

“Sharing water and benefits in transboundary river basins” by D. Arjoon et al.

The authors would like to thank the reviewer for his/her interesting and constructive comments. Our responses and the proposed changes/corrections are detailed below.

Referee #2

Summary

This paper describes an approach to equitable sharing of benefits among multiple stakeholders in transboundary river basin systems. The basic idea is to maximize efficiency by allocating water where its value is highest, and then to collect payments from users using an axiomatic rule based on the marginal value of water at each site.

General comments

I like the paper and think it proposes an interesting approach. I see four main shortcomings that are not at all discussed, however. Ignoring them diminishes the credibility of the work.

- 2.1 The first problem is that the issue of property rights is never discussed. Given how water rights are usually assigned in real world systems (and given their existence in the authors’ application of interest, the Nile), this is a major problem.

RESPONSE: A brief history of water sharing agreements in the Nile River Basin is given in Section 3.1 of the paper. The purpose of the presented methodology is as an alternative to these types of agreements on international river basins, which can lead to distrust and tension between riparian countries, as is the case in the Nile River Basin. What we present is an entirely different perspective that may help to avoid the pitfalls and limitations of current agreements. For example, with respect to the Nile Basin, the current agreement driving water allocation legally constrains Sudan to 18.5 bcm of water use. Sudan has land resources to expand irrigation and use much more water than this (Allan et al 2013), but is limited due to the agreement. As well, uncertainty with respect to changing climate and the possibility of increased evaporation, uncertain hydrology and sea level rise could create an imbalance in water demand and supply in the basin (Whittington, 2014). A rise in sea level would result in the loss of agricultural land in the Nile Delta, and, subsequently, a large portion of Egypt's historic water use would no longer be required (Whittington, 2014). We have added a sentence to the last paragraph in the introduction (Section 1) which states *“The institutional arrangement described in this paper should encourage full cooperation between water users because it is intended as a replacement for traditional types of agreements on international river basins, which can lead to distrust and tension between riparian countries. What we present is an entirely different perspective that may help to avoid the pitfalls and limitations of current agreements.”*

- 2.2 The second concern I have is about transaction costs. The need for a river basin authority to implement the allocation and sharing rule is taken for granted, and the cost of setting it up is totally ignored.

RESPONSE: As stated in P21-L9 “One obvious constraint of this method is its dependence on the existence of a strong basin-wide authority...”. The assumption is made that the RBA exists. This is not unrealistic given that there are a number of river basins that already have an RBA in place (OMVS on the Senegal, MRC on the Mekong, ZAMCOM on the Zambezi, NBA on the

Niger River, etc.) and others that are working toward this goal (Volta Basin Authority, for example). As well, in this methodology, we assume that the countries cooperate through the RBA and we agree that this involves transaction costs. If countries agree to the kind of institutional arrangement described, they do so because these transaction costs are less than the cost of cooperation. As well, the transaction cost is not proportional to water allocation or use and, hence, could be introduced as a fixed cost, as we have done in the case study. A fixed cost would diminish the estate available to share and, ultimately, the final benefits of the water users, but it would not alter the proportion.

- 2.3 The third concern is about perfect information (for the RBA). In a way, the authors fall directly into this trap with their rather simple assumptions about irrigation and hydropower values, by assuming that these are uniform across space and time in the Nile. It is almost certainly true that costs and productivity varies across sites, however. In general, this will greatly complicate the ability to establish an effective RBA for achieving the efficient and equitable allocation. Private information will also pose a problem, given that users at different locations in the basin have differing incentives to reveal their true valuations. The authors spend some time discussing preference revelation, but do not fully acknowledge the challenge.

RESPONSE: We agree that simple assumptions about irrigation and hydropower values in the case study were made. These assumptions have been made by other researchers (Whittington, 2005) and are generally consistent with international experience in well-run irrigation schemes and power systems. However, it is obvious that the quality of the results are dependent on the quality and availability of data to run the models, and on the assumptions made. This is a challenge in all studies of this type.

The authors believe that, in the future, it will be realistic to get some of this data. Currently, market prices, either national or international ones, can be observed and transportation costs can be estimated, allowing for an approximation of the mark-up that may accrue to farmers, for example. We stress that this paper describes a system in which it is assumed that there is cooperation over the whole basin. This means that water users have agreed to bid for water and to supply the information that is necessary to make the methodology work. It is up to the RBA to check that the information is reliable. Increasingly, river basins are being monitored and the information required is becoming available (for example, current hydromet projects in the Senegal River Basin). The system may not seem realistic at this point but, in the long-term, exchange of information will increase the availability of data over river basins. This increase in information exchange is in keeping with the obligation to cooperate and exchange information that is outlined in the UNConvention on the Law of the Non-navigational Uses of International Watercourses.

