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Irrigation versus hydropower: sectoral conflicts in southern Sri Lanka

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Abstract

Although hydropower does not directly consume water, its generation frequently conflicts with other uses, notably irrigation, because its release schedule does not always correspond to the timing of water use by other activities. This article analyses a case from the Walawe river basin, Sri Lanka, where economic efficiency can be raised by reducing releases from the dam for irrigation for the benefit of hydropower generation. The tradeoff is analysed in financial and managerial terms and different options for reducing irrigation diversions are reviewed. Although the high level of current diversions for irrigation warrants the possibility of improvement in management, it is shown that finding ways to reduce supply faces technical and socio-political constraints that make the realization of economic benefits costly and difficult.

Keywords: Economic valuation; Hydropower; Irrigation; Sri Lanka; Water management; Water rights

1. Introduction

Hydropower generation meets 19% of the world's energy needs and has been one of the main driving forces behind the construction of 45,000 large dams worldwide (WCD, 2000). The generation of electricity has little impact on the quantity of water (it is limited to the loss by evaporation in the dams) but it alters the timing of streamflows, both season-wise and hour-wise (within a day), as the timing of water releases is generally governed by the demand curve for electricity. This explains why conflicts between hydropower and downstream uses, including irrigation, in-stream uses and supporting ecosystems, often occur (Briscoe, 1999).

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A typical case of such conflict is found in central Asia, where the Kyrgyz Republic needs to release water in the winter to generate electricity, while Uzbekistan and South Kazakhstan need water in the summer for their irrigation schemes (World Bank, 2004). Another classical conflict between dams and both irrigation and ecosystems is found in the Columbia river basin, in north-western USA, where salmon conservation has led to the decommissioning of some dams and where agriculturalists occasionally cede their rights to hydropower companies (NRC, 2004).

In some particular cases, hydropower is generated by diverting water into a contiguous basin. In such instances, third party impacts on downstream riparian users are potentially much higher, although often mitigated by releasing a minimum flow to the river. Examples include the Kali Gandaki "A" hydroelectric project in Nepal (Upadhaya & Shrestha, 2002), The Nam Theun-Hinboun Hydroelectric dam in Laos (IRN, 1999; Ryder, 1999) and the diversion of part of the flow of the Alto-Tietê river (Sao Paulo, Brazil) to the coastal zone through the Billings reservoir (Braga, 2000). Likewise, Helmi and Ifdal (2003) documented the case of the Ombilin river in Sumatra whose average natural flow of 49 $m^3 s^{-1}$ has been reduced to a staggering 2–6 $m^3 s^{-1}$, after diversion by a tunnel to another basin.

There are also abundant cases of dam managers being instructed to release water during dry spells, even if electricity demand is low, because of problems experienced downstream: shortages in irrigation schemes or cities or low flows in rivers that prevent navigation or threaten ecosystems. The question of water allocation between sectors in general and between hydropower and other activities in particular, is thus crucial. This paper provides a case study from the Walawe river basin, in southern Sri Lanka, where such a situation of conflict occurs. We start by describing the actual situation of energy generation in Sri Lanka. We then describe the Walawe river basin, the conflict between the Samanalawewa dam and the Kaltota Irrigation System (KIS) and their respective management of water and we conclude by investigating possible solutions to the conflict.

2. Energy generation and Hydropower in Sri Lanka

The total installed power generation capacity in Sri Lanka is 1,828 MW, two-thirds of which come from 16 hydropower stations (Ceylon Electricity Board, 2005). In practice, hydropower generation depends on the amount of water stored in the dam and is now around 39% of the total energy produced. It is striking to note that this percentage was as high as 95% in 1995. This "power transition", where hydropower becomes minimal, is observed in many countries. It is in general paralleled by a shift in priority, whereby electricity generation gradually loses its higher degree of priority to the benefit of irrigation (and sometimes environmental flows). Yet, this generally comes at the cost of economic efficiency since energy is often generated in a lesser quantity and when prices are lowest (Chatterjee *et al.*, 1998). However, the Ceylon Electricity Board (CEB) is busy maximizing the amount of water that goes through its turbines, especially in a context of rising energy prices and where most of the growth in supply is provided by independent suppliers who need to be paid in cash by the government.

Half of the hydropower capacity comes from the Mahawelli system, where six major dams face the dual objective of generating electricity and supplying irrigation. This source of hydropower is currently under threat from both siltation and reduction in rainfall (Shantha & Jayasundara (2005) identified a staggering 39% decrease in average rainfall in the Mahawelli dams catchment). At the moment irrigation tends to receive priority during cropping seasons but available volumes also depend on how much water has been released during off-seasons. The upper Kotmale dam diverts water to an adjacent river basin before generating hydropower. The CEB is trying to find ways to limit its direct releases from the dam to a downstream irrigation area. A similar situation can be found in the Walawe river basin and the efforts to achieve this objective in this basin – which is the subject of the present paper – are seen as a pilot initiative that can potentially be applied to other cases.

