

HISTORICAL PERSPECTIVE - THE ANCIENT WATER CONSERVATION ECOSYSTEMS OF SRI LANKA: A DISCUSSION OF SOME ENVIRONMENTAL ISSUES

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Introductory Background

The ancient irrigation works in Sri Lanka are well known as one of the wonders of the ancient world. They are of two basic types, namely, gravity fed river diversion systems, and storage reservoirs, most of these being in the dry zone.

The dry zone covers about two thirds of the island, with a wet zone covering the remainder as shown (Figure 1). Sometimes, a strip called the intermediate zone is also identified in between. In terms of topography the dry zone is largely a flat plain sloping from about 500 feet above sea level to near sea level. Local undulations also occur as well as occasional protrusions called rock knobs. The wet zone is mostly a south-central hill massif with comparatively sharp drops to the intermediate zone on the southern and southwestern sides. Ancient Sri Lanka had been divided into three separate administrative regions, Rajarata and Ruhunurata mainly in the dry zone, and Pihitirata in the wet zone. (Figure 1)

The essential components of the river diversion systems are the diversion structure itself, called an *amuna*, *tekkam* or anicut, and a diversion channel. Other ancillary structures came to be built along the channels, namely weirs and spillways, and a head sluice and silt reach, but these were constructed later, and the first diversion channels did not have them. Ancillary structures were built using dressed-stone, and were essentially iron age constructions, unlike the earliest river diversion channels which were probably begun in the stone age.

Storage reservoirs had been built in Sri Lanka after the invention of the sluice, somewhere around about 300 B.C. (Parker, 1909). In terms of size, small, medium and large reservoirs had been built from that time till about the 12th century. All true storage reservoirs are equipped with spillways and sluices. Contrary to popular misconception, construction of reservoirs did not follow a sequence according to size of structures. Small storage reservoirs, called village tanks, continued to be built throughout this long period, because they fulfilled a specific purpose and functioned in combination with the larger reservoirs, as the heart of the dry zone village in Sri Lanka. (Brohier, 1937, Iriyagolla, 1981)

Small Tanks

The small village tanks had always been something of an enigma to irrigation engineers, and scholars, because of their large number. About 30,000 appear to have been built in an area of about 15,000 square miles in the dry zone of Sri Lanka, of which

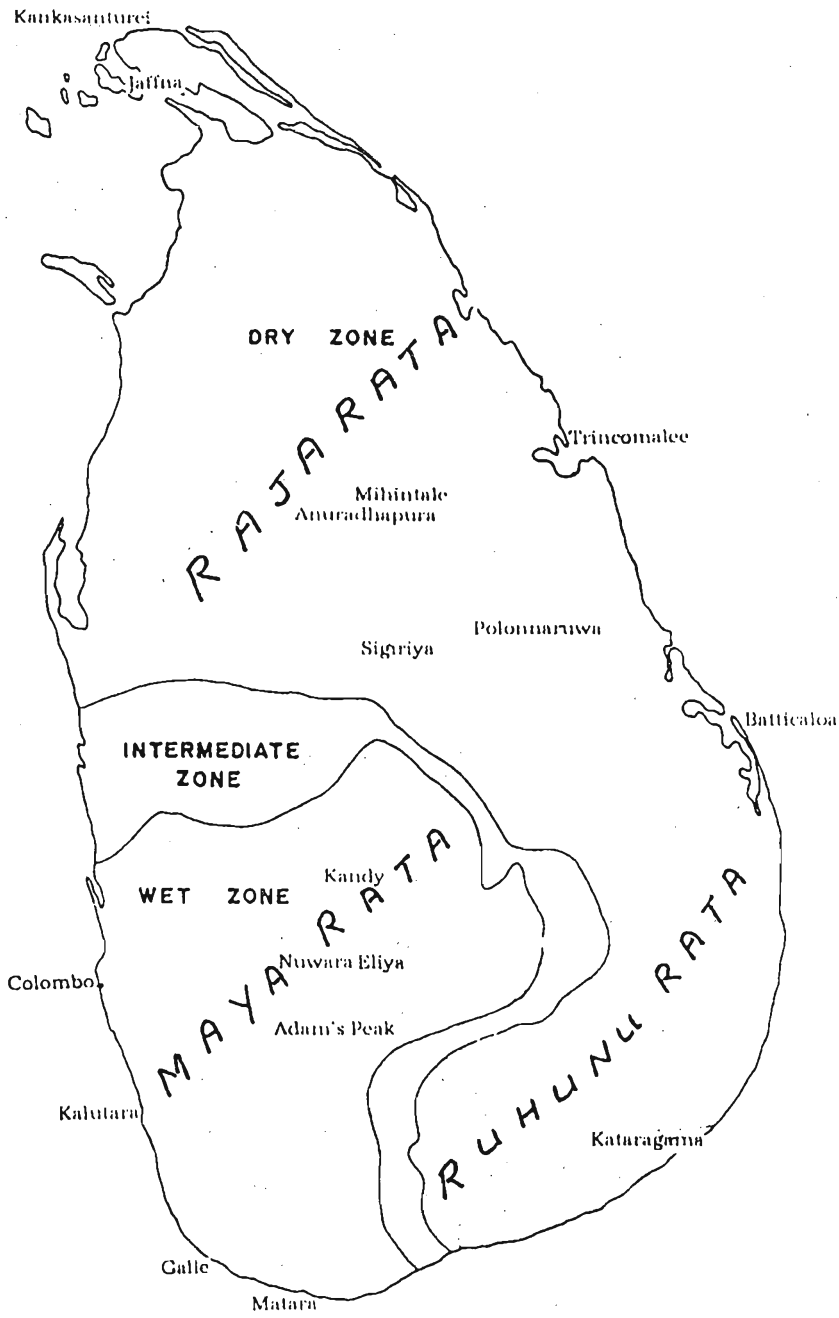


Figure 1: Rainfall and the major zones

about 17,000 are shown on the one mile to an inch topographical survey sheets, about 8000 described as 'working' and the rest as 'abandoned'.

However, not all the small 'tanks' shown as such on the one mile to an inch topographical survey sheet, were equipped with sluices (Figure 2). The Surveyor on the field would identify a man-made earth embankment in the jungle, and log it in his field book as a 'tank bund', and the Draughtsman in the Surveyor-General's office would plot it, add a chain-dotted line behind the bund and describe it as 'Tank -Abandoned'. The function of a small tank with a sluice was to store water for issue to fields lying in the impermeable soils, directly below. Without a sluice, the function of an earth embankment was to divert water - to be quickly absorbed in the pervious soils on the valley sides (Figure 3).

This is thus a method of water conservation, new to western trained irrigation engineers who still find it difficult to accommodate their minds to anything other than the conventional storage tank or reservoir commanding the low humic gley paddy soils in the valley bottoms. However, they must now distinguish between small tanks equipped with sluices, and those not so equipped, and give a lead on these lines to other scientists in future discussions and research studies on ancient irrigation or water conservation systems or ecosystems in Sri Lanka.

As discussed above it may now be asserted that many of these small tanks were in fact diversion structures. The Culavamsa, compiled starting in about the 5th century and continuing till about the 12th century, refers to *Dvadasasahassaka* and *Atthasahassaka* in the southern area of the ancient Ruhunarata, which have been interpreted as twelve thousand village settlements and eight thousand village settlements, respectively (Geiger, 1960, 11-12). Each settlement would have been synonymous with one or occasionally more than one, small village tank.

However, many of these tanks too would have been small diversion structures as shown in Figure 3. It should be noted that during the Maha rainy season water would pond up behind the earth bunds giving the appearance of small tanks.

It has been confirmed on the field that the bunds of by far the large majority of these small village 'tanks' in the southern area, were not equipped with sluices, and that they really were diversion structures or *amunas*, although made of earth and not stone (Figure 3). There also is evidence in the records of the Irrigation department, in the Hambantota division, that what are called Junction block or Village tank type sluices were introduced to some of these bunds, starting in the British colonial period and continued to this day, thereby changing their function. What had been a diversion structure whose function was to conserve water by diverting and spreading it through permeable soils in the valley shoulders, had been converted to a small storage reservoir which provided water directly to the low humic gley paddy soils in the valley bottoms.

