ANCIENT WATER AND SOIL CONSERVATION ECOSYSTEMS OF SRI LANKA

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INTRODUCTION

Background: Sri Lanka is an island in the Indian ocean, located between 6 and 8 degrees latitude north of the equator, at the southern tip of the Indian sub-continent. It's area is approximately 65,000 sq. kms or 25,000 sq. miles, and it experiences two monsoons, the northeast monsoon between October and March, and the southwest monsoon between April and September, with inter-monsoon rains as well. The southwest monsoon rainfall is largely intercepted by a south-central hill massif, and then blows over the northeast region as a dry wind, whereas the northeast monsoon rainfall is spread over most of the island. Consequently, a wet zone and a dry zone, with an intermediate zone lying in between, is recognized in the country today. In ancient times, however, there were three regions described as Rajarata (King's country), Ruhunurata and Mayarata. On account of the rainfall pattern and the topography, many of the 103 rivers in Sri Lanka rise in the central highlands and flow in a radial pattern to the sea. Perennial rivers are called *ganga,* and non-perennial rivers and streams are called *oya, ara* or *ela* in Sinhala, (the Sinhalese constituting 74% of the population), and *aru* in Tamil. (Figure 1).

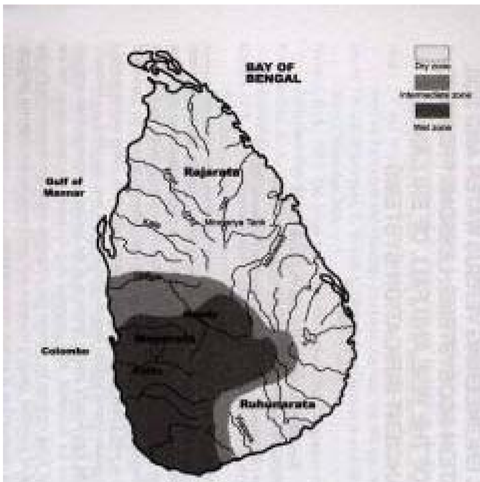

Figure 1

Sri Lanka is unique in that it has a written history, that goes back to the mid first millenium, BC. The actual writing was done on what are called ola (palm) leaf manuscripts some centuries into the Christian era. These are confirmed by contemporaneous stone inscriptions and other sources recognized by historians. (History of Ceylon, 1959, 1960). We learn that, beginning in about the mid first millenium BC, an extensive system of water and soil conservation had been created, that is still in use, and it is recognized as a wonder of the ancient world. Its purpose was to conserve the excess rainfall of the northeast monsoon for agricultural production, mainly irrigated rice, which is a water intensive crop, and tropical climatic conditions in Sri Lanka are ideal for its cultivation throughout the year.

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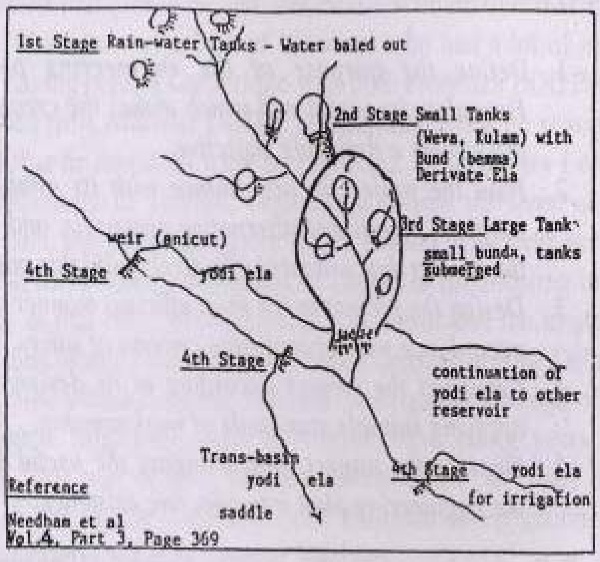
Features of this water conservation system were river diversion structures, and storage reservoirs, in the ancient Rajarata and Ruhunurata, the modern dry zone. The former included stone anicuts (anicut being a word derived from the Tamil language) or weirs, called *amuna* in Sinhala and *tekkam* in Tamil, that diverted stream flow for irrigated agriculture, and for storage in reservoirs, as well as small earth dams called *vetiyas*. These latter structures were designed and constructed to check surface runoff from rainfall, in small non-perennial or seasonal streams, the *oya, ara*, and *ela*, the runoff being stored in the earth itself. The storage reservoirs were small, medium and large scale, and there was a symbiotic relationship between diversion systems, vetiyas, and storage reservoirs. The functions of the systems were irrigation, flood control, and drainage, as well as conservation of the environment, both flora and fauna, the latter after the advent of Buddhism in about 223 BC. (Weeramantry, 2000). However, the predominant function down the ages has been irrigation, and these human-made ecosystems are usually described as irrigation systems. Three important aspects of these water and soil conservation ecosystems are, their

- evolution and development over a period of more than 15 centuries beginning in the mid first millenium BC
- stability and sustainability over this long period
- final apparently irreversible decline after about the 12th century

A comprehensive statement on the ancient irrigation system of Sri Lanka is a 1997 judgement in the International Court of Justice (the World Court) by its Vice-President Dr C G Weeramantry, the *Separate Opinion* in the Gabcikovo – Nagymaros case (Danube dam case) (Weeramantry, 2000). It strengthened awareness of the damage done to ancient water and soil conservation ecosystems of Sri Lanka, in the name of development, that leads to mal-development and conflict, discussed in this paper.

Hydraulic engineering vs. Water and soil conservation ecosystems, perspectives:

A hypothesis (Brohier, 1956) that was re-published by Joseph Needham in 1971, described the evolution and development of the ancient irrigation systems in four consecutive stages. (Figure 2, alongside). This hypothesis is based on a simple hydraulic engineering perspective, for the sequential development of storage reservoirs according to increase in size. An alternative seven stage hypothesis based on an ecosystems perspective (Figure 3, page 4) was proposed by this author who was then invited to work at the Needham Research Institute in Cambridge, England, in the 1980s and 1990s, under Dr Joseph Needham, who wrote: *"My treatment of the subject can be improved upon and I am counting on you to do it".*



Brohier's Theory, quoted by Needham

The process of evolution which is thought to have occurred may be described as follows :

First the farmers made numerous small tanks in the hills and foot-hills, near their fields or terraces to catch the run-off water they baled out at leisure. Then numbers of small dams, bunds (bemma) were built, often in series, on the upper reaches of tributaries of the greater rivers, thus retaining the annual or innundatory flow and discharging it as desired by small canals (ela) along the valley sides, as time went on larger dams were built submerging or rendering unnecessary the smaller ones. The next step was revolutionary: a weir (anicut, Tamil = tekkam) was built much higher up the main river (ganga, oya, Tamil = aru) to form the headworks for a long lateral waterway to join the annual monsoon supplies in the great reservoir. This method ambitious as well as scientific, had numerous advantages :

a. It harnessed a greater volume of water than any local catchment area could yield.
b. It put both monsoons and other rainfall to full use
c. It secured a resource in drought periods as well as an even supply in normal years, and
d. It lessened the silt accumulation problem because the feeder canals could be cleared periodically much more easily than the tanks (Needham et al, 1971, 368)

Figure 2

The hydraulic engineering perspective is well illustrated by the following extract from an Irrigation department Reconnaissance Report for construction of a new large reservoir, Heda oya, which however has not been constructed for other reasons. (Kahawita, 1950):

The development of Heda oya is recommended as it compares very favourably, from technical and financial viewpoints, with other major schemes already undertaken by government. There does not exist any doubt as to the need to achieve self-sufficiency in food. This is an achievement that cannot be realized by spending large sums of money on tiny village tanks which do not have the staying power in a drought nor can a better standard of living be taken to a people depending on them. Vagaries of the monsoons and resulting destitution can be fought only by spending public funds on large schemes and not by creating little evaporating pans and relief works. The age of the village pond has passed away and the time has come to embark on large projects like the scheme under review.