We have added a paragraph to the conclusions Section 5 (second to last paragraph) to discuss the constraint of available/reliable data. This paragraph reads: *“Another constraint is the availability of reliable data. Some information such as market prices, either national or international ones, can be observed and transportation costs can be estimated, allowing for an approximation of the mark-up that may accrue to farmers, for example. This paper describes a system in which it is assumed that there is cooperation over the whole basin and that water users have agreed to bid for water and to supply the information that is necessary to make the methodology work. Increasingly, the information required is becoming available through the use of remote sensing and monitoring of river basins.”*

- 2.4 Finally, the approach depends on allowing all stakeholders a place at the table, but this seems unlikely. In the specific application, urban and environmental uses are imposed as constraints, which is one example of asymmetric bargaining position. There are likely other users that would be ignored as well.

RESPONSE: Allowing all stakeholders a place at the table is indeed challenging, especially for large systems with diversified water use activities. In the irrigation sector, for instance, farmers could send a representative, e.g. a member of the water user association. For uses of water as a public good (e.g. environmental flows), the representative could be the Ministry of Environment of the country of interest. For municipal uses, the system could be designed in such a way that a minimum amount of allocated water is guaranteed (a fixed constraint in the allocation system) while quantities beyond that minimum would be part of the pool for which municipalities would have to bid. Industrial and power companies are easier to handle. All users that can be rationed (mainly private water users) are allowed a place at the table for the purpose of defining fairness with respect to transfer payments.

Another possibility is that the government (or at least a high level representative of the stakeholders) has the ultimate negotiation power, akin to negotiations on trade liberalizations. Clearly, different lobbies exist that would try to influence the government, implying, ultimately, some form of compensation (the analysis of which would lie outside the scope of this paper).

Specific comments

Besides these three main comments, I have a few specific comments.

- 2.5 The abstract makes it seem like there is no efficiency-equity tradeoff, but in general there is, except when a fully efficient compensation mechanism exists. The main paper acknowledges this more clearly.

RESPONSE: With the physical allocation of water, policy makers face an efficiency-equity trade-off. With the proposed benefit-sharing mechanism, the trade-off still exists but the extent of the imbalance between the two is reduced because benefits are maximized and redistributed according to a key that has been collectively agreed on by the participants. We have added the following sentence to the abstract to highlight this: *“With the proposed benefit-sharing mechanism, the efficiency-equity trade-off still exists but the extent of the imbalance is reduced because benefits are maximized and redistributed according to a key that has been collectively agreed upon by the participants.”*

- 2.6 Introduction: Unidirectional flow is not what imposes externalities. Rephrase.

RESPONSE: This sentence in the introduction (Section 1) has been rephrased to read: *“This is particularly evident in the case of transboundary river basins in which unidirectional, negative externalities, caused by the upstream regulation of the natural flow, often place some parties at a disadvantage and results in asymmetric relationships that add to the challenge of coordinating resource use (van der Zaag, 2007).”*

- 2.7 Introduction: Is there really consensus that cooperative management increases benefits? Can you provide more than one citation to back this up? What about transaction costs?

RESPONSE: Additional citations have been added. The statement now reads: *“There is a consensus among water professionals that the cooperative management of shared river basins should provide opportunities to increase the scope and scale of benefits (Phillips et al., 2006; Grey and Sadoff, 2007; Leb, 2015), stepping beyond the volumetric allocation of water that reduces negotiations between riparians to a zero-sum game.”*

2.8 Can you discuss the implications of assuming constant marginal product of water in irrigation?

RESPONSE: In our case study there are 3 (upstream) irrigation schemes that do not (on average) get the amount of water demanded. This is because the productivity of water that is used over the entire basin (0.05 USD/m³) is less than the marginal value of water at these nodes in the system. This productivity value is used because there is currently a lack of data for irrigation in the basin. The availability of economic/agricultural data in each irrigation scheme over the basin, as well as details of cropping patterns in each scheme, would allow us to develop a non-horizontal demand curve. If this were the case, high value crops in the upstream schemes may be irrigated and the low value crops in downstream schemes may not be irrigated. This means that the irrigation water users that are rationed may change and may be spread out over the basin. The first paragraph in the results section (Section 4) has been updated to the following statement: *“The rationing of water for upstream irrigation users is a result of the horizontal demand curve used for irrigation. If more detailed economic/agricultural data were available, a non-horizontal demand curve could be produced. This may result in irrigation schemes with high value crops having priority to water and those areas with low value crops not being irrigated. This means that the irrigation water users that are rationed may change and they may be more spread out over the basin.”*