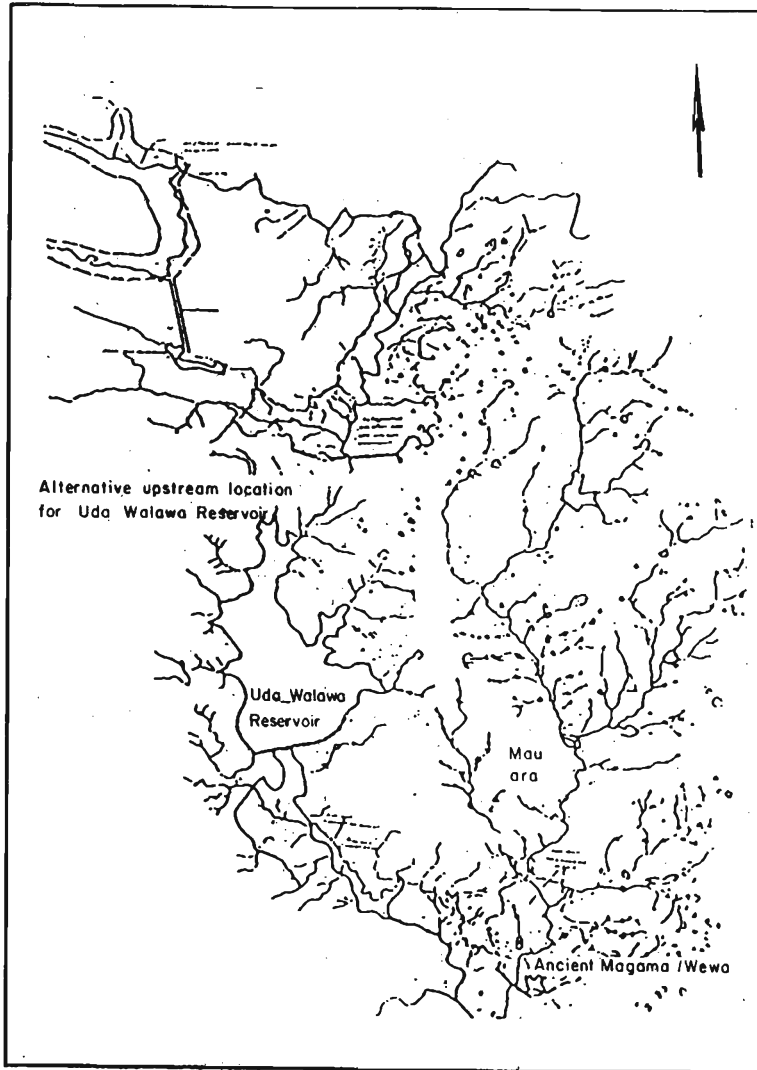


Figure 2: Walawe basin development -Ancient dispersed small-scale system vs modern centralised large-scale system.

In the former arrangement, on account of the shallow soils, the water seeped back into the valley bottoms for re-use in production of the rice crop. Other field crops, including both perennial tree crops and seasonals would have been cultivated on the permeable soils. This has been demonstrated, quite by chance, on a modern project for cultivation of other field crops in this area under the Integrated Rural Development Program. In the latter arrangement, the valley sides remain dry while all the water flows

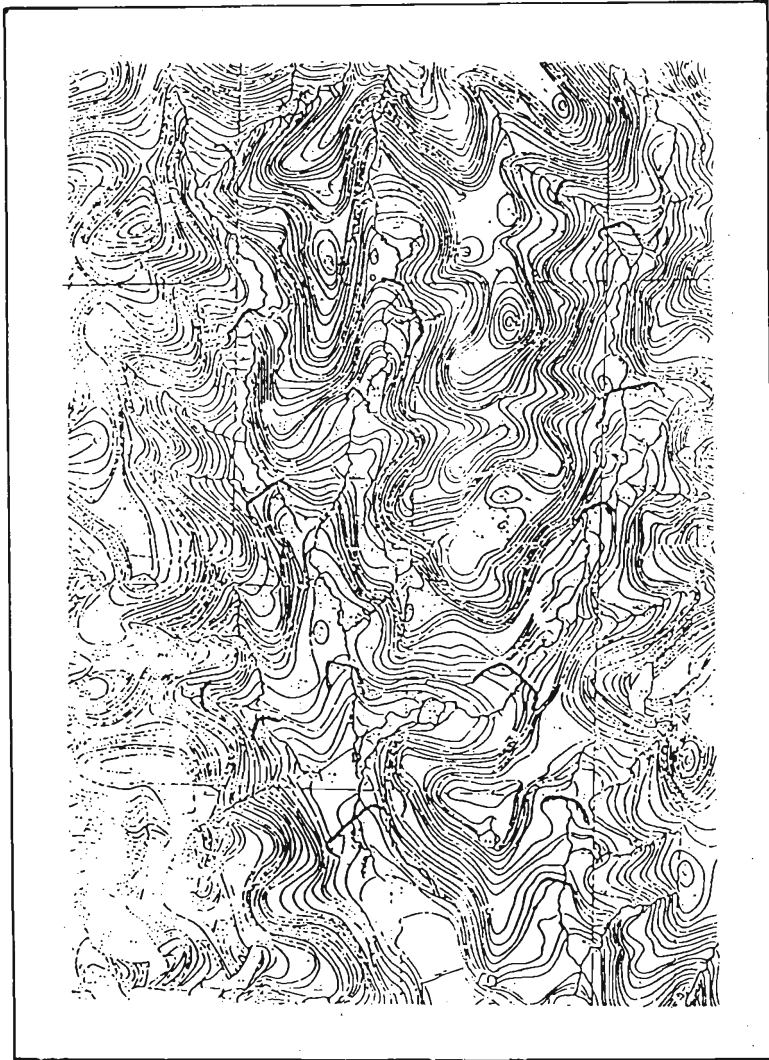


Figure 3: Detailed engineering surveys - Walawe left bank area showing ancient water conservation ecosystems (2 ft. contours)

along the valley bottoms. The ancient system is an extraordinary water conservation ecosystem, and is the first clue we have to explain the large numbers of small 'tanks' shown on topographical survey maps.

There are indications that this water conservation system or ecosystem was not confined to the southern area of Sri Lanka. Such an arrangement had existed for example in the present day System B area under the Mahaweli project. Large numbers of these earth bunds without sluices, built in echelon, have been found on the field there. Sadly, they are being levelled off and a system of channels

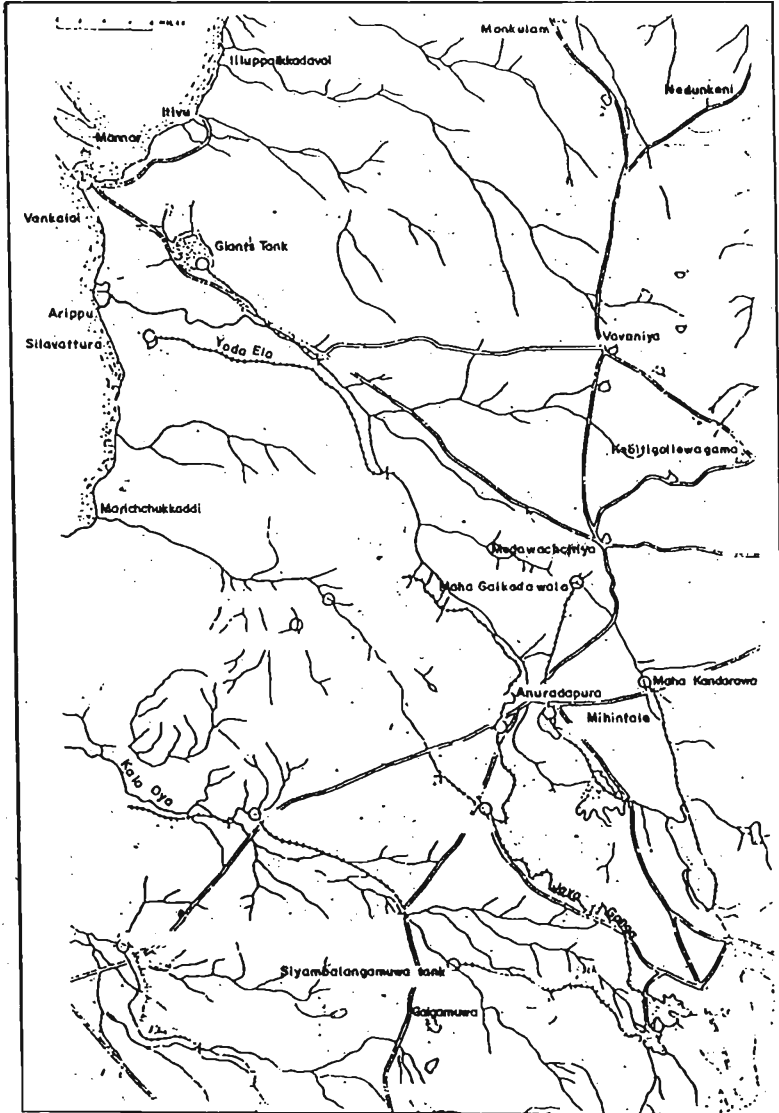


Figure 4: Macro irrigation ecosystems in Anuradhapura district.
 Source: Brohier, 1937 (*Jras Ceylon Branch*, Vol. XXXIV No. 90, p. 72).