Water management in Sri Lanka is coordinated at weekly meetings held at the Water Management Secretariat in Colombo. The meeting is attended by representatives from the CEB, the Director and Deputy Director of the Water Management Secretariat, officials from the Mahaweli head works and representatives from the Water Board and the Irrigation Department (ID). Decisions about allocation for the whole country are based on a thorough review of the entire water resource situation in Sri Lanka both for agriculture and power generation (Somatilake, 2002). After each meeting, power stations are informed, via the System Control Centre of the CEB, about the amount of water releases authorized for both irrigation and electricity generation for the next week. On an hourly basis, however, turbines are switched on and off by request from Colombo, without predefined schedules.

3. The Samanalawewa Reservoir and KIS: competition for water

The Walawe river basin covers approximately 3,000 km^2 and extends from the ridge of the central highlands of Sri Lanka, at an altitude of over 2,000 m, down to the southern coast. The basin offers a clear contrast between, on the one hand, its highlands and its intermediate mountainous association of ridges and valleys and, on the other, the lowland plain itself. Precipitation varies significantly in the basin, from over 3,000 mm in the northwestern tip to around 1,000 mm along the seashore; the Walawe river discharges 1.1 billion m^3/yr to the sea on average.

The Uda Walawe reservoir was constructed in the mid-1960s, allowing irrigation of 15,000 hectares (Molle & Renwick, 2005). A dam site for hydropower generation had long been identified in the mountainous part of the basin but only became a reality in 1992, with the construction of the Samanalawewa dam in the upper reach of the Walawe river (Figure 1).

Constraints specific to the local landscape made it easier/safer to locate the power station in the adjacent Katupath Oya basin and to supply the turbines through a tunnel cutting through the mountain (Figure 1). By doing so, the flow of the Walawe was diverted to another basin and water users located downstream of the dam were deprived of the abundant water they had enjoyed hitherto. In effect, 10 km downstream of the dike of the Samanalawewa dam two very old *anicuts* (diversion weirs) can be found: these two anicuts divert water to each side of the river and supply the 865 ha of the KIS. Figure 1 shows that the outflow of the power plant returns to the Walawe river precisely at the downstream tip of the Kaltota scheme; in other words, while this outflow is made available to the Uda Walawe Irrigation Scheme (UWIS), further downstream, it totally bypasses KIS. This sets the scene for a potential conflict between the Ceylon Electricity Board (CEB) and KIS.

The KIS is the responsibility of the Irrigation Department (ID). Management is ensured by a technical assistant (TA) assisted by two members of field staff. Main canal maintenance is also under the purview of the ID but is contracted out to farmer organizations (FOs). All the main gates located along the main canals are operated by the ID according to a rotation schedule (secondary canals receive water for three days and are closed for three days). All other gates within the command area are controlled by farmers. Cleaning of the field canal is also done by farmers.

The Samanalawewa dam has been built mainly for power generation and flood control purposes and has a capacity of 278 Mm^3. A valve located in the Samanalawewa dam allows water to be released to the

