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Environmental flow in Sri Lanka: ancient anicuts versus modern dams

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Abstract

Environmental flow describes the stream flow (quantity and regime) required to sustain upstream and downstream habitats, riparian vegetation, human livelihoods and wildlife. When natural rivers or tributaries are held back by weirs, anicuts, barrages or dams, for a variety of purposes such as diversion for irrigation, hydropower generation or flood control often the downstream flow requirement is ignored or neglected. Although there is no universally accepted definition, convention or law on environmental flow, it has been now recognized that environmental flow is essential for sustainability of riparian ecosystem and their services, which are essential for our own existence, livelihoods and many more. This paper looks at physical structures constructed across rivers and tributaries in Sri Lanka since ancient times to date (including mini-hydro power stations) with a view to understand whether simple ancient wisdoms are more appropriate than modern structures for nature conservation. There are tangible evidence to defend that the ancient anicuts known as “amuna” surged sufficient water in tributaries and rivers, to sustain the environment than modern engineering works which has created dead river beds immediately downstream in many streams and rivers.

Keywords: Environmental flow; anicuts, river continuum; weirs; mini-hydropower

Introduction

River basins have been important sites of human settlements for thousands of years, although it was not until the early twentieth century that development began to transform basin ecosystems into modified man-made ecosystems in order to achieve socio-economic benefits. With the technological and engineering supremacy and ability to control nature for its own benefit, river basin development was carried out by the humans with little or no recognition of the ecological, social, economic, and cultural benefits of free-flowing rivers. As a consequence, river basins suffer from significant ecological degradation in the global context. Large-scale, multipurpose mega basin developments were initiated in the US in particular, where, during early nineties, and prior to World War II, basins such as those of Tennessee, Columbia, and Colorado underwent massive transformations. This development model was adopted by the developing countries in the South including Sri Lanka. River basin development facilitated irrigated agriculture, downstream settlement and industrialization. In other words, basin development promoted modernization and regional development. In the latter half of the twentieth century and the early years of the twenty-first century, concern for the ecological and social impacts of river basin development has built up incessantly. As a result, basin development projects and management plans – and the narrow vision of modernization upon which they are often based – tend to be more politicized and contested than was the case in the early and mid twentieth century. Today, in response to critiques, sustainable development and integrated water resources management are key concepts guiding river basin–community relations. While advances in sustainable management have been significant in the North, many challenges remain in the South. This is especially the case in fast tracked developing countries such as Sri Lanka, where the political will is so strong than ecological legacy when sharing and managing natural resources.

Environmental flow describes the quantity of water flow required to sustain upstream and downstream habitats, riparian vegetation, human livelihoods and wildlife when a river or tributary is held back by a weir, anicut, barrage or dam, for a variety of the purposes such as diversion for irrigation, hydropower generation or flood control. Although there is no universally accepted definition, convention or soft law of environmental flow, it has been now recognized that environmental flow is essential for healthy running water and associated riparian ecosystems. The impacts of physical structures constructed for stream/river flow regulation are perceived to be of critical importance on riverine and riparian aquatic flora and fauna due to microhabitat alteration, discontinued linkages of food chains, changes in benthic drift, nutrient spiraling and catadromous and potamodromous fish migration (Angermeierand Karr1984; Townsend1996; Ledec and Quintero 2003). Silva and Davies (1986) reported upstream spawning migration of riverine fish in Sri Lankan streams, whereas Silva (1993) highlighted the potential negative impacts of trunk stream dams across the Mahaweli River on riverine fish populations.

Weirs, dams and anicuts often re-route water through canals, channels, tunnels or pipelines to increase the pressure and remove silt, leaving long stretches of dry bed rocks. Exposed bed rocks and boulders are heated up by incident solar radiation increasing adjacent water temperature during day time and cooling during night due to blackbody radiation. Weirs barrages, dams and tunnels also have a negative impact on fish populations as many fish species migrate for spawning (Arthington et al. 2006). Fish ladders give fish an alternative means to move up or downstream. They can be used to improve fish movements; however, in most cases, this has not been facilitated in Sri Lanka. In contrast, there are tangible evidences to assume that an ancient irritation weir known as "amuna" had facilitated upstream and downstream fish movements. According to Fernando (2002) the fall of the ancient hydraulic civilization of Sri Lanka in the 13th century was due to sudden natural cataclysmic change of the river course of the Mahaweli and was not due to foreign invasions as historians would want us to believe. But there is no evidence to show a sudden geological catyclysm that changed the river course that sustained our ancient hydraulic civilization, leading to disease and famine. Nonetheless, it is sensible to compare ancient systems with modern constructions. The vision behind the ancient hydraulic civilization of Sri Lanka was based on scientific principles of integrated water resource management with recognition of company property rights. According to the ancient chronicles, *Arahat Mahinda*, the monk son of Emperor *Asoka* of India, is recorded in the *Mahawamsa* as advising to then king of Sri Lanka that the land belongs to the people and all living beings, while the ruler is only the guardian of the land (Weeramantry 2000).Therefore the aim of the present analysis is to highlight certain vital features of both systems to understand whether the ancient wisdoms of stream flow regulation is more suitable than modern technologies with respect to nature conservation.