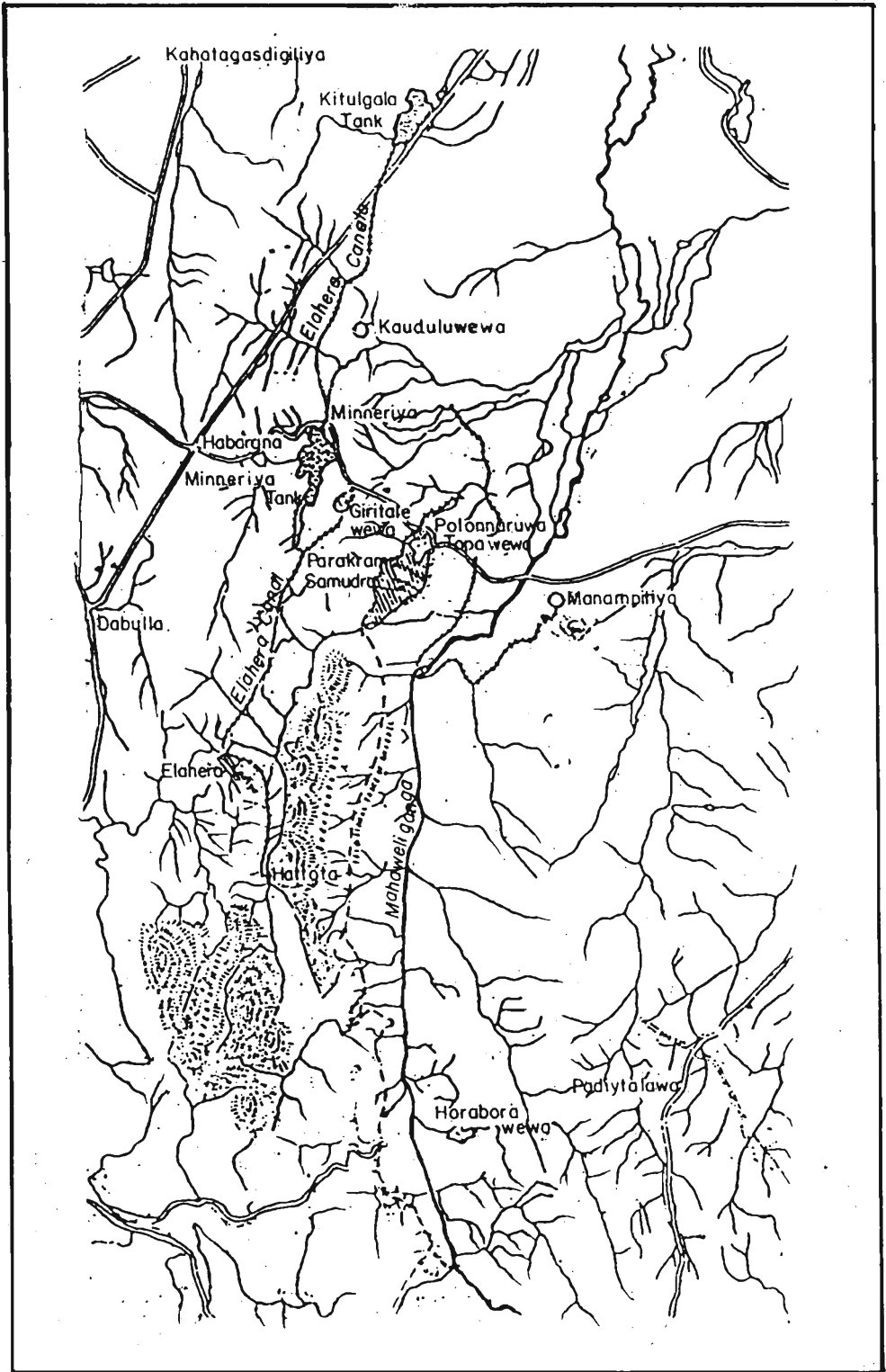


Figure 5

designed by foreign Consultants for the Mahaweli Authority of Sri Lanka, to carry water from a central source, is being built in the area instead (Cooke, 1983)

Large Reservoirs

In the ancient Rajarata, Brohier first established the fact that the large reservoirs were all inter-connected by means of large channels (Figures 4 and 5, from Brohier, 1937). This has been further elaborated and documented by Nicholas and Paronavitarana. (Figures 6 and 7, from Nicholas and Paronavitana, 1960). Brohier also showed how small tanks were dependent for water on the interconnected system of large reservoirs and channels, for example from the Kalaweva Jayaganga, which diverted water from the Kala oya to the Malwatu oya:

The Jayaganga, indeed an ingenious monument of ancient irrigation which was undoubtedly designed as a combined irrigation and water supply channel, was not entirely dependent on its feeder reservoir, Kalaweva, for the water it carried. The length of the bund between Kalaweva and Anuradhapura intercepted all the drainage from the high ground to the east which otherwise could have run to waste. Thus the Jayaganga adapted itself to a wide field of irrigation by feeding the little village tanks in each subsidiary valley which lay below the bund. Not infrequently it fed a chain of small tanks down these valleys - the tank lower down receiving the overflow from the tank higher up in each chain. (Brohier, 1937, 7)

It should be noted that these small tanks that Brohier described may or may not have been equipped with sluices in ancient times, although those that have been restored in recent times are so equipped.

Leach made a similar observation concerning these small tanks, in his well-known essay "Hydraulic Society in Ceylon", which was a rejoinder to Wittfogel's theory that all ancient 'hydraulic civilizations' were based on 'oriental despotism':

Down to the end of the eighth century A.D. the capital was continuously at Anuradhapura and around this city there gradually developed a vast network of major hydraulic works (in Wittfogel's sense). This hydraulic system served two functions; it provided water for the capital and it provided a large region around the capital with a much more reliable source of irrigation water than that obtainable from the small scale village tanks alone. (Leach, 1959, 21)

But, Leach then went on to suggest that small tanks could function independently of the large reservoirs (*Ibid*, 23):

although the major irrigation works provided food for labourers as well as amenities for palaces, the hydraulic system was not of crucial economic significance for the society as a whole. When the central government was disrupted

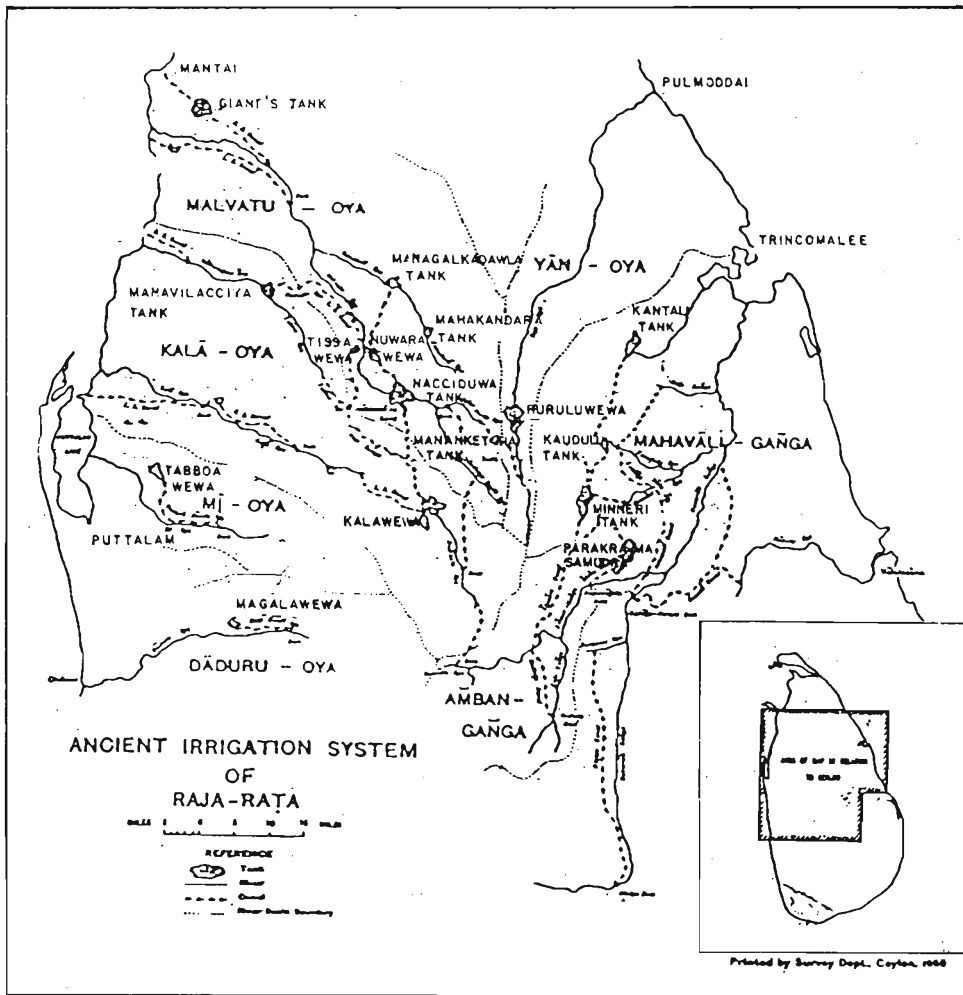


Figure 6
(Source: *A concise history of Ceylon*)

