RESEARCH REPORT

94

Balancing Irrigation and Hydropower:
Case Study from Southern Sri Lanka

François Molle, Priyantha Jayakody, Ranjith Ariyaratne and H.S. Somatilake

International Water Management Institute

COMPREHENSIVE Assessment of water management in agriculture

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International Water Management Institute
P O Box 2075, Colombo, Sri Lanka

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The authors: François Molle is a Principal Researcher at the Institut de Recherche pour le Développement (IRD), France, currently seconded to the International Water Management Institute, Colombo; Priyantha Jayakody and Ranjith Ariyaratne are Research Officers at IWMI, Colombo. H.S. Somatilake is Chief Engineer at the Ceylon Electricity Board, in charge of the Samanalawewa Power Station, in Kapugala, Balangoda District.

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Summary

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. In some cases, water passing through the turbines is not returned to the river but diverted to an adjacent basin, which greatly alters natural regimes in the river and potentially impacts on users located downstream of the dam. This report analyzes a case from southern Sri Lanka, where the Samanalawewa dam and the Kaltota Irrigation Scheme (KIS) compete for the water of the Walawe river.

The KIS currently diverts approximately 80 million cubic meters per year (Mm^3/yr.) through two anicuts from an annual flow composed of some constant seepage loss from the Samanalawewa dam (around 55 Mm^3/yr), releases from the dam (40 Mm^3), and occasional runoff generated between the dam and the diversion point. Dam releases correspond to foregone hydropower benefits amounting to approximately 8 percent of current production, with a corresponding monetary value of Rs 210 million. The Ceylon Electricity Board (CEB) seeks to reduce its allocation to KIS in order to maximize its production. With a water depth of 5,400 mm delivered over 850 hectares, mainly of paddy fields, KIS is categorized as a project with extremely low efficiency and is a likely candidate to improving management and water saving.

This report investigates current water management at three successive levels in order to identify where losses occur and how these can be remedied. At the catchment level, it is shown that dam releases are well attuned to the needs of KIS and to the occurrences of natural runoff, and that little of the dam water is “lost” to the river. At the scheme level, land preparation uses large amounts of water, because of the large capacity of the main canal, with a 3-day rotation during the crop-growth period is loosely adhered too, with ad-hoc on-demand adjustments. At the plot level, it was observed that a large portion of the project is endowed with sandy soils, which incur very high infiltration losses and which are rapidly left without any standing water. This pushes farmers to access water quite frequently during their turn, or during the off-period.

Improving management has a cost, in terms of both improvement of hydraulic structures and managerial efforts from both the Irrigation Department and the farmers. Stricter scheduling requires increased collective action and more individual discipline, and means less flexibility and more work on the fields. For managers, it means more attention to deficit areas, monitoring and enforcement of the schedule and measurements of volumetric flows, and more frequent conflicts to be solved. Unilateral curtailment of dam releases in the face of the current high levels of diversion is not advisable for a scheme with 2,000-year-old customary rights and in a region of high political volatility. Plot-level techniques that reduce water intake such as System of Rice Intensification (SRI), already introduced in the scheme, are unlikely to reduce river diversions because of their limited extent and the lack of any relation between these diversions and actual crop needs and practices.

Three options for achieving higher overall benefit are proposed: the first relies on supply augmentation or management improvements mainly driven by the agency; the second is based on incentives for farmers to change cropping patterns and cropping techniques, or to save water at the system level (with management transferred to a Farmer Company); and the third proposes a water-right based system of reallocation. From a bottom allocation of 40 Mm^3, farmers could be collectively

financially compensated for leasing part of their entitlement, at a level equivalent to one fraction of the benefit generated by the water redirected to the power plant and to be negotiated.
In association with the option of management transfer, this mechanism would ensure that farmers use their expert knowledge of the scheme to achieve improved management and would strike a better balance between their needs and those of hydropower, allowing for adjustments when changes affect the agriculture or energy sectors.

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Introduction

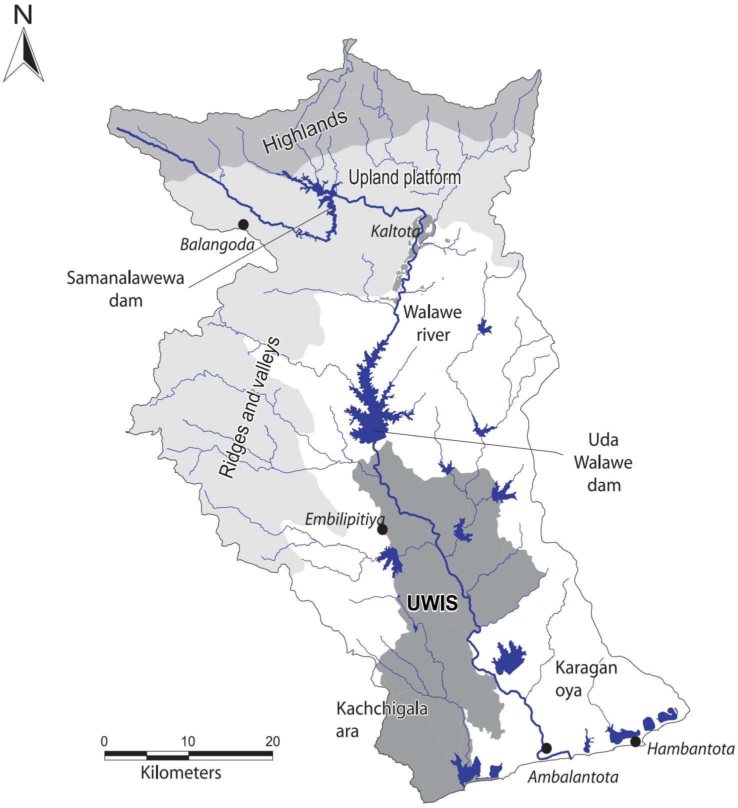
Hydropower generation meets 19 percent of the world's needs and has been one of the main driving forces behind the construction of the 45,000 large dams that can be found worldwide (WCD 2000). The generation of electricity impacts little on the quantity of water (it is limited to the loss by evaporation in the dams) but it alters the hydrograph of streamflows, as the timing of water releases is governed by the demand curve for electricity. This explains why conflicts between hydropower and downstream uses, including irrigation, instream uses and ecological systems, often occur (Briscoe 1999).

A typical case of such conflict is found in Central Asia, where the Kyrgyz Republic needs to release water in the winter time 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 US, 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. Upadhaya and Shrestha (2002) discuss the case of the Kali Gandaki "A" hydroelectric project in Nepal, which diverts water from the Kali Gandaki and returns it at a point 50 km further downstream, with significant impact on fisheries. The Nam Theun-Hinboun Hydroelectric dam in Laos has altered regime flows in both the "giver" and "receiver" basins, with impacts on fisheries, turbidity, bank erosion, induced altered flood regime, fluctuating water levels, loss of navigability and flood of vegetable gardens (IRN 1999; Ryder 1999). The diversion of part of the flow of the Alto-Tietê river (Sao Paulo, Brazil) to the coastal zone through the Billings reservoir in order to generate electricity has severely affected the water quality in the river, and diversions had to be limited to flood time in 1992 (Braga 2000). Likewise, Helmi and Ifdal (2003) report on the case of the Ombilin river in Sumatra: this river originates from the Singkarak lake but the outflow from the lake has been regulated at 2–6 m^3/s, against an earlier average natural flow of 49 m^3/s. The difference is transferred by a tunnel through the mountain range to the Ani river basin, on the western side of the island, in order to generate hydropower. This staggering diversion has left the Ombilin river with a limited flow that has created problems to the waterwheels of the traditional irrigators in the valley. No impact assessment was done at the beginning of the project in 1996/1997 and no compensation was offered, but efforts have recently been made to establish a dialogue between stakeholders (Helmi and Ifdal 2003).

This report provides a case study from the Walawe river basin, in southern Sri Lanka, where a similar situation occurs. The Walawe river

FIGURE 1.
The Walawe river basin.



basin[1] 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 meters, down to the southern coast (figure 1). 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 highlands are cut by many valleys in which small streams, which are often perennials, can be found. They feed the Walawe river, which has an average discharge to the sea of 1.1 billion m^3/yr.

The Walawe basin was settled in the early stages of the Aryan migration, starting around 500 years BC. It was part of the Ruhuna southern kingdom and harbored several cities and numerous tanks, some of which are still in use. Irrigated agriculture developed early through the construction of anicuts (small weirs diverting small streams) (see Molle et al. 2003) and small tanks (Brohier 1934; Mendis 1993). The Ruhuna society flourished in the basin until approximately the thirteenth century, when it started to decline. During British times, most of the basin was hardly inhabited and the population was concentrated on the coastal and lower basin areas, as well as on the mountain ridge. The first plans to develop large-scale reservoirs and irrigation facilities date from the 1940s, when a set of seven dams were supposed to fully control the different rivers and supply irrigation water to the lower part of the basin (Batalm 1943). However, initially only a central reservoir, the Uda

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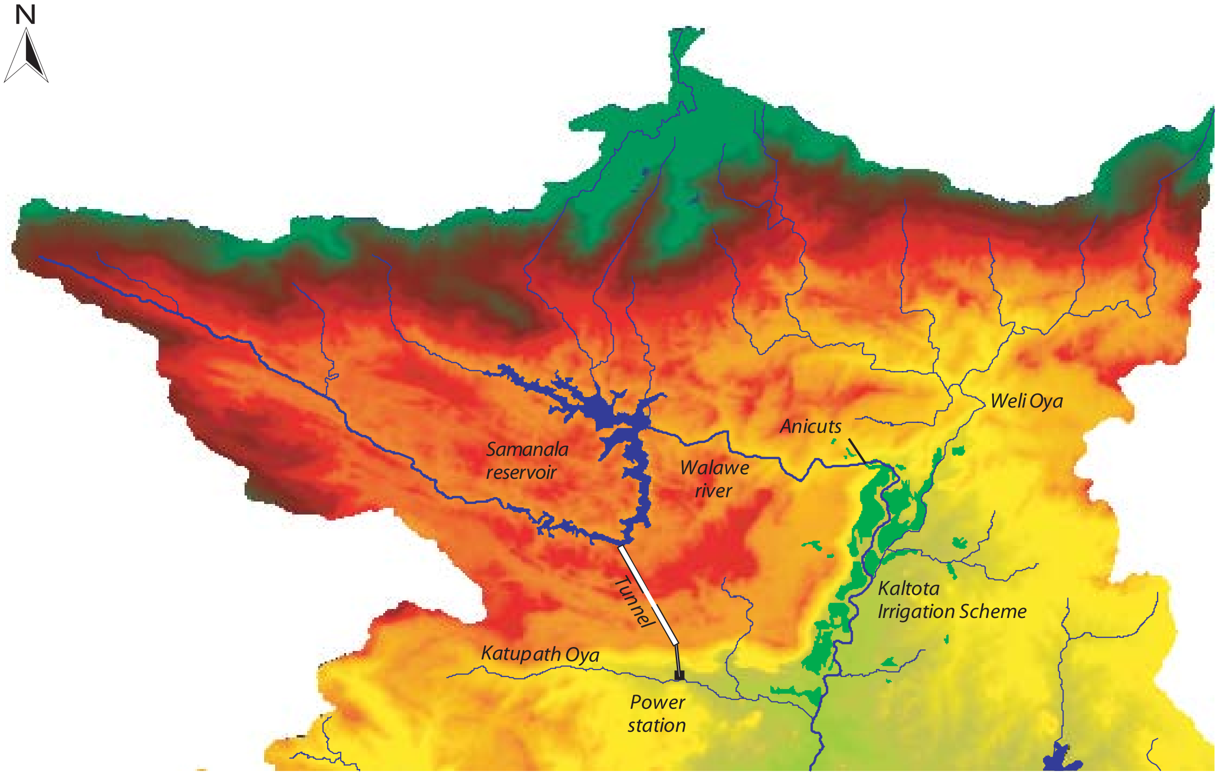
[1] The small Kachchigala and Karagan Oya basins, adjacent to the lower Walawe basin, have been hydrologically linked with the Walawe basin through the Uda Walawe Project.

