Integrated Water Management for Agriculture

Developing tools, processes and knowledge to help water resources managers respond to changing needs and expectations.

Identifying and promoting sustainable options for increasing water productivity and reducing poverty

Strengthening the research capacity of partners to achieve sustainable improvements in water productivity in agriculture.

Research Themes:

Integrated Water Management for Agriculture • Sustainable Smallholder Land & Water Management Systems
Sustainable Groundwater Management • Water Resources Institutions & Policies • Water, Health & Environment

Impacts of water consumption by perennial vegetation in irrigated areas of the humid tropics

A case for rethinking traditional views of irrigation design, management and performance assessment

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Summary

Water developed primarily for irrigation tends to find many uses beyond the supply of water to crops. In irrigated areas of the humid tropics, water diverted for crop production supplies homestead gardens and other beneficial perennial vegetation, primarily trees, growing naturally within the command area. However, the degree of water use by this vegetation and the benefits derived from it are not well understood and is rarely taken into account in irrigation management.

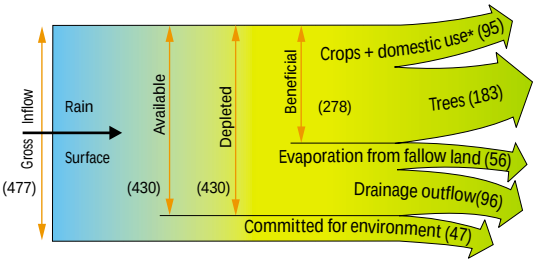
In 1998, IWMI performed a comprehensive water balance study in the command area of Sri Lanka's Kirindi Oya Irrigation Scheme to assess the impact of water consumption by perennial vegetation. The study found that perennial vegetation consumes almost twice the amount of water as crops in the area. The main conclusion from this study is that water consumption by perennial vegetation should be a significant consideration in tropical humid environments in irrigation planning, management and performance assessment.

Irrigation in tropical regions often provides benefits far beyond crop production (Bakker et al. 1999). In the dry zone of Sri Lanka, irrigation has dramatically changed the local environment, enabling ecosystems quite similar to those of the wet zone to flourish. In these irrigation systems, recharge of shallow groundwater by percolation from irrigated fields, canals, and tanks has provided a continuous supply of water for beneficial natural vegetation and homestead gardens.

In 1998, IWMI performed a comprehensive water balance study in the command area of the Kirindi Oya irrigation scheme, which is located in Sri Lanka's dry zone, to assess the water use by non-crop vegetation. The assessment was based on surface flow measurements, rainfall data and estimation of crop water requirements. This water balance showed that perennial vegetation consumed 43 percent of the water available; crops consumed only 22 percent.

It is not surprising that perennial vegetation can consume such a large proportion of the total amount of water made available in a given irrigated area. What is surprising is that little consideration has been given to this consumption. The efforts of water managers and farmers have been focused primarily on the delivery of water to crops, with little or no recognition of non-crop water use. With increasing water scarcity, more focus is being placed on the overall water balance of irrigated areas. In this context, other types of consumption besides crop consumptive use become more important.

Diagram representing the water balance in Kirindi Oya. Values shown are in million cubic meters.