Materials and Methods

Flow regulatory structures namely ancient weirs (*amuna*), British anicuts, ancient and modern irrigation and hydro dams, barrages and mini-hydro weirs already existing on five river basins (viz., Mahaweli, Walawe, Kala, Yan and Maduru Oya basins) designated under Mahaweli development programme were examined for a period of six months from July to December 2013. The locations were identified using published literature (Arumugam 1969), one inch and metric (1:50,000) topographic sheets and also information obtained from respective government officials and peasants. Observations were made mainly on the nature of the immediate downstream of the physical structure (e.g. nature of the bottom, micro-habitats and aquatic organisms including fish), riparian conditions of river banks to some extent downstream, and the magnitude of the physical structure. Geographical positions were taken using a GPS which were later corrected with Google-Earth land satellites. Google-Earth Ruler and New Path were used to measure straight-line distances and meanders respectively.

Results and Discussion

Basic feature of the five river basins are summarized in Table 1. These river basins have been subjected to intensive stream flow regulations since ancient time to date, the hydrological networks are more artificial courses than natural flow regimes. Besides, the existing on-stream artificial structures constructed for flow-regulation, there are different types of regulatory structures of different magnitude as shown in Table 2. Further, water retention in the basin by constructing reservoirs, tanks and canals have resulted in less water and material discharge into the Indian Ocean (Table 1). Except, Mahaweli and Walawe other three watersheds are mainly confined to the dry zone with small potions being located in the intermediate zone. The Walawe river basin discharges the maximum amount of water into the Indian Ocean as a percentage annual precipitation. Kala Oya basin receives the minimum annual precipitation volume per unit watershed area whereas the highest value is computed for Mahaweli basin (Table 1). This can be attributed to the geographical distribution of the basin to experience both southwest and northeast monsoonal rains. Basic hydrological data of five river basins indicate that there is an acute water shortage in Kal Oya basin compared to the other four river basins.

Ancient weirs (amuna)

Hydraulic civilization of ancient Sri Lanka has direct bearings with early human settlements in the dry zone. Two types of ancient systems were prominent. Partial diversion of major rivers to achieve inter-basin transfer or to feed lateral storage tanks for irrigation was common during the ancient time. An example is partial diversion of the Mahaweli River at Minipe constructing "Manimekkala dam" across the river to convey water though about 22 km long Minipe Yoda Ela (Aggabodhi I, 575-608 A.C.) which was extended to 78 km during the reign of King Sena II (853-887, A.C.). The height of 224 m long anicut was raised to 4.2 m in 1947. This indicates that there had been a sufficient flow over the ancient anicut constructed by ancient kings. An ancient diversion scheme with 46 km long feeder channel constructed across the Kalu Ganga, a tributary of Amban Ganga near Pallegama (7°34'16.46"N; 80°50'8.76"E @ 163 m amsl) during the reign of Aggabodhi II (608-618 A.C.) which had been repaired and rehabilitated by Parakrama Bahu I (1153-1186 A.C.) had been in existence according to the ancient chronicles. According to Arumugam (1969), Hattota *amuna* may not be the identical one which was restored in 1952-1957. It looks more abandoned at present and there is no continuous river flow over the 97 m long weir.