Walawe reservoir, was constructed in the mid-1960s. Its capacity was sufficient to allow the gradual development and irrigation of 15,000 hectares of land in the lower part of the basin, a process which will be completed by 2005, after the addition of 5,000 hectares in the so-called left-bank extension area (Molle and 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.

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 2). 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 can be found: these two anicuts divert water to each side of the river and supply the 865 hectares of the KIS. Figure 2 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 and illustrates the wider issues of river basin management and water rights.

The second section of this report first briefly describes the Samanalawewa reservoir and KIS and their competition for water. The third section then analyzes water management at several nested levels, from the dam to the intake of KIS, and further to the farmers' fields. It seeks to identify where the water coming from the dam (leakage plus releases) flows to. The fourth section looks at options for finding common ground and trade-offs, and points to a few solutions that can be implemented to maximize the benefits from the Walawe water.

FIGURE 2.
Samanalawewa dam and power station.



The Samanalawewa Reservoir and KIS: Competition for Water

KIS

The KIS is situated in the Ratnapura district and is fed by two anicuts that divert the flows of the Walawe river at the very point where it abandons its rough course across the mountain to enter the main plain. That the site is propitious for establishing irrigation facilities is well demonstrated by the very early construction of the first anicut, sometime in the first century BC. The area was lost to jungle and malaria probably around the sixteenth century, but the anicut diverting water to the right bank (RB) was renovated in the late 1890s by the British, who tried to revitalize the area, to no avail. The two anicuts were reconstructed in 1956 by the Irrigation Department (ID), as part of a plan including rehabilitation of the area and settlement of the population from neighboring districts. The design command area of the project was about 760 hectares but the actual irrigated area is 865.5 hectares, with a total number of 1,501 settler families.

Although Puranagama, the ancient village at the foot of the mountain, is very old, most of its remaining villagers left the area in the 1930–1960 period because of the high incidence of malaria. They settled in nearby villages such as Molamure, Mulgama and Tenna and would come to Kaltota early in the morning to return home in the afternoon after finishing their work. With malaria control in the early 1950s, people gradually resettled in their ancient village. Most of the farmers in the Puranagama area are tenants, as these lands belong to old rich people (e.g., the lands of the Mahawalatenna *walawwa*[2]).

Before 1960, *chena* (slash-and-burn) cultivation was very popular among the Kaltota farmers. Chenas were cultivated during the rainy season in Welipothayaya, Medabedda, Pahathbima, Diyavinna and other places near Puranagama. Old people in the Kaltota area report that they earned a lot of money from chena cultivation and this explains why paddy lands were only cultivated in the *yala* (dry season from April to September) season. The extent of paddy was more than enough to produce food for this limited population in a single season; water management in the *maha* (wet season from October to March) season may also have been made difficult by the high flow in the river and since chena cultivation provided handsome returns there was no incentive to grow more rice in an area with such difficult access to water.

With the colonization and the resulting influx of people, chena lands were not accessible to all. In addition, the rehabilitation of the scheme was intended to grow two crops per year. Each farmer on the left bank (LB), where the settlement first began, was provided with 1.2 hectares of lowland and 0.4 hectare of upland. Later, each settler on the RB received 0.8 hectare of lowland and 0.4 hectare of highland. Most of these lands are now fragmented into smaller plots. An additional 50-hectare area of land is cultivated with drainage water from the scheme and has now been included under the project. Before the construction of the Samanalawewa dam, the flow in the Walawe river was abundant and farmers used to enjoy unrestricted access to water, except during a few rare dry spells when the flow would drop.

As land in the Kaltota area is limited very few people now come to the area. The second generation of settlers have been provided land in the Uda Walawe scheme. The plots tend to be divided among children and migration is quite significant. Although Kaltota has a Technical College, the lack of jobs in an area that remains isolated for lack of good roads is driving the youth away in search of job opportunities elsewhere.

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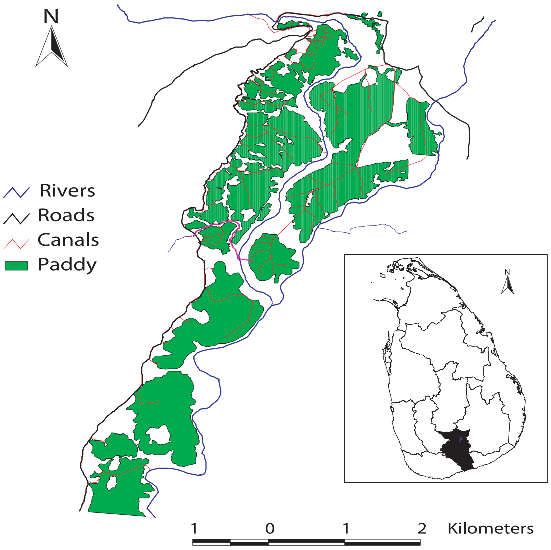
[2] Usually a large house of a high-caste or distinguished person, so named to distinguish it from other houses.

The layout of the KIS is quite simple (figure 3). The 12.7-km RB main canal follows the foot of the Kaltota escarpment and delivers water to a strip of land located along the RB of the river. There are 39 direct offtakes to lateral canals, 26 in the upper part (Puranagama) and 13 in the lower part (Welipothayaya).[3] There are also three gates to control the water level in the main canal. The LB main canal follows the central and higher part of the tract of land located between the Walawe and Weli Oya rivers. It serves approximately 300 hectares.

FIGURE 3.
Layout of the Kaltota Irrigation Scheme.



The KIS is under the responsibility of the 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. All other gates within the command area are controlled by farmers. Cleaning of the field canal is done by farmers.

At the beginning of each season, a meeting is held in Kaltota to decide the dates for starting water releases and the quantities of water to be released to the KIS during the next season. These meetings are attended by representatives of the Divisional Secretary, the Irrigation Engineer in Ratnapura, Officers of the Department of Agriculture, an engineer from the Samanalawewa power station and members of each farmer organization (FO).

The Samanalawewa Reservoir and Power-Generation Capabilities

The Samanalawewa dam in the Uda Walawe basin has been built mainly for power generation and flood control purposes and has a capacity of 278 Mm^3. As explained earlier, the flow to the hydropower station is directed towards the adjacent basin. However, a valve located in the Samanalawewa dam allows water to be released to the 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 due to some weak subsurface soil formation. The permanent leak of 2.2–2.7 m^3/s was later reduced (after wet-blanketing) to below 2 m^3/s (varying with the water level in the dam: see appendixes 3 and 4). Thus approximately 55 Mm^3 are made available without any control along the year. The dam is operated at full capacity only since the repairs of the leakage 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 2). 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).

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[3] In Puranagama, these lateral canals are called CPO while in Welipothayaya they are named FC (field canal) and DC (distributary canal), depending on the size of the area served. In what follows, all canals branching from the main canals are called lateral canals for the sake of simplicity.

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 ID. Decisions of 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). This coordination is made necessary by the importance of hydropower in the production of energy in the country (around 50% of the total generated) and by the “sharing” of the reservoirs with the irrigation sector. After each meeting, the Samanalawewa Power Station is informed, via the System Control Center of the CEB, about the amount of water releases authorized for both irrigation and electricity generation for the next week.

In times of normal supply, Kaltota receives the bulk amount decided at the preseason meeting. However, CEB may reduce its release in a particular week if it rains. Such reductions commonly occur three or four times by season (see next section), and information on when to reduce supply is provided by the Technical Assistant of the ID stationed at Kaltota. On the other hand, this assistant may also request additional water in times of shortage. The request has to be first radioed to the Samanalawewa Power Station. Then, the Shift Engineer at the Samanalawewa Power Station informs the system control center in Colombo about the request.[4] Based on his decision, the discharge from the dam can be adjusted (Somatilake 2002). The CEB never stops generating energy since it has never found itself in a situation where water stocks in the dams were not sufficient or getting close to the dead volume. Turbines are switched on and off at the request from Colombo, without predefined schedules.

Outline of the Conflict

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. Prior to the construction of the dam, the water rights of the 2000-year-old downstream area of Kaltota 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 out of the dam a yearly average volume of 55 Mm^3, the flow in Walawe river is composite and includes this leak, a 40-Mm^3 “allotment”[5] 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 (more on this later) 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 a reduction of its allocation and thus benefiting 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, against more than 30 days in the past. This reduction of the land preparation period affects farmers located in the tail-end area of the system and those who have no plowing 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

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[4] The formal decision, however, is taken by CEB headquarters in Colombo. It does not appear that it is helpful to have such decisions taken in Colombo, since their relevance is purely local (in fact, authorization is never denied).

[5] 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.

fields. They also state that the yield of their paddy has dropped from 4.5 t/ha to about 3.2 t/ha after the curtailment of water but this is not confirmed by the Agriculture Instructor (AI) of the area. It is also argued 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 but that applying such systematic internal water distribution schedules is difficult with the present irrigation offtakes of varied sizes, the lack of proper control structures, the damaged status of many structures and silted canals.

However, there is little doubt that KIS can be successfully irrigated with less water. The CEB has tried to help solve the problems and develop options to reduce water use. It has provided tractors to expedite land preparation but such an action was not successful in the absence of FOs to manage them. The tractors were said to have been used by some office bearers of the FOs but not collectively managed. 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 next section).

The CEB would ideally see farming in Kaltota relying solely on the leakage and natural runoff, in order to reallocate the amount of water saved for power generation. For two seasons, in 1997 and 1998, the CEB experimented with not releasing water to the scheme and compensating farmers through the Assistant Government Agent (AGA).[6] Some farmers cultivated their lands with the water from the leak but the inequity resulting from this generated complaints and the experiment was discontinued.

The issue can be framed in terms of water rights. CEB officials at Samanalawewa have hitherto adhered to a strict reading of their obligation of releasing water from the dam but they are now considering arguing with the Water Management Secretariat that the leakage does amount to a release from the dam and that only the shortfall of the agreed amount should be released through the sluice. Should this fail to be considered, KIS's existing water right could be partly leased to CEB, or other types of arrangements devised in order to compensate farmers while maximizing benefits from energy generation.

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 as per official records
Total yield (two seasons) = 8,310 tons
Average selling price per kg of paddy in 2003 = Rs 15
Average production costs per ha/season = Rs 22,000 (Hussain et al. 2002)[7]
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

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[6] The total compensation was Rs 1.5 million.

[7] Excluding family labor.

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.[8] Therefore, out of the 55 Mm^3 coming 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 (releases + 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 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 out of its 46 Mm^3 allotment, 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 rainfal 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 labor: 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 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).

One should also mention that rice production has backward and forward linkages that multiply its benefits. People involved in input supply, transport, milling, processing or retailing also get derived benefits from agricultural production. In addition, Kaltota is a remote area with little alternative job opportunities. In such a context, the overall multiplier effect of investments often ranges between 1.5 and 3.0 (see Bhattarai et al. 2003).