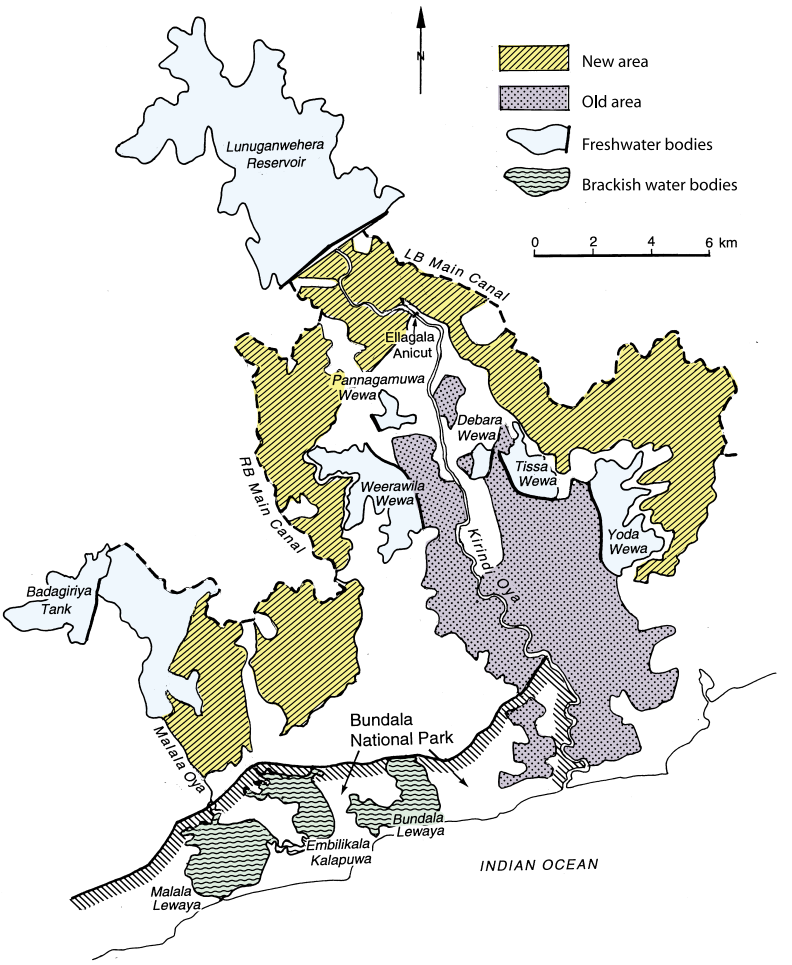


Profile of the Kirindi Oya Irrigation Scheme

The Kirindi Oya scheme is located in the dry zone of Sri Lanka. Average annual rainfall is 1,000 mm, 70 percent of which falls in a three-month period. The dry season (*yala* season) is from April to October. Minimum average temperatures vary from 26 °C in December to 28 °C in April. Values of reference evapotranspiration vary from 110 mm in November to 184 mm in August, with an annual value of 1,765 mm. During the dry season, reference evapotranspiration less rainfall is about 700 mm, indicating that much additional water is needed to support crops, mainly paddy.

In the scheme, perennial vegetation has developed over time and now covers a great part of the area. It must be stressed that the importance of perennial vegetation is the result of paddy cultivation. Other crops and other irrigation techniques at the field level would have led to a completely different picture. A survey made during the yala season in 1998 has shown that, on average, groundwater depth in the older part of the Kirindi Oya scheme, the Ellegala system, varies from 1.6 m to 2.8 m below the surface. Tree roots can readily tap groundwater at this depth even in the dry season.

Map of Kirindi Oya Irrigation System showing both the older and the newly developed areas.



Vegetative coverage in the Old System (EIS) is much more than in the New System (NIS) for three main reasons:

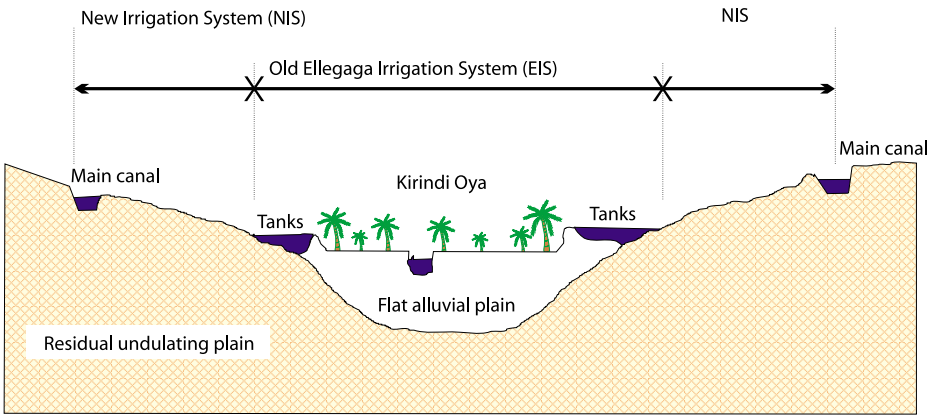
- Historical-the old system has been in existence from ancient times, while the new system development is recent (14 years);
- Topographical-the light soils of the undulating NIS command area are quickly drained once irrigation is cut off; and
- Managerial-so far the intensity of irrigation in NIS has been low, reaching only 103 percent per year, i.e, one crop per year, which does not allow enough water to sustain wet-zone type perennial crops throughout the year.