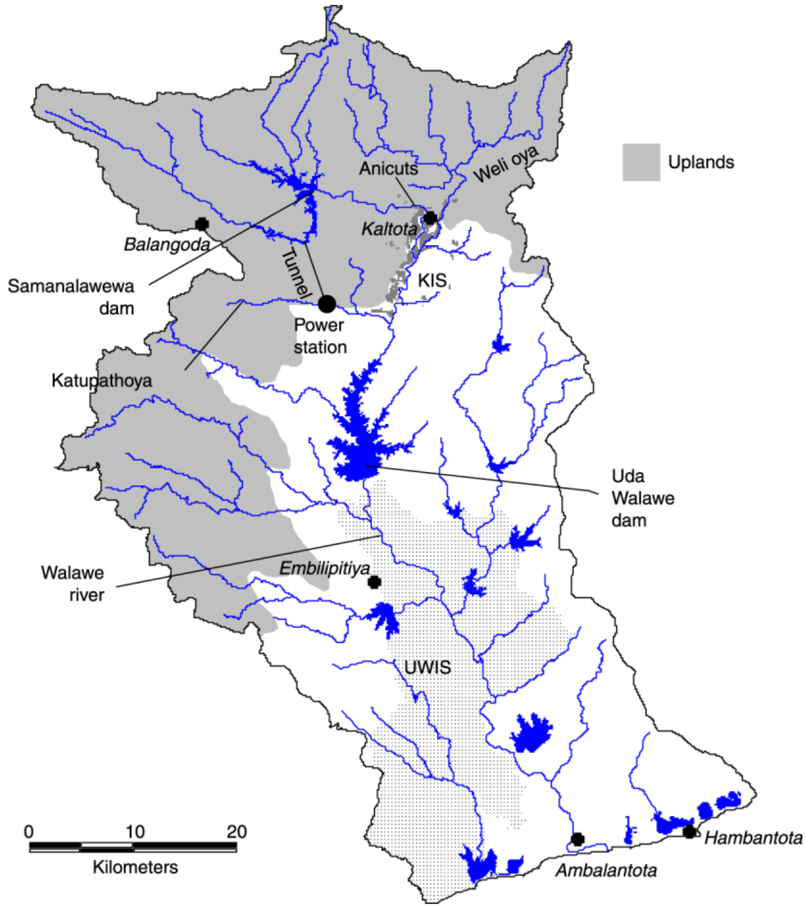

Fig. 1. The Walawe river basin.

natural course of the Walawe river. After construction, an unexpected water leakage, emerging about 250 m downstream of the dam, appeared in the right abutment owing to some weak subsurface soil formation. A permanent leak of 2.2–2.7 $m^3 s^{-1}$ was later reduced (after wet-blanketing) to below 2 $m^3 s^{-1}$ (varying with the water level in the dam). Thus approximately 55 Mm^3 are made available without any control during the year. The dam has been operating at full capacity only since the leakage was repaired in 1997. Water for power generation is sent through a 5.5-km-long tunnel that cuts across the interbasin range to the 120 MW power station of Kapugala (see Figure 1). The station has two generators with an annual average energy generation of 300 GWh, which is approximately equal to the energy demand of the Sabaragamuwa province (300,000 households).

After the construction of the Samanalawewa dam, the catchment area of the Walawe river flow entering Kaltota was reduced from 410 km^2 to 56 km^2 (Bellaubi, 2004), which resulted in a dramatic change in supply and made it necessary to plan releases from the reservoir in order to ensure cultivation in KIS. Prior to the construction of the dam, the water rights of this 2000-year-old scheme were implicitly acknowledged by the CEB during the feasibility study and the dam releases required were estimated at 46.36 Mm^3/yr (CEB, undated).

However, because of the unexpected leak in the abutment that siphons a yearly average volume of 55 Mm^3 out of the dam, the flow in Walawe river is composite and includes this leak, a 40-Mm^3 "allowance"[1] released through the sluice, as well as the runoff generated by the small catchment between the dam and the scheme. Data relative to four successive seasons (2001–2003) point to a yearly diversion by KIS of around 88 Mm^3. At face value, this volume of 88 Mm^3 would seem to amount to around twice the volume that would be theoretically necessary to irrigate the nominal command area of 865 hectares. This suggests that KIS should be able to reduce its use, allowing for both a reduction of its allocation and higher energy generation.

That KIS now depends partly on the CEB for its water supply creates some constraints on cropping calendars and timing of supply. Farmers have to follow the cropping calendar defined by the planning of releases from Samanalawewa. For example, the land preparation period is now reduced to 15–20 days, compared with more than 30 days in the past. This reduction in the land preparation period affects farmers located in the tail-end area of the system, and those who have no ploughing equipment and depend on others to prepare their land. Farmers complain that hasty completion of land preparation within a short period of time affects the productivity of their fields; they also argue that a reduced supply to KIS has made it necessary to establish rotational distribution in lieu of the earlier free and constant flow to all areas, an arrangement that is hard to implement with a lack of proper control structures, damaged structures and silted canals.

However, there is little doubt that KIS can be successfully irrigated using less water. The CEB has tried to help solve problems and develop options to reduce use: it has provided tractors to expedite land preparation but this action was not successful in the absence of FOs to manage them. The CEB has also called for a change in cropping patterns, with the adoption of shorter cycle crops, and for the adoption of water-saving techniques (see later). For two seasons, in 1997 and 1998, it also experimented with not releasing water to the scheme and compensating farmers through the Assistant Government Agent (AGA). Some farmers cultivated their lands with the water from the leak but the inequity resulting from this practice generated complaints and the experiment was discontinued.

4. Financial analysis

The value of water in both rice and power production can be assessed in order to estimate the benefit foregone by CEB (Somatilake, 2002), as well as to determine lower and upper bounds of the price of water in a possible transaction: the value to farmers gives the lowest bound of what they would accept for relinquishing the use of their right (for a season), while the value to CEB would provide a maximum value for what it would be ready to pay.