Elehera anicut (*amuna*), a work of ancient antiquity (Arumugama 1969), has many references to ancient kings namely Vasaba (65- 109 A.C.), Aggabodhi II (608-618 A.C) and Parakrama Bahu I (1153-1186 A.C.). There are two weirs, the 115 m long large one across the Amban Ganga and small one across Kuda Ganga (29 m long) to divert water in the Amban Ganga for direct development of irrigation and augment supply to Minneriya and Giritale tanks through Elaehera-Minneriya Yoda Ela, which bifurcates after 34 km at Diyabeduma. This system was reported to be restored in 1887 and again in 1945 with several modifications including the weir height. At present flood flow spills over the main weir across Amban Ganga. The weir and the conveyance canal, which was known as Akasa Ganga, now call Angamedila–Yoda Ela was a partial diversion of Amban Ganga water to feed Parakrama Samudra (Parakrama Bahu I, 1153-1186 A.C.). This was restored in 1948-1952 raising the 27.4 m long weir arresting continuous flow over it. However, there is a scour gate of 1.5x1.2 m^2 which also regulates the water level behind the weir but fish cannot swim against the flow. Uggal Kaltota diversion weir on the Walawe River which also belongs to ancient category was built under the regime of King Gaja Bahu (112-134 A.C.). In 1892, the right bank channel was restored and an independent weir of 71 m long and 1 m high was constructed upstream (6°39'50.63"N; 80°52'46.64"E @ 155 m amsl) in 1956 to provide water for new left bank irrigation. Because of the relatively small height of the weir there is a continuous spill over.

Table 1.Basic features of five river basins (MWR =Mahaweli River; WLR = Walawe River; KLO = Kala Oya; MDO = Maduru Oya; YNO = Yan Oya; W= Wet Zone; I= Intermediate Zone; D = Dry Zone)

Flow regulatory feature	MWR	WLR	KLO	MDO	YNO
Watershed (km^2)	10448	2471	2805	1559	1538
% of land mass	15.9	3.8	4.3	2.4	2.3
River length (km)	335	138	148	135	142
Max. elevation (m amsl)	2215	2180	296	670	345
Annual rainfall (mcm)	26368	4577	3974	2816	2476
Discharge (mcm)	8141	2200	855	777	482
(Discharge/ Precipitation)*100	30.9	48.1	21.5	27.6	19.5
Climatic zones intercepts	W,I,D	W,I,D	I,D	I,D	I,D
Rainfall (mcm) per km^2	2.524	1.850	1.337	1.806	1.609
Discharges through	Delta/lagoon	estuary	lagoon	lagoon	delta

British anicuts

During the early period of British rule (1815-1857) the maintenance of ancient irrigation works was totally neglected. Nevertheless, a large number of ancient irrigation systems were restored or new systems were constructed especially following the establishment of Irrigation Department in early 1900s under the British rule. Of these irrigation works, water regulatory cum diversion structures built by the British; Liyangastota anicut on the Walawe River, Budulu Oya Anicut on the Badulu Oya and Bowatenna anicut built on Amban Ganaga at Bowetenna are of important regulatory structures. These flow regulatory diversion weirs and anicuts are quite different to diversion weirs of ancient Sri Lanka with respect to structure and function. Liyangastota anicut, built in 1889 is a diversion weir to feed Ridiyagama and Kadawara tanks through left bank channel whereas right bank channel feeds Mamadola and Oluwila tanks. Three m long and 5.8 m high Liyangastota anicut across the main stem of the river has four scour sluices but only flood flow can spill over the anicut. Nevertheless, there is a continuum of the river flow although the anicut does not allow the upstream migration of fish. Badulu Oya anicut built across the Badulu Oya in 1948 about 16 km upstream of its confluence with the Mahaweli River is a diversion weir with a 13 km long right bank irrigation channel. Although 66 m long anicut is only 0.9 m high, the river bed immediate downstream is almost dead under base flow. Bowetenna anicut was a regulatory weir built across Amban Ganga in 1895 at 7°39'41.61"N; 80°40'31.96"E @ 236 m amsl to provide irrigation water for 230 ac of rice fields blocked only 6.6 m of about 66 m wide river channel by a 1.5 m high dam. This small anicut is abandoned now after the construction of Bowetenna reservoir under the Mahaweli Programme leaving about 2 km between Bowatenna dam and its power plant outflow. British also built several small anicuts across other highland tributaries of the Mahaweli River namely Murapola Ela and Ma-Ela anicuts across the two tributaries of Maha Oya near Marassana and Rikillagaskada, Lamasuriyagama anicut across Belihul Oya, and Maha-Eliya, Mahatotilla and Bathmedila anicuts in the Uma Oya basin. Although the details of these anicuts are beyond the scope of this report, none of the British anicuts facilitated environmental flows.