It is not easy to estimate the value of a KWh generated. One way to value this energy is to consider the price paid by the CEB for one KWh when bought from independent producers, that is, Rs 7/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 percent 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 somewhere between 1 and 5.25 Rs/m^3. In all cases, it is important to realize that we are not faced here with an "either-or" dilemma but, rather, with the possibility of increasing power generation by up to 8 percent, *while* maintaining agricultural production thanks to improved management. A transaction at the margin would thus only have to reflect the costs incurred by an improvement in management (higher system efficiency for KIS).

Supply cannot be reduced without identifying precisely at what level in the system managers

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

should intervene and for what reasons so 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.

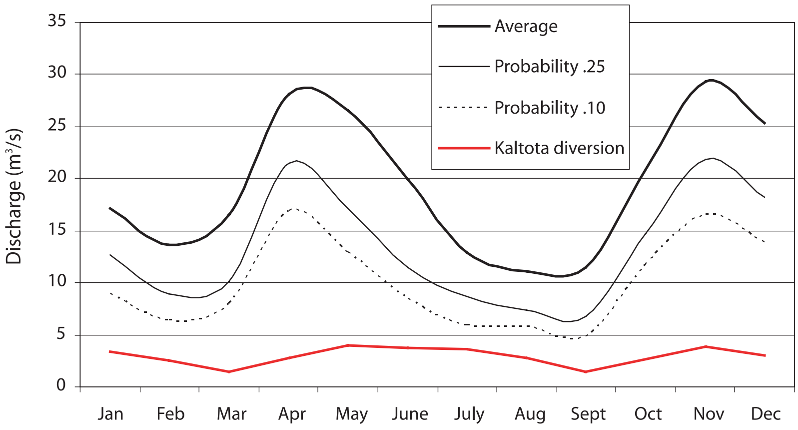
Analysis of Current Water Management

Releases from the Dam and Natural Runoff

There is little doubt that farmers in KIS enjoyed an abundant supply of water before the construction of the Samanalawewa dam. Figure 4 plots the average natural runoff estimated at the Kaltota anicut as well as monthly values with probabilities of 0.1 and 0.25[9] and compares these flows with the actual diversion discharges recorded at the anicuts (LB and RB). It is apparent that even the one-in-ten dry-year diversion needs can be fully met.

With the construction of the dam, the catchment has been reduced from 410 km^2 to 56 km^2, that is, to 16 percent of the initial area. In addition, the remaining part of the catchment receives an average rainfall of 2,500 mm, against an average of 3,185 mm for the whole Samanalawewa catchment (Molle et al. forthcoming). Assuming a runoff coefficient of 0.28,[10] the actual runoff of the intermediate basin

FIGURE 4.
Monthly flows at the Kaltota anicut before the construction of the dam.



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[9] This is based on a series of flows for the 1960–2000 period reconstituted by Bellaubi (2004).

[10] The balance of the small catchment between the dam and the anicut during the November 2002–August 2003 period (for which diversion flows and spill are available) gives a rainfall of 63 Mm^3 (average of Kaltota [60 Mm^3] and Samanalawewa [66 Mm^3] stations), a volume diverted to KIS of 75 Mm^3, a spill (at the second anicut) of 10 Mm^3, and a flow coming from the dam (leak+release) of 67 Mm^3. This points to a runoff coefficient of only 0.28, very close to the value (0.29) of the runoff coefficient of the Uda Walawe catchment (–minus Samanalawewa catchment), which confirms the consistency of the flow data.

FIGURE 5.
Estimated average flow at KIS without dam releases compared with needs.

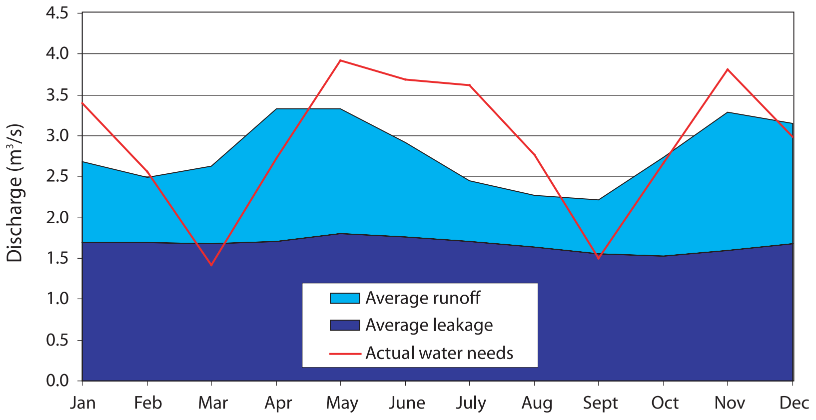
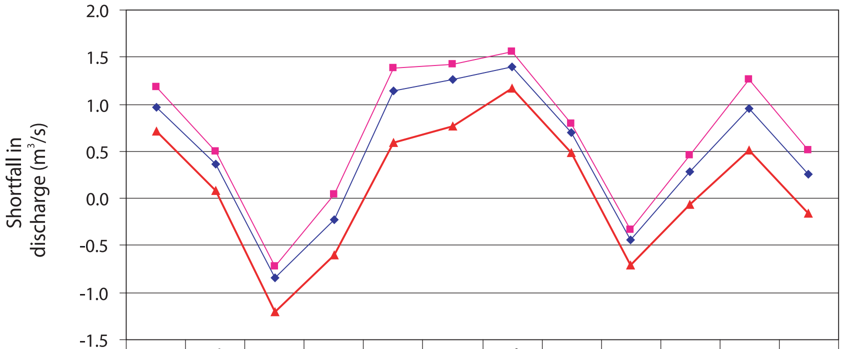


FIGURE 6.
Shortfall in irrigation needs to be met by dam releases.



	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
■ Shortfall probability 0.1	1.19	0.50	-0.72	0.04	1.38	1.43	1.56	0.80	-0.33	0.46	1.26	0.51
◆ Shortfall probability 0.25	0.97	0.36	-0.84	-0.22	1.14	1.26	1.40	0.70	-0.44	0.29	0.95	0.25
▲ Shortfall average year	0.71	0.08	-1.21	-0.60	0.60	0.77	1.16	0.49	-0.71	-0.06	0.52	-0.16

of 56 km^2 can be estimated at a fraction of the Samanalawewa catchment flow. We can then compare the total river flow (average leakage and natural runoff) with current levels of water diversion at KIS anicuts. These two flows combined cannot ensure the actual needs of 6 months out of 10 of cultivation, which points to the necessity of releasing additional water from the dam, if current levels of diversion are to be maintained (figure 5).

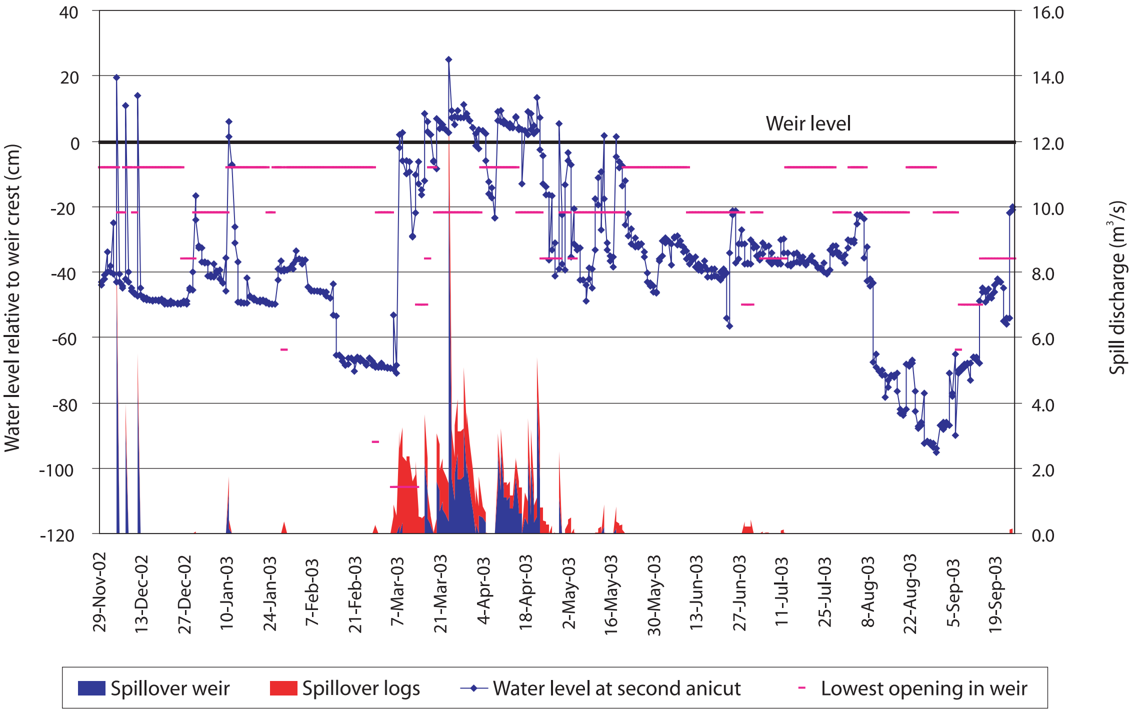
By subtracting irrigation needs (taken as the actual diversion), from the inflow expressed as a sum of the leakage and the estimated natural runoff (in average terms, and for probabilities of occurrence of 0.25 and 0.10, i.e., one in 4 and 10 years, respectively), one obtains the shortfall that has to be made up for with releases from the dam (figure 6). It can be seen that, on average, 2 months need additional supplies in each maha, and 4 months in each yala season. When dry years are considered, this requirement increases, but not as much as expected because of the stable and continuous contribution of the leakage. For the one-in-ten dry year, for example, an additional discharge must be ensured during the 4 months of the yala season and be as high as 1.5 m^3/s in May-July. The volume corresponding to the average shortfall for the whole year is 24 Mm^3 (computed for the months with positive shortfall only).

Volumes Diverted at Kaltota Anicuts

Water can possibly be saved at two levels. First, it is possible that diversion to KIS be reduced and that dam releases be adjusted accordingly. Second, it is also possible that a significant part of actual dam releases does not actually flow to KIS but is "lost"[11] to the river. To estimate how much water is diverted and how much is passed on to the Walawe river, a monitoring of the spill at the lowest anicut (LB diversion) was carried out between December 2002 and September 2003, with two daily observations (morning and evening). The estimation of the spill was complicated by the profile of the weir and the removal of the logs in several parts of the weir but the results obtained are nevertheless quite satisfactory (see appendix 1 for more details). In addition, inflows into the RB and LB main canals were monitored by the ID between October 2001 and August 2003. All these data allow us to better understand the final destination of the water released by the dam, both by leakage and by opening the sluice.

Figure 7 shows that, in most instances, the water level in the river was under the level of the weir; in some cases, however, logs were taken out and the spill level in some of the spillways was lower than the weir reference level. The resulting spill in March and April was commonly between 1 and 3 m^3/s, and sometimes higher. Natural runoff added to the flow coming from the dam; releases from the dam, if any, could thus be reduced.

FIGURE 7.
Water level and spill at the second anicut.



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[11] "Lost" with regard to CEB objectives: this flow might be important or essential to the sustainability of river ecosystems.

FIGURE 8.
Water balance of the water flow at Kaltota, yala 2003.