- Total land extent cultivated in Kaltota = 865.5 hectares
- Total number of families = 1,501 from official records
- Total yield (two seasons) = 8,310 tonnes
- Average selling price per kg of paddy in 2003 = Rs 15

[1] The average in the last 4 years is 38 Mm^3. The average since 1994 is 40 Mm^3 but two seasons had very low values because of repairs.

- Average production costs per ha/season = Rs 22,000 (Hussain *et al.* (2002); excluding family labour)
- The gross value of total yield (GV) = Rs 124,650,000
- The net value of total yield (NV) = Rs 86,568,000

The benefit of this production is attributable to (effective) rainfall, runoff, leakage and dam release water and it is difficult to assess their relative values. However, one may consider that rain-fed water rice cultivation would be impossible because of too much uncertainty in supply. If the actual yearly supply (88 Mm^3) is considered, then the net value of water is 1.0 Rs m^{-3} (NV/88). We must however distinguish between the sources of water that make up this volume of 88 Mm^3. As will be shown later, the bulk of dam releases (i.e. around 40 Mm^3/yr) is diverted. The remaining 48 Mm^3 come from the leakage and natural runoff. A crude analysis also shows that the value of the leakage is zero during more than one month out of the 160 days of a given cropping season[2]. Therefore, from the 55 Mm^3 from the leak each year, only 38 Mm^3 (55 × 2 × 120/360) really contribute to irrigation. The remaining 10 Mm^3 come from the runoff (or from the leak but at a time when the runoff would suffice to cover KIS's needs). In other words, KIS receives and uses approximately 78 Mm^3 of "effective" dam water (release + leak), while 17 Mm^3 of water from the leak are unproductive.

If a right of 46 Mm^3 is considered (or rather, the current release of 40 Mm^3) and the whole product is ascribed to it, then an upper limit of the value of water is 2.16 Rs/m^3 (NV/40). It is difficult to estimate the marginal value of the non-leakage water supply. Since KIS has been receiving a maximum amount of 40 Mm^3 from its 46 Mm^3 allowance, we can infer that the marginal value of water beyond 40 Mm^3 is zero. The marginal value to the farmers of the next "slice" of, say, 10 Mm^3, varies with rainfall but is also very dependent on the cost of managing the scheme with less water. This volume of 40 Mm^3 of released water is not only valuable as an input to crop production but also as a substitute for capital and labour: tighter management requires more care and workload (for farmers and managers), investments in hydraulic infrastructures and herbicide (when water cannot be used as a means of controlling weeds). Managing the scheme with, say, 20 Mm^3 is arguably possible but with significant additional costs is not directly amenable to estimation. For the sake of comparison with hydropower, a value of 2 Rs/m^3 will be tentatively taken as an order of magnitude of the total value (reflecting the costs described above).

It is not easy to estimate the value of a KWh of energy generated. One way to value this energy is to consider the price paid by CEB for one KWh when bought from independent producers, that is, Rs7/unit. For a volume of water of 40 Mm^3, the average forgone benefit is 30 GWh, which gives a total of Rs 210 million, that is approximately US$2,100,000. This is equivalent to an increase of 8% in production, while fixed costs and recurrent expenditures remain roughly unchanged. In comparison, this volume of water sent to KIS contributes (together with other sources of water) to generating a net added value of Rs 87 million.

- The total release (for irrigation) = 40 Mm^3
- The value of the hydropower foregone (30 GWh at Rs7/unit). = Rs 210,000,000
- The value of one m^3 of water for hydropower = 5.25 Rs/m^3

The average value of water for hydropower generation is therefore between 2 to 3 times the net value to farmers and a negotiated lease of KIS's water rights would therefore yield a price for water

[2] The duration of a cultivation season is 160 days because the two main canal schedules are staggered by 3 or 4 weeks.

somewhere between 1 and 5.25 Rs/m^3. CEB managers at Samanalawewa are familiar with the above calculation and use it as a justification of their efforts to reduce allocation to KIS. Yet, supply cannot be reduced without identifying precisely at what level the system managers should intervene and for what reasons such large amounts of water seem to be lost, returning to the drainage system. The cost of improving management depends on where and how water could be saved and the implications in terms of incentives and of who would bear these costs have to be investigated. We now turn to these issues.

5. Brief analysis of current water management[3]

5.1. Releases from the dam and natural runoff

Farmers in KIS enjoyed an abundant supply of water before the construction of the Samanalawewa dam. Data on average natural runoff estimated at the Kaltota anicut show that even the one-in-ten dry-year diversion needs could be easily met. With the construction of the dam, the catchment was reduced to 16% of the initial area. The remaining part of the catchment receives an average rainfall of 2,500 mm and generates a natural runoff which, added to the average leakage, can only ensure actual needs for four months of the 10 of cultivation, which points to the necessity of releasing additional water from the dam, if current levels of diversion are to be maintained. Frequency analysis shows that for the one-in-ten dry year, for example, an additional discharge must be ensured during the four months of the *yala* season and be as high as 1.5 m^3 s^{-1} in May–July.

