.
- The 'Shapley value', which is a focal point that may or may not lie in the core, prioritizing the fairness of benefits' allocation. The fair allocation, according to this method, is based on the contribution of each state to the coalitions[40], which is defined through answering the question of what if this state is not a member (how much the benefits will be affected).

Another principle aspect, in the hydropolitical cooperative game studies, is the type of benefits to be generated and re-allocated among riparian states. Hence, the variables of each comparative analysis differ, according to the research scope. Particularly, the Nile River Basin is a rich case study for this type of cooperative games, where literature shows several scopes of calculating and allocating net benefits of various possible coalitions, as shown in Table 4.

5.3 Multi-Level Games

One significant critique, about various models of game theory, is treating the whole state as one player. While in reality, the policy makers, representing states in international negotiations, are definitely influenced by many aspects of domestic politics, such as ratification of national jurisdictions and probabilities of re-election (Kilgour & Wolinsky-Nahmias, 2004, pp. 322, 323). This perspective inspired the development of games that consider both intra-national and international institutional levels. Putnam (1988) introduced the model of 'two-level' games, arguing that domestic politics shape the bargaining power of states in international agreements.

This concept is widely applied in the hydropolitical studies (Table 4 & Figure 3), analyzing the complex interactions, within a state, between multiple water users (governmental, private and civil stakeholders), and the impacts of these on the basin-wide relations between riparians (Qaddumi, 2008, p. 8). Questions, investigated by scholars, covered the role of both internal and external factors[41] on the states' tendency

[37] The state's benefits of joining the grand coalition will exceed those of acting unilaterally or joining partial groups (bottom line), but to the extent that all other states remain in the coalition (top line), as reviewed in: (Wu & Whittington, 2006, pp. 8, 9).

[38] One critical problem of 'Nucleolus' is calculating the net benefits of each coalition whatever the number of players is. The 'Nucleolus per capita' solves this issue, distributing the benefits of a coalition among its members based on the population size of each, as reviewed in Wu & Whittington (2006, p. 10).

[39] The Rawls's notion is concerned with those cooperative games of which the players maybe unaware about their future interests. Hence, the notion assumes that they will seek for the least worst possible outcome, whatever the others' courses of action are (Rawls, 1971), as reviewed in Wu & Whittington (2006, pp. 9, 10).

[40] One critique of the 'Shapley value' is equalizing the probabilities of coalitions' formation, in which the 'generalized Shapley value' method is developed to put further conditions on coalitions' probabilities, as reviewed in Wu & Whittington (2006, p. 10).

[41] As reviewed by Schmeier (2010, p. 12), Brochmann & Hensel (2009) argued that democratic states more likely to cooperate with co-basin riparians, while Kalbhenn (2009) found that the relationship between democracy and

towards conflict or cooperation while sharing common water resources (Schmeier, 2010, p. 12). Moreover, a 'three-level' game can be studied in river basin, taking into account the greater international actors and sub-national groups in addition to national players (Waterbury J. , 2002, pp. 57-90). Furthermore, a 'multi-level' game is that one concerned with coordination mechanisms of vertical dimension (local, regional, national and international levels) and horizontal one (stakeholders of various sectors) (EEA, 2012, pp. 5-11).