Irrigation cum hydro dams

Two types of trunk stream irrigation dams, namely ancient and modern, are in existence. Although most ancient types are found in Malwathu Oya basin (e.g., Nachchaduwa, Nuwara Wewa, Basawakkulama, Tisa Wewa) there are few in Kala Oya (e.g. Kalawewa-Balaluwewa twin reservoirs) and Yan Oya basins e.g., Hurulu Wewa. There is evidence for the existence of a trunk stream reservoir on the Maduru Oya, immediate downstream of the present irrigation cum hydro dam. However, no trunk stream irrigation tanks of ancient category are found on the Mahaweli and Walawe river basins. Major ancient irrigation tanks found on the Mahaweli basin (e.g., Minneiriya, Giritale, Parakrama Samudra, Kaudulla, Sorabora), and Kala Oya basin (Usagala Siyabalnagamuwa and Angamuwa) are lateral reservoirs fed by either their own local watershed and augmented by diverted water. Kala Wewa was built during the reign of King Dhathusena (459-447 A.C.) impounding Dambulu Oya by 3.46 km long earthen embankment of 18 m height. This was restored in 1887 and the dam was raised by another 2 m in 1939. In 1958, two reservoirs Kala Wewa and Balalu Wewa merged together forming one large reservoir. There are three sluices to release water; one to Jaya Ganga and two for irrigation command, and 182 m long concrete masonry spill and high level natural spill at the Left Bank end (Arumugam 1969). Nevertheless, river carries flood water and irrigation return flows from Kala Wewa to Rajangana for 40 kilometers.

Hurulu wewa on the Yan Oya basin is also a main stem irrigation tank that belongs to ancient category, built during the reign of King Mahasena (276-303 A.C.). The reservoir was restored in 1949 but the tank bund was breached during 1957 December flood. The present dam, 2.6 km long with 24 m height with double curve concrete and natural spills of 22 m and 152m respectively does not provide upstream-downstream connectivity except during floods.

Rajanganya wewa, built in 1957 is a terminal reservoir in the Kala Oya basin, meant only for irrigation has a 1.66 km long and 6 m high reservoir bund with 68 m wide concrete spill and two sluices (left bank and right bank) to convey water for irrigation command. Downstream river channel is dead to some distance and collect water from local precipitation and irrigation returns flows in addition to ground water recharge.

Udawalawe reservoir, the third largest inland water body built on the Walawe River is the only trunk stream dam in the river basins of the designated Mahaweli areas which generates hydropower in addition to irrigation supply. The river has been held back by a 4.5 km long and 40 m high earthen embankment to impound 268 mcm of water in the reservoir. The reservoir conveys irrigation water through left bank and right bank sluices which also generate hydropower and flood water spill through five radial gates and 380 m wide natural spill. In this case also there is no continuous river flow and downstream the dam river water is mainly local precipitation, groundwater recharge and irrigation return flows.

Hydro-power dams

Kotmale Oya, one of upper most tributaries of the Mahaweli River has been dammed at Talawakele forming Upper Kotlame Hydropower reservoir (UKHP), a so-called run-off river system. It is a gravity dam, 180 m crest length and 35.5 m high with five spillways of 3000 m^3/s capacity. However, immediate downstream of the UKHP dam, the river is almost dead, for 4.36 km till water from the Devon fall merges with Kotmale Oya at 6°57'31.42"N; 80°38'4.85"E @ 974 m amsl. Kotmale Oya has been blocked again creating Kotmale Oya reservoir, at Kadadora village, 28.8 km downstream of UKHP dam about 6.6 km upstream where it confluences with Hatton Oya, near Pallegama to form the Mahaweli River proper. A rock-filled dam across Kotamale Oya at Kadadora is 87 m high and 600 m long has a chute spillway with a capacity of 5500 m^3/s consisting of 3 radial gates of 14x15m. However, there is no water in this stretch of the stream under dry weather for 6 km up to Pallegama where Hatton Oya merges with it on left bank.