Water can possibly be saved at two levels. First, it is possible to reduce diversion to KIS and adjust dam releases accordingly. Second, it is also possible that a significant part of actual dam release does not actually flow to KIS but is "lost"[4] to the river. To estimate how much water is diverted and how much is passed on to the Walawe river, monitoring the inflows into the right bank and left bank main canals and the spill at the lowest anicut (left bank diversion) was carried out between October 2001 and September 2003.

Observations showed that very little water spilled at the second anicut (except during rainfall events). Figure 2[5] plots the total inflow into the two canals during four seasons and compares it with the total flow coming from the dam (both the leak and the leak plus the releases [TotRelease] are indicated). It can be seen that *maha* 2001/02 and *maha* 2002/03 seasons were able to start only when the dam released water; in contrast, canal diversion in yala 2002 and yala 2003 started before water was released from the dam. This indicates abundant runoff and shows that CEB has waited for the natural flow to decline before releasing water from the dam. Several slumps in dam releases during both *maha* seasons indicate that CEB has also adequately attuned dam releases to the needs and discontinued them when natural rainfall generated sufficient runoff to meet KIS requirements. *Maha* 2002/03, for example, shows several periods when releases have been interrupted or reduced, allowing a considerable reduction in the dam contribution of almost half of the average value. The conclusion that can be drawn from this analysis is

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[3] A more detailed analysis of water management in KIS can be found in Molle *et al.* (2005).

[4] "Lost" with regard to CEB objectives: this flow might be important or essential to the sustainability of river ecosystems. However, in that particular case impacts are minimized by the fact that the Walawe river receives water from other tributaries at a short distance downstream of the anicut.

[5] Inflow observations have been made at intervals varying between 1 and 7 days. Therefore, the data do not properly describe daily fluctuations in water level and discharges. Nevertheless, they provide a smoothed quantification of inflow into KIS.

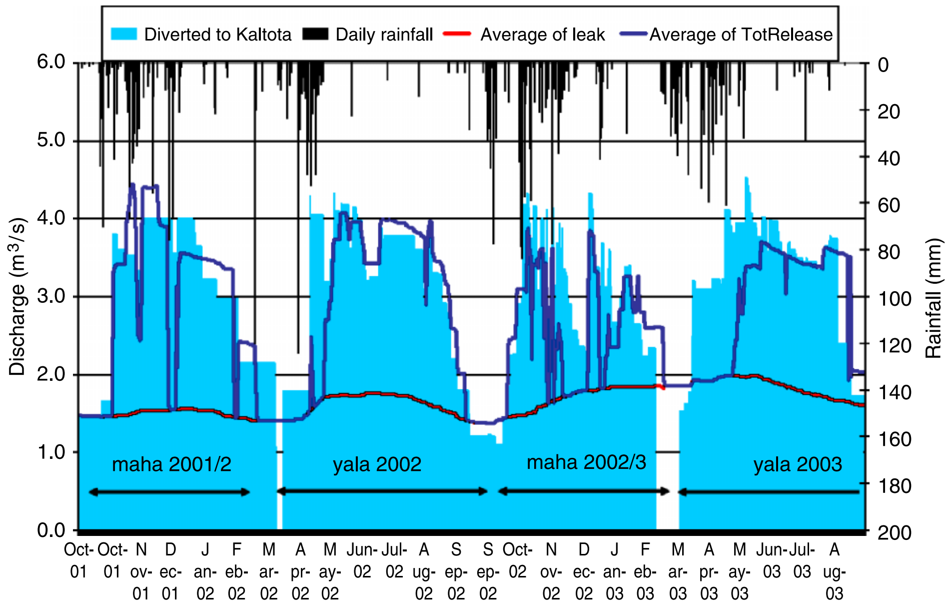

Fig. 2. Water diverted at Kaltota and total dam releases.

that little of the water released by CEB is "lost" to the river. Natural runoff is made use of and management is quite responsive to fluctuations in the magnitude of this flow.

