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TITLE : Ancient Water and Soil Conservation Ecosystems of Sri Lanka – Some Aspects

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Preamble: It is an honour and privilege to have been invited by Shri Bhavanishankar Benkipur, President of the Sahayoga Foundation, to present a paper and participate in the National Seminar on Water and Culture, at Hampi University, 25 – 27 June 2007. I know that Sahayoga Foundation is doing good work to bring traditional knowledge from the practioners of ancient systems, to the attention of others, and I shall try to contribute also.

In the letter of invitation Shri Bhavanishankar said:
As you have worked in the field of water and culture and developed special knowledge in traditional methods of water management specially in tank systems and small water bodies that have been put to use since centuries in various parts of our country to serve the basic needs of the people specially in the rain fed areas, it is requested that you may kindly contribute a paper relating to above subject. The paper may deal with the design, operation and management of such water sources as practiced in the past and put to use by the community and many of them are still in service to bring out the specialties and features of those systems.
The objective is to collect at one place in the form of a monograph or a document that will be useful to those who are in the field of improved water management techniques in the current times to integrate the traditional wisdom with the modern scientific technology so that in the current conditions of fresh water stress that is being experienced due to population expansion, pollution and competing demands in various sectors of use, better water management practices may be developed for access to all with equity on a sustainable basis.

Accordingly I decided to present a paper on some aspects of the Ancient Water and Soil Conservation Ecosystems of Sri Lanka, better known as the ancient irrigation systems.

India or Bharath, and Sri Lanka formerly Ceylon, have much in common, in fact we have virtually identical history and culture. As is well known, Sri Lanka history and proto history have their origins in India, while much of Indian pre-history came from Persia. It is interesting in this connection that I met Shri Bhavanishankar, at a recent conference in Tehran, modern Iran, ancient Persia, where he first invited me to this National Seminar.

Sri Lanka history is well documented in ancient chronicles whose contents have been authenticated by contemporaneous rock inscriptions, and other sources like foreign sources. (University History of Ceylon, 1959). The great chronicle the *Mahavamsa* was compiled only in the 4th century of the Christian era, by a bhikkhu Mahanama, who drew from oral traditions and from earlier chronicles like the *Dhatuvamsa*, as well as from written records maintained by

Buddhist monks on ola (palm leaf) manuscripts dating back to the mid first millenium of the pre Christian era. The Mahavamsa originally written in Pali or Prakrit has been translated by many scholars. In the time of British rule a German scholar Wilhelm Geiger did a translation into German, which was rendered into English by a woman named Mabel Haynes Bode. More recently a translation into
English was done by a Sri Lanka scholar Dr Ananda Guruge.

There are western trained and western oriented Sri Lanka scholars who discount such sources, as the Mahavamsa. In fact, in my own research on the ancient irrigation systems I have met with what can be described as "Mahavamsa bashing", by some of these scholars who used to say that I was suffering from the "Mahavamsa syndrome", defined as glorifying the past without adequate scientific justification. Very recently a landmark study titled *Beyond the Seeing Eye, The Mahathupa of Anuradhapura, An Insight*, by a woman architect Shereen Amendra was ridiculed by such a scholar. (D L O Mendis Book review, Sunday Island newspaper April 1, 8 and 22). Apart from discounting the book this critic described the author as a "crackpot". Since this critic is well known in some Indian academic circles, this unfortunate controversy may appear sooner or later in India also. This opportunity is being taken to forewarn others about the background. That critic compared Amendra's work to that of the science fiction writer Von Danikken. He should have compared it to the discovery of what Jeremy Seabroook in a New Yorker magazine article described as an early computer used by the Greeks 2000 years ago, the remains of which had been found in a sunken ship a hundred or so years ago. (Seabrook, 2007)