Victoria, the third main stem high dam of the Mahaweli River is a double curvature arch concrete dam at Vitoria falls, 64 km downstream of Kotmale dam creating two wings (Hulu and Mahaweli) Victoria reservoir. The dam is 122m in height with a crest length of 520m impounding 770 mcm of water with eight spillways of 8.200 m/s capacity. Aquatic habitats and riparian vegetation of the Mahaweli River is almost dead from immediate downstream of Victoria dam to 5.78 km until it receives power station out-flow from its right bank although three left bank tributaries of minor importance merge with the main stream. The mainstream of the Mahaweli River is again blocked by a rock-filled dam (94 m high and 485 m long with three spillways of 8,300 m^3/s capacity), 19 km downstream of Victoria reservoir, creating Randenigala reservoir, which is also fed by Belihul Oya and Kurundu Oya on the right bank. The Mahaweli water which is released from Randenigala power station is then conveyed directly into Rantembe reservoir (21.0 mcm) through 2.98 km long concrete channel which is also fed by the Uma Oya, a tributary with the largest right bank catchment that spread over Uva basin. The water is held back by 420 m long and 43.5 m dam facilitated with spillway of 10,235 m^3/s. The tailrace of the power house is located immediate downstream and water is diverted to Minipe Yoda Ela and right bank channel after 3 km leaving no sufficient river flow from the Minipe anicut to Weragantota for 17.5 km. A recent study has shown the low abundance and diversity of fish species in this stretch of the river in relation to Legal Oya (Rajakaruna et al. 2013). Apparently the massive structures of the five hydro dams on the trunk stream of the Mahaweli River have no facilities for environmental flows what so ever. The situation is bit different at Samanala Wewa reservoir on Walawe River basin because of existing leakage which appears as a small spring in the right bank about 300 m downstream of the dam. The dam was rock filled 100 m high and 530 m long impounding a total storage of 218 mcm water with a spill-way with three gates which has the capacity of 3,600 m^3/s. The stretch of the river between the dam and the Diyawini Oya goes dry depriving the farmers any water for their cultivation, except for some little water coming from a few small tributaries in between.

Table 2. Major flow regulatory features of five river basins (MWR =Mahaweli River; WLR =Walawe River; KLO = Kala Oya; MDO = Maduru Oya; YNO = Yan Oya; MHP = mini-hydro-power plant; number right to slash denotes visited; na - not applicable; e-flows - environmental flows; Irr- Irrigation)

Flow regulatory features	MWR	WLR	KLO	MDO	YNO
Puranaamuna	04/04	01/01	00	00	00
British anicuts	02/02	01/01	00	00	00
Trunk stream Irrigation dams	00	00	04/04	00	01/01
Hydropower dams	05/05	01/01	00	00	00
Trunk stream Irr./hydro dams	00	01/01	00	01/01	00
Tributary/Diversion /Hydro dams	01/01	00	00	00	00
Barrages or Diversion	01/01	00	01/01	00	00
Number of MHP	60/55	07/07	00	03/03	00
MHP with sufficient e-flows	01	00	00	00	00
MHP with fish ladders	03	00	00	00	00
Trunk stream Hydro dams	05/05	01/01	00	00	00
No of trunk stream anicuts	01/01	01/01	01/01	00	02
No of major lateral reservoirs	12	03	05	01	03
No of link tunnels	05	00	00	01	00
No of trunk stream causeways	00	00	01/01	00	00

Polgolla Barrage and Neela Bemma

Under Mahaweli River Development programme the river was blocked by a barrage at Polgolla (7°19'17.11"N; 80°38'41.39"E @ 450 m amsl) partially diverting water through 5.6 km trans-basin tunnel which releases water to Sudu Ganga at Ukuwela after generating 2x20 MW. Subsequently, Mahaweli water is conveyed to Dambulu Oya, Kandalama Wewa and Hurulu Wewa via Bowetenna reservoir through 8.22 km link tunnel. The place where the tunnel opens called Lendora village is unique since Mahaweli water is transferred to Kala Oya and Yan Oya. Polgolla barrage, which is 14.6 m high and 144 m long has 10 sluice gates to release water as the need arises. However, when all sluices are closed, the river has no flow for 13 km until it meet the Victoria reservoir indicating an irregular river flow through this stretch of the Mahaweli River as a result of no inbuilt facility for environmental flow.

Neela Bemma, which is a 147 m long and 14 m high concrete dam with two spills, with regulator gates and two sluice tunnels was constructed across Kala Oya at 8°12'57.29"N; 80° 4'57.89"E @ 31 m amsl about 18 km downstream of Rajanganaya dam in 1995. Apparently there is continuous flow over this dam except under extreme dry conditions. However the attempts of fish jumps over the dam are not successful because of the height of the dam.