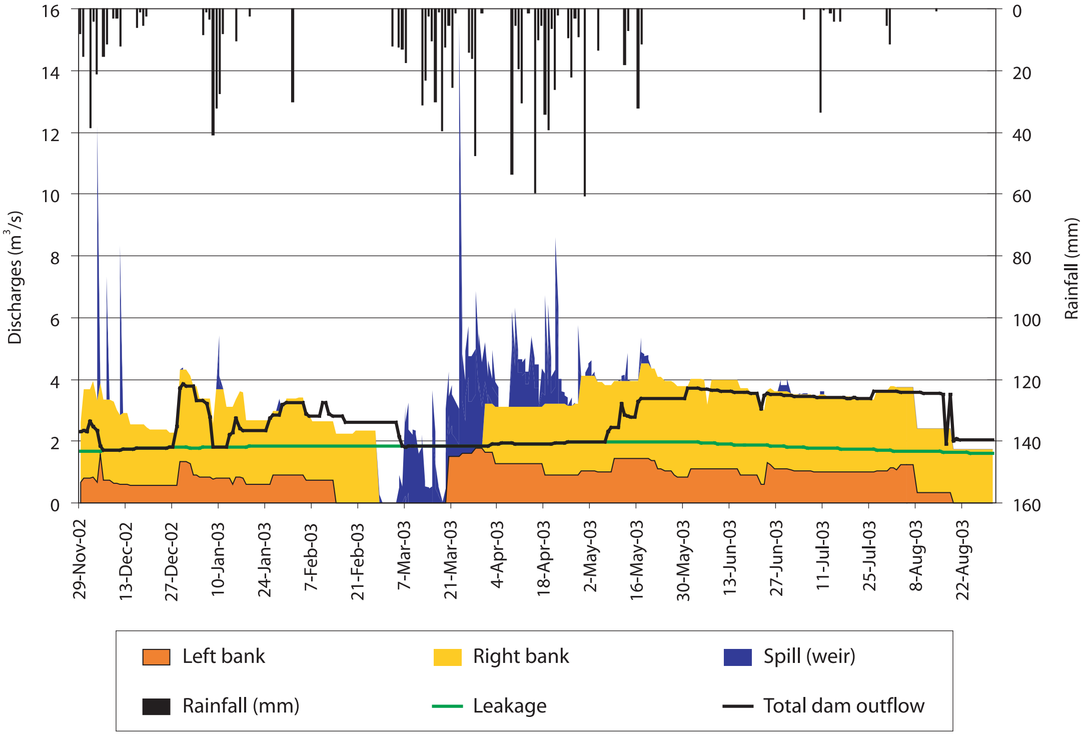

Figure 8 provides an answer to this question and shows how the Walawe river flow was divided at Kaltota during the end of the 2002–2003 maha season and the 2003 yala season. After abundant rainfall in November, dam releases were discontinued during most of December. They were resumed in early January, interrupted again after 3 days (January 7–9) of sustained rainfall, and increased gradually until the end of the season. Significant runoff was generated during the off-season interval and lost to the river. On the opening of the LB canal on March 20, this runoff and the leak provided a total flow of around 4 m^3/s and there was no need for additional dam water. It was only by May 7, one month later, after natural runoff subsided, that it was necessary to gradually increase the supply, up to around 2 m^3/s. The absence of spill at the lower anicut from June to the end of the season shows that management has been sound and "waste" avoided. One might question here whether avoiding spill is an acceptable strategy given that the interruption of flows might have an impact on the ecosystems downstream. This impact is probably minimal because both tributaries and return flows from the fields find their way to the river again a few hundred meters downstream.

The inflow to RB and LB canals observed by the ID during four seasons provides additional information.[12] Figure 9 shows the total inflow to 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 in figure 9). It can be seen that maha 2001/2002 and maha 2002/2003 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

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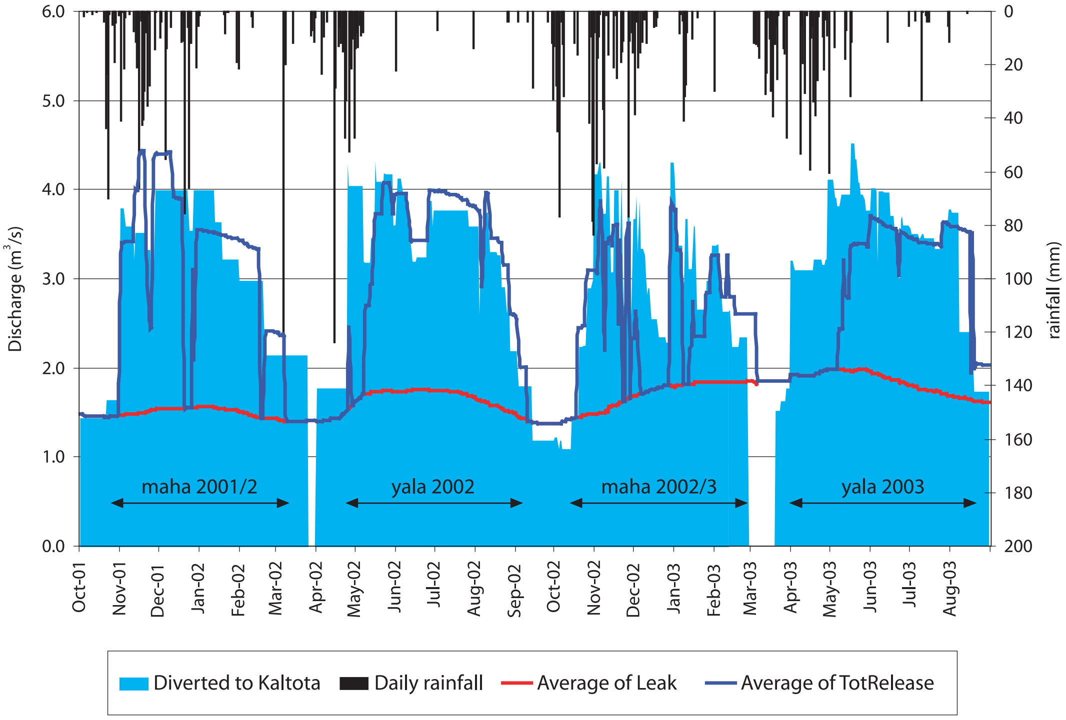
[12] Inflow observations have been made at intervals varying between 1 and 7 days. Therefore, the data do not properly describe daily fluctuations in water level and discharges. Nevertheless, they provide a smoothed quantification of inflow into KIS.

FIGURE 9.
Water diverted at Kaltota and total dam releases.



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 2002/2003, 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 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.

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.[13] In addition, two FC canals (FC1 and CPO11) were

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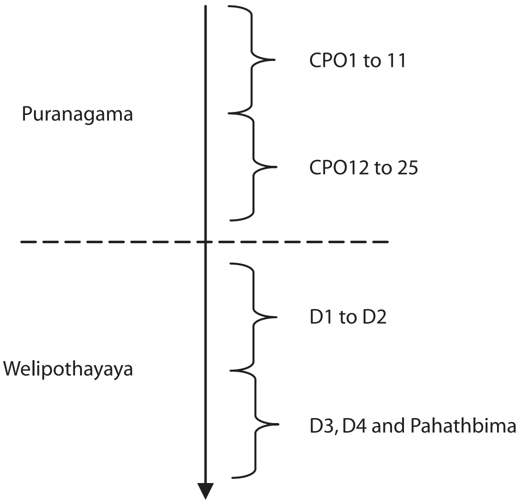
[13] One student from the Sabaragamuwa University was involved in observing water management practices at the main and lateral canal levels.

selected for a more detailed analysis of plot-to-plot water management.

Rotational schedule

The rotation schedule in KIS has two 3-day turns. During the first turn of 3 days, water is provided to CPO1 to CPO11 as well as to D3, D4 and Pahathbima (figure 10). The second 3-day turn supplies CPO12 to CPO25, and D1 and D2. However, this theoretical management rule is not strictly enforced. More water is provided to canals which have water problems. Long lateral canals (like D2)[14] and sandy soil areas tend to receive continuous flow. Personal relationships between farmers and members of field staff are important in obtaining ad hoc adjustments of supply in case of need.

FIGURE 10.
Division of the command areas for the definition of rotational schedule.



Water management problems at the system level

Several problems related to water management are mentioned repeatedly by users:

- Proper control of water is not possible because many gates have been broken. Members of the ID field staff try to close offtakes with straw, weeds and debris but these materials are often subsequently removed by farmers.
- The main canal has five lateral security spillways. At the intersection of the canal with the Gonakandura ara (river), there is a large structure that allows the flow of the river to be incorporated into the RB main canal, and also to spill to the Walawe river, if need be. The wall of this structure is broken and a significant leak can be observed.
- 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 plowing or cultivating large tracts of land (3-5 hectares) can never complete their work on time.
- Most of the farmers want to keep water standing in their paddy fields as in the past, especially when their soil is sandy. Due to this reason, farmers often reopen the gates after they have been closed by the ID.
- Some farmers live far away from their fields or have other activities. They are hardly aware of the rotation schedule 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.”

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[14] D2 canal is the longest lateral canal and provides water to around 100 hectares. It is divided into two parts and receives continuous flow with an internal rotation: 4 days for the canals FC13 to FC21 (60 ha) and 3 days for FC22 to FC24 (37 ha).

- In longer canals, tail-end parts are given extra hours of supply at the farmers' request but farmers located on the way also divert this source of water.
- Wastage is apparent in some field channels. Some paddy fields have more water than required while others do not get enough water (see next section).
- Head-end/tail-end disparities are also observed at the main canal level: Welipothayaya (tail-end) farmers believed that they received/used less water than the Puranagama (head-end) farmers, which is confirmed by the ID staff. It is not clear whether this reflects differences in soil type or just uneven distribution.

All these problems are quite commonplace. Nevertheless, the general impression is that supply is rather abundant and that occasional mismatches between demand and supply can be dealt with by contacting the ID staff who will in general arrange some additional supply.

Water Management at the lateral canal level

There are eight FOs on the RB canal of Kaltota, three in the Puranagama area and five in Welipothayaya/Pahathbima. The Pahathbima FO is independent of the ID because it is not officially part of KIS and only uses excess water in the RB main canal (if any). Most residents settled there only recently and do not have legal rights to their lands. The Katupath Oya water diversion scheme now provides water to this area, using tailrace water from the power station.

FOs convey the decisions taken at the *kanna* meeting, organize canal cleaning and appoint one or several of their members as "Water Controllers." Overall, these 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 keys to open offtakes to field channels within the area. These keys are kept by the Water Controller or the Chairman of the FO. The FOs have no role in the operation of the main canal.

In larger lateral canals, farmers practice rotations within the canal. The Water Controller of the FO manages the rotation. Some provide 2 days for the upper part and one day for the lower part, others 1.5 days for each, depending on the layout of the lateral canal area.