Ancient irrigation systems in Sri Lanka

Ancient Sri Lanka had three administrative regions, Rajarata or kings' country, Ruhunurata and Mayarata (Fig. 1). R.L. Brohier (1937) showed that the ancient water and soil conservation ecosystems, or irrigation systems, in ancient Rajarata consisted of inter-connected large reservoirs and channels as discussed below. Historians tell us that in ancient Ruhunurata, there were *Dvadahassaka desa*, and *Aththahassaka rata*, the regions of twelve thousand villages, and eight thousand villages, respectively. Engineers do not as a rule know history, and there was no attempt to study and understand the grand design underlying the ancient systems, mentioned below. An incorrrect four stage hypothesis for the evolution and development of the ancient systems was announced by Brohier in 1956 and republished by Joseph Needham in his *Science and Civilization in China*, in 1976. (Fig.2). This was the basis for a map prepared by the Irrigation department in 1959, called the "Water Resources Development Plan, 1959" which ignored all but the very largest of the ancient irrigation works, and that too in a piece-meal manner. Many years later I was invited to work at the Needham Research Institute in Cambridge, as a visiting British Council scholar after Dr Needham graciously acknowledged "My treatment of the subject can be improved upon and I am counting on you to do it".

In the southern area, two large modern projects were taken up with large reservoirs selected from the Water Resources Development Plan, 1959, Uda Walawe in the Walawe ganga (river) basin (1965 – 67), and Lunuganvehera in the Kirindi oya (non-perennial river) basin (1978 – 1986). In these schemes, the grand design of the ancient irrigation systems in two interdependant parts, large-scale centralized systems, and dispersed small-scale systems was replaced by a single large-scale centralized system alone. Walawe is an outstanding example (Fig. 3). Environmental degradation in this region, and the origins of civil unrest in 1971 (Uda Walawe) and in the late 1980's, (Lunuganvehera) can be traced to the wrong location of these two gigantic reservoirs.

The situation will not change for the better with the mere passage of time, it will probably become worse.
Corresponding to the grand design of the storage systems, there was an ancient system of what Brohier described as the irrigation and distribution of water (Fig. 4) where there was group responsibility and water sharing. This was replaced on modern schemes with a system where there is only individual responsibility and competition for water (Fig. 5).
My own research into these systems has been substantiated by two jurists, Vice President of the World Court Judge C G Weeramantry in his *Separate Opinion* in the Danube dam case (Weeramantry, 200), and Supreme court Judge A R B Amerasinghe's judgement in the Eppawala phosphate rock Fundamental Rights case (Mendis, 1999, 2000a, 2000b).

Sustainable development

In the case concerning the Gabcikovo-Nagimaros project (Hungary / Slovakia), - the Danube dam case - 1997 General List No. 92, 25 September, 1997, before the International Court of Justice, the Vice-President of the Court, Judge C.G.Weeramantry, referred at length to the ancient irrigation works of Sri Lanka which, he said, "embodied the concept of development par excellence. " He said:

> *'Just as development was the aim of this system, it was accompanied by a systematic philosophy of conservation dating back to at least the 3rd century B.C.*
> *The ancient chronicles record that when the King (Devanampiya Tissa, 247-207 B.C.) was on a hunting trip (around 223 B.C.), the Arahat Mahinda, son of the Emperor Asoka of India, preached to him a sermon which converted the King. Here are excerpts from that sermon:*
> *"O great King, the birds of the air and the beasts have as equal a right to live and move about in any part of the land as thou.The land belongs to the people and all living beings; thou art only the guardian of it." ...*
> *The juxtaposition in this heritage of the concepts of development and environmental protection invites comment immediately from those familiar with it. Anyone interested in the human future would perceive the connection between the two concepts and the manner of their reconciliation. Not merely from the legal perspective does this become apparent, but even from the approaches of other disciplines. Thus Arthur C. Clarke, the noted futurist, with the vision that has enabled him to bring high science to the service of humanity, put his finger on the precise legal problem we are considering when he observed:*
> *'the small Indian Ocean island ... provides textbook examples of many modem dilemmas: 'development versus environment', and proceeds immediately to recapitulate the famous sermon, already referred to, relating to the trusteeship of land, observing, 'For as King Devanampiya Tissa was told three centuries before the birth of Christ, we are its guardians - not its owners.' The task of the law is to convert such wisdom into practical terms.*