Two comments are necessary. Firstly, the scathing reference to 'little evaporating pans' shows a type of contempt that is born of the urban citizen's ignorance of the sociological significance of the village tank, which is recognized as the heart of the dry zone village in Sri Lanka. Indeed the name of a village is most often synonymous with the name of its village tank. Secondly, the 'other major scheme' referred to is the Gal oya project in the southeast of the island, the first large scale project imposed on ancient water and soil conservation ecosystems in recent times. The model for planning this project in the 1940s, was the Tennessee Valley Authority of USA, not the ancient irrigation systems of Sri Lanka.

[However, when TVA failed to deliver as promised, it became discredited in the USA, and this reflected adversely on the work of the USBR, the United States Bureau of Reclamation (Reissner, 1986). This news has never reached Sri Lanka, however, and Irrigation engineers continue to visit the USBR in Denver, Colorado, in connection with their work, to the present day. I think it should be the other way around - USBR personnel should visit Sri Lanka, and join us in studying the sustainability and stability of Sri Lanka's ancient water and soil conservation ecosystems - many of which are still functioning as intended after more than two thousand years. This latter fact was also mentioned by Judge Dr C G Weeramantry in his celebrated Separate Opinion in the Danube dam case in the World Court in 1997, a judgement now much cited in the field of modern Environmental Law].

Contrasting consequences of the two perceptions are summarized in Table 1:

Hydraulic Engineering vs. Water and Soil Conservation Ecosystems

	Hydraulic engineering (Hard technology/Transferred knowledge)	**Ecosystems perspective** (Soft technology/Traditional knowledge)
1. Water	inanimate, active	animate, passive
2. Small tank	"inefficient" stage in evolution and development - to be replaced by large reservoir	micro-irrigation ecosystem - essential part of total complex of man-made ecosystems
3. Large reservoir	"efficient" system in combination with channel distribution irrigation system	macro-irrigation ecosystem with micro-irrigation ecosystems in its command area
4. **Diversion Channel**	built to augment a large reservoir - last stage in irrigated agriculture system	earliest stage in irrigated agriculture and evolution of ecosystems
5. Vetiya	"abandoned small tank"	deflection structure - micro water and soil conservation ecosystem
6. Downstream development areas	must be cleared of all vegetation to lay out channel distribution irrigation systems	designed as a series of micro water and soil conservation ecosystems
7. **Forest areas**	limited to catchment areas	not only in catchment areas - interspersed with fields in development areas for better nutrient flows

Table 1

The stability and sustainability of the ancient systems from the time they were built to the present day, may be explained in terms of the ecosystems perspective of irrigated agriculture, but not in terms of the hydraulic engineering perspective. However, in modern times, the hydraulic engineering perspective has held sway.

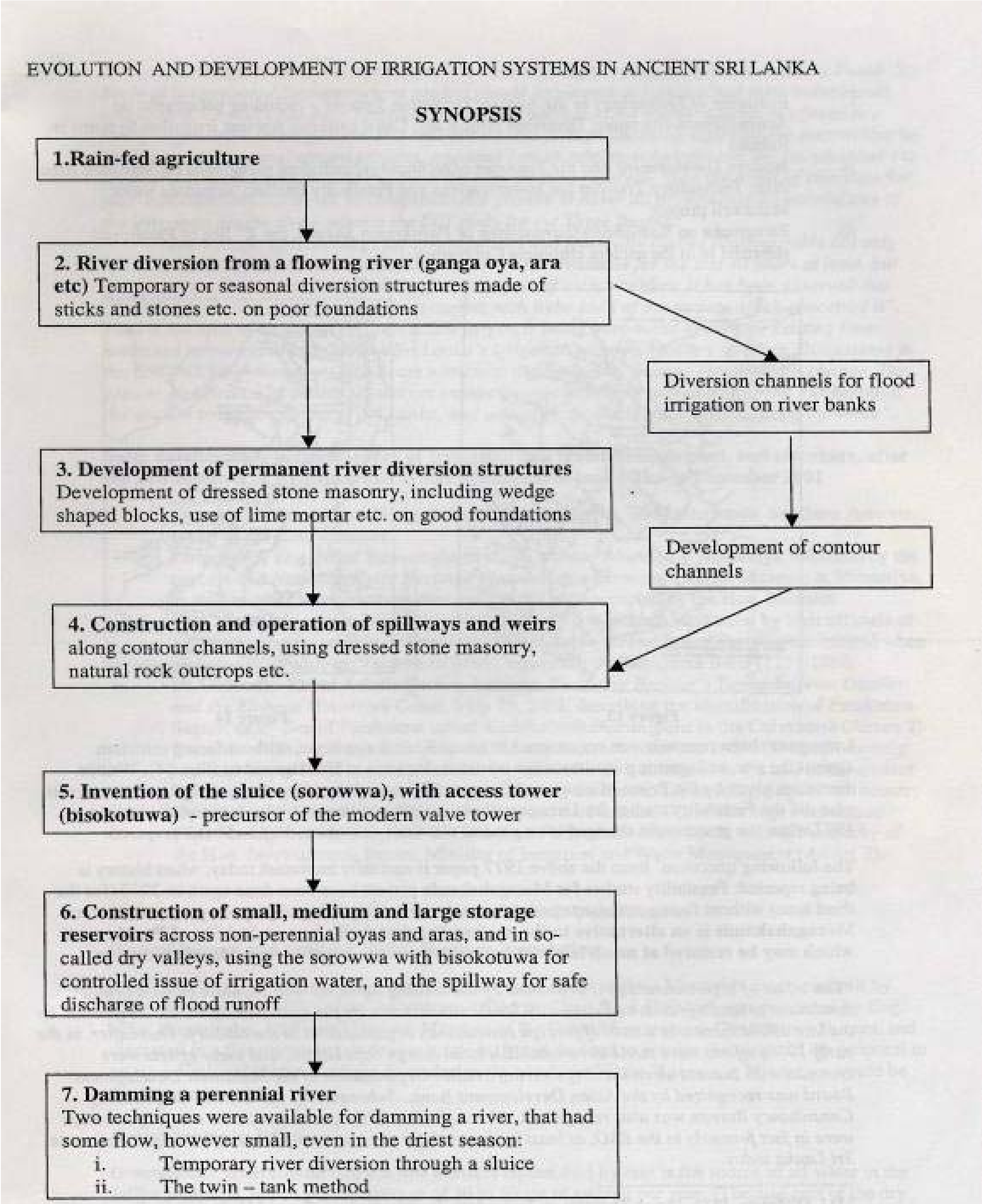


Figure 3

Water Resources Development Plan, 1959: A map titled the *Water Resources Development Plan* published in 1959, is based on the 4 stage hypothesis. Only the largest of the ancient reservoirs and diversion systems are recognized and included in this map. Smaller systems are ignored, or worse still, will be submerged under new large reservoirs identified on one mile to an inch topographical survey sheets, following the third stage of the 4 stage hypothesis. (Figure 2)

MODERN DEVELOPMENT AND UNDERDEVELOPMENT: ANCIENT RUHUNARATA

Ancient development – small tanks and vetiyas:

The topographical survey of Sri Lanka, then Ceylon, was a comprehensive ground survey completed in British colonial times. The one mile to an inch “topo” sheets, as they are called, give a wealth of information about ancient irrigation works. Unfortunately these topo sheets have been replaced recently by new metric sheets, based on aerial surveys, which do not carry the wealth of detail given in the older ground survey sheets.

An important one among the older topo sheets is the Timbolketiya sheet in the southern area, the ancient Ruhunurata, which shows the middle reaches of the Walawe ganga (perennial river). The Mau ara (non-perennial river) in the left bank of the Walawe basin has long been an enigma as shown in Figure 4 alongside and Figure 5.