Mini-hydropower plants

Up to recent past, the state-of-the-art of the power industry in Sri Lankan is construction on mini-hydropower plants (MHPP) on running water including streams, rivers, and irrigation channels. At present, Ceylon Electricity Board has stopped signing power purchase agreements with MHPP developers (personal communication, Prof. M.J.S. Wijeyaratne). During the present survey 65 of the 70 sites of the MHPP in the Mahaweli River basins, of various stages (i.e., approved, under construction, grid connected) of which a majority were connected to the national grid were visited and examined. Of the 70 sites, 60 are located in the Mahaweli River basin including two cascade mini-hydropower plants in Sudu Ganga and Hatton Oya, which were reported to be extremely high in aquatic biodiversity especially riverine fish including endemic and migratory (De Silva and Wansapura 1991; Silva et al. 2013). A large majority of small hydro plants are assigned as “run-of-the-river” systems, meaning that they have no or relatively small water storage capability. The turbine produces power only when the water is available in the river. In the case of low head projects, either the water is diverted to a power intake with a short penstock, as in the high head schemes, or the head is created by a small dam, provided with sector gates and an integrated intake powerhouse and fish ladder. Nevertheless, fish ladders and environmental flow must be inbuilt into these mini-hydropower plants as an ecological requirement. Ecological flow is also equally important as fish ladders when dams are built across rivers. The existing irrigation canals can be modified to establish min-hydropower plants by enlarging them to accommodate the intake, the power station, the tailrace and the lateral bypass.

Over 90 % of the mini-hydropower plants were established within a narrow time-frame. Each and every hill stream of Mahaweli and Walawe basin have been tapped for mini-hydropower depending on the water availability with substantial micro-catchments. Fish were found in almost all weir sites and at tailraces except in few instances. The community structure and the abundance of fish population varied with stream width and the elevation. Apparently, most of the stream habitats were almost dead between the weir and the power station when water is transferred by a headrace channel to a fore-bay and subsequently to penstock. A small amount of water is released from the weir as environmental flow, although they highlight these power plants under the category of run-of-river system (e.g. Hulu Ganga Phase I and II, Giddawa and Loggal Oya Mini-hydropower plants).

At certain power plants namely Mulgama mini-hydropower plant, located downstream of Samanala Wewa natural leakage, no water was noticed in the stream channel between the weir and the power station. Ceylon Electricity Board is planning to construct another mini-hydropower plant upstream of the Mulgama weir. Of the 67 mini-hydropower plants constructed across the mainstream or tributaries only one, i.e., Koladeniya mini-hydropower plant constructed across the Mahaweli River upstream Nawalapitiya was incorporated with a fish ladder and two openings for environmental flow. Fish were crossing over the weir during overflow according to the developer. Koladeniya mini-hydropower plant which is owned by the Bank of Ceylon maintains the environmental requirements to acceptable norms. This is a good message for the other developers as well as project approving agencies to adhere to environmental requirement. Table 2 shows different types of flow-regulatory features of five river basins which affect the stream ecological features and fish community structure in respective river basins in the Mahaweli areas. None of the regulatory structures, either ancient or modern, irrigation or power generation except for Koladeniya mini-hydropower plant (dams, barrages, anicuts, diversion weirs etc.) is facilitated with fish by-passes or hardly concerned on environmental flow requirements.

Conclusions

There were no trunk stream reservoirs on the mainstream of Mahaweli River as the ancient kings used the profuse base flow of the river to divert water using diversion canals to major reservoirs located elsewhere. Construction of Kala Wewa on the trunk stream of the Kala Oya could be an only option of transferring water to Malwathu Oya via Jaya Ganga. Haththota Amuna, Minipe Elahera and Angamidela systems are classic examples for partial diversion of running water maintaining flow-continuum. British anicuts are quite different from ancient irrigation anicuts of the kingdom of built tanks, because they did not consider the river continuum. The reservoirs constructed since independence either under River Valley Development Board or Mahaweli Development Programme were not planned according to holistic ecosystem approach in the case of river basin development. In the present context, environmental flow, riverine fish migration, endemic bio-diversity are the bouncing ecological aspects related to stream flow regulation that cannot be ignored although some considered that power generation by stream-flow regulation is a non-competitive entrepreneurship.

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