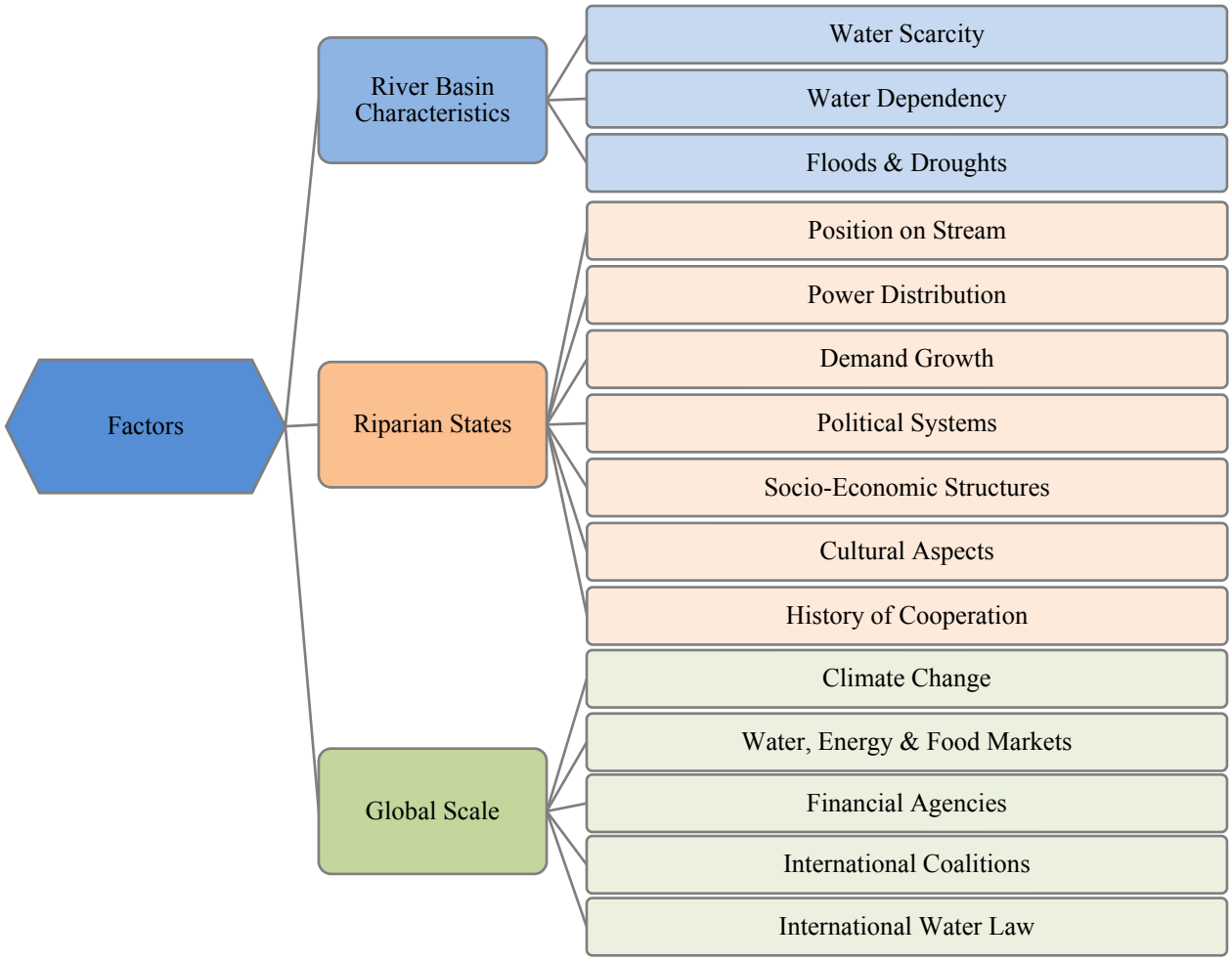

Figure 3. Various factors influencing the cooperation or conflict status between riparian states, adopted by author after: (Schmeier, 2010).

international cooperation is non-linear. Beside, Mostert (2003) argued that external financing bodies help in achieving cooperative outcomes in transboundary rivers, but they are not sufficient by their own.

Table 4. Comparison of various hydropolitical game studies with special focus on the Nile case.