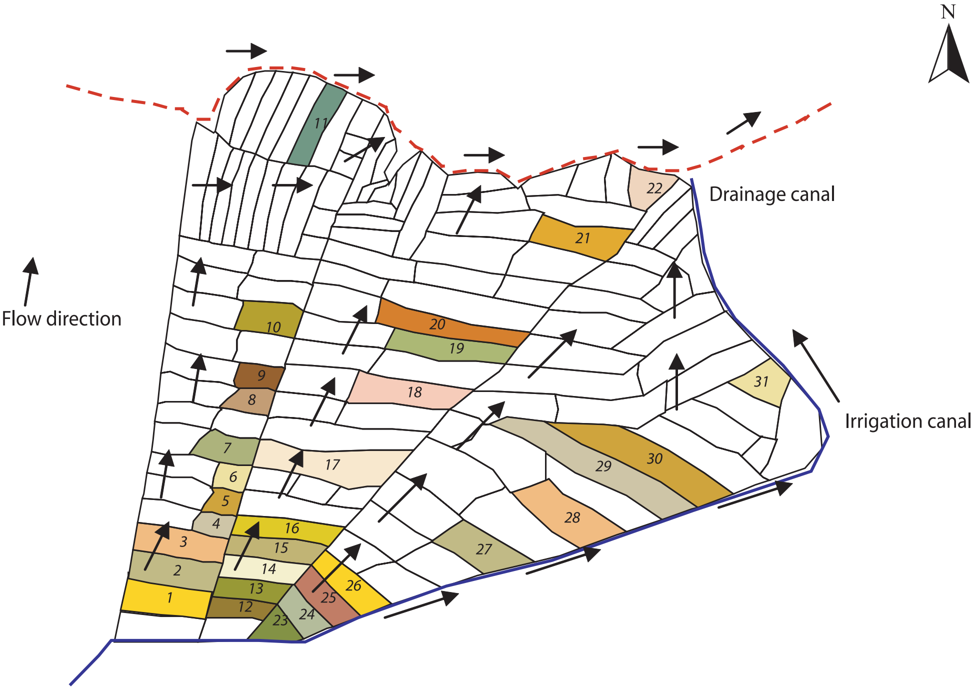
However, most villagers said farmers in the upper parts get more than enough water while others get very low quantities. Head-end farmers block the canals and take water even in the period when it is allocated to tail-enders.

Plot-to-plot water management

As in most parts of Sri Lanka, farmers' allotments are composed of several *liyaddas* (sections of paddy fields demarcated with bunds) distributed along a topo-sequence. Water is delivered to the highest field and then passed on to the adjacent lower plots through notches made in the bunds. At the lowest point water generally spills into a drain. This plot-to-plot system is quite complex and the behavior of a given set of interconnected plots depends on numerous factors, including soil type and permeability, topography, layout, subsoil characteristics, pattern of water inflow, and quality of the field bunds. In Sri Lanka, topo-sequences are often quite short and over a few hundred meters or less there is a succession from sandy soils (red brownish earth [RBE] soils) in upper parts down to clay soils (low-humic gley [LHG] soils) in the lower parts.

To understand whether and how the 3-days on/3-days off rotation in KIS gives way to water waste, one needs to observe the behavior of a few particular sets of plots during and between rotations. Plots which quickly dry up will need more frequent watering but the return flow, both surface and subsurface, may also be reused by other plots. Two lateral canals were selected (Welipothayaya FC1 and Puranagama CPO11) for close observation. During two 3-day rotations, water levels in different plots were measured

FIGURE 11.
Sample plots selected and equipped with pegs (FC1).



twice a day. Pegs were installed close to the outlets where water flows to the next plot because this is generally the area which dries up last. A total of 31 pegs forming three lines were installed in successive plots as indicated in figure 11 (plots with pegs are colored). The three sets of plots along the topo-sequence are pegs 1-11, 12-22, and 23-31.

The following figures show the evolution of the water level in the plots during two successive 3-day “off” periods, after supply to the lateral canal was interrupted. Figure 12 indicates that plots P1, P2, P7, P8 quickly dry up. These plots are very sloppy and show a lot of superficial cracks. P1 and P2, the top plots, are particularly sandy. It can also be seen that the initial water levels in the plots are quite low. The sill levels of the bund notches are kept rather low in order to speed up the filling up of the whole sequence but farmers fail to raise them by the end of the turn.

Figure 13 shows a similar pattern with topmost sandy plots drying up very rapidly. Plots 21 and 22 are close to the drain which is rather deep at this point. The drawdown of the water table probably explains the rapid drop in water level in the lower portion of the topo-sequence. In the third line (figure 14) the drop is even more significant. Although several plots start with a water depth of 10 cm or more, they have no more standing water after 3 days. The lower part is also sandy and dries rapidly. All these data are summarized in figure 15 which confirms that the extremities of the topo-sequence tend to dry rapidly.[15]

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[15] In addition, since pegs were placed in the lower part of the plots; parts of uneven fields were sometimes already dry although there still was standing water near the peg. It must be noted that the pattern of seepage (losses through holes, cracks, or subsurface flows from one plot to the other) is quite complex. Holes are sometimes difficult to detect and farmers constantly repair the bunds, as new infiltrations appear. It is almost impossible to document the evolution of such losses, although they, of course, also impact on the evolution of the water status of the plots.

FIGURE 12.
Evolution of water depth in the fields (peg nos. 1 to 11).

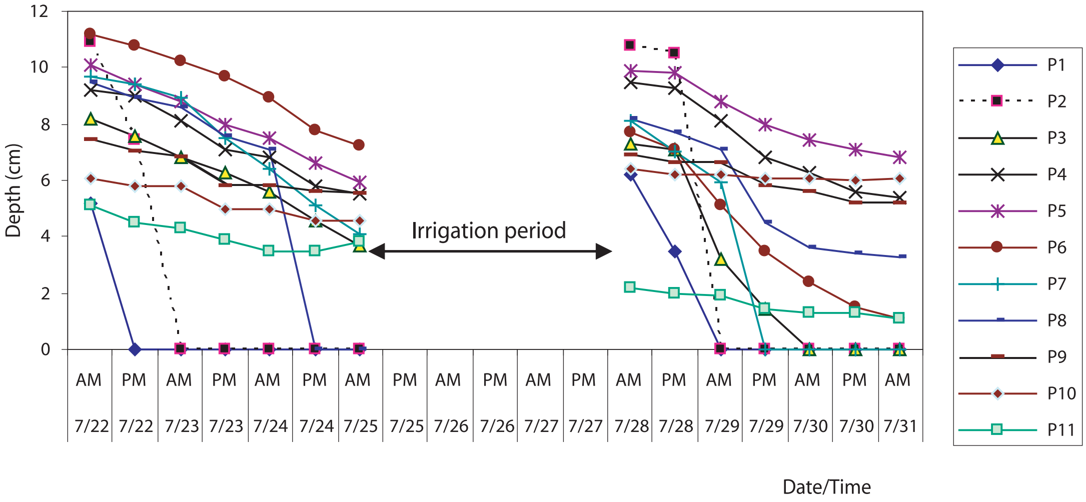


FIGURE 13.
Evolution of water depth in the fields (peg nos. 12 to 22).

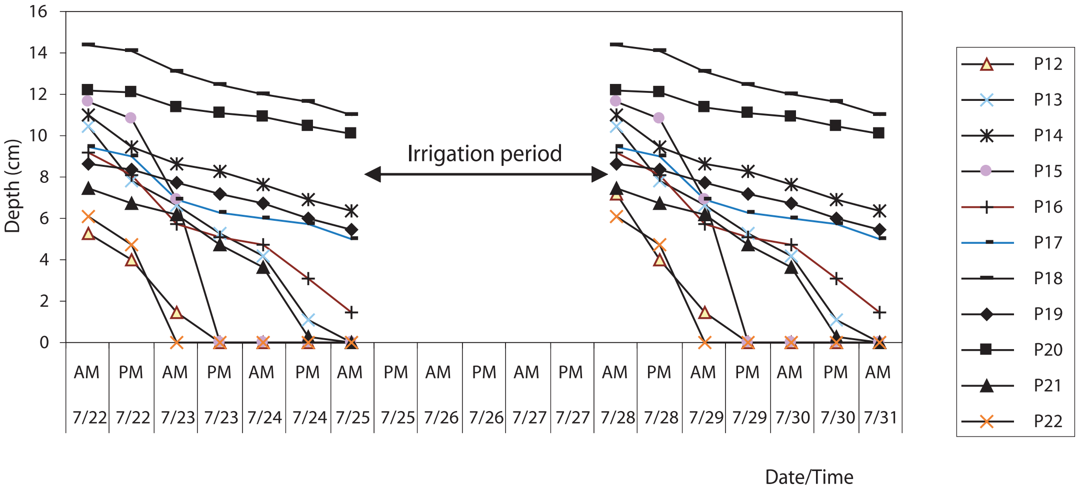


FIGURE 14.
Evolution of water depth in the fields (peg nos. 23 to 31).

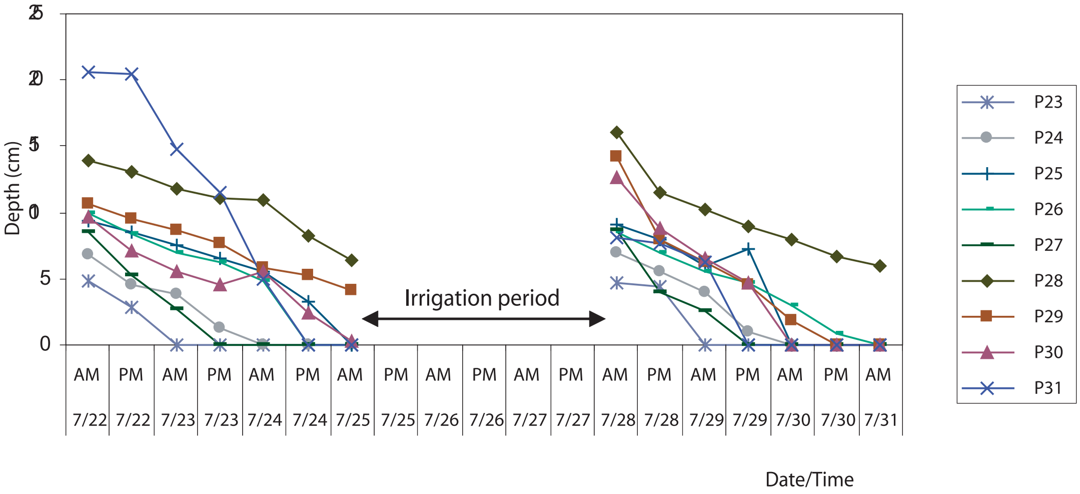
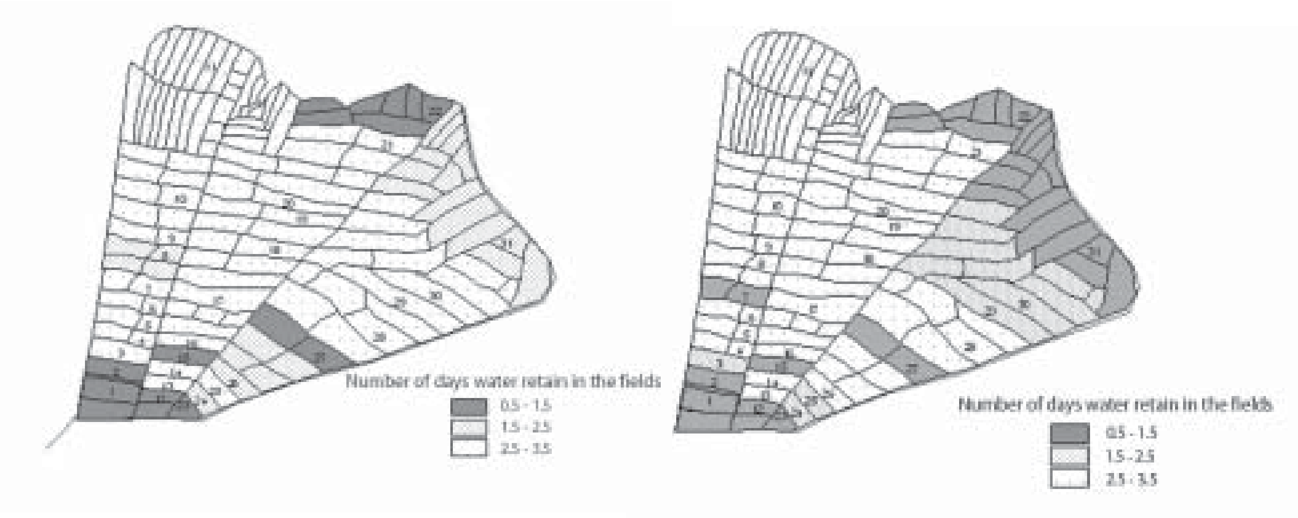


FIGURE 15.
Number of days water is retained in the fields (two successive rotations).