The concept of sustainable development is a result of such recognition in engineering and in law. In a real world sense, examples of sustainable development are structures in use to this day that had been built long ago, like the ancient irrigation systems of Sri Lanka, and the qanats in Persia, called alfalaj in Oman, and so on. However, the very concept of sustainability is the subject of discussion, and the idea has been promoted that when there is sustainable development, Nature is not harmed. By an extension of this definition, it is argued that because Nature is being harmed in modern development projects the extended meaning of sustainability should be healing

Nature. Environmental Impact Assessment, (EIA) studies are meant to safeguard against such harm. But, projects that are directed towards healing Nature, may lead to confrontation with proponents of so-called development, or modernisation, especially money lending agencies, like the World Bank and the Asian Development Bank, and the World Trade Organisation which supports multi-national corporations. In fact Mahatma Gandhi's salt march was an early example of such confrontation. In a sense all our efforts are following in his footsteps.

More recently, attention has been focussed on agriculture as complimenting irrigation for sustainable development. Multi-tier polyculture has been popularised, and now some special techniques to grow fruits and vegetables in the limited space available for gardening in the urban household, such as by cultivating in pots and roof gardening.

Sustainable Water Infrastructure for the 21st Century in USA

The US Environmental Protection Agency, EPA, monitors water supply in that country. A website is available which gives information about the EPA. In January 2003, the Administrator of EPA convened a Forum – "Closing the Gap: Innovative Responses for Sustainable Water Infrastructure". At this Forum, the Assistant Administrator for Water highlighted the "Four Pillars of Sustainable Infrastructure" - Better Management, Full-Cost Pricing, Water Efficiency, and Watershed Approaches to Protection. A superficial study of these criteria shows that they are not really relevant to sustainable development that is needed in developing countries. Rather, they are the criteria relevant to those countries like the US described as developed world countries. For example, water has long been considered a basic human right in our culture, but this seems to be no longer valid when water is treated as a commodity according to the above description. This is where confrontation between the traditional and the so-called modern systems arises.

Such a confrontation was seen in a book titled Buddhism Betrayed? (Thambiah 1993).
A famous economist Dr Lal Jayewardena, one time Secretary to the Treasury and Secretary to the Ministry of Planning and Economic Affairs, said in a Foreword:

> "there was a harking back to an idealized village community assumed to characterize ancient Ceylon and constituting a valid model for Sri Lanka's modern development. The underlying form of Sinhala cultural identity comprised the weva (irrigation tank), dagaba (temple) and yaya (paddy field)"

Unfortunately, the book was banned, and it was not possible to expose the wrong implications of such false and potentially dangerous statements.

Sri Lanka history - Western Rajarata

Sri Lanka history has documented that the first capital city Anuradhapura in western Rajarata was established in the 4th century BC. The ancient water and soil conservation ecosystems of Rajarata were centred around the capital Anuradhapura. It was shown by R L Brohier, (1937), that all the ancient large reservoirs and channels in Rajarata were inter-connected. (Figs. 6, 7). The most notable of these in western Rajarata is the Kalaweva – Balaluweva - Jayaganga ecosystem or cultural landscape. Water from the large twin reservoirs, Kalaweva – Balaluweva is conveyed by the 54 ½ mile long contour channel, Jayaganga, to augment the Anuradhapura city tanks. A very large deposit of apatite, phosphate rock, was discovered at a place called Eppawala in the Kalaweva – Jayaganga ecosystem, described as a cultural landscape by archaeologists. In recent times, a proposal to exploit the Eppawala phosphate deposit to exhaustion by a US multinational corporation was stopped in the nick of time by local people assisted by

environmentalists in Colombo, who filed a Fundamental Human Rights case in the Supreme Court of Sri Lanka. (Mendis, 1999, 2000a. 2000b). The Eppawala area has one of the highest densities of chains or cascades of small tanks in the island (Fig. 8). The judgement in the Eppawala case is much cited in the field of environmental law.