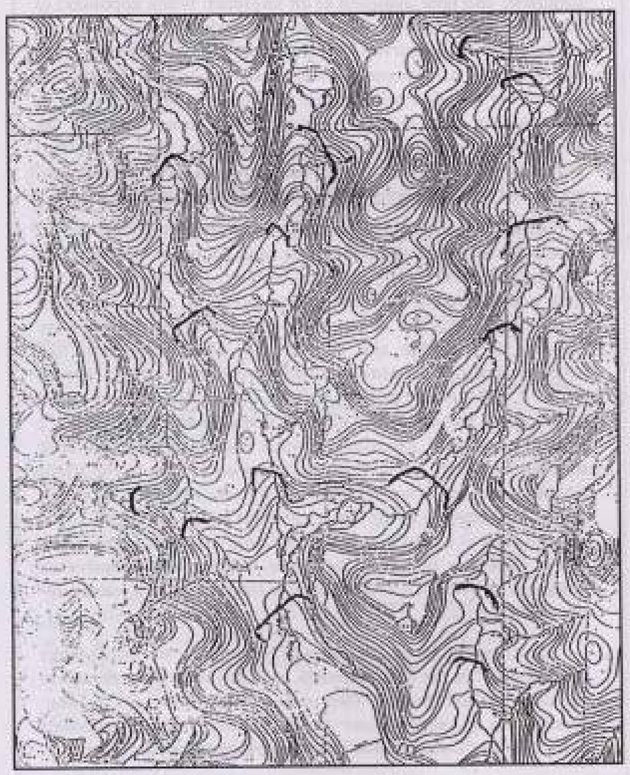


Figure 4
Detailed Engineering Surveys in Mau ara basin showing 2 ft contours and ancient vetiyas.

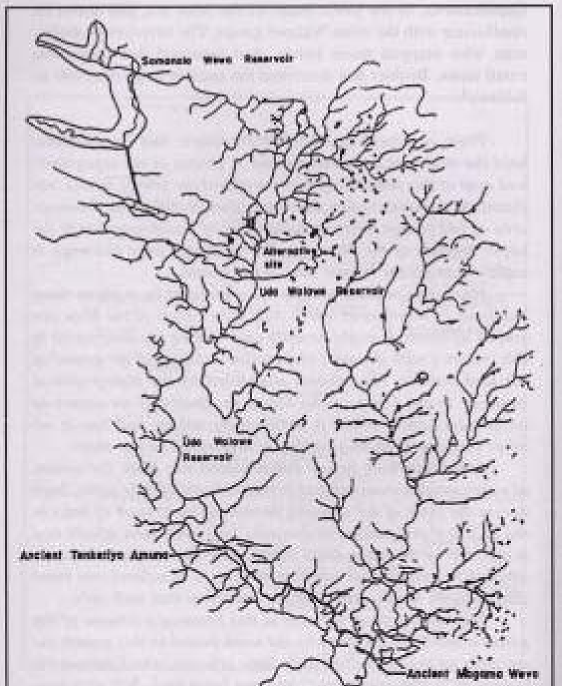
Figure 5
Extract from Timbolketiya topographical survey sheet, showing Vetiyas in Mau ara basin, wrongly described as small tanks (abandoned)

Hundreds of small breached earth embankments called bunds were found in the Mau ara basin, as well as three large breached reservoirs. (Figure 5) The small bunds were assumed to be the embankments of abandoned small tanks.
(see Box in Figure 5)

However, in recent times, it has been established that these breached structures did not have any sluices (Mendis, 1997 etc).

Furthermore, it was found that these earthworks are well known to local people as the *vetiya*, (Figure 4) an unique small embankment, built across non-perennial oyas and aras to check rapid runoff of rainfall and raise the water table in the reddish brown earth (RBE) soils in the surrounding area during the rain season.

Uda Walawe reservoir project:
The first new large reservoir identified from the Water Resources Development Plan, 1959, to be taken up for construction was the Uda Walawe reservoir. During construction of this project, in 1965 – 68, an alternative upstream location at Ukgal Kaltota, for a large reservoir in the Walawe ganga basin, was identified by this author in 1967 and given publicity. (Figure 6, alongside). (Mendis, 1968). This was the first serious critique of the *Water Resources Development Plan, 1959*, and it was not well received by engineers when presented at the annual sessions of the Institution of Engineers, Sri Lanka, then Ceylon. (Transactions, 1968). However, today there is general agreement that the upstream site is a better location for a large reservoir in the Walawe ganga basin, and such a location will fit into a long term development plan for the southern area, as discussed below.



WALAWE BASIN DEVELOPMENT – ANCIENT DISPERSED SMALL-SCALE SYSTEM Vs MODERN CENTRALISED LARGE-SCALE SYSTEM.

Figure 6

Lunuganvehera reservoir, Huratgamuva site, and the proposed Southern Area Plan:

Lunuganvehera weva (reservoir) in the lower Kirindi oya basin (Figure 7) was the next large reservoir, after Uda Walawe, to be selected from the *Water Resources Development Plan, 1959*, for investigation and construction. An alternative location at Huratgamuva (Figure 7), upstream of Lunuganvehera, for a large storage reservoir in this non-perennial river basin, fits into a long-term development concept called the *Southern Area Plan* (Figure 8), prepared by an engineer, M S M de Silva, in the mid 1960s, while Lunuganvehera does not. This plan, also based on a hydraulic engineering perspective, envisages construction of large reservoirs in the southwest wet zone for flood control, and diversion of excess water to the southeast dry zone.

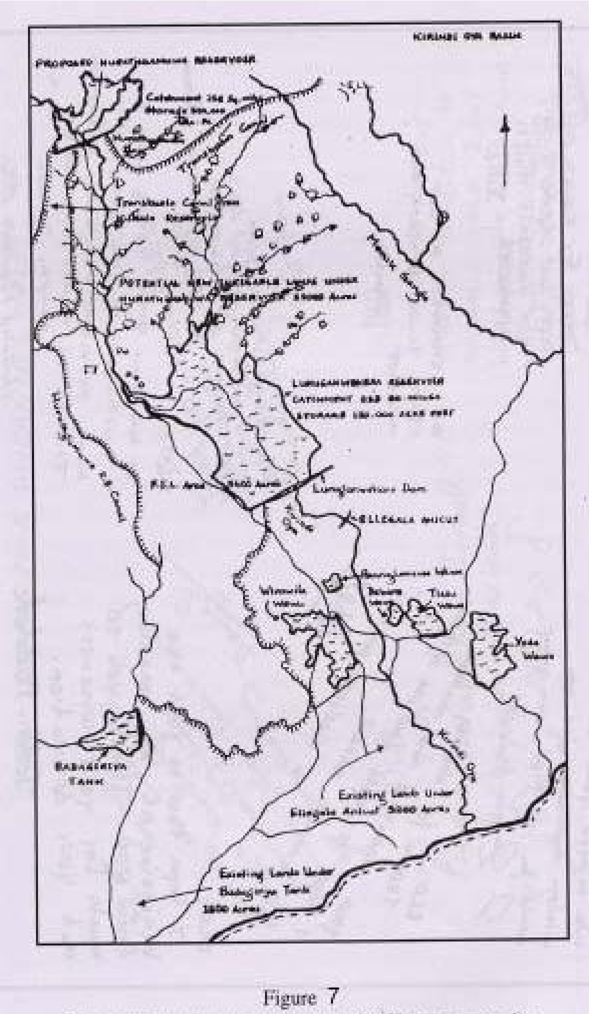


Figure 7
Lunugamvehera weva and Alternative Huratgamuva site.

Huratgamuva site had been identified and brought to the attention of irrigation engineers by Engineer M S M de Silva. This author who worked in the Ministry of Planning and Economic Affairs, at the time, brought the plan and Huratgamuva site to the attention of national planners in the early 1970s, but to no avail: Lunuganvehera weva had been investigated and was taken up for construction after a change of government in 1977, without investigating Huratgamuva alternative.