Aerial photographs confirm the importance of perennial vegetation in the area. Even in urban areas (called settlement areas or homestead gardens), the density of perennial vegetation is important. In homestead gardens, the vegetation is generally developed in three layers. The highest is composed of coconut trees, the medium, of fruit and medicinal trees

and the lowest, of vegetables and grass. It can be concluded that the whole area is an evaporative surface made of paddy fields, fallow lands, water bodies and perennial vegetation.

It must be pointed out that perennial vegetation is also found in nonirrigated areas of the dry zone. It is however mainly composed of shrubs and small drought-adapted trees, which evaporate much less than their well-fed counterparts in irrigated areas and in the Sri Lankan wet zone.

Schematic cross-section of the Kirindi Oya Project.



Causes of overestimation of water availability

Since its implementation, the Kirindi Oya project has supplied the whole area during the wet season, but it has not been able to provide enough water to sustain a second crop during the dry season for the entire project service area. An overestimation of water availability is often advanced as the reason for the gap between designed and actual irrigated areas. However, it is clear that water requirements have been based only on estimations of requirements for paddy (rice) without taking into account additional evapotranspiration from perennial vegetation. This is a major reason for the discrepancy between predicted and actual consumption.

Kirindi Oya is not an isolated example of this type of problem. All the major irrigation schemes in Sri Lanka (400,000 ha) in the dry part of the country are significantly covered with perennial vegetation. This situation is also very common in many areas of the humid tropics worldwide.

Perennial vegetation's impact on the water balance

Perennial vegetation has two major effects on the water balance:

- A reduction of the potential contribution of rainfall to crops; and
- An increase in evaporative depletion of water resources within the irrigated area.

It is well known that perennial vegetation reduces the rainfall contribution to runoff because of interception. Part of the rainfall is intercepted by the canopy, and evaporates directly without reaching the ground.

Tropical perennial vegetation transpires on a continuous basis throughout the year. Because roots can tap groundwater, transpiration rates are at full level during much of the year. Therefore, it was hypothesized that consumption of water from perennial vegetation in irrigated areas is high in terms of volume per unit area at Kirindi Oya.

The source of water for perennial vegetation is directly from rainwater and indirectly from irrigation supplies. Irrigation supplies and rainwater percolating past the root zone enters a shallow groundwater system where it can be tapped by tree roots. Without extensive vegetation, part of this water will reenter the drainage system, be available for crop evapotranspiration, or flow out to the Indian Ocean.

Benefits of perennial vegetation

The water consumption by perennial vegetation must be understood in terms of both the water balance and the non-intended but beneficial outputs. Perennial vegetation, whether planted on homesteads, or growing naturally in irrigated areas, has contributed substantially to the improvement of the

Beyond research: IWRM is a people-to-people challenge

If we leave aside the technical approaches and constraints surrounding water resources management we are left with people. People are both the beneficiary of water resources and the cause of its misuse. They are the key component in making Integrated Water Resources Management (IWRM) work. For those who think it naïve or simplistic to reduce the IWRM question to interactions between people, consider some real-life examples from Sri Lanka, taken from our research.

- The town of Kurunegala, population 50,000, lies between a rural farming area, which supports around 100,000 people, and the Maguru Oya River. Wastewater from the town has polluted the river to the point where it is unfit for domestic use – forcing local residents to travel several kilometers to get water for their homes and vegetable gardens. The population of Kurunegala is served by piped, treated water. The rural population depends on poor-quality river water and shallow wells fed by the river.
- In the Dedru Oya basin, five percent of the local population (total 870,000) is served by piped water. The remainder of farmers and domestic users in this area depend on water from shallow wells. The government's goal is to provide safe drinking water to the entire population by 2010. When the authorities explore the possibility of tapping the Mangala irrigation tank for domestic water supply, they come up against fierce resistance from the local farming community, who oppose any access to this water that is not for agriculture. Research shows that the tank can supply water for farming and domestic use if responsibly managed.
- Sand mining to supply the construction industry is a useful and profitable enterprise practiced in several river basins in Sri Lanka. If done in a non-planned way (as is often the case) mining deepens the river as it empties into the sea and deforms the river's banks. The result is a surge of salt water for several kilometers inland – killing crops and filling domestic wells with undrinkable water.