and the major works fell into disrepair, village life could carry on quite adequately; for each village still possessed its own small scale irrigation system which was maintained by the villagers themselves.

Next, a strange misconception reveals underlying ignorance of historical facts:

Ancient Sinhala was located exclusively in that part of the Northern Dry Zone of Ceylon which is now known as the North Central Province. (*Ibid*, 7)

'Exclusively' is the operative word which indicates confusion and ignorance. Finally, there is this extraordinary slander, quite surprising from a scholar of his stature, with first hand experience in the dry zone of Sri Lanka, which proves that Leach had no deep

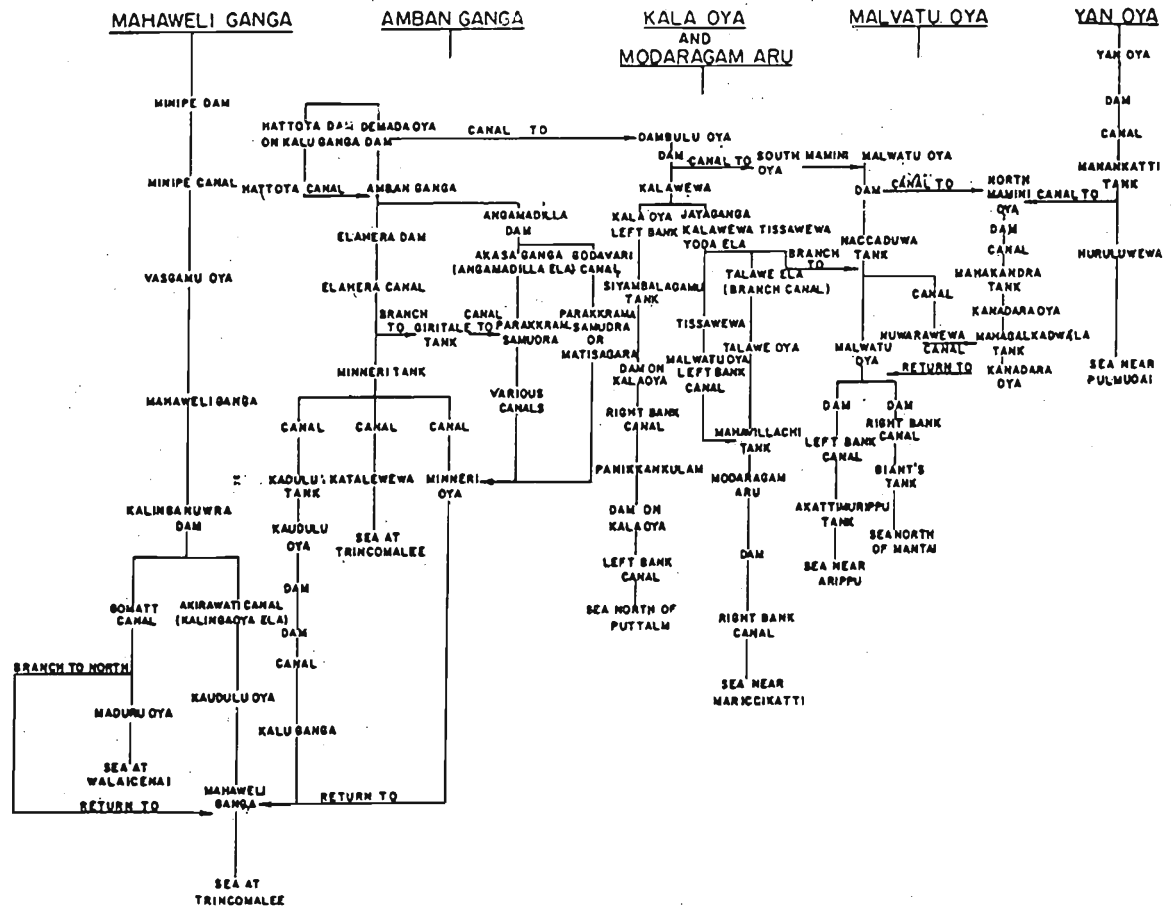


Figure 7: The inter-relationship of irrigation works (Source: A concise history of Ceylon)

knowledge about the functions of the ancient inter-connected systems of large reservoirs and channels in his 'Ancient Sinhala':

The major hydraulics works are not created rationally and systematically but haphazard as pieces of self advertisement by individual leaders. But once started, such constructions survive and can be enhanced by later adventurers of the same type. (*Ibid*, 24)

Neither Leach nor any of the other scholars who have studied the history of the ancient systems have realized that the clue to understanding them is to see them as water conservation systems and not as hydraulic systems. Even today, only a very few engineers and agriculturists are convinced about this, and it will take a while before it becomes accepted as common knowledge. This shows the importance of inter-disciplinary studies on the ancient so-called irrigation works, which should rather be known as the ancient water conservation ecosystems of Sri Lanka. A scheme for such an inter-disciplinary study has been prepared (Figure 8).

The principle difference in the two perceptions of the ancient systems can be stated in rather simple terms. In the hydraulic engineering perception, water is inanimate but active, exactly as in the study of hydraulics. In the ecosystems perception, water is animate but passive, as in the study of life sciences.

While Leach showed contempt for the builders of large reservoirs, some modern irrigation or hydraulic engineers have shown a deep-rooted contempt for small tanks, whether equipped with sluices or not. Trained primarily as hydraulic engineers, and quite ignorant of the life sciences, they always see water in terms of Bernoulli's theorem (which defines the energy component of water in terms of potential, kinetic and pressure energies), and never in terms of its function in bio-geo-chemical cycles, and in photosynthesis. An early example of this is the following statement from a Reconnaissance Report prepared in the Irrigation department in 1950 on the proposed Heda oya scheme, one of the large new reservoirs to be included in the *Water Resources Development Plan of Ceylon*:

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 realised 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.