Lunuganvehera project has been plagued with problems, from the time construction started. Construction time doubled from the original 4 years to more than eight, costs increased exponentially, and civil disturbances resulted in the area. Two attempted insurrections against the government had originated in the southern area, the first in 1971, in the Uda Walawe project area, and the second, much worse, in 1988-89 in Lunuganvehera project area. They were both suppressed with much loss of life and destruction of public infrastructure and private property.

time! The following reference by this author to a 1992 study by Charles Nijman at the International Irrigation Management Institute (IIMI), now the International Water Management Institute (IWMI), describes some adverse consequences, in financial terms (Mendis Ed. 2003):

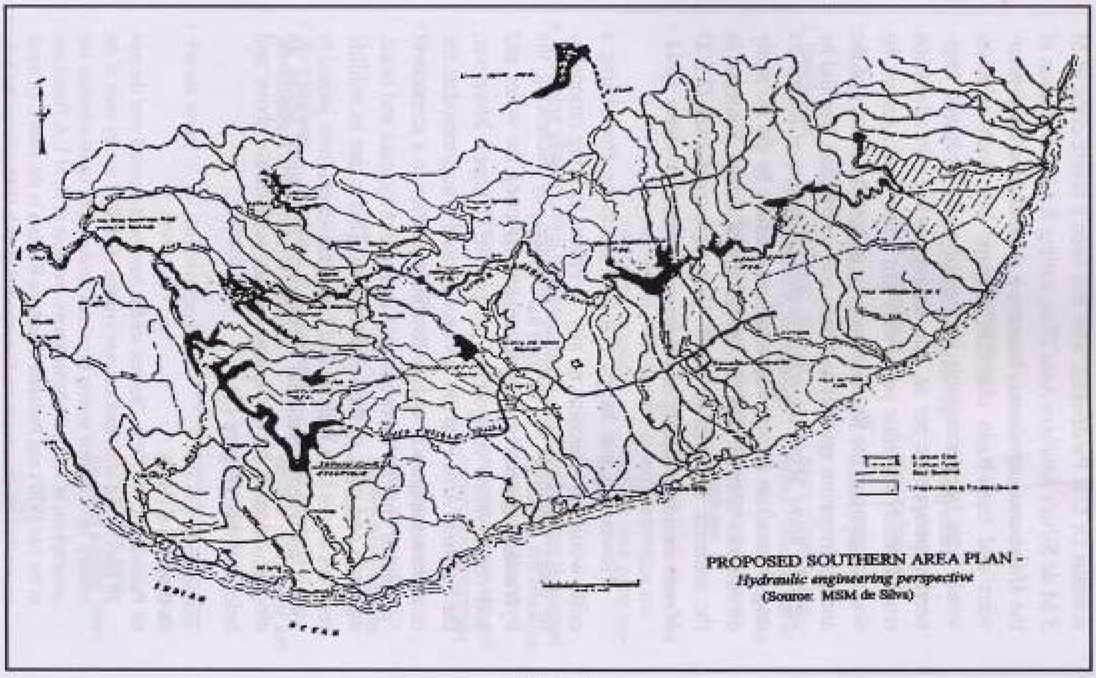


Figure 8

When Irrigation Ministry officials were planning Lunuganvehera project, directions given by the Prime Mnister in her capacity as Minister of Planning to investigate the alternative Huratgamuva site, were ignored, in breach of all norms and the State's Establishment Code itself, allegedly *to save time*! The following reference by this author to a 1992 study by Charles Nijman at the International Irrigation Management Institute (IIMI), now the International Water Management Institute (IWMI), describes some adverse consequences, in financial terms (Mendis Ed. 2003):

> *"In 1977 ADB approved a loan of $ 24 million and the Sri Lanka contribution was $ 6.5 million. Nijman says: 'In 1982, two years after construction activities started, the project was re-appraised due to cost escalations, and the cost was estimated at $ 106 million. Because the financing gap was considered too large to be met from available sources, and because of implementation delays, the government agreed with the Bank and the co-financiers to implement the project in two phases' ".*

Later, when various, diverse problems surfaced in the Lunuganvehera project, attention was focussed on shortage of water only, in accordance with the hydraulic engineering perspective, and a proposal to divert an adjacent river, Menik ganga, to augment Lunuganvehera reservoir was proposed and investigated. Following Amory Lovins in his Soft Energy Paths (Lovins, 1977), the question was then posed: *"If technology is the* *answer, what was the question?"* The point is that when hydraulic engineering is the cause, it is futile to seek a hydraulic engineering solution to these very problems.

Instead, Huratgamuva, must be investigated, sooner rather than later, and another reservoir built there.

Storage in this new reservoir will irrigate new lands above Lunuganvehera, and the full supply level at Lunuganvehera, will be reduced year by year. Surface area of Lunuganvehera at FSL is over 10,000 acres. When reduced in stages, after Huratgamuva is built, land so released will also be cultivated. Also, the gigantic embankment of Lunuganvehera could be used for extensive housing and settlement, because it covers a very large area. A precedent for such a reduction in full supply level is the Allai Extension Scheme, where Allai tank is located close to the sea, south of Trincomalee, famous for its natural harbour. This author was an assistant engineer in Allai when this was achieved in the 1950s.

Other obvious benefits from construction of Huratgamuva reservoir will include regular re-use of irrigation water, availability of grazing land for cattle (Ruhunurata was once famous for its curd and honey), and conservation of the coastal mangrove swamps and wildlife reservations that are presently endangered, and causing much heartburn among nature lovers and environmentalists.

Huratgamuva also fits into the Southern Area plan which has a lot of potential for restoring the ancient water and soil conservation ecosystems in the area, and relieving the ever increasing conflict between the local peasants and wildlife, especially elephants, whose numbers are said to be decreasing at an alarming rate. This then would be the final permanent solution to a problem that will grow in intensity with the passing years unless faced with courage, especially by engineers, and resolved from an ecosystems perspective, sooner rather than later.

As preparation for this final solution, the Southern Area plan has been modified from an ecosystems perspective. This essentially envisages restoration of abandoned ancient small-scale reservoirs or wevas, vetiyas, and diversion systems, in the southeast dry zone, and relocation of the Uda Walawe National Park, (said to be home to nearly 300 elephants) prior to construction of large reservoirs in the southwest wet zone, as shown in Figure 9, below.

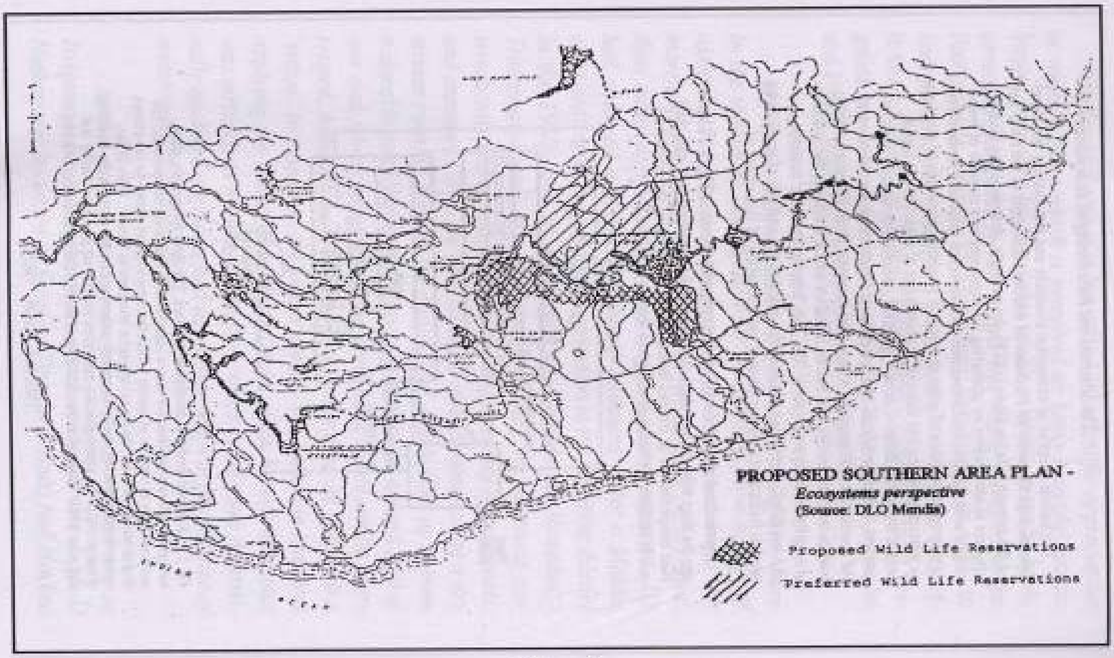


Figure 9

ANCIENT RAJARATA

Ancient development in western Rajarata:

R L Brohier had shown in a Royal Asiatic Society lecture in 1935, that all the ancient large reservoirs in ancient Rajarata were interconnected by means of human-made channels, natural rivers, and streams. (Figures 10 and 11). This was developed further by Nicholas and Paranavitana in 1960 (Figures 12 and 13). The outstanding feature on the western side of Rajarata, of this interconnected trans-basin system built down the ages, is the Kalaweva – Jayaganga ecosystem described as a cultural landscape (Mendis, 1997) (Figure 10). Systems of small storage reservoirs (called tanks after the Portuguese *tanque*) in Anuradhapura district in western Rajarata, had been constructed in cascades, when Anuradhapura was the capital city from about the 3rd century BC till about the 8th century. (Figures 14 and 15). Brohier had already discovered and documented these cascades, which he described as chains of small tanks, in his seminal 1935 R A S lecture as follows:

"The Jayaganga, indeed an ingenious memorial of ancient irrigation, which was undoubtedly designed to serve as a combined irrigation and water supply canal, was not entirely dependent on its feeder reservoir, Kalaweva, for the water it carried. The length of bund between Kalaweva and Anuradhapura intercepted all the drainage from the high ground to the east which otherwise would have run to waste.

Thus the Jayaganga adapted itself to a wide field of irrigation by feeding little village tanks in each subsidiary valley which lay below its bund.

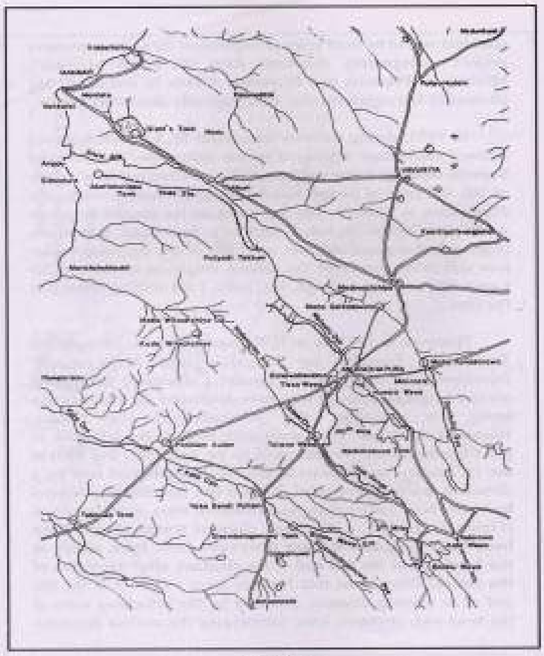


Figure 10
Ancient large reservoirs and channels in western seaboard of Rajarata. (Source: Brohier, 1937)

Figure 11
Ancient large reservoirs and channels in eastern seaboard of Rajarata. (Source: Brohier, 1937)

The ancient water and soil conservation ecosystems of Rajarata are far better known than the ancient systems in Ruhunurata. Nevertheless, they were treated with disregard in two instances. On the western side of Rajarata it was the proposal to mine the Eppawala phosphate deposit to exhaustion in 30 years that would have destroyed the Kalaweva-Jayaganga cultural landscape. On the eastern side it is the proposal to implement the Moragahakande project that would destroy Parakrama Sagara. (Fig. 16)

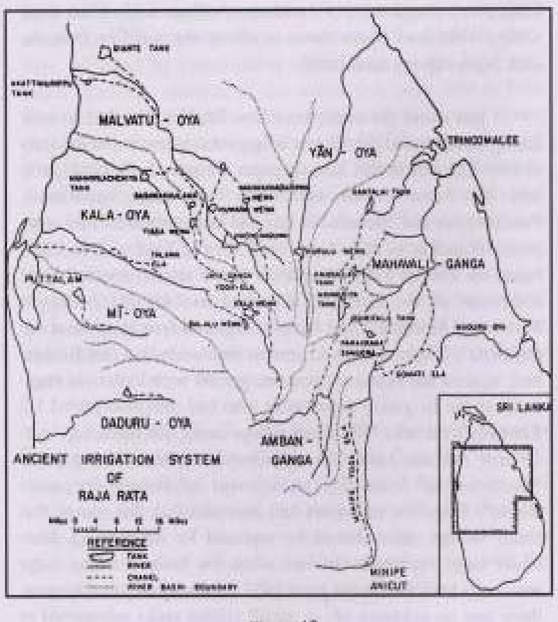


Figure 12
(Source: Concise History of Ceylon, 1960)

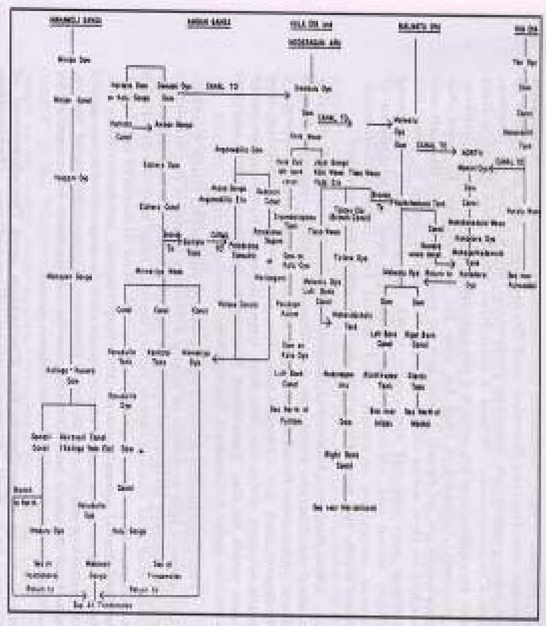


Figure 13 Inter-Relation of Irrigation Works
(Source: Concise History of Ceylon, 1960)

Eppawala phosphate rock deposit in western Rajarata:

A massive deposit of igneous phosphate rock was discovered by the Geological Survey and Mines Bureau in the western area of ancient Rajarata in the early 1970s. A proposal to mine this deposit to exhaustion was made in the 1990s, that would have destroyed the ancient water and soil conservation ecosystems in the area (Mendis, 1999). (Figure 15). A Fundamental Rights case was filed in the Supreme Court of Sri Lanka by local people, and a now much-cited judgement was given in favour of the plaintiffs. (Law Reports, 2000). Rice yields are known to be consistently higher in this area than elsewhere in Rajarata, and a research project to study the impact of the Eppawala phosphate rock was published by this author (Mendis, 2000), that was cited in the historic Eppawala judgement.