Karl Wittfogel made a study of ancient societies and wrote a book *Oriental Despotism* to show that large water conservation systems came to be developed in China side by side with development of an extensive hydraulic bureaucracy. An engineer turned sociologist E R Leach studied the ancient irrigation systems and published his *Hydraulic Society in Ceylon* in 1959 to refute the Wittfogel thesis in as far as this country is concerned.
But Leach made some wrong statements in his essay. He said:

> *Ancient Sinhala was located exclusively in that part of the the dry Zone of Ceylon which is now known as the North Central Province.*

By using the word exclusively, Leach here refers to ancient Rajarata alone, which means that the village settlements in ancient Ruhunu, like Dvadasasahassaka (the region of twelve thousand villages), and Atthasahassaka (region of eight thousand villages) were unknown to him. Next, he gives a rather unusual statement about village tanks, perhaps overly impressed by the intensity of small tanks in Anuradhapura district (Fig. 8):

> *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 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.*

Finally, he makes a sweeping statement which shows total lack of awareness of the wonderful inter-relation of groups of large reservoirs and channels, in ancient Rajarata:

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

In this manner some colonialists denigrated the ancient water and soil conservation ecosystems which are an economic heritage as much as a cultural heritage. Sadly, some Sri Lanka scholars have followed in their style of ill-informed criticism of the ancient systems while promoting modern projects that are creating all sorts of problems. This has been seen in ancient Ruhunurata as described above, and will be repeated in the near future in a new project Moragahakande reservoir and Kaluganga that has been launched in eastern Rajarata.

But some foreign observers have understood the problem. For example Pfaffenburger:

> *The supposed causal relation between gravitiy 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 argue, a more useful definition of technology would certainly include cultural values and social behaviour, which are after all vital to the operation and mantenance of a technical system …… The question …… is not why Sri Lanka's modern irrigation technology creates socio-economic differen-tiation; on the contrary, the question is why the schemes*

social design omitted the customs and behaviours that could have mitigated the differentiation process.

There are other examples of colonial administrators who left records of their experiences in this country which are valuable sources of information for scholars today. A C Lawrie in his Annals of the Central Province (1896) has the following fascinating item:

SIRIMALWATTA - A village in Udagampaha korale, Lower Dumbara, about 2 miles from Kandy and half a mile on the north bank of the Mahaweli-ganga at the ferry formerly called Palugantota, now Lewella. Road on right to Hakketuwagala. It is bounded on the south by the Mahaweli-ganga, on the north by Gunnepana, on the west by LewelIa, and on the east by Degaldoruwa.

Tradition says that this was a royal flower garden made by King Dutugemunu (164 B.C.); that there was a street between the city of Anuradhapura and the flower garden, so thickly peopled that a basket of flowers picked in the morning passed from hand to hand and reached the city in time for the evening offering.

The capital city Anuradhapura is about a hundred miles as the crow flies, from the hill city now called the hill capital, Kandy, and the difference in elevation is about 1000 ft. Even today on full moon days it is a common sight to see devotees passing small baskets of flowers from hand to hand within temple premises, but this legend is something else!

Another example is from a famous British administrator, Sir James Emerson Tennant, who compiled several volumes which are rich source books for modern scholars. The following extract describes the northern Jaffna peninsula in the 19th century:

In the immediate vicinity of Point Pedro (and the description applies equally to the vicinity of Jaffna and the western division of the peninsular in general), the perfection of the village cultivation is truly remarkable; it is horticulture rather than agriculture, and reminds one of the market gardens of Fulham and Chelsea more forcibly than anything I have seen out of England. Almost every cottage has a garden attached to it, wherein are grown fruit-trees and flowers, the latter being grown in great quantities for decoration and offering in the temples. Each is situated in a well-secured enclosure, with one or more wells. From these, night and day, but chiefly during the night, labourers are employed for raising water by means of vessels (frequently woven of palm leaves) attached to horizontal levers; something like the sakkias used by the peasants on the Nile for a similar purpose, except that in Jaffna two persons at least are required for each well, one of whom walks back and forward along the lever; whilst the other below directs the bucket in its ascent and empties its contents into a reservoir; whence by removing a clod of earth with the foot, it is admitted into conducting channels, and led to the several beds in succession. The value of these wells is extreme in a country where rivers and even the smallest stream are unknown, and where cultivators are entirely dependent on the rains of two monsoons. But such has been the indefatigable industry of the people in providing them, that they may be said to have virtually added a third harvest to the year by the extent to which they have multiplied the means of irrigation around their principal towns and villages. (Tennant, 1858)

Eastern rajarata

Invasions from India caused the capital city to be moved from Anuradhapura in western Rajarata to Polonnaruwa in eastern Rajarata after the 8th century. There are indications of Indian cultural

influence in Polonnaruwa ruins, like the unfinished Demala Maha Seya that would have been the largest Buddhist stupa if it was completed, about 600 ft in diameter, compared to about 400 ft for the Jetavanarama the highest, and about 330 ft. for the Maha Thupa, the Ruvanweliseya, the most venerated to this day.