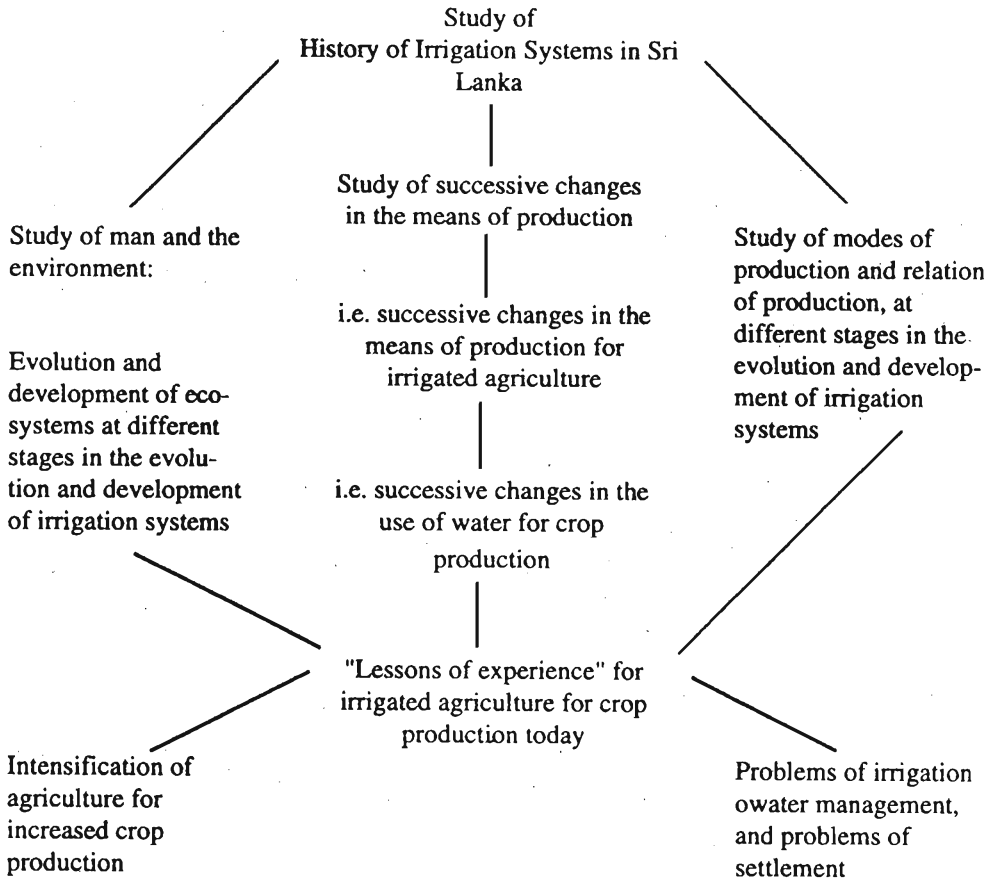


Figure 8

Source: Theory, Paradigm and Crisis in Understanding the History of Irrigation Systems in Sri Lanka, by D.L.O. Mendis.

Paper presented to the International Association of Historians of Asia, 11th Conference, Colombo, Sri Lanka. August 1988.

Contempt is shown in the scathing reference to 'little evaporating pans', and also in the withering statement that the age of the village pond has "passed away!" However, serious scholars like Joseph Needham are not so sure that the ancient systems can be dismissed in such cavalier fashion. Moreover, lessons of the past must be learned and used for crop production today by local scientists, not only foreign consultants, who must interest themselves in these ancient systems.

Some Engineering Features

Engineers and surveyors have long puzzled over the knowledge and skills that had been brought to bear for construction of the large reservoirs and channels. Comparisons have been made and will be made with modern constructions, for example in regard to the precision and accuracy known to exist in grades in the ancient channels, about which there has been much speculation. It can be shown, using only the information made available by historians, that the ancient channels were built earlier than the large reservoirs, and this simple fact to some extent de-mystifies some of the achievement of the ancient engineers.

Inter-connection of large reservoirs and channels was possible because channels were built earlier than reservoirs. Another very significant fact is that with just two possible exceptions, all large reservoirs were built away from perennial rivers, in what are called 'dry valleys', though this description should not be taken too literally. The two possible exceptions are the Parakkama sagara and the Parakkama talaka referred to in the Culavamsa which may have been constructed across the Amban ganga by Parakkama Bahu I, in the 12th century (Mendis, 1977).

There are features of the ancient systems however, which are so striking in their demonstration of scientific design that it is not easy to account for them in terms of empirical development. For example, the geologist Pattiarachchi said:

A striking fact that emerges is that the bunds of most irrigation tanks, large and small, follow the geological strike of the country rocks. The ancients were thus assured of the continuity of rock types for the foundations of the tank bund. The Giritale and Minneriya tanks in the Polonnaruwa area, the Sorabora weva on the right bank of the Mahaweli ganga, the Galgamuwa and Maha Usweva in the Galgamuwa area, the Karangahawela, Tungiriya weva, Mayalanwela weva on the left bank of the Mahaweli ganga, groups of tanks in the Dambulla and Kantalai areas, are good examples.....

The site of the ancient Hattota amuna, which is also the location of the restored amuna, is located where the beds strike mainly east-west and is the most favourable site available around for building an engineering structure across the Kalu ganga to impound a body of water.

Again, recent investigations done by engineers at a small village tank in the dry zone, Wandurapeenu weva, where the soil is mainly an expansive type of clay, montmorillonite, revealed that a non-expansive clay, kaolinite, had been brought to the site from far away and used to build the earth embankment of the tank. There must have been similar instances which are yet to be investigated: a great deal of scientific investigation has yet to be done on these ancient systems.

Many colonial engineers and administrators were interested in the ancient irrigation works, especially in British colonial times. To those who took the trouble to investigate their remains lying in the tangled jungles of the dry zone, the ancient irrigation works presented a spectacle comparable in scope to anything then known in the world of other ancient civilizations. Names like Emerson Tennent, Governors Henry Ward and William Gregory, and a number of others are examples of such men who have left records of their visits to ancient sites. Of the technical men, the name of Henry Parker is perhaps the best known.

In Colonial times most engineers preferred to be concerned, in the course of their official duties, with the large reservoirs and channels, many of them trans-basin channels, while Government Agents and lesser administrative officers were responsible for administering the smaller works, especially the small village tanks. This led at times to differences between engineers and administrators about the division of authority over the irrigation works, which is documented in administration reports and records. (For example, Woolf, 1961). [These differences persist to the present day, with an extra component of political input into the division of authority. Some modern irrigation and multi-purpose projects which are causing serious environmental damage cannot be scientifically re-assessed with a view to correction of some errors, for this reason].

The first occasion that the small village tanks made any significant impact on the official consciousness of the engineering fraternity was after the 1923 Medawachchiya railway disaster. A small village tank in the upper reaches of a chain of small tanks had breached after heavy monsoon rains. The resulting flood started a chain reaction of breaches of small tanks, ending with a breach of the railway embankment which caused much loss of life and damage to property.

The Irrigation department then launched a systematic study of the minor irrigation works as they were called, which reached fruition ten years later with a presentation at the Engineering Association of Ceylon by J.S.Kennedy, then a Deputy Director and later Director of Irrigation. His paper titled "Evolution of Scientific Development of Village Irrigation Works in Ceylon (Kennedy, 1934)" was later re-published and used as a Handbook in the Irrigation Department, until it was superceded by another publication by Arumugam (Arumugam, 1958). This in turn was superceded by Ponraja's Handbook on Design of Irrigation Headworks, and other monographs prepared in the eighties in the Irrigation department (Ponraja, 1981).

The Influence of Kennedy's 1933 Paper

Kennedy's paper was a landmark which was to be the basis for a hypothesis that, with hindsight, can perhaps be seen as an unintended misinterpretation of what he said. Beginning with the remark that "the small village tanks, like the village cattle are far too numerous for efficiency", Kennedy argued that:

There are many cases where the total yield of the catchment could be more efficiently and economically stored in one improved tank instead of in half a dozen or more, and used with scientifically guaranteed certainty of sufficiency for the irrigation of all the present fields, and of all beds of the superfluous tanks as well, if tradition would allow them to be turned into paddy fields. If tradition would not allow, a promising development project has to be reduced in its scope, to irrigate only the present fields, and such extension thereof as will not encroach on the territory occupied by the jealously preserved tanks. (Kennedy, 1934, 251)

This statement clearly refers to the small village tank equipped with a sluice to command the low humic gley soils in the valley bottom, and not to the small 'tank' without a sluice, described previously, which deflected water to the permeable soils on the valley shoulders (which had not been identified as such at the time). It was interpreted later by a majority of irrigation engineers to mean that the small village tank was a stage in the evolution and development of irrigation reservoirs. A corollary was that the small village tanks should be replaced by large reservoirs wherever possible, at some later date.

Kennedy also said that there were 'other conveniences' which are conferred on the village by the 'traditional preservation of redundant tanks':

Science must recognize of course, that the traditional preservation of redundant tanks is, at least in part, due to the other conveniences which they confer on the village besides that of efficient storage for irrigation. In any case, anything like highhanded interference in the traditional rights would be a calamitous blow to all hopes of cooperative progress. (Ibid, 251)

Kennedy was possibly referring to a practice of keeping some tanks inactive in a manner similar to letting some fields lie fallow. But there is no evidence that he thought differently from irrigation engineers who, trained in the science of hydraulics and hydraulic engineering alone, and being quite ignorant of the bio-sciences, never agreed that some of these small tanks had been built in echelon to conserve water and maintain the water table. All irrigation engineers assumed that the ancient small tanks, like the large reservoirs had been built to 'irrigate' the low humic gley soils in the valley bottoms for cultivation of paddy (rice). Their dominant influence carried over to other scientists as well. Social scientists like Leach, have discussed some 'other conveniences' from time to time but by and large irrigation engineers chose to ignore these other aspects of traditional village life in which the small village tank had a central place. Leach in a comprehensive documentation of traditional cultural practices in the dry zone villages, had highlighted the practice known as '*bethma*' (Leach, 1961).