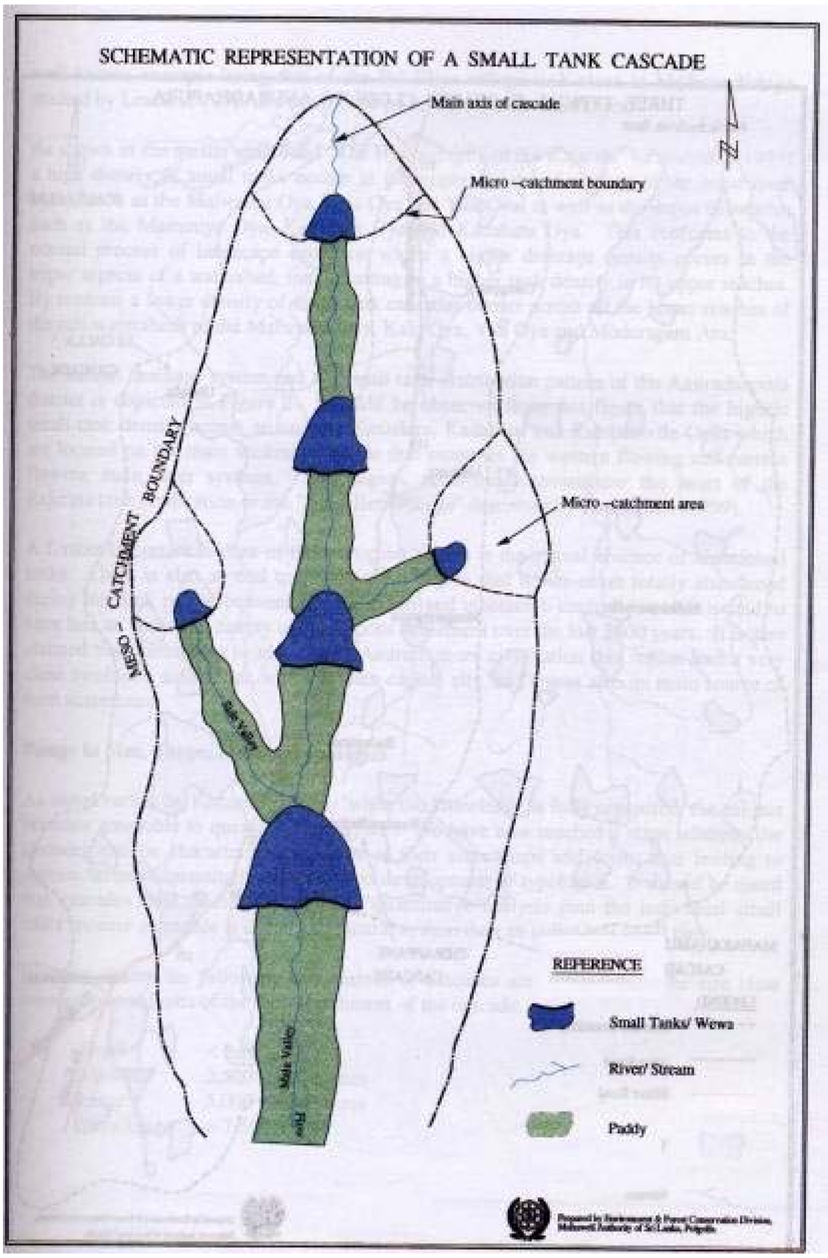
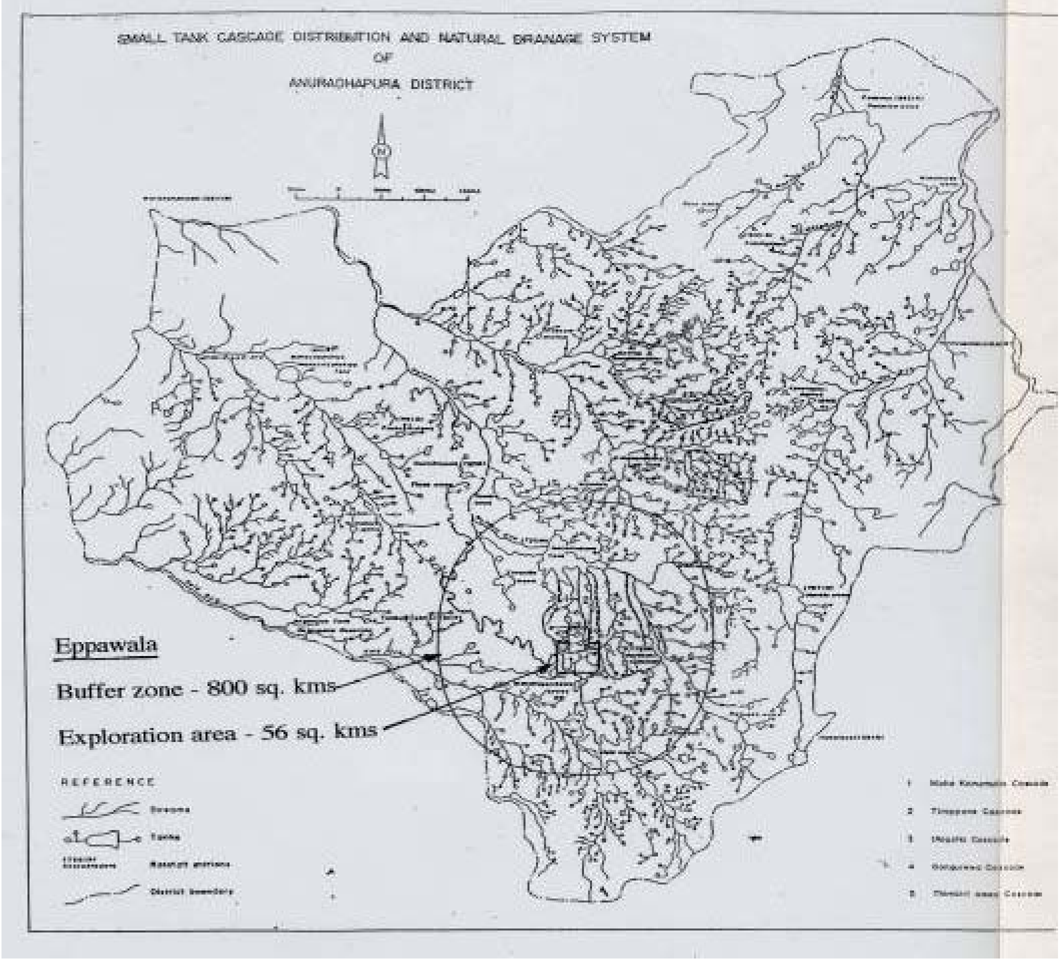
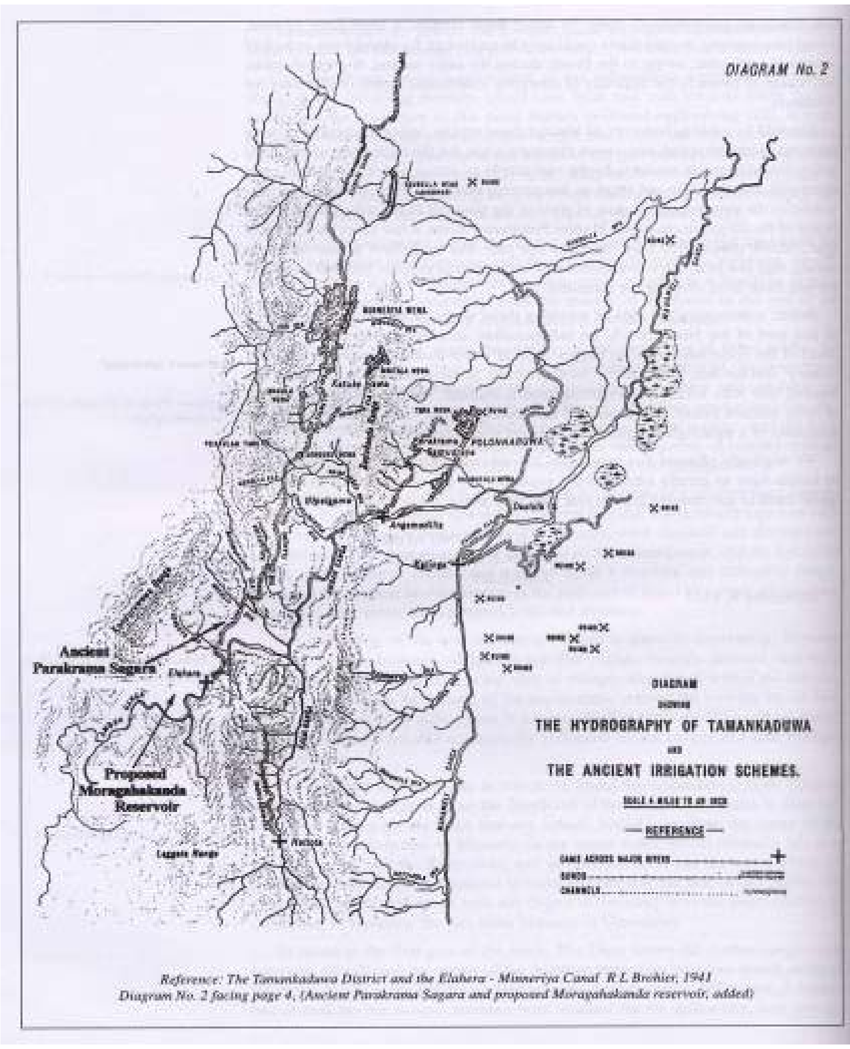


Figure 15



Ancient development in eastern Rajarata:

The eastern area of ancient Rajarata was the scene of truly spectacular development of water and soil conservation ecosystems over an almost unbelievably long period of eleven hundred years. The ancients made use of natural geological formations, and the rainfall and runoff in the area, in a manner that has surpassed anything modern engineers have developed. It is this fact, combined with a certain arrogance on the part of modern engineers, that has created problems in this area.