A similar experiment was conducted in the command area of CPO11 (3 ha, 4 farmers; see appendix 2). Many plots also showed a loss of 10 cm within a day or two. However, the gate was broken and debris used to close it, but farmers opened it again due to water shortage after more than one day. Even with such additional supply two of the three lines exhibited plots with water levels close or equal to zero at the end of the rotation (see figures in appendix 2). It showed that the majority of plots do not retain water during the 3 days “off.” Many plots are therefore under a “wet and dry” irrigation regime. This is not necessarily a problem if no water stress is imposed on the plant, although weeds (and rat) problems tend to increase when water disappears. Farmers consider it important to have frequent access to water to minimize the duration of the period with no standing water in the plots. 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 better endure the next off-period. It also shows that it would not be advisable to design rotations with more than 3 days “off.” Similar observations made by IWMI (unpublished results) in the Uda Walawe Irrigation System and other parts of the country confirm that plots with RBE soils generally dry up between two rotations and that the behavior of a series of plots along a topo-sequence varies according to factors such as slope, soil infiltration rate, and depth of the drain with relation to the last plot.[16]

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[16] In some cases, when the slope is limited and the drain shallow, lower plots tend to accumulate water and are always well irrigated. In situations where the slope is steeper and the drain deeply excised, lower plots tend to dry up very quickly because of the drawdown of the water table.

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 center 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 quantities 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.

Can Water Diversion to KIS be Reduced?

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. Table 1 provides an estimate of requirements of the rice crop for each season. Table 2 calculates plot-level requirements by adding water for land preparation (LP) (in soils with fine and loamy texture, taken here as 350 or 800 mm) and replenishment of daily losses by percolation and seepage. Observations (see section under Plot-to-plot water management, p.15), have shown that it is extremely difficult to assess these losses at the plot level. Primarily there is a high variability in percolation depending on soil type: some plots may lose 10 cm in one day or two, while others may have losses of 1 mm/day. In some instances, part of this percolating water reemerges in lower plots of the topo-sequence but we do not have information on the magnitude of these flows. In addition, seepage to adjacent plots is often not a loss because the plot-to-plot system ensures recycling through capture of seepage by lower plots.

If we tabulate the value of total plot water requirements according to average S&P loss, we can see that this value varies widely (table 2). However, there is a limit beyond which this conventional method of estimating irrigation requirements becomes meaningless. The method considers that irrigation supply must make up for the S&P loss because it is assumed that maintaining standing water is a target objective. In sandy soils[17] with a few centimeters of S&P losses per day, this is only possible with continuous supply but it is problematic with a rotation schedule, especially if “off” periods are long. In practice, it is observed that such plots are *already* under a “wet and dry” irrigation regime. Consequently, the conventional method of estimating crop irrigation requirements is of limited interest, as it leads to gigantic values. What prevails is practical experience that 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 3 days off does not incur yield loss. If it is not the case, then these canals are attributed more time.

Table 2 provides estimates for two values of LP: 350 and 800 mm. The first value is a common (high) estimate of LP in paddy soils, while the latter corresponds to the observed flow in KIS (~ 4 m^3/s) for a duration of 20 days and a total area of 850 hectares. This is a very high value that is partly explicable by the nature of the soil and the lack of mechanical means in the area to expedite the operation. It is also due to the high discharge capacity of the main canal, with regard to the area served: over 4 m^3/s for 850 hectares, which allows a flow close to 5 l/s/ha. This can be compared with the design discharge of the Right Bank Main Canal in UWIS,

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[17] Under lateral FC22, 5 hectares of paddy land have been abandoned due to the highly sandy nature of the soil. Affected farmers were given lands in other places but these abandoned lands are still cultivated using canal water.

TABLE 1.
Rice (agronomic) water requirements by season (mm).

			Paddy agronomic requirements	
Month	Penman ETo (mm/day)	Days	Kc Paddy	Total (mm)
May	5.33	20	1	107
June	5.66	30	1.15	195
July	6.57	30	1.2	237
August	6.66	25	0.9	150
Total				689
December	3.96	20	1	79
January	4.38	30	1.15	151
February	5.34	30	1.2	192
March	5.34	25	0.9	120
Total				542

TABLE 2.
Plot water requirements, for different values of S&P losses and land preparation requirements.

Percolation (mm/day)	1	3	5	10	15	20	25
LP=350 mm							
Maha	1,143	1,353	1,563	2,088	2,613	3,138	3,663
Yala	998	1,208	1,418	1,943	2,468	2,993	3,518
Total	2,141	2,561	2,981	4,031	5,081	6,131	7,181
LP=800 mm							
Maha	1,593	1,803	2,013	2,538	3,063	3,588	4,113
Yala	1,448	1,658	1,868	2,393	2,918	3,443	3,968
Total	3,041	3,461	3,881	4,931	5,981	7,031	8,081

which serves 10,000 hectares with a maximum discharge of 25 m^3/s: this gives us a module of 2.5 l/s/ha (in line with a design peak water requirement of 2.25 l/s), i.e., half that of KIS.

The impact of this on dam water use, however, must be downplayed since data for the two yala seasons studied earlier showed that LP was mostly achieved with natural runoff and the leak flow. The maha seasons showed otherwise but it is likely that LP in maha seasons also use dam water frequently. We lack exact data on the start of the cropping season dates to confirm this hypothesis but the late starting dates of dam releases (CEB daily data) combined with cropping calendars that are ahead of those in Uda Walawe suggest that most seasons do indeed start without contribution from dam releases. This is also confirmed by the average duration of dam-release

TABLE 3.
Amounts of water diverted to KIS during four seasons (Mm^3).

Season	Maha 2001/2	Yala 2002	Maha 2002/3	Yala 2003	Gross area (ha)	Net area (ha)
LB	13.8	14.6	10.9	14.3	440	300
RB	30.8	33.1	25.9	32.1	700	540
Total	44.6	47.7	36.8	46.4	1,140	840
Total (mm)	5,259	5,612	4,381	5,459		
Dam releases	19.9	20.2	11.1	14.6		
Leak	20.6	23.7	22.8	26.2		

periods for the last nine cropping seasons, 124 days,[18] which is more than one month shorter than the overall diversion duration at the anicut.

Early season start, at least when natural runoff is available, and staggering of the cropping calendars of the two sides (RB and LB) are two effective ways to maximize the use of the leakage and to reduce dam releases. These two possibilities seem to be fairly well exploited under present conditions. An automatic recording and transmission of flows at the second anicut could inform dam managers in real time about the status of the flow in the river and allow a fine-tuning of dam releases but the benefits would not be that high under present circumstances, since attention is already directed to this issue.

The gross diversions to the two main canals amount to around 5,400 mm of water applied to the fields, with the exception of maha 2002/2003, which enjoyed abundant rainfall, judging from the four seasons for which we have records (table 3). This value is close to that observed in the Uda Walawe scheme, which has diversions between 2,000 and 3,000 mm/season, depending on the season (since the rehabilitation in 1992). If we consider tentatively that conveyance losses make up 25 percent of the inflow, then the water depth applied at the plot level is around 4,000 mm which, according to table 2 is the water required for a percolation loss of approximately 6 mm/day. The average actual S&P rate is probably much higher than this, which explains why many plots are left with no standing water at the end of the "off" period. As mentioned earlier, this does not necessarily impact on crop growth but it probably increases the need for weed control and imposes the necessity for frequent rotations (water coming back every 3 days).

The 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 ease management by ensuring a continuous flow into farmers' plots half of the time. Because of the location of KIS along the river itself, any excess water quickly makes its way to the drain, either directly or through subsurface flows. 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 will go back to the Walawe river and are made available to downstream users. The particular reason 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 at the downstream part of KIS.

As discussed earlier, 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

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[18] This does not consider occasional days in the middle of the cropping season when releases are discontinued.

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. (Increasing the duration of the “off” periods is the second option but it is likely to compound the situation of sandy soil plots and is therefore not considered viable). There are, however, several constraints to such reductions:

- First, if farmers within a lateral canal have to irrigate their plots within a shorter period they will have less flexibility in choosing the time to go to their fields and they will have to expedite the different operations needed to irrigate all of their plots; they will also have to achieve greater coordination among fellow farmers along the same lateral so that everyone can be served during a shorter time. Less time means more managerial constraints and more burden.
- Second, fine-tuning the number of days of “on” of each lateral will make the existing rules more complex by having laterals with different durations of “on” and “off” periods; this would create additional work for field staff, and confusion among farmers.
- Third, if reductions are to be sizable, they will necessarily place a constraint on farmers, thus eliciting more “deviant” behaviors and 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. On the contrary, more tampering with and destruction of structures can be expected.

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.

Briefly, the technique includes transplanting of young seedlings (8–15 days) at low density (25 cm x 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 (Namara et al. 2003) have shown that average increases in yield of 40 percent are achieved when shifting from conventional rice farming to SRI, but that labor requirements are around three times those of the conventional method. SRI is therefore attractive to farmers who have a large family labor force. Water control is also paramount and reduced water diversions must be paralleled with predictable supply.

It is important to note that the quantity 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; it also does not affect other users (or only positively, by increasing water available to them) or the water that is supplied to the lateral canal. Therefore, even if a significant number of farmers within a lateral canal command area adopt SRI, this will 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. It is only if all farmers were to adopt SRI, an unlikely event, that this could be translated into a change of schedule for the lateral canal. In compensation, this inflow would have to be made more predictable because the implications of an interruption of irrigation are magnified in a SRI system, where soil moisture is often close to the limit under which stress may occur. Water savings can only be effective if factored in water management at the scheme level.

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 the adoption of cash crops is constrained by market risk, lack of skill and capital, and above all by transportation: Kaltota is still a very remote area, with a narrow and winding access road that hinders commercial activities.

Increasing Supply to the Left Bank

Another possible option to decrease the contribution of the Walawe river to KIS is to supply the LB with the adjacent Weli Oya river (see figure 2), which would necessitate some head works and a canal to link this river with the LB canal. The Weli Oya river is being diverted several kilometers before it reaches the Kaltota area through a weir. This new project is designed to take Weli Oya's water to an area of approximately 1,600 hectares that includes a few existing tanks. The diversion canal has a capacity of 4 m^3/s. Figure 16 shows the monthly discharges in the Weli Oya at its junction with the Walawe river, as estimated by Bellaubi (2004). It is apparent that with a diversion set at 4 m^3/s, the discharge of 1.2 m^3/s needed for the LB can only be ensured 2 months each season (April-May and November-December) for the dry year with a probability of occurrence of 0.25. Depending on the environmental flow required probability of supply will be reduced accordingly. There is, therefore, scope for a partial supply of the LB through the Weli Oya but the cost of the diversion needs to be assessed to confirm whether this is a viable option or not.