In each of these cases, the root of the problem is the same. There is no mechanism for any of these conflicting water users to meet and discuss solutions. This is a lack of Integrated Water Resources Management. IWRM brings accountability to all user sectors in a river basin, with the goal of achieving the harmonious development of the basin so that all users can coexist, causing the least degradation possible.

A concept which has often been distorted – to the detriment of the world's poor – is that water belongs to a country's national heritage, and its use should not be regulated. In large countries with small populations, this thinking might have been valid in centuries past. In today's world, the unaccountable use of water and the lack of coordination between water-user sectors serves only to allow the inefficient development of water, leaving less water and opportunity for the poor.

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environment as a whole (Wickramasinghe 1992). There are many benefits to the presence of perennial vegetation:

- It provides shade and coolness, thus allows escape from the harsh tropical sun.
- It allows for increased biodiversity within the ecosystem.
- Homestead forestry is an important source of income for farmers.

As in other regions such Kerala in southern India (Salam and Sreekumar 1991), homestead gardens in Sri Lanka are of great importance to farmers. They provide them with food, medicinal plants, fuel, a pleasant environment, and raw materials for handcrafts. One of the favorite trees planted by farmers in their forestry gardens is the coconut palm tree which is called 'the tree of life' because every part of it is used (Persley 1992): the kernel, leaves, shell, husk, trunk, coconut water and roots. In addition to homestead gardens, natural vegetation along rivers, ditches and canals represents another source of water depletion, which has to be accounted for in water balances.

Rethinking irrigation 'efficiency'

The main finding of this study is that in the Kirindi Oya system, perennial vegetation is a significant factor in the use of water resources (43%), while only 22 percent of the available water is really consumed by crops. As perennial vegetation is a common feature of

Water balance for Kirindi Oya.

Inflow (Mm^3)					
Irrigation	Rain	Storage variation	NET INFLOW	Committed	Available
245[a]	230[a]	3[a]	478[a]	47[b]	431[c]

Outflow (Mm^3)				
Available water	Uncommitted	crop process depletion	Non-process depletion	
			ET from non-beneficial vegetation, evaporation from fallow	ET from beneficial non-crop vegetation
431 100%	96[a] 22%	95[c] 22%	56[c] 13%	184[d] 43%

[a] Measured [b] Estimated [c] Measured + Estimated [d] Closure of the balance

many irrigated areas in the humid tropics, planners should consider rethinking traditional criteria for design and performance assessment in these areas.

Improving water productivity is a priority for many decision makers and managers, and a reliable water balance is the ground on which strategies for improvements must be built. This water balance study demonstrated that evaluations based on classical notions of efficiency are inadequate. A better approach is to calculate the rate of beneficial utilization, which is the ratio of consumption by beneficial uses to the amount of water available for use in the irrigated area. Classical efficiency calculations yield 22 percent while the rate of beneficial utilization is 65 percent. Classical efficiency does not take into consideration the beneficial use by trees.

The significance of these findings is that common approaches to irrigation management and performance assessment are not adequate to deal with irrigation systems with a high degree of beneficial consumption of water by trees. There is a need for approaches in design, management and performance assessment that explicitly include other beneficial uses of water. This paper gave evidence from one location in Sri Lanka. We feel that there are many other locations worldwide where this is true.

REFERENCES

Bakker, M; R. Barker; R. Meinzen-Dick; and F. Konradsen, eds. 1999. Multiple uses of water in irrigated areas: A case study from Sri Lanka. SWIM paper no. 8, 1999. IWMI Colombo.

Persley, G. J. 1992. Replanting the tree of life: Towards an international agenda for coconut palm research. Wallingford, UK: CABI; ACIAR; Technical Advisory Committee of the CGIAR. xii, 156p.

Salam, A. and D. Sreekumar. 1991. Kerala homegardens: A traditional agroforestry system from India. In *Agroforestry Today* 3:2 (1991).

Wickramasinghe, A. 1992. Trees for sustainable survival. In Proceedings of the 3rd Regional Workshop on Multipurpose Tree Species. Bangkok May 1992. Ed. Prof. H.P.M. Gunasena, Faculty of Agriculture University of Peradenyia. Sri Lanka. p 144-170.

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