	Benefit Calculation Unit	Players	Methods & Tools	References
Non-Cooperative Game	Modeling the 2-person game of international conflicts, in general, between a challenger and defender of status quo, and the conflict of diverting the Jordan River, in particular, between Israel and Arab countries	Israel and Arab League (2)	The 'Asymmetric Deterrence' (2-person game of incomplete information)	(Zagare & Kilgour, 1993; Kilgour & Wolinsky-Nahmias, 2004)
	Playing the chicken game in the Eastern Nile Basin, analyzing the conflict of new development projects between constructing dams in Ethiopia and irrigation schemes in Egypt	Egypt and Ethiopia (2)	The 'Chicken' game	(Waterbury & Whittington, 1999)
	Investigating the stability outcomes of the Nile game based on the graph of actions and reactions of each player, according to options and preferences of each	Egypt, Equatorial States, Ethiopia and Sudan (4)	The Graph Model of Conflict Resolution (GMCR)	(Madani, Rheinheimer, Elimam, & Connell-Buck, 2011; Madani & Hipel, 2011)
Cooperative Game	Distribution of economic benefits of water trade (within the base and internationally) for various possible coalitions in the Eastern Nile Basin	Egypt, Ethiopia and Sudan (3)	The 'Core', 'Shapley value' and 'Nash-Harsanyi' methods	(Dinar & Nigatu, 2013)
	Economic incentive-compatibility of the co-management of irrigation and hydropower projects for various possible coalitions in the whole Nile Basin	Egypt, Equatorial States, Ethiopia and Sudan (4)	The 'Core', 'Nucleolus', 'Nucleolus per capita', 'Shapley value' and 'generalized Shapley value'	(Whittington, Wu, & Sadoff, 2005; Wu & Whittington, 2006)
	Options of investments in enhancing the efficiency of water projects in the Nile Basin under the uncertain severe impacts of climate change (+/- 20% of water availability)	Egypt, Ethiopia, Sudan and Uganda (4)	The 'Agent-Based' simulation model	(Piontek, 2010; Link, Piontek, Scheffran, & Schilling, 2014)
Multi-Level Games	Analyzing the complex three-level interactions in the Nile Basin since the end of 19th century and along the 20th century	International, national and sub-national actors	The 'three-level' game	(Waterbury J. , 2002, pp. 57-90)
	Enhancing coordination mechanisms between various sectors on different levels in the transboundary rivers of the EU	Stakeholders in vertical (levels) and horizontal (sectors) dimensions	The River Basin Management Plans (RBMPs)	(EEA, 2012)

6. INSTITUTIONAL MECHANISMS

In order to transform cooperative visions into development on ground, international research studies and initiatives worked on exploring the optimum institutional structures and mechanisms of river basin organizations (RBOs). In broader context, progressive works of this approach have been dealing with the collective action problems of international common resources (Ostrom, 1990). Governing transboundary freshwater resources, in particular, obtained intensive focus. As shown in Figure 4, four main aspects define the institutional design of RBOs (ODI & AEC, 2001, p. 67): constitutional; decision-making; operational; and financial rules. The member states of any agreement should agree upon these settings, clarifying who is to participate and at what level, how to take decisions and how to make the process transparent, what benefits to be shared, and where the fund comes from. The following sub-sections discuss three topics of institutional studies: the continuum; the resilience; and the equity of cooperation.