5.2. Water management within the KIS

Since the management of dam releases does not seem to incur significant losses at the second anicut, we must now turn our attention to KIS itself. No quantitative flow data are collected by the field staff of KIS, which makes any analysis or water balance problematic. Therefore, a qualitative assessment of water management in the RB command area was undertaken. In addition, two secondary canals were selected for a more detailed analysis of plot-to-plot water management. Several problems related to water management were identified:

- Proper control of water is not possible because many gates have been broken. Members of the ID field staff try to close off-takes with straw, weeds and debris but these materials are often subsequently removed by farmers.
- Some farmers do not follow the schedule agreed during the *kanna* (seasonal) meeting. A particular problem is that of land preparation. Farmers without means of ploughing or cultivating large tracts of land (10–15 acres) can never complete their work on time.
- Some farmers live far away from their fields or have other activities. They are hardly aware of the rotation schedule (3 days on, 3 days off) or are unable to come on the day when rotation commences. Therefore, they try to access water illegally when they come to their field "out of turn".
- Many plots show losses by percolation of 10 cm within a day and do not retain water during the 3 days "off" the rotation. This explains why farmers with sandy plots are not content with filling them up at

the beginning of the rotation but try to get water at the end of it (or after completion of their turn), in order to endure the next off-period better. Most of the farmers want to keep water standing in their paddy fields as in the past, especially when their soil is sandy.

- Head-end/tail-end disparities are observed at the main and secondary canal levels. In longer secondary canals, tail-end parts are given extra hours of supply at the farmers' request but farmers located on the way also divert water.
- Overall, FOs are rather inactive and are undermined by the fact that some farmers do not respect rotations and solve their problems directly through personal relationships, rather than through the mediation of the FOs. The FOs have no role in the operation of the main canal and organize rotations in some secondary canals.

All these shortcomings are quite common in gravity irrigation schemes. They remind us that paddy cultivation in plot-to-plot gravity systems with soils that are often too sandy is always a difficult task, especially when hydraulic control structures are deficient and staffing limited. In other words, reducing supply is not as easy as the high supply/requirement rate suggests.

6. Seeking common ground

The above evidence shows that a substantial amount of water is in effect diverted to KIS, while little of the water released by CEB is "lost" to the river itself. The discussion must therefore centre on what kind of incentives and practical solutions can be designed in order to elicit in KIS a type of water management that can rely on reduced diverted amounts of water. This section first reviews the different alternatives for reducing diversions and then looks at how they can be implemented or made effective, distinguishing between three categories, namely, bureaucratic (or centralized), incentive-based and right-based.

6.1. Present water application and possible improvement in scheduling

Before estimating what could be a reasonable reduction of supply to KIS, it is important to compare agronomic crop requirements and actual gross diversion volumes and to understand the reasons for the gap between these two values. Rice water requirements (not accounting for seepage and percolation (S&P) losses amount to 543 and 688 mm in the *maha* and *yala* season, respectively. Estimating irrigation water requirements is more problematic. First, because such requirements are hard to estimate: water needs for land preparation vary between 350 or 800 mm, depending on soil texture and so do percolation and seepage vary (some plots may lose 10 cm in one day or two, while others may have losses of 1 mm/day). Observations have shown that it is extremely difficult to assess these losses at the plot level (especially in a plot-to-plot distribution system). Second, the conventional method of estimating irrigation requirements assumes that maintaining standing water and making up for the S&P loss is a target objective, but this becomes meaningless in sandy soils with a few centimetres of S&P losses per day. What prevails is practical experience which determines whether a duration of 3 days (or any other duration) is sufficient to irrigate the full area under a given lateral canal and if an interval of three days off does not incur yield loss.

Water diversions are readily available: for the four seasons studied totalled 5,259, 5,612, 4,381 (more rainfall observed) and 5,459 mm and flows observed in KIS ($\sim 4\,m^3\,s^{-1}$) during the 20 days of land preparation (for 850 hectares) are close to $5\,L\,s^{-1}\,ha^{-1}$. All these values are twice as high as the values observed in the Uda Walawe Irrigation Scheme. These rates of water diversion are certainly high but it is important to understand that, in isolation, high rates of diversion are not a problem *per se*. Indeed they are, rather, a rational way to minimize risk and labour by ensuring a continuous flow into farmers' plots (at least during turns). The amount of water *depleted* in KIS is largely a given parameter (the evapotranspiration of rice fields and surrounding vegetation) and all amounts beyond this value quickly go back to the Walawe river and are made available to downstream users. The particular reason why such practice is not optimal in the present case is that CEB would increase its benefits by diverting part of this water through its turbines, while returning it but only in the downstream part of KIS.