As shown in Figure 16, alongside, the topography in eastern Rajarata consists of anticlines and synclines located approximately north – south. A perennial river, Amban ganga, springs in the central highlands and flows initially in a northerly direction. Near the anticline called the Konduruweva range it turns eastward and breaks through the anticline. Further down river it breaks through the next anti -cline, Sudukande, and still further down it joins the main river Mahaweli ganga, the longest river in the island with the largest amount of runoff.

Figure 16

Source: Brohier, 1941

Development began in the 1st century, when King Vasabha (65 – 109) built a diversion weir, at Elahera on the Amban ganga just beyond the Konduruweva range, and the Elahera canal from Elahera to Konduruweva, (about 20 miles) (Figure 16). This channel intercepted in succession seven seasonal streams (oya and ela) from the Konduruweva range, namely Kongeta oya, Heerati oya, Bakumane ela, Kottapitiya oya, Attanakadawela oya, Hegolla ela, and Radakegey oya. For over two centuries this ***river diversion water and soil conservation eco-system*** irrigated more than 10,000 acres between Elahera canal and the western side of the Sudukande range, and generated enormous economic surpluses that were used to construct and maintain the irrigation ecosystems themselves, and also to build numerous religious edifices, stupas, temples etc. during this period (History of Ceylon, 1960), all of which are in evidence, and some in use, to this day.

In the 3rd century, King Mahasen (276-303) built Minneriya and Giritale reservoirs at the tail end of the Elahera canal as it then was, and it became the Elahera - Minneriya canal - in its entirety an unique water and soil conservation ecosystem at the time.

For the next three centuries or so, this eco-system generated more enormous economic surpluses that enabled extension of Elahera – Minneriya contour canal beyond Minneriya, crossing the non-perennial Gal oya, Alut oya, Kaudulu oya and Kitulutu oya seasonal rivers, in succession, (see Figure 11), harnessing their waters for irrigated agriculture on the eastern side of the canal. (King Aggabodhi I (576 - 608) is given credit by historians for constructing the Elahera - Minneriya canal extension, but it may have been built in stages over the years).

King Aggabodhi II (608 - 616) who succeeded Aggabodhi I, built Gantalawa weva (Kantalai tank) at the tail end of the extended Elahera-Minneriya canal, just as King Mahasen had built Minneriya weva at the tail end of the Elahera canal.

Finally, King Parakrama Bahu, (1153 - 1186) improved the Elahera-Minneriya-Gantalawa canal and strengthened its headworks to make the canal navigable from Elahera to Tambalakamam bay via Minneriya and Gantalawa (Kantalai). A British administrator Hugh Neville said that the improved headworks formed the second Sea of Parakrama, (Brohier, 1934, I, pp. 28-33), now identified as the **Parakarama Sagara** or **Koththabadhdhanijjara,** the second **Sea of Parakrama** of the Culavamsa (Geiger, 1959, 1960), (Mendis, 1977, p. 60). It consisted of seven reservoirs at different levels since there is a total drop of about 60 ft. from Elahera to Minneriya, and these reservoirs were interconnected by short lengths of canal which had canal locks incorporated to make it navigable.

It is thus seen that the Elahera - Minneriya - Kantalai system, was an extraordinary water and soil conservation ecosystem, comparable in every respect to the better known Kalaweva - Jayaganga ecosystem. In fact it may prove to be an even more incredible achievement than the latter, when all its finest aspects are studied and understood in a multi-disciplinary research study by modern scientists and engineers that is to be done under the *Science and Civilization in Sri Lanka* project in the Institute of Fundamental Studies.

MODERN DEVELOPMENT AND UNDER-DEVELOPMENT:

Moragahakande reservoir vs. Ancient Parakrama Sagara or Koththabadhanijjara:

The next large reservoir to be identified for construction from the *Water Resources Development Plan, 1959,* is Moragahakande reservoir and the North Central Province canal or *NCP canal*. Here is another dramatic example of the ignorance of history and a certain arrogance on the part of the engineers who prepared that plan, as will be seen in the following statement of facts.

Referring to Figure 16 and Figure 11, the Elahera-Minneriya-Kantalai canal was restored in modern times, on a crude hydraulic engineering basis, doing great damage to its original water and soil conservation ecosystems basis. Aqueduct crossings were constructed for the channel that did not harness the waters of the cross drainage streams. (Brohier, 1941). (The Herati oya crossing road bridge alongside the aqueduct crossing, for example, has some five spans indicating the huge volume of water that runs to waste under it).

The ancient Elahera canal thus became just another hydraulic engineering structure merely delivering water from the Amban ganga source to Minneriya and Giritale reservoirs at its ends. However, about ten years after this construction, all the aqueduct crossing structures were demolished and replaced by level-crossings as in ancient times. However, the ancient rock-cut spills and sluices had all been virtually destroyed when the hydraulic engineering restoration of Elahera-Minneriya canal been done. Later, extension from Minneriya weva was also truncated without rhyme or reason, from Gal oya, to augment the ancient Kantalai reservoir, under a project described as the *Kantalai Augmentation scheme*. (Figure 11). This description was suggestive of an application of the 4th stage in the four stage hypothesis for the evolution and development of the ancient systems, as shown in Figure 2.

- At this point, it may be repeated that irrigation is only one function of the ancient water and soil conservation ecosystems. But, so also were flood control, drainage, and soil conservation, for example, so that the term *ancient irrigation systems* is inappropriate and can be misleading - Some features of the evolution and development of these *water and soil conservation ecosystems* will now be presented using the example of the Elahera - Minneriya - Kantalai ecosystem.

When King Vasabha (65-109), built the Elahera anicut in the first century, some perennial river flow in the Amban ganga was diverted into Elahera canal for irrigated agriculture in the valley between the Konduruweva and Sudukande ranges. The Elahera - Minneriya canal is a contour channel with a single embankment on the eastern side, originally designed to also capture and divert water from the cross drainage streams rising in the Konduruweva range of hills in the west during the NE monsoon season. The excess flow was allowed to escape over channel spills built in the natural rock at appropriate points on the canal, as vividly described by the intrepid British surveyors Adams, Churchill and Bailey (Brohier, 1934, I, pp. 28-33). The Surveyors' Report was seen by the Governor of Ceylon, Sir Henry Ward, who then inspected the site himself and incorporated the Surveyors' report in his inspection Minutes. (Ceylon Almanac, 1857, reproduced in Brohier, 1934).

After a few centuries of this diversion irrigation system, Minneriya weva and also Giritale weva, were built at its tail end, by King Mahasena (276 – 303). At this stage the system was comparable to the better known Kalaweva - Jayaganga built later, but with one difference - there was no reservoir at its head end. There was still excess of water at the tail end Minneriya weva, and the Minneriya - Kantalai extension was therefore built. The extended system functioned like the Elahera - Minneriya canal, as a water and soil conservation ecosystem. Thereafter it must have been observed that there was still excess of water at the tail end of the Minneriya -Kantalai canal, which was why Kantalai weva was built at its tail end, three centuries later, and channels were built to reach the sea from this last great reservoir.