Climax of the Polonnaruwa period in history was the reign of Parakrama Bahu, (1153 – 86) who unified the country and created three gigantic "Seas of Parakrama". Of these, Parakrama samudra has been restored starting in colonial times, and Parakrama sagara had been discovered by British surveyors in 1855 and inspected by the Governor Sir Henry Ward. Ward's inspection Minutes were published in 1857, and republished by Brohier in 1934, but has been ignored by modern engineers (Brohier, 1934, I, 28 – 32).

In a seminar discussion on the decline of the Rajarata civilization and the drift to the southwest (Indrapala, 1971) causes for this decline, were identified, like internecine strife, invasions, abolition of a class of persons called kulinas responsible for operation and maintenance of the systems, salination and loss of soil fertility, and so on. Later, Prof. Sirima Kiribamune suggested another cause, namely decline of trade with the Vijayanagar empire, and this brings in Hampi which was the capital of Vijayanagar.

Eastern Rajarata has the longest river in Sri Lanka, the Mahaweliganga, and its main tributary Ambanganga. (Fig. 9). In the WW II years the Irrigation Department had created a simple hydraulic enginering project for diverting Amban ganga to Minneriya weva, with concrete aqueduct-cum-bridges over six non-perennial rivers that used to flow into the ancient contour channel, Elahera – Minneriya yoda ela, vandalising it, and with it the ancient Parakrama Sagara with its canal locks, never to be seen again.

Government demolished the concrete structures ten years later, but restoring the ancient Parakrama sagara was not even thought of because engineers do not read history. This incident was reminiscent of what a British engineer Henry Parker who worked in Ceylon from 1870 to about 1905, had warned, as stated in his book *Ancient Ceylon*, quoted in Brohier's *Ancient Irrigation Works in Ceylon*, Vol. I, page 27:

> *"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 1 000 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 those 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 that were needed for that purpose".*

One of the technical features of the ancient large reservoirs was the *sorowwa* or sluice with its *bisokotuwa* or access tower. Parker in his *Ancient Ceylon* (1909) described the ancient bisokotuwa as follows:

> *Since about the middle of the last century, open wells, called 'valve-towers' when they stand clear of the embank ment, and 'valve-pits' when they stand on it, have been built on numerous reservoirs in Europe. Their duty is to hold the valves, and the lifting gear for working them, by means of which the outward flow of the water is regulated or totally*

stopped. Such also was the function of the bisokotuwa of the Sinhalese engineers. They were the first inventors of the valve-pit, more than 2100 years ago. (Parker, 1909, 379)

Mahaweli ganga development

UNDP and FAO did a study project in mid 1960s for development of the Mahaweli ganga, and this so-called 'Master Plan' has been the basis for construction of a number of very large reservoirs for irrigation and hydro-power development. This Master Plan, following the Water Resources Development Plan, 1959, did not take adequate advantage of the ancient irrigation works, but imposed new large reservoir and channels on the map of Sri Lanka on the basis of hydraulic engineering theory, not the concept of ecosystems.

After the electoral victory of J R Jayewardene in 1977, the Accelerated Mahaweli Development project was started which all but destroyed what remained of ancient Parakrama Sagara, and numerous small tank systems. Today the last great new reservoir on the Mahaweli master plan has been launched, Moragahakande, and I have been trying to caution authorities against it, without success. But my criticism of the project was interpreted by a former head of the State Peace Secretariat as an attempt to prevent "good Sinhala water from going to Tamil areas", thus politicizing the issue to the lowest and crudest common denominator of ethnic strife. (Mendis, 2002, 147 – 172).