This was a system of sharing the right to water so that each farmer got a fair proportion of the limiting resource water in times of drought. Irrigation engineers focussed their attention on hydraulic and hydrologic aspects that they understood, and concluded that since the small village tanks were 'inefficient' when viewed from such a

perspective, they should be replaced by more 'efficient' large reservoirs. It has been observed, not unfairly, that their arithmetic was correct, but little else besides.

New Settlement Schemes

It is not easy to establish such traditional practices in new settlement schemes originally based on restored ancient large reservoirs, which were designed on the basis that a settler is an independent (capitalist) entrepreneur. As a result, it has been found that a very few farmers were successful and became quite rich, while the majority became 'pauperized' (Shanmugaratnam and Dvroey, 1983)

In a comparatively recent study, Pfaffenberger has commented on this aspect of the modern settlement projects in the following terms:

The supposed causal relationship between gravity flow irrigation and socio-economic differentiation is, in the Sri Lanka case, illusory and deceptive. The appearance is created, and becomes convincing, only to the extent that observers adopt a highly restricted definition of technology, a technology that includes only the hardware of irrigation (such as dams, pumps, and canals). As scholars in the history of technology frequently argue, a more useful definition of technology would certainly include cultural values and social behaviour, which are, after all, vital to the operation and maintenance of a technical system.....

The question this article addresses, therefore, is not why Sri Lanka's modern irrigation technology creates socio-economic differentiation; on the contrary, the question is why the schemes' social design omitted the customs and behaviours that could have mitigated the differentiation process (Pfaffenberger, 1990, 364)

This observation is relevant in the context of the present discussion. Modern schemes based on new reservoirs, Uda Walawe and Lunuganvehera, as well as the Mahaweli scheme, are geared towards 'modernization' of agricultural production. Ultimately this means the introduction of agribusiness, a-la the western model, to the traditional sector which is known as the subsistence sector. The hydraulic engineering approach is only a part of that exercise. Other aspects include the contradictions of a centralized system vs. a dispersed system, competition vs. community interests, specialization vs. diversification, domination of nature vs. active harmony with nature, dependence vs. non-dependence, and exploitation vs. restraint (Beus and Dunlap, 1990). Consequently, introduction of agri-business in a developing country almost inevitably leads to environmental degradation of a type not associated with traditional agriculture. Beginning with introduction of hydraulic engineering principles, then, the door has been opened to adverse environmental impacts on these projects which need to be very closely monitored. (Fox, 1989, etc)

Brohier's Hypothesis (1956)

The Engineering Association of Ceylon where Kennedy had presented his paper in 1933, became the Institution of Engineers, Ceylon, after 50 years, in 1956, its Golden Jubilee year. R.L.Brohier, a Surveyor, happened to be President of the Engineering Association in that Jubilee year, since membership of the Association had been open to 'engineers and other professions'. (After transformation to the Institution of Engineers, membership was available only to qualified engineers).

Brohier had earlier been commissioned by D.S.Senanayake, Minister of Agriculture and Lands in the State Council to prepare a comprehensive documentation of the ancient irrigation works, published in 1934 in 3 volumes, which remain the best starting point for any serious study of the subject. However, it is apparent that as a member of the Engineering Association, Brohier had early come under the dominant influence of irrigation engineers, and been won over (no doubt against his better judgement) to their (erroneous) view that the small village tank was a "stage in the evolution of irrigation storage reservoirs".

In his Presidential Address titled "Some Structural Features of the Ancient Irrigation Works", Brohier presented a 4 stage hypothesis for the evolution and development of the ancient irrigation systems in Sri Lanka, which was no more than a statement of this prevailing view of members of the Engineering Association, based on a hydraulic engineering perspective:

1. Rain-water tanks from which water was baled out at leisure
2. Small village tanks
3. Large storage reservoirs submerging numbers of small village tanks
4. River diversion systems to augment the large storage reservoirs

Brohier had explained in his address what he meant by 'rain-water tanks' - they were not the small tanks without sluices described above which were an advanced stage of water conservation ecosystem: water was never 'baled out' at all, but gravitated into the permeable soils in the valley shoulders as was described. (Figure 3). Brohier however referred to just two small tanks which he said he had found in a wildlife sanctuary, which were examples of this stage of development.

In order to establish the fourth stage of this hypothesis, Brohier had to disagree with historians who said that the Elahera channel had been built in the reign of Vasabha in the first century. Brohier said that it had in fact been built after construction of Minneriya and Giritale tanks (which it supplies), in the third or fourth century. He further stated that the channel credited to Vasabha in the first century could not have been the Elahera channel, which he said required a much more advanced knowledge of engineering than was available in the first century. Engineers however disagree with that view, and agree with the historians that construction of the supply channel to the two

reservoirs, Minneriya and Giritale, pre-date the construction of the reservoirs themselves. Brohier's hypothesis thus reveals an inadequate knowledge of engineering, both theory and practice, as well as of history and pre-history.

In December 1957 catastrophic floods, unprecedented in living memory, were caused by the heaviest sustained rainfall ever recorded in all parts of the island in recent times. All the major ancient reservoirs that had been restored after Independence in 1948 were breached within the space of a few days in the festive Christmas season. Only the newly built gigantic Senanayake Samudra dam in the Gal oya valley, escaped - but barely. At this time all the beds of all the ancient reservoirs stood exposed to view - and there was no evidence whatsoever that small tanks had been submerged when they were built, but this significant fact which gave the lie to Brohier's hypothesis went unremarked at the time.

Later, in 1968, Dr Joseph Needham, F.R.S. visited Ceylon and did a tour of some ancient irrigation works in the dry zone, accompanied by Brohier and Professor Senarath Paranavitana, and others. Thereafter Needham devoted a dozen or so pages in Volume 4, Part 3 of his monumental work *Science and Civilization in China* to the ancient irrigation works in Ceylon, highlighting Brohier's hypothesis for their evolution and development in four stages. (Needham, 1971, 368-9) Professor Needham has since accepted that this needs revision and has invited this author to undertake the work, saying inter alia: 'my treatment of the subject can be improved upon, and I am counting on you to do it'. (Needham, 1989)

The Water Resources Development Plan of Ceylon (1957)

A map first described as the Proposed Development of Water Resources in Ceylon was published by the Survey Department in 1957, and republished in 1959 under the title *Water Resources Development Plan of Ceylon*. This map shows suitable sites for construction of large reservoirs in the major river basins, identified from an inspection of the 100 foot contours on the one mile to an inch topographical survey sheets. The capacity of each reservoir had been worked out on the basis of a within basin or single basin balance of water and land resources in each river basin (Figure 9). Available run-off had been calculated from river gaugings where available, or synthesised from rainfall figures where not available.

A glance at the ancient system of interconnected large reservoirs and channels (Figures 4 and 5) which Brohier himself had mapped, shows the existence of many transbasin diversion channels, built in ancient times. This Water Resources Development Plan, since it was based on the restricted evaluation of water and land within each river basin, was therefore a manifestly retrograde step in water resources development planning in this country. This has been pointed out since, but at the time the map was published it was not subject to any such criticism. It soon became the basis for future planning, design, financing and construction of major water resources development