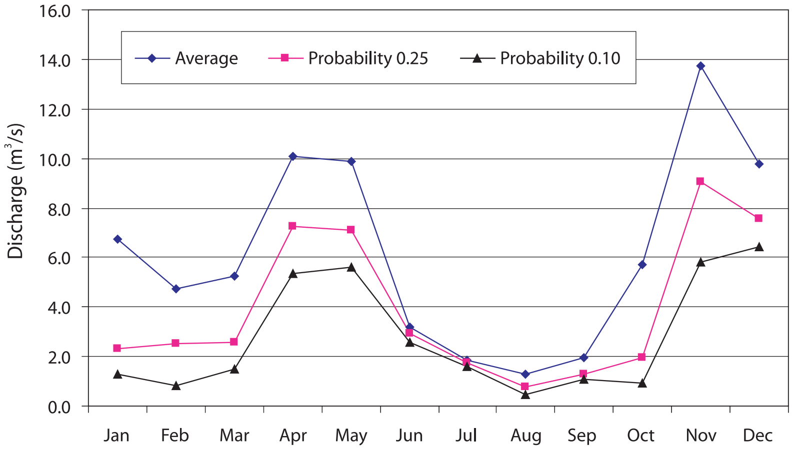
Available options for improved management

The options reviewed above cannot be implemented without concerted efforts or adequate incentives to stakeholders. Three situations can be distinguished.

Bureaucratic options

Enforcing stricter scheduling. Improving scheme management as outlined earlier can be achieved by the ID. The focus must be on fine-tuning the amount of water distributed to each lateral, interrupting flows when all plots are served. It is likely that several laterals can be served within two, or two and a half days instead of three, at the cost, again, of tighter management. At the

FIGURE 16.
Monthly flow in the Weli Oya river (values for various probabilities).



main canal level, rotations must also be stricter, lateral spill avoided, and water flows at key points monitored. This implies a drastic increase in monitoring and enforcement capacity, rehabilitation of broken offtakes and other structures, and strict mechanisms to impose sanctions on deviant behaviors. This option is, under present conditions, not considered realistic because of the lack of staff and adequate structures to enforce strict scheduling and volumetric monitoring of supply to different parts of the system.

Diversion of Weli Oya. An increase in supply to the LB is possible (with a full coverage of needs in an average year but only partial in dry years), as shown earlier. Compared with possible win-win arrangements, this option requires substantial capital investments and is not the best one.

Reducing supply. While it would be tempting, in the face of very high water duties enjoyed by KIS, to unilaterally curtail dam releases, 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.

Incentive-based options

The second option is to opt for incentive-based policies that encourage farmers to implement some of the measures conducive to reduced diversions.

Support to diversification. Options such as crop diversification to less water-intensive crops or the introduction of SRI are unlikely to spread on a large scale unless they are encouraged by strong incentives. Extension services for improved cropping techniques and patterns, coupled with secured markets (e.g., contract farming), might convince farmers to move away from rice. However, it must be noted that the resulting decrease in water demand must be translated in a change in scheduling (shorter “on” periods for the D canals concerned), and these changes consolidated at the canal level in order to be transformed in reduced diversions. If the plots with such cropping patterns or techniques are scattered it will be very difficult to fine-tune deliveries and schedules in order to take these changes into consideration. In sum, such measures have limited potential unless they occur on a large scale, just like banana cultivation in UWIS has now spread over 45 percent of the area, with some D canals having their paddy areas reduced to 5–10 percent of their command area.

Bonuses. 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).[19] 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. This subsidy scheme could be agreed for a given number of years (e.g., 10 or 15 years) and then phased out,[20] with a new cap (upper limit) established at a lower level (say 15 Mm^3) after adjustments have been incorporated in new management procedures.

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[19] Such policies are uncommon in water management but have been envisaged in Spain (see Sumpsi 1998): in contrast with other pricing policies, they do not incur substantial income losses before becoming effective.

[20] The level of the subsidy could be calculated as a percentage of the sale price of the KWh, to avoid problems with inflation.

This poses the thorny problem of how this subsidy could be channeled to farmers while escaping capture by some more powerful stakeholders. It can be imagined, for example, that a KIS Farmer Company could receive the money and use it for a maintenance fund or for reselling fertilizer at a much reduced price.[21] Indeed, distribution of bonuses as well as adjustment of water management rules are hardly possible without transferring the management of the scheme to farmers. This, of course, does not ensure that they will be able to successfully "internalize" these tasks, but leave to the users the responsibility to share both benefits and the (relative) water "scarcity" to be created. Such a transfer of O&M cannot be achieved overnight and would also require the rehabilitation of structures and offtakes, and support to train and organize FOs and a Farmer Company.

In all cases, it is important that—even if reduced—the inflow into the main canals be predictable. Fortunately, the leak ensures a regular flow of around 2.2 m^3/s; the KIS will therefore be assured of a minimum supply that will protect it from more critical vagaries. If a stricter set of management rules is to be designed, it will become important to have quantitative monitoring of flows at a few points, which will require modernization/repair of some structures.

The CEB is "willing to spend Rs 2–3 million a year" for 5–10 years to ensure that no water is released from the irrigation sluice. The CEB sees this project as a pilot project which, if successful, could be extended to Kotmale, where a similar situation exists. Saving 20 Mm^3 "bought" back from farmers at 2 Rs/m^3 would mean not only a cost of Rs 40 million but also a benefit of 15 GWh priced at Rs 7/unit, that is, over Rs 100 million.

Right-based options

All the preceding options are likely to be undermined by the status of KIS as a 2000-year-old water user. Instead of the trouble with designing and administering a system of bonuses, it might be preferable to fully 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 would be renegotiated whenever needed.

This shows the potential interest of a right-based approach, as a basis for water resource management at the basin level. Water rights do have the advantage to provide water users with some kind of compensation when they agree to have some of the water they use reallocated to other users. However, there is no such system of formal rights at present in Sri Lanka. The state has legal ownership of all surface water and does not recognize any system of individual or collective water ownership rights (Meinzen-Dick and Bakker 2001). In practice, water abstraction is often chaotic and unregulated (Samad 2005) and allocation is chiefly an issue within irrigation schemes and within the Mahaweli system, where it is left to the discretion of the line agencies concerned. 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).

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[21] Or the subsidy from CEB could be granted directly in kind (fertilizer, mills for the Company, etc.)

Beyond political dimensions, the difficulties to arrive 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). Establishing a full registry of users, with a quantitative assessment of the water they both withdraw from and return to the system is not an easy task in a country with thousands of small tanks and anicuts. Monitoring of use, law enforcement, and judicial capacity may also be lacking. Just like in the preceding case of the bonus system, a strong Farmer Organization is 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 are needed but these may currently be beyond the reach of the Farmer Organization.

Arrangement based on water rights (or entitlements) must preferably be enshrined in a legal framework that gives due recognition to such rights, as well as in a mode of basin management that is effectively based on bulk allocation and monitoring of quantities of water used. However, even in countries where rights are not fully established, or in which irrigation is supposed to give priority to urban use in case of shortage, such arrangements are observed in times of shortage. In China, the city of Tsingdao bought out nearby irrigation dams, instead of using costly water diverted from the Yellow river (Molle and Berkoff 2005). In Spain, the city of Seville inked agreements with both irrigation districts and the hydropower company to secure supply during the last drought (del Moral 1998).

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 the 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 allotment 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 coming from the dam.

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 had consistently complied with its (informal) commitment to provide KIS 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 quantity of water per hectare diverted to KIS is high. However, this quantity 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 labor-minimizing strategy when water is abundant.

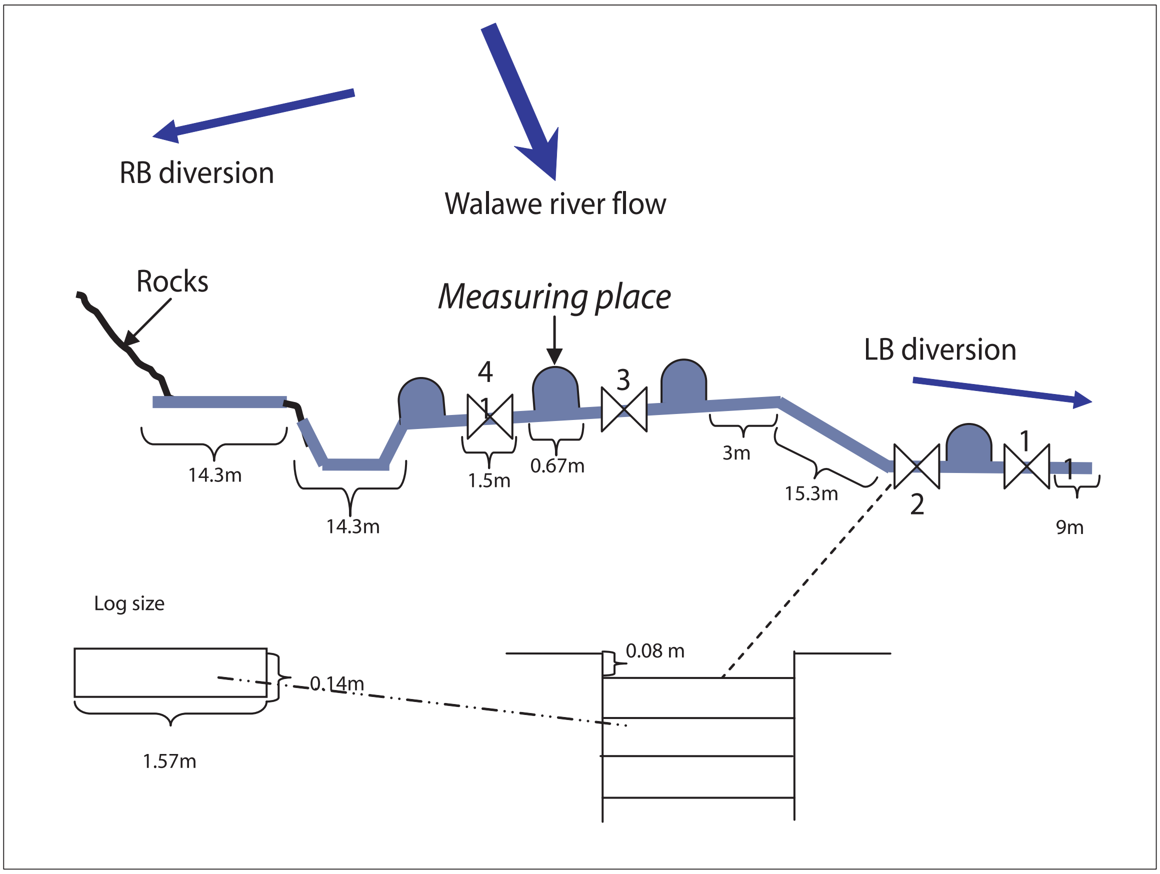
The CEB faces the challenge to instill a change in water use behavior that would allow a reduction in dam release and a corresponding increment in the power generated. It would be a mistake to deduce from the rather high per hectare rates of diversion that water savings can be easily obtained. Achieving 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. Some 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 quantities of water saved could be negotiated. Such subsidies could be channeled 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 to establish a thorough diagnosis of water management in KIS in order to better identify structural and nonstructural constraints before embarking in partial modernization of the scheme and in institutional reform. The substantial benefits that can potentially accrue to both sides are sufficient to warrant further consideration of the way to improve management while sharing the benefits generated.