Conclusion

Some comparisons with traditional cultures in some other countries may be useful for general discussion and future reference at this conference. From amongst a number of such items available, the following selection has been made.

In Bali, Steven Lansing, in his book *Priests and Programmers* wrote:

The role of water in rice paddy ecosystems goes far beyond providing water to the roots of paddy plants. By controlling the flow of water into terraced fields, the farmers are able to create pulses in several important cycles. The cycle of wet and dry phases alters soil pH; induces a cycle of aerobic and anaerobic conditions in the soil that determines activity of micro-organ isms; circulates micro-nutrients; fosters the growth of nitrogen-fixing cyanobacteria; excludes weeds; stabilizes soil temperatures; and over the long term governs formation of a plough pan that prevents nutrients from being leached into the subsoil. On a larger scale the flooding and draining of blocks and terraces also has important effects on pest populations. If farmers on adjacent fields can synchronize their cropping patterns over a sufficiently large area, rice pests are temporarily deprived of their habitat and pest populations can be sharply reduced.

In Angorvat, Kampuchia, Prof. Fletcher of Western Sydney University has a Sri Lanka graduate student working on a study of water management in relation to temple rituals on similar lines to Lansing's study in Bali, and he is in contact with me on email.

In the Philipines, the ecologist E P Odum (1983) wrote:

It is perhaps significant that rice paddies have been cujltivated for over a thousand years in the Philipines (Sears, 1957), a record of success that few agricultural systems can claim. According to Sears these rice paddies are interspersed with patches of forests that are "preserved by religious taboos"…… We should first find out if the inter-mixture of

forest and paddies has something to do with admirable balances before we rush in and recommend that the forest be bulldozed in order to plant more rice.

In Borobodur, Caesar Voute who is a fifth generation Dutchman in Indonesia has been studying the relationship between temple rituals and water management procedures, which he used to inform me about on email. However he has now moved to Bulgaria.

The recent IRNCID conference in Tehran was an opportunity to learn about Qanats and Water Museums in Persia. I have submitted a paper to the Institution of Enginers, Sri Lanka, titled "Climate change and water: Lessons from the Qanats of semi-arid and arid regions, and water and soil conservation ecosystems of the monsoonal humid tropics". The intention is to establish continuing contacts between two different climatic regions, the arid and semi-arid lands of West Asia and the humid tropical island of Sri Lanka.

This is seen as specially important because UNESCO has supported Iran to set up a Water Museum project in the ancient city of Yazd. In Sri Lanka, a proposal for a Water Museum at Minneriya prepared in 2002, was developed into a broader concept of a Water Heritage of Sri Lanka, when I was Technical Adviser in the Ministry of Irrigation and Water Management, 2003. Later, a personal and professional visit to Canada by me established collaboration with the National Science and Technology Museum in Ottawa.

Finally, and in conclusion, an extract from *Water Heritage of Sri Lanka* (Mendis, 2002):

"The following extract from Professor Will Durant's The Story of Civilization, Volume II, (pages 563/564) is presented here for the benefit of those who still cannot accept the fact that the ancient water and soil conservation ecosystems of Sri Lanka had once been the basis of a stable society, and still remain as our greatest asset on which we can yet build a strong, sustainable, modern economy:

Decay of religious belief promoted the growth of compensatory utopias: Zeno the Stoic described an ideal communism in his Republic (ca. 300) and his follower Iambus (ca. 250), inspired Greek rebels with a romance in which he described a Blessed Isle in the Indian Ocean (perhaps Ceylon); there, he reported all men were equal, not only in rights but in ability and intelligence; all worked equally, and shared equally in the product; all took equal part, turn by turn, in administering the government; neither wealth nor poverty existed there, nor any war of the classes; nature provided fruit abundantly of her own accord, and men lived in harmony and universal love".