This system functioned for five centuries more amid various vicissitudes, including invasions and internal strife, until Parakrama Bahu I (1153-1186) unified the country, and consolidated the existing water and soil conservation ecosystems. He raised the original Elahera anicut and strengthened the channel bund to form Parakrama Sagara, the second Sea of Parakrama or Kottabadhdhanijjara, (translated by Geiger as a weir furnished with a reservoir, or a reservoir whose flood-escape was walled up), between the Konduruweva range and the Elahera canal. This must rank

as one of the greatest feats of hydraulic engineering in our history, equaling if not surpassing even the epic Kalaweva - Jayaganga ecosystem built some centuries earlier.

The Sea of Parakrama was not really one great reservoir, but a '*series of lagoons'* as the British Surveyors had described it. (Brohier, 1934, I, p. 28). This was because there is a drop in elevation of about 60 feet from Elahera to Minneriya, and the streams that spring from the Konduruweva range of hills met the Elahera – Minneriya channel at different, decreasing levels. The lagoons were joined by short lengths of channel in which the incremental difference in elevation was accommodated in ancient times by means of canal locks to permit water transport. Evidence of this is still available in the form of new shoots growing from the ancient *Orubenda Siyambalagaha* - literally, the '*tamarind tree on which the boats were moored'* (Ibid, 28). Dr Needham was very interested to know whether there was any evidence of locks on canals to facilitate canal transport in ancient Sri Lanka, as in China. I am ashamed to say that I had not recalled this evidence at the time that I worked under him at the Needham Research Institute.

This background of our cultural and economic heritage is unknown to those who have dismissed all this on account of a misguided sense of their own cleverness. These foolish engineers may be reminded what Henry Parker a British engineer who served in Ceylon from 1870 to 1901, wrote:

> *"If we rashly think, after a mere glance at the site (in comparison, on the other hand, with the actual practical experience of the Sinhalese for nearly 1000 years), that we can change all that, and effect untold improvements on the general designs of the ancient works we may find, when too late, that they were right and we are wrong. Experience constantly impressed on me that if there was one subject which these wonderful old engineers understood better than another, it certainly was the irrigation of paddy fields, and the designing, at least in outline, of the great structures which were needed for the purpose".* (Brohier 1934, I, p. 27)

There is no better example of what Parker has called "rash thinking" than the proposed *Moragahakande reservoir and NCP canal*, which has been launched on January 25, 2007. It is a meaningless alternative to the ancient river diversion cum reservoir ecosystem, built in stages in the Amban ganga region over a period of nearly eleven centuries, starting 20 centuries ago in the 1st century, as described. It should also be mentioned that there is a belief amongst some not so well informed people that the *Moragahakande reservoir and NCP canal* will transfer Mahaweli water to northern areas, even up to the semi-arid Jaffna peninsula. As a result, anyone who opposes this project may be accused of not wanting *"good Sinhala water to go to Tamil areas"*. (Mendis, 2002, p. 187) But it should be realized that even if water is not the limiting resource, this would involve lifting and pumping and create an unnecessary and unmanageable situation of sharing water in northern areas, when a far better alternative is available. This is the proposal called **A River for Jaffna - the Arumugam Plan**, already partly implemented. (Figure 17) which is not presented at this symposium.

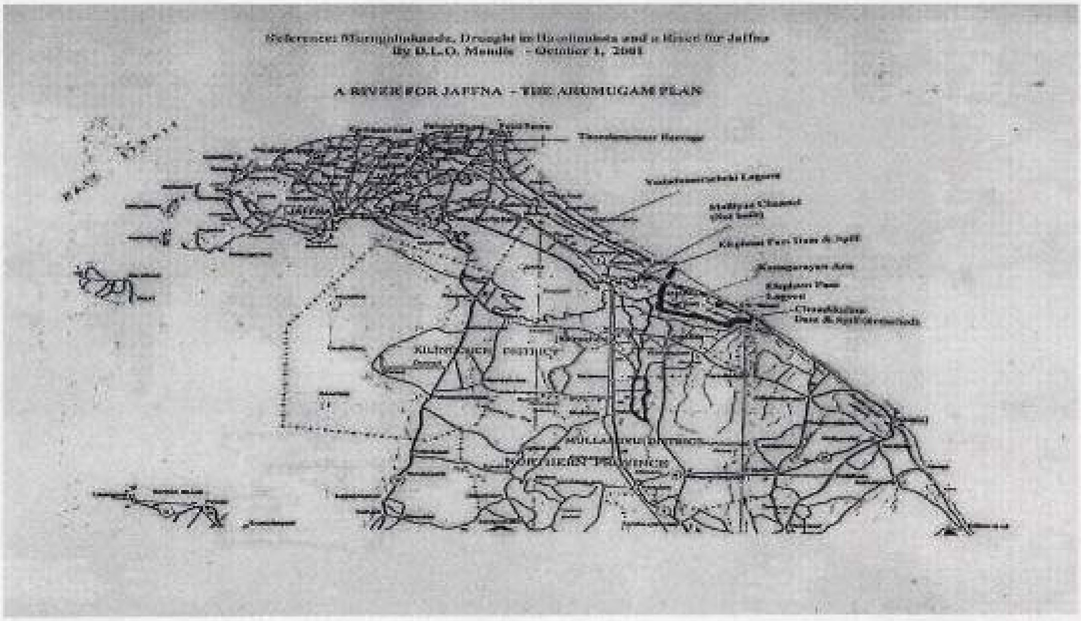


Figure 17

CONCLUSION

It is appropriate to conclude this paper with a reference to the truly arid lands of west Asia where water conservation has been practiced with a deep understanding of nature in accordance with Islamic law from ancient times. The following quotation is from the website islamonline.com.

WATER AND ISLAMIC LAW

The harsh desert climate of Arabia, the Near East, and Saharan North Africa makes water a highly valuable and precious resource. Islamic Law, the Shari`ah, goes into great detail on the subject of water to ensure the fair and equitable distribution of water within the community.

The word *Shari`ah* itself is closely related to water. It is included in early Arab dictionaries and originally meant "the place from which one descends to water." Before the advent of Islam in Arabia, the shari`ah was, in fact, a series of rules about water use: the *shir`at al-maa'* were the permits that gave right to drinking water. The term later was technically developed to include the body of laws and rules given by Allah. Water is a gift from God. It is one of the three things that every human is entitled to: grass (pasture for cattle), water, and fire. Water should be freely available to all, and any Muslim who withholds unneeded water sins against Allah: "No one can refuse surplus water without sinning against Allah and against man." The hadiths say that among the three people Allah will ignore on the Day of Resurrection there will be "the man who, having water in excess of his needs refuses it to a traveler."

There are two fundamental precepts that guide the rights to water in the Shari`ah: *shafa*, the right of thirst, establishes the universal right for humans to quench their thirst and that of their animals; *shirb*, the right of irrigation, gives all users the right to water their crops. The Qur'anic metaphors in which water is used to symbolize Paradise, righteousness, and Allah's mercy are quite frequent. From numerous Qur'anic references to cooling rivers, fresh rain, and fountains of flavored drinking water in Paradise, we can deduce that water is the essence of the gardens of Paradise. It flows beneath and through them, bringing coolness and greenery, and quenching thirst. The believers will be rewarded for their piety by (rivers of unstagnant water; and rivers of milk unchanging in taste, and rivers of wine, delicious to the drinkers, and rivers of honey purified) (Muhammad 47:16). The water in Paradise is never stagnant; it flows, rushes, unlike the festering waters of Hell. The Qur'an also equates the waters of Paradise with moral uprightness: (In the garden is no idle talk; there is a gushing fountain) (Al-Ghashiyah 88:11-12).

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