Water management can be improved but at a cost, both financial and managerial. Therefore, it is not enough to reckon that per-hectare water diversion levels are high; one needs to understand how these could be reduced, what the implications for users would be and how incentives to change could be designed. Diversion to KIS can be reduced only if the allocation to at least a significant number of lateral canals can also be reduced: in practice this means that the actual 3-day "on" turn should be reduced to 2.5 or 2 days whenever possible. There are, however, several constraints to such reductions: irrigation operations will have to be expedited, requiring greater coordination among fellow farmers along the same lateral; the durations of "on" and "off" periods will vary for each canal, creating additional work for field staff and confusion among farmers; and sizable reductions are likely to elicit more "deviant" behaviours (tampering and destruction of structures), increasing the need for monitoring and enforcement (it is unlikely that the existing ID staff members are in a position where they can impose a strict scheduling and control farmers).

6.2. Improving cultivation techniques: SRI

Water diversions could also be reduced if cropping techniques, or the crops themselves, were changed. The System of Rice Intensification, or SRI, is a cultivation technique that may lead to significant reduction in water diversion for paddy irrigation. It was introduced in Sri Lanka in the late 1990s and was identified by CEB officials as a potential means to reduce water use in Kaltota (Namara *et al.*, 2003).

Briefly, the technique includes transplanting young seedlings (8–15 days) at low density (25 cm × 25 cm or more), organic fertilization, mechanical weed control and water management that alternates wetting and drying rather than permanently flooded conditions. Experiments in Sri Lanka have shown that average yields increase by 40% but that labour requirements are around three times those of the conventional method (Namara *et al.*, 2003). Water control is also paramount and reduced water diversions must be paralleled with predictable supply.

It is important to note that the amount of water depleted by evapotranspiration is globally unchanged, since the alternate wet-and-dry irrigation technique is not deficit irrigation and is careful in not generating water stress: only the flow diverted to the plot can be reduced, as flooded conditions are not required. The decision to admit water into the plot, however, belongs to the farmer and is independent of what other farmers do; therefore, even if a significant number of farmers within a lateral canal command area adopted SRI, this would only result in increasing return flow to the drain (especially by spill to the river at the tail end of the canal), not in water savings. Only if all farmers were to adopt SRI, which is an unlikely event, could this be translated into a change of schedule for the lateral canal (provided that inflow can be made more predictable) and, eventually, into reduction of diversion at the scheme level.

6.3. Changes in cropping patterns

The preceding sections have abundantly shown that a large part of the soils in KIS are not paddy-soils and that growing rice incurs high losses by percolation. It is therefore easy to come up with the recommendation that farmers should shift to other field crops. The issue of diversification is beyond the scope of this report but it is worth mentioning that, beyond local consumption, the adoption of cash crops is constrained by market risk, lack of skill and capital (Molle & Berkoff, 2007) and above all by transportation: Kaltota is still a very remote area, with a narrow and winding access road that hinders commercial activities.

6.4. Increasing supply to the left bank

Another possible option to decrease the contribution of the Walawe river to KIS is to supply the left bank canal with the adjacent Weli Oya river (see Figure 1), which would necessitate some head works and a canal to link this river with the LB canal. While there is sufficient water to supply KIS through the Weli Oya, the cost of the diversion needs to be assessed to confirm whether this is a viable option or not.

7. Available options for improved management

Reducing supply to KIS can be achieved either by administrative decision, by incentive-based measures or by right-based options. These main options are briefly reviewed here and cannot be expanded for lack of space.

Improving scheme management by fine tuning the amount of water distributed to each lateral and enforcing stricter scheduling means tighter management: this implies a drastic increase in flow measurement, monitoring and enforcement capacity, rehabilitation of broken off takes and other structures and strict mechanisms to impose sanctions on deviant behaviour. Under present conditions of staffing and infrastructure, this is not considered realistic. It could also be tempting, in the face of the very high water duties enjoyed by KIS, to curtail dam releases unilaterally. This option would, in all likelihood, backfire; it would antagonize farmers and generate turmoil in a region of high political sensitivity and volatility. The issue would be couched in terms of poor farmers versus hydropower and of spoliation of ancient customary water rights and would undoubtedly stir much unrest.

The second option is to opt for incentive-based policies that encourage farmers to implement some of the measures conducive to reduced diversions. Crop diversification to less water-intensive crops or the introduction of SRI are desirable but unlikely to spread on a large scale unless they are encouraged by strong incentives, and they cannot be translated into savings at the system level unless they spread at a large scale. This means strong incentives in terms of extension services and provision of alternative and stable markets for output.

Another incentive-based option would be to reward farmers for whatever water saving they would make under a threshold of 40 Mm^3 (taken as the actual average use)[6]. For example, farmers could receive, say, Rs 2 for each m^3 of water deducted from the existing level of 40 Mm^3. This would be a win–win situation whereby CEB would increase its benefit from electricity generation while farmers would be compensated for the improvements in management they would need to do to accommodate the reduced supply. Yet, such mechanisms pose the thorny problem of how this subsidy could be passed on to farmers while escaping capture by some more powerful stakeholders.