Appendix 1.

Measuring spill at the second anicut

The second anicut diverts water to the LB canal. The anicut has four gates made up of seven wooden logs with a 1.57 m length, 0.14 m height and 0.06 m width. When the gates are fully closed, with all these logs in place, there remains an 8-cm gap between the crest of the anicut and the topmost log. The water level was measured twice a day. Morning readings were taken around 7 a.m. and evening readings around 5 p.m.



Flow Calculation

Two types of flows were distinguished:

1. Spillover the cement crest of the anicut
2. Spillover the gates (either when fully closed or when a few logs were removed)

Spillover the anicut crest

The weir formula is used:

Q (l/s) =Cd*W*H^1.5 where, Cd=1.6, W=width of the anicut (65 m), H=spill height (cm) (1).

Spillover the gates with all logs

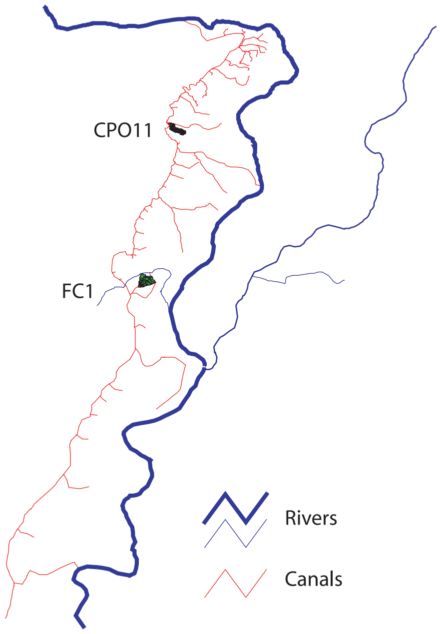
Same formula as above with a width of 1.67 m for each gate.

Spillover the gates when a few logs are missing

Same formula as above with H changing according to the number of logs missing.

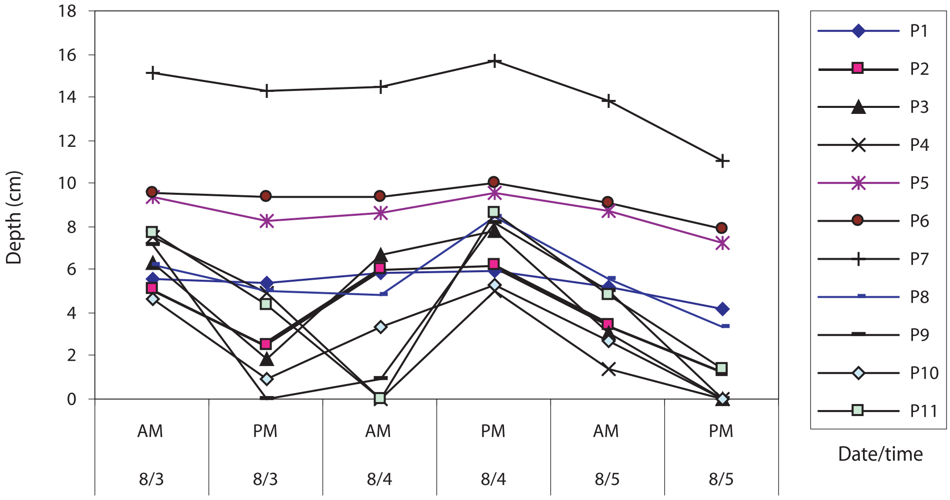
Appendix 2.

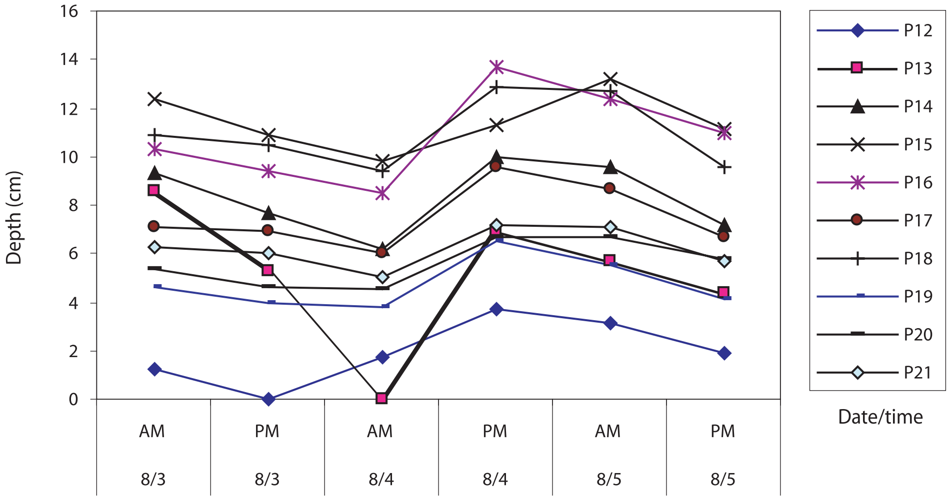
Plot-to-plot observations

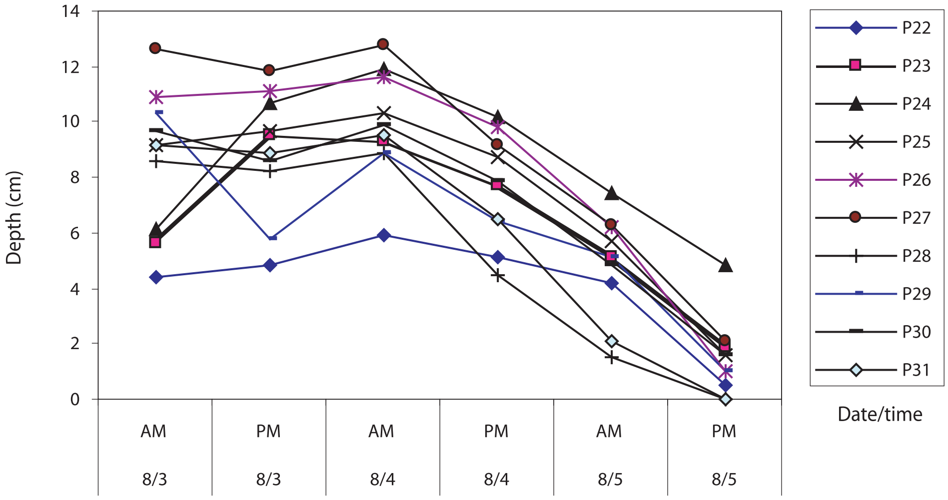


Layout of CPO11

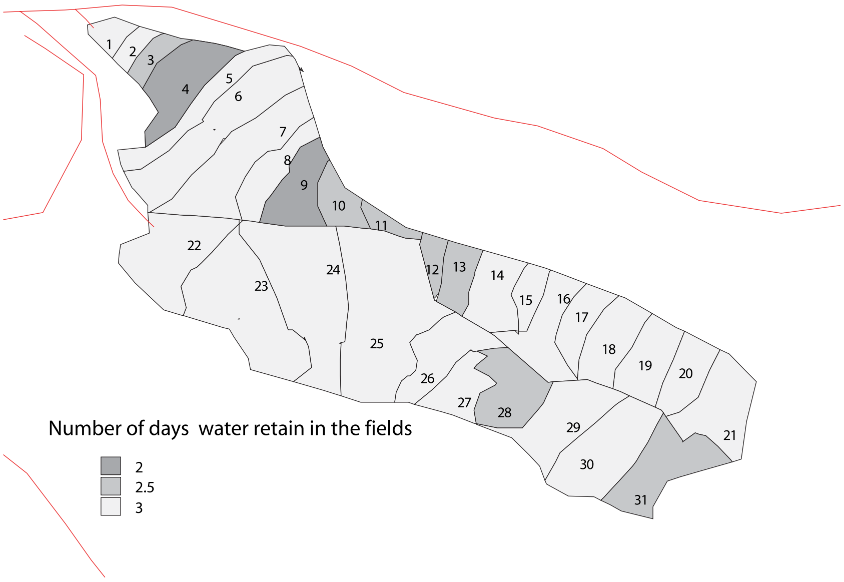
* Evolution of the water level in the plots of CPO11





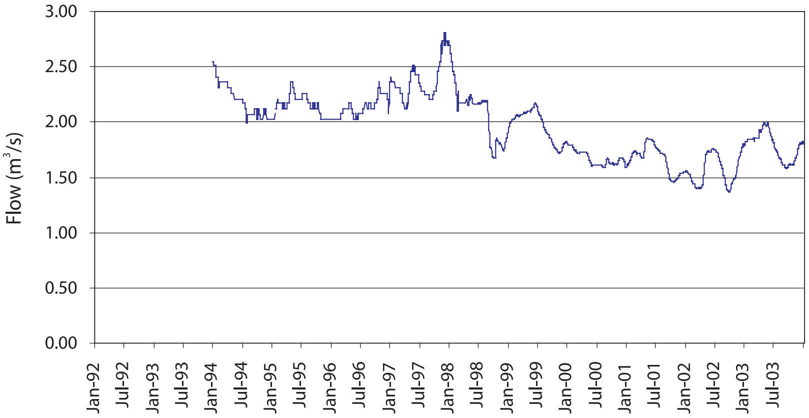


* Number of days with standing water (CPO11)



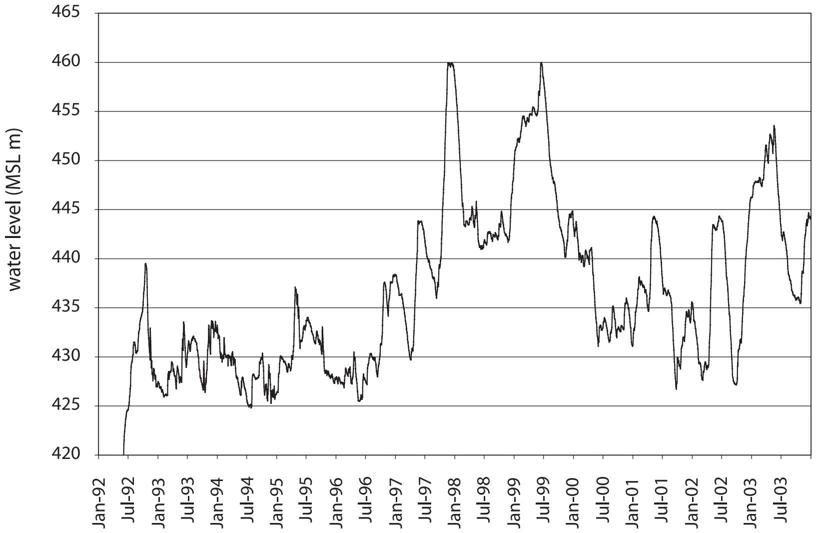
Appendix 3.

Evolution of the leak discharge



Appendix 4.

Historical evolution of the water level in Samanalawewa



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Postal Address:
P O Box 2075
Colombo
Sri Lanka

Location:
127, Sunil Mawatha
Pelawatta
Battaramulla
Sri Lanka

Tel:
+94-11-2787404

Fax:
+94-11-2786854

E-mail:
iwmi@cgiar.org

Website:
http://www.iwmi.org

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