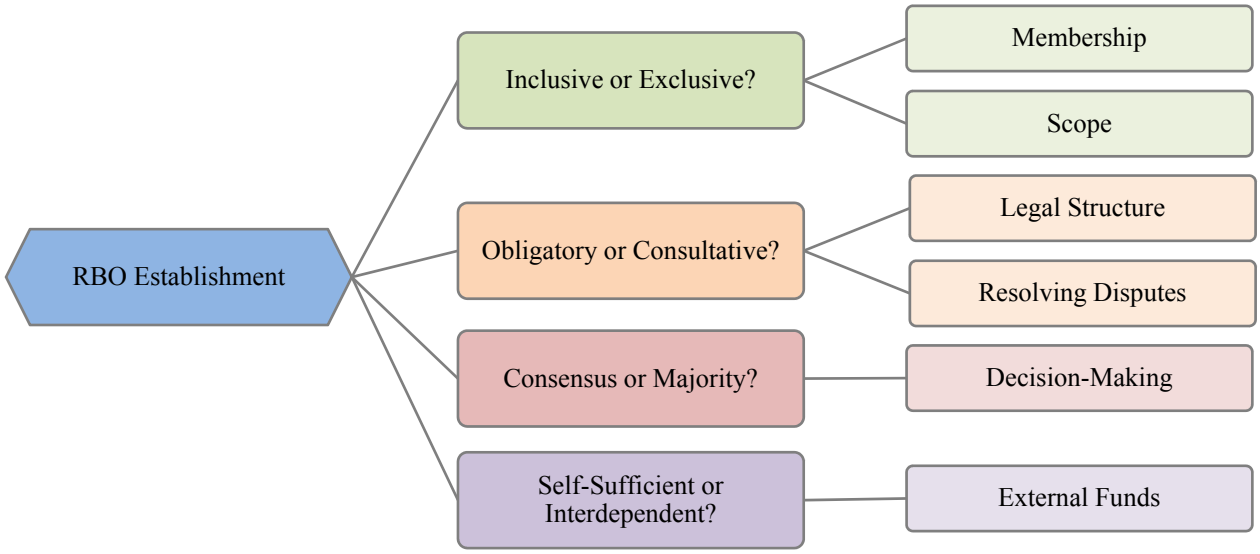

Figure 4. Institutional design of River Basin Organizations (RBO).

6.1 Cooperation Continuum

The 'cooperation continuum' is an institutional process developed by Sadoff & Grey (2005). As shown in Figure 5, it aims at transforming the relationship between riparian states "from unilateral action (independent, non-transparent national plans), to coordination (communication and information on national plans), to collaboration (adaptation of national plans for mutual benefits), to joint action (joint plans, management or investment)" (Sadoff & Grey, 2005, p. 424). The three linking mechanisms, transforming each phase to the next one, are built on the willingness of states to 'inform', 'adapt' and 'join'. The process is described to be non-directive, dynamic and iterative, realizing the 'uniqueness' of each river basin and its complex conditions and interactions. Sadoff & Grey (2005, p. 425) applied the continuum measures on the Mekong, Indus, Orange, Rhine and Senegal rivers to investigate the level of cooperation in each basin, using their previous classification of benefits (sub-section 4.1).

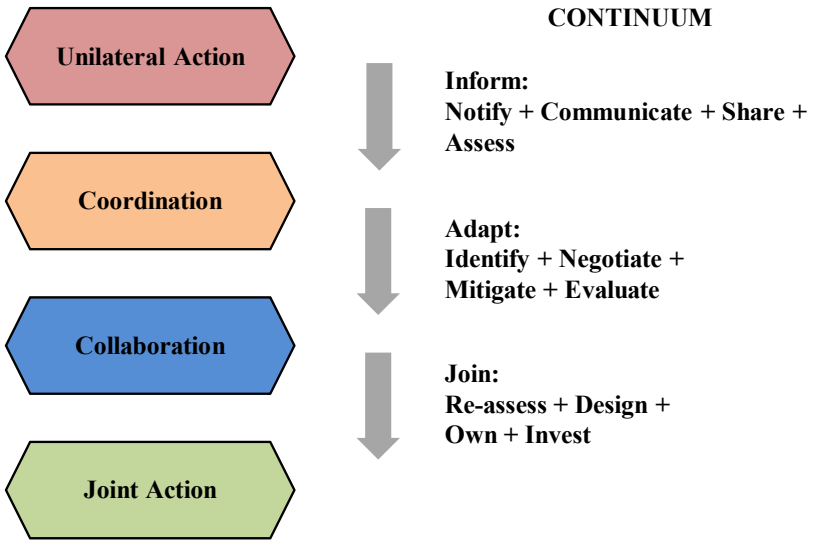

Figure 5. The cooperation continuum, adopted by author after Sadoff & Grey (2005).