All the preceding options run the risk of being undermined by the status of KIS as a 2000-year-old water user. Instead of trouble with designing and administering a system of bonuses, it might be preferable fully to recognize the water right of KIS and negotiate a seasonal compensation for any "borrowing" of a share of it. This would allow flexibility with regard to future expansion of the command area, adjustments in cropping patterns (that might be governed by external factors), or in the relative price of energy generation. According to the above analysis, the transaction would probably fetch a price between 2 and 5 Rs/m^3 but this price could be renegotiated whenever needed.

Water rights do have the advantage of providing water users with some kind of compensation when they agree to have some of the water they use reallocated to other users. However, in Sri Lanka the state does not recognize any system of individual or collective water ownership rights (Meinzen-Dick & Bakker, 2001). Allocation is left to the discretion of the line agencies concerned[7]. The lack of clear definition of water rights reduces users' incentive to save water (see Chatterjee *et al.*, 1998 for a case study in California). Beyond political dimensions, the difficulties in arriving at both institutional and technical performing arrangements probably also explain why right-based transactions and management of water were not established and are so infrequent in practice (see Molle, 2004). In the present case a strong FO would be necessary (but not sufficient) to take the collective decision to lease part of the water entitlement and to take care of the redefinition of water management as well as of the distribution of financial compensations. Much transparency, as well as a sound control of water flows, is needed but these may currently be beyond the reach of the FO.

A right-based approach will have to decide whether the leakage is part of the right or not (assuming that it is there to stay and can only increase in the future). If the "effective" 38 Mm^3 coming from the leakage and diverted each year are computed then only 8 Mm^3 will remain to be obtained from the dam, if the original 46 Mm^3 are taken as KIS's entitlement. Given current levels of diversions, this would be impracticable and would probably lead to questioning of the validity of the 46 Mm^3 "entitlement". On the other hand, not considering the leakage would probably endow KIS's farmers with a right that is substantially above standards, even considering the high permeability of its soils. It is likely that a renegotiation of the allowance would have to take place and CEB's officials are now considering shifting from an early position where the leak was disregarded to one where it would be considered as part of the supply from the dam.

[6] Such policies are uncommon in water management but have been envisaged in Spain (see Sumpsi Viñas, 1998).
[7] A recent attempt to introduce a system of administered water rights has been faced with much public opposition (MONLAR, 2004) and eventually failed (Garduño, 2001; Samad, 2005).

8. Conclusions

This study has investigated a classical case of conflict between power generation and irrigation, whereby reductions in diversion to irrigated areas would allow an increase in power generation. It was shown that CEB has consistently complied with its (informal) commitment to provide KIS with a historical water right of 46 Mm^3, despite an unexpected 55 Mm^3 flowing to the river each year by seepage from the dam abutment. Management of dam releases was shown to be efficient in that little of the dam water released for irrigation was not diverted to KIS.

By any standard, the amount of water per hectare diverted to KIS is high. However, this amount has to be viewed keeping in mind that most of the land is subject to high losses by seepage and percolation, that current infrastructure and staffing do not allow stricter management and that continuous flow is a rational risk and labour-minimizing strategy when water is abundant.

The CEB faces the challenge to instil a change in water use behaviour that would allow a reduction in dam release and a corresponding increment in the power generated. It would be a mistake to deduce from the rather high per hectare rates of diversion that water savings can be easily obtained. Achieving a quantum leap in management efficiency will place a significant additional burden on both farmers and managers. Neither an outright decrease of supply, nor a support to water-saving cultivation methods like SRI, is likely to help achieve this objective. A carefully designed incentive system, coupled with a process of turnover of management to a farmer company, accompanied by due rehabilitation of critical structures, has the potential to achieve a trade-off that would satisfy both parties. Innovative incentives such as "compensations" proportional to the amounts of water saved could be negotiated. Such subsidies could be channelled through the farmer company and feed a maintenance fund and/or be used to buy and resell subsidized input for cultivation to farmers. Alternatively, a right-based approach whereby KIS would lease some of its entitlement against a negotiated compensation, in accordance with changing conditions in the agriculture and energy markets, could be considered.

The implementation of such reforms, however, has several prerequisites. The most important is the political will by the ID to turn over transfer to farmers. It is also recommended that a thorough diagnosis of water management in KIS be established in order better to identify structural and non-structural constraints before embarking on partial modernization of the scheme and on institutional reform. The substantial benefits that can potentially accrue to both sides and the further incentives provided by soaring energy prices are sufficient to warrant further consideration of how to improve management while sharing the benefits generated.

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