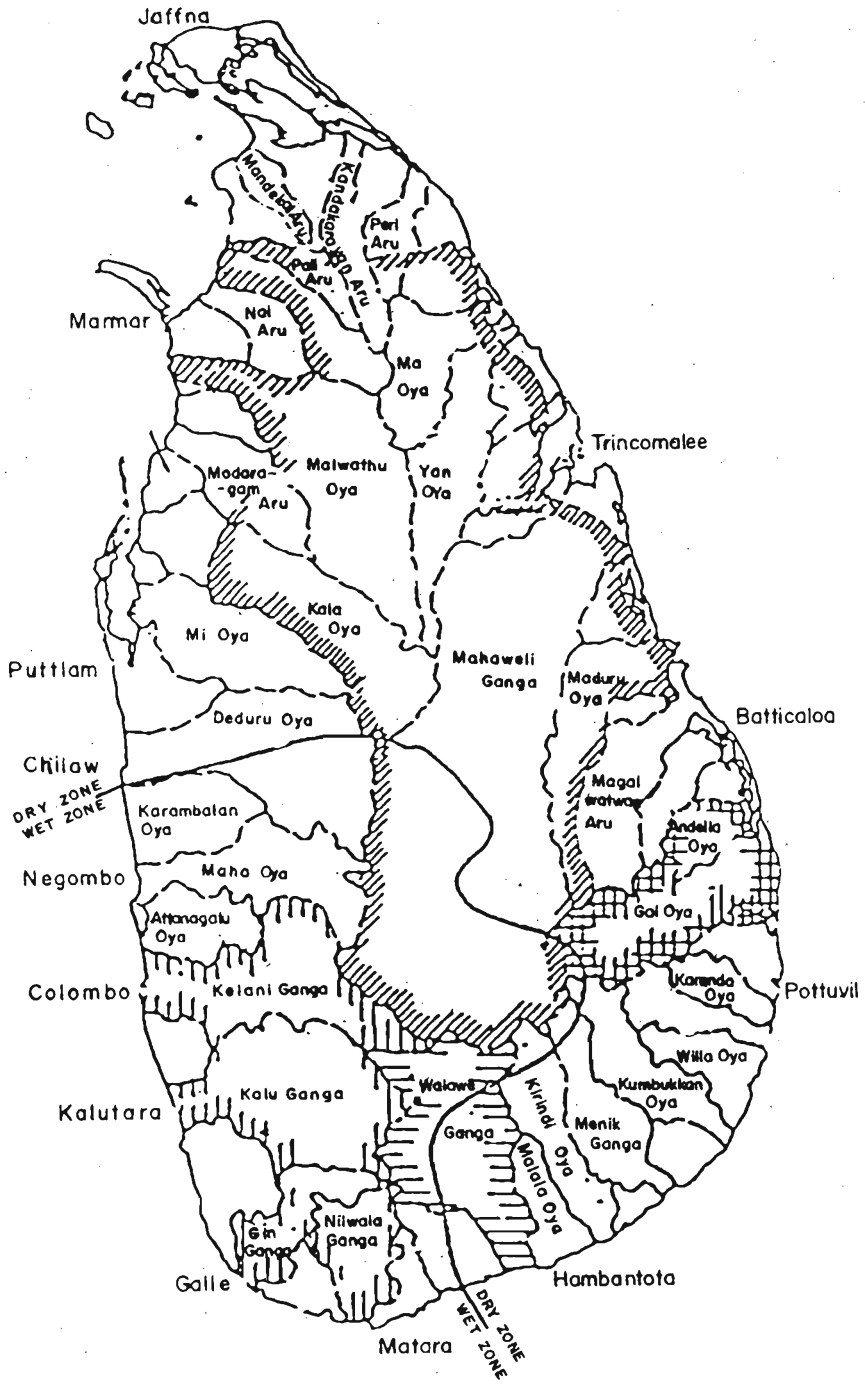


Figure 9: Major river basins

projects, usually described as irrigation and multi-purpose development projects in this country, and remains so today.

Another feature of this map is that in several instances proposed large storage reservoirs submerge large numbers of ancient small village tanks, thus conforming to the third stage of Brohier's (erroneous) hypothesis. Prominent examples are Uda Walawe and Lunuganvehera, the first major projects based on large reservoirs identified from this map to be taken up for implementation.

The 7 Stage Hypothesis for the Evolution and Development of Ancient Water Conservation Ecosystems

A 7 stage hypothesis was proposed in 1983 to replace the Brohier hypothesis:

1. Rain-fed agriculture
2. Seasonal or temporary river diversion irrigation, using sticks and stones to build temporary river diversion structures and assist the natural seasonal flooding of a river, for flood or inundation irrigation agriculture on river banks
3. Permanent river diversion irrigation, using permanent diversion structures made of stone or brick masonry, sited on good (rock) foundations
4. Construction of weirs and spillways on diversion contour channels, using technology similar to that necessary for construction of permanent river diversion structures
5. Invention of the sluice (*sorrowa*) with its access tower (*bisokotuwa*) based on the experience of operating weirs and spillways on contour channels
6. Construction of storage reservoirs incorporating the sluice for control and issue of irrigation water to the fields
7. Damming perennial rivers, either using a sluice for temporary river diversion during river closure, or by using the twin-tank method (Mendis, 1967, 25)

It has to be stressed that the sequential evolution and development of each successive stage was a cumulative process, since any stage did not replace or substitute for any previous stage but only complemented or supplemented what already existed. Finally, all seven stages co-existed together as is well known from the Sri Lanka experience until very recent times.

The seven stages in this hypothesis follow the natural logic of human experience, starting with rain-fed agriculture which heralded the neolithic revolution. Rain-fed agriculture is strictly not an irrigation system, but is the preceding stage to the first irrigation system which was based on the natural flooding of rivers.

Arising from this 7 stage hypothesis, it was possible to develop a concept of irrigation ecosystems, and to identify five examples of irrigation ecosystems that came into existence on account of the ancient irrigation works in Sri Lanka:

1. Inundation or flood irrigation ecosystems
2. Channel irrigation ecosystems
3. A micro irrigation ecosystem based on a small village tank
4. A macro irrigation ecosystem based on a large storage reservoir, with one or more micro irrigation ecosystems in its command area
5. A complex of macro irrigation ecosystems also described as a mega irrigation ecosystem of which the interconnected systems of large reservoirs and channels in the ancient Rajarata of Sri Lanka are the best examples (Brohier, 1937)

Using this concept it is possible to describe the ancient irrigation works of Sri Lanka, as being a composite of irrigation or water conservation ecosystems, and they have to be studied and understood accordingly.

Decline of the Ancient Systems

The three most important aspects of any study of the ancient irrigation or water conservation systems or ecosystems of Sri Lanka are:

- their evolution and development over a long period of time
- their sustainability over such a long period
- their final decline after about the 12th century

The superior attitude, illustrated above, of irrigation engineers towards the ancient irrigation systems, was largely due to lack of real knowledge concerning the final decline of these systems after the Parakkama Bahu era (1153-86). They therefore assumed that the decline of those systems was proof of their lack of stability and sustainability. From the hydraulic engineering perception, the small tanks were 'inefficient' and as there were so many small tanks and so few large reservoirs, *ipso facto*, the ancient systems had finally declined. Further, on account of the dominant role of the hydraulic engineers, this attitude had been adopted by other disciplines, so much so that anyone trying to give another interpretation to the ancient systems was liable to be dismissed as an ultra-nationalist trying 'to glorify the past'.

Since the hydraulic engineering analysis that small tanks were 'inefficient' was the explanation for the decline, Brohier's 4 stage hypothesis for the evolution and development of the ancient irrigation systems was also adapted to these pre-conceptions: small tanks had to be replaced by large reservoirs.

The 7 stage hypothesis gives a new framework within which to study the evolution and development of the ancient systems. Certain logical conclusions can be derived from this hypothesis, for example, that the large channel systems were built before the large reservoirs with which they are connected, which was mentioned previously. [Examples include the Elahera yodi ela built before the Minneriya weva and Giritale weva which Brohier said was built after to suit his hypothesis; the Minneriya-Kantalai yodi ela which

fed Kantalai tank, which has been 'restored' only from Gal oya and not from Minneriya in recent times; etc].

The sustainability of the ancient systems follows from the ecosystems perspective and requires little further elaboration. For example, the hundreds of so-called 'small tanks' in the Mau ara and Weli oya basins on the left bank of the Walawe ganga, were not fitted with irrigation sluices, but functioned as diversion structures for water conservation, giving the appearance of ponds during the rainy season. (Figure 3) They have been dismissed as 'little evaporating ponds' by modern hydraulic engineers, and probably inspired Brohier to propound his hypothesis that small tanks were a stage in the evolution and development of irrigation systems and should therefore be replaced by large reservoirs. (Brohier, 1934, 18).

What then were the causes for the decline of the ancient systems after the 12th century? This issue has been discussed by scholars who have come up with a variety of causes, including the following (Indrapala, 1971):

Foreign invasions

Inter-necine strife

Occupation of the heartland of the ancient irrigation systems by foreign invaders for extended periods of time

Elimination of the Kulinas, the class of people responsible for maintenance of the irrigation systems

The advent of malaria

Prolonged cyclonic rainfall

Earthquakes

Collapse of foreign trade

To this list of causes may be added:

the impact of hydraulic engineering after the Parakkama Bahu era

It should be added that the final decline must have occurred when the tropical jungle over-ran the man-made water conservation ecosystems. Tennent has surmised that there must be a critical mass of population (presumably in both quantity or numbers of people, and quality or skills of people) to withstand the threatened inroads of the jungle:

The ruin of a reservoir when neglected and permitted to fall into decay was speedy and inevitable; and as the destruction of the village tank involved the flight of all dependent on it, the water once permitted to escape, carried pestilence and miasma over the plains they had previously covered with plenty. After such a calamity any partial return of the villagers, even where it was not prevented by the dread of malaria, would have been impracticable; for the obvious reason, that where the whole combined labour of the community was not more than sufficient to carry on the work of conservancy and cultivation,

the diminished force of the few would have been utterly unavailing, either to effect the reparation of the watercourse or to restore the system on which the culture of rice depends. Thus the process of decay, instead of a gradual decline as in other countries, became a sudden and utter desolation in Ceylon.