6.2 The Equity of Cooperation

There are different theoretical concepts defining what is 'equity', each of which reflects social, economic or moral issues, according to its philosophic root (Jaeger, 2005). These concepts differ in their distributional criteria of shares (sub-section 5.2) among stakeholders, whether to be based on their contributions, rights or needs, where each case orients the process and consequences in a specific direction (Corbera, Brown, & Adger, 2007, p. 589). Hence, Corbera, Brown & Adger (2007, p. 590) illustrated that 'legitimacy' is the other face of the coin to balance the socio-economic, environmental and political aspects of development, providing the rules of how to participate in the decision-making, set the basis, secure 'plurality' of the process, and negotiate and accept the outputs. However, this can be realized on the national level, where there exists an overarching jurisdiction that assures justice among individuals or national sectors, which is not the case in the level of international relations (Qaddumi, 2008, p. 3).

The riparian states of a transboundary river often have different understanding of the concept of equitable sharing. Yet, it was interesting for Wolf (1999, p. 3) to find that "while many international water negotiations begin with differing legal interpretations of rights, they often shift to a needs-based criteria for water allocations". The 1997 UN Convention on the Non-Navigational Uses of International Watercourses (sub-section 2.4) uses the term 'equitable', in Article 5, describing the appropriate process of water 'utilization and participation' in order to be 'optimal' and 'sustainable'. Article 6.1 of the convention states seven factors to be taken into account in order to achieve that recommended 'equitable' and 'reasonable' water utilization. Those factors are: a) the natural and climatic characteristics of the basin; b) social and economic needs of the riparian states; c) the population dependent on the watercourse; d) effects of each state's uses on the others; e) existing and potential uses of states; f) conservation, protection and development of water resources; and g) the availability of alternatives for planned and existing uses.

Those statements of international water law provided specific criteria to be assessed by research studies. Van der Zaag, Seyam & Savenije (2002) evaluated six criteria of water allocation in the Orange, Nile and

Incomati rivers in order to investigate the most equitable criterion. The evaluated criteria were divided into two groups: allocating blue water only; and allocating both blue and green water. Each group involved three allocation criteria: equal distribution among states; proportional distribution according to the basin area in each state; and proportional distribution according to the population of the basin in each state. The study found the optimal equitable criteria to be the population-based allocation of both blue and green water, taking into consideration two vital variables: the relative weight of green water utilization compared to the blue water; and the reserved blue water in each state. Iyob (2010) studied the role of each of the seven factors in the Article 6.1 of the 1997 UN Convention to explore the cooperation opportunities on equitable benefit sharing basis in the Nile, Jordan, Mekong, Indus, Danube and Columbia rivers.

6.3 Institutional Resilience

Walker et al. (2004) defined 'resilience' as "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks". Accordingly, the resilience of an institution is directly linked to the full understanding of what causes a pressure, what it results in, and how the system responses. One useful method, for modeling this cyclic progression of causal effects, is the DPSIR tool[42], analyzing the 'driving forces' of 'pressures', the 'state' of the affected system, the consequent 'impacts', and the 'response' of the decision-makers, which cyclically influences all of the former components of the chain. Phillips et al. (2008, p. 26) applied this method to transboundary water resources, arranging the cycle into three main stages:

- Stage 1: Driving forces (of global warming, population growth and urbanization) form pressures on the shared basin in the way that change its state (in quantity, quality and timing), such as more floods/droughts and pollution rates.
- Stage 2: The change of the river state may impose different social and environmental impacts, such as displacement of population residing in flood plains, shortages of water, energy and food supplies, and disruption of biodiversity.
- Stage 3: Various responses are then required to be well-studied and processed, such as monitoring schemes, infrastructure development, and reforms of agricultural and industrial plans. Simulation studies should be carried out to analyze the expected effects of each response on the former two stages.