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List of Figures

1. Sri Lanka map showing ancient regions
2. Brohier's 4 stage hypothesis (1956) republished by Needham (1971)
3. Walawe basin development – Modern large-scale centralised system vs. Ancient dispersed small-scale system
4. Ancient System of Irrigation and Distribution of water (Source Brohier)
5. Modern System of Irrigation and Distribution of water (Irrigation dept.)
6. Inter-related large reservoirs and channels in western Rajarata
7. Inter-related large reservoirs and channels in eastern Rajarata
8. Eppawala showing chains of small tanks in Anuradhapura district
9. Ancient Elahera and Parakrama sagara vs. Modern Moragahakande

Fig. 1. Sri Lanka map showing ancient regions

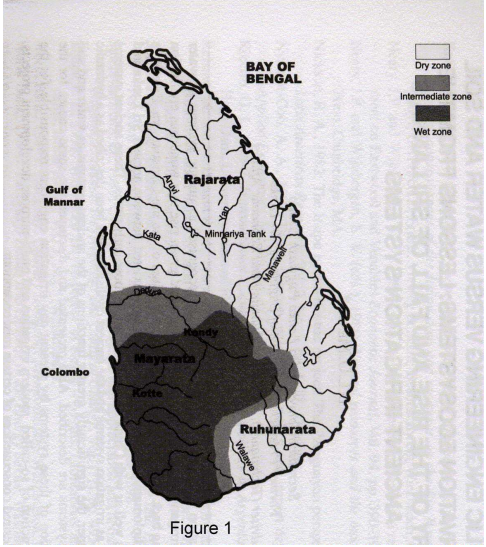
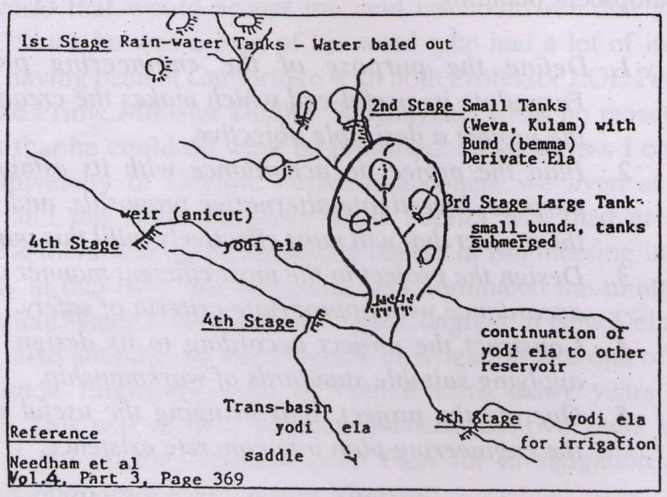


Figure 1

Fig. 2. Brohier's 4 stage hypothesis (1956) republished by Joseph Needham (1971)



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

Fig. 3 Walawe Basin development – Ancient dispersed small-scale system vs. Modern large-scale centralized system (old Figure 6)

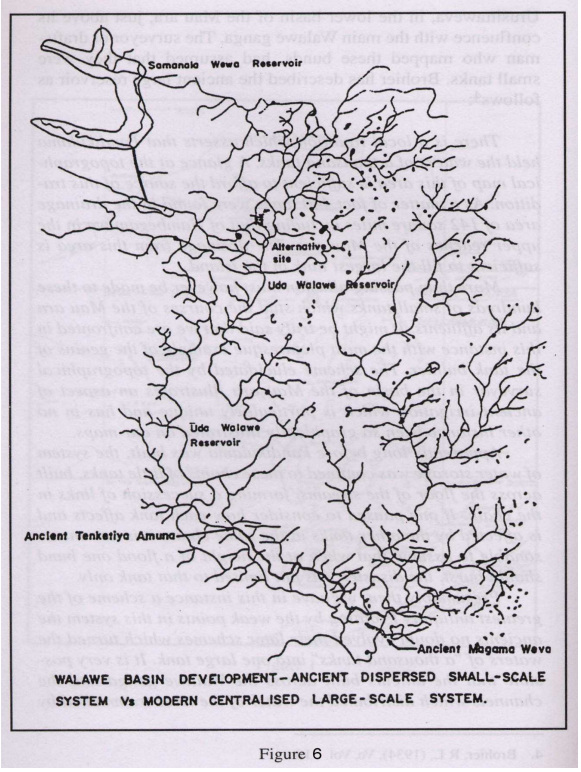