It has to be added that the final manifestation of collapse of the systems would have been break-down of the socio-political system, the equivalent of the Rule of Law in those times.

Whereas the ancient systems had flourished for centuries, generating considerable economic surpluses, before their final decline after the 12th century, modern irrigation systems designed on hydraulic engineering principles, without exception, have shown ecological and economic stress from a very early stage. This makes it imperative that the old systems be re-examined without prejudice, so that any useful lessons learned could be applied on modern schemes.

Conclusion

The history of the ancient irrigation systems has been mis-interpreted on account of prejudice arising from an assumption that their decline after about the 12th century had been due to intrinsic deficiencies in their design and construction. This misconception was due to irrigation engineers, who being ignorant of the life sciences and the social sciences, had applied their hydraulic engineering 'hard technology' methods to re-design systems which in ancient times had in reality been water conservation ecosystems. On account of their dominant role in restoration of the ancient schemes, these hydraulic engineers have also misled other professionals and students of history into thinking on similar lines. The result has been something like the fable of the blind men feeling the elephant -each researcher has focussed on one aspect of the ancient systems, and come up with a misleading picture of the whole.

Next, these hydraulic engineers prepared a map they described as the Water Resources Development Plan of Ceylon, a long term development plan for the land and water resources of the country. In preparing this map they ignored all the features of the ancient water conservation ecosystems, except only the large reservoirs and channels which had already been restored in recent times. They tried to erase the smaller features of the ancient systems from their new development plans for Walawe, Mahaweli and Lunuganvehera projects for example, assuming that they were liabilities rather than recognizing them as assets.

The results have been disastrous. Serious problems and conflicts have arisen, especially in the Walawe and Lunuganvehera projects in the southern area that can be explained in terms of environmental degradation (Mendis, 1991, Mendis, 1992). Solutions to these problems have been proposed from the water conservation ecosystems 'soft technology' perspective (Mendis, 1990, Mendis, 1993)). At the present time,

however, the hydraulic engineering perception is still dominant, and 'hard technology' technical fixes are being investigated to solve these problems. An example is the proposal to divert the Menik ganga to augment the Lunuganvehera weva, on the assumption that the problems in that scheme are due only to a shortage of water. The question of the wrong location of the reservoir, so far down in the Kirindi oya basin, is not faced. It is taken for granted with a sort of karmic resignation by high level decision makers who appear to be able to follow the initiatives only of foreign Research Institutes and aid givers.

In these depressing circumstances there is little prospect of achieving a stable and sustainable lifestyle for the large majority of poor peasants engaged in subsistence agriculture in the southern area, who face impoverishment. The only alternative presently favoured by some policy makers is the establishment of agri-business transferred *en masse* from the west, and employment of some of these almost destitute peasants as agricultural wage labour. While achieving short term benefits this will result in total destruction of fragile natural ecosystems in these humid tropical regions in the longer term, apart from further increasing social differentiation in the area, which is an ever present cause of tension and conflict. A similar experience may lie ahead in Mahaweli Systems B and C which, unlike System H, are not based on ancient water conservation ecosystems.

References

- Arumugam, S (1958) Village Irrigation Works, in Transactions of the Institution of Engineers, Ceylon.
- Beus, Curtis E, and Riley E. Dunlap (1990) Conventional vs. Alternative Agriculture: the Paradigmatic Roots of the Debate, in *Rural Sociology*, Vol 55, No 4, 590-616.
- Brohier R.L. (1934) *Ancient Irrigation Works in Ceylon*, Ceylon Government Press.
- Brohier R.L. (1937) Inter-relation of Groups of Ancient Reservoirs and Channels in Ceylon, in *Journal of the Royal Asiatic Society, Ceylon Branch*, Vol 90.
- Brohier, R.L. (1956) Some Structural Features of the Ancient Irrigation Works in Ceylon, Presidential Address, Engineering Association of Ceylon, 1956.
- Cooke, R.S. (1983) Accelerated Mahaweli Development Programme: Discussions on paper in Transactions of the Institution of Engineers, Sri Lanka, 1983, page 172.
- Dvroey, Michael and N.Shanmugaratnam (1984) Peasant Resettlement in Sri Lanka, Tricontinental.
- Fox, Michael W (1986) *Agricide, the Hidden Crisis that Affects Us All*, Schocken Books, New York.

- Geiger, Wilhelm (1953) Translation of the Culavamsa, Ceylon Government Information Department.
- Geiger, Wilhelm (1960) Culture of Ceylon in Medieval Times, Otto Harrossowitz, Weisbaden.
- Goude, Andrew (1982) *The Human Impact, Man's Role in Environmental Change*, MIT Press.
- Indrapala, K (1971) Ed. The Collapse of the Rajarata Civilization and the Drift to the Southwest, Ceylon Studies Seminar.
- Iriyagolla, Gamini (1978) The Truth about the Mahaweli,
- Kahawita, R (1950) Reconnaissance Report on Proposed Heda oya Reservoir, Irrigation department, Colombo (unpublished).
- Kennedy, J.S. (1934) Evolution of Scientific Development of Village Irrigation Works in Ceylon, in *Proceedings of the Engineering Association of Ceylon, 1934*.
- Leach, E.R. (1959) Hydraulic Society in Ceylon, in *Past and Present*, April 1959.
- Leach, E.R. (1961) *Pul Eliya - A Village in the Dry Zone of Ceylon*, Cambridge University Press.
- Mendis, D.L.O. (1967) Planning by Network for Construction of Uda Walawe Headworks, in *Transactions of the Institution of Engineers, Ceylon, 1967*.
- Mendis, D.L.O. (1968) Some Observations on the Designs for Uda Walawe headworks, in *Transactions of the Institution of Engineers, Ceylon, 1968*.
- Mendis, D.L.O. (1977) Some Thoughts on Technology Transfer for Irrigation and Multi-purpose Development Projects in Sri Lanka, in *Transactions of the Institution of Engineers, Sri Lanka, 1977*.
- Mendis, D.L.O. (1990) Lessons from Sri Lanka's Ancient Irrigation Ecosystems, in *Proceedings of the 14th Congress of the International Commission on Irrigation and Drainage*, New Delhi.
- Mendis, D.L.O. (1991) Non-ethnic Causes of Violent Conflict in Sri Lanka: Environmental Degradation on Account of Destruction of Ancient Irrigation Ecosystems by the Impact of Hydraulic Engineering, in *Proceedings of the 41st Pugwash Conference on Science and World Affairs*.
- Mendis, D.L.O. (1992) Environmental Degradation: Little Known Cause of Violent Conflict in Sri Lanka, in *Proceedings of the 42nd Pugwash Conference on Science and World Affairs* (in the Press).

- Mendis, D.L.O. (1993) A Regional Water Management Strategy: the Proposed Southern Area Plan in Sri Lanka, *Proceedings of the 15th Congress of the International Commission on Irrigation and Drainage*, New Delhi (forthcoming)
- Nicholas C.W. and Paranavitana S. (1961) *A Concise History of Ceylon*, University of Ceylon Press.
- Needham, Joseph (1989) Personal communication, 12 May 1989.
- Needham, Joseph, Wang Ling and Lu Gwei Djin (1971) *Science and Civilization in China*, Vol. 4, part 3, Section 28f, Conclusions and Comparisons, pages 365-378.
- Odum, Eugene P (1989) *Ecology and our Endangered Life-support Systems*, Sinauer Associates Inc. Sunderland, Massachusetts.
- Parker, Henry (1909) *Ancient Ceylon*, Lusacs, London.
- Pattiarachchi, B (1956) Some Aspects of Engineering Geology in Ceylon, Presidential Address, Section D, Sri Lanka Association for the Advancement of Science.
- Pfaffenberger, Bryan, (1990) The Harsh Facts of Hydraulics: Technology and Society in Sri Lanka's Colonization Schemes. *Technology and Culture*, July 1990.
- Ponrajah A.J.P. (1988) *Handbook for the Design of Headworks*. Irrigation Department, Colombo.
- Tennent, E (1934) *Ceylon*, in 2 volumes, quoted in Brohier, R.L.
- Wittfogel, Karl (1957) *Oriental Despotism*, Yale University Press, New Haven.
- Woolf, Leonard (1961) *Hambantota Diaries*, Tissara Prakasakayo.