Hamouda, Nour El-Din & Morsy (2009) used the DPSIR model to develop vulnerability indicators of water resources in the Eastern Nile. Piontek (2010, p. 29) used another method of 'causal chain' after UNEP (2006) to model the impacts of climate change on the complex interactions in the Nile Basin, proposing a group of recommendations to develop the institutional resilience of the basin. The 'causal chain' traces the 'root causes', 'activities', 'immediate cause', 'conflict resolution capabilities', and 'issue', to follow the potentials of 'conflict' and 'cooperation'.

Iyob (2010) argued that applying the principle of equitable benefit sharing (sub-section 6.2) enhances the resilience of the Nile Basin Initiative (NBI) to confront three groups of pressures: biophysical (floods and droughts); socio-economic (increased domestic, irrigation and hydropower demands); and geopolitical (local, regional, national and international effects). The study investigated the degree of resilience of the institutional measures, taken by the NBI for each pressure, according to a point-scale of 5 stages,

[42] The DPSIR tool was adopted by the European Environmental Agency (EEA) as an extension of the PSR framework of the Organization for Economic Cooperation and Development (OECD) (EEA, 1999).

including statement of pressure, research study, proposing response, implementation, then evaluation, where no statement indicates no resilience, while evaluation of implementation reflects very high resilience.

7. CONCLUSION

Although both the neo-realist and institutionalist branches of hydropolitics are based on the thesis arguing that states are self-interested actors, each approach realizes the interactions and consequences, which take place in transboundary river basins, in a different way. The institutionalist conceptualization, which is the main focus of this paper, argues that the increasing pressures of population growth, scarcity of resources and climate change are driving forces for cooperation over shared waters rather than conflict, where the former can bring more benefits for everyone unlike the expensive costs caused by the later.

The studies, related to the institutionalist hydropolitical approach, have been developing applicable analytical tools to assist in exploiting cooperation opportunities between riparian states sharing a river basin. According to the literature reviewed in this paper, cooperative methodologies, emerged from this school of thought, attempt to answer four inter-connected questions: 1) how to fully understand the basin resources and potentials; 2) how to generate additional benefits with minimum costs; 3) how to distribute those benefits and costs among states; and 4) how to institutionalize the whole process of basin planning and management.

Treating the basin as a one-system is a fundamental key for answering the first question. One principle method is to track the hydrologic cycle of the river in order to promote integrated water resources management (IWRM) and the green-blue water approach. The security nexus is another method that considers the inter-dependencies of water, energy and food sectors in the basin. In addition, bridging the gap between spatial and river basin planning systems enhances the efficiency of both.

The second question guided several studies for developing the classification of benefits and costs. While most of these categorizations comprise the environmental, social and economic pillars of sustainability, in addition to political aspects, each study introduces a specific framework of analysis, such as the cooperative regional assessment (CRA), transboundary waters opportunity (TWO), and the integrative dam assessment modeling (IDAM).

The game theory, with its different branches, inspired scholars to model the complex interactions between riparian states (players) in a transboundary river basin. Studies based on cooperative games tested the rationality of collective-action under various distributional methods. While, other studies argued that even in non-cooperative games, where no information sharing exists between players, conditional cooperation can take place in open iterated games. Beside, the multi-level game studies involved the multiple impacts of domestic and international dimensions.

Finally, the studies under the fourth question aimed at the enhancement of effectiveness and efficiency of the institutional mechanisms of river basin organizations (RBOs), such as the cooperation continuum, equity in benefit and cost sharing, and resilience capabilities.

The literature review, presented in this paper, aimed at analyzing the methodologies, developed for modeling transboundary river basins, in a comparable and inter-linked manner, in order to pave the way for scholars to synthesize their own methods and frameworks that fit the specific gaps in their case studies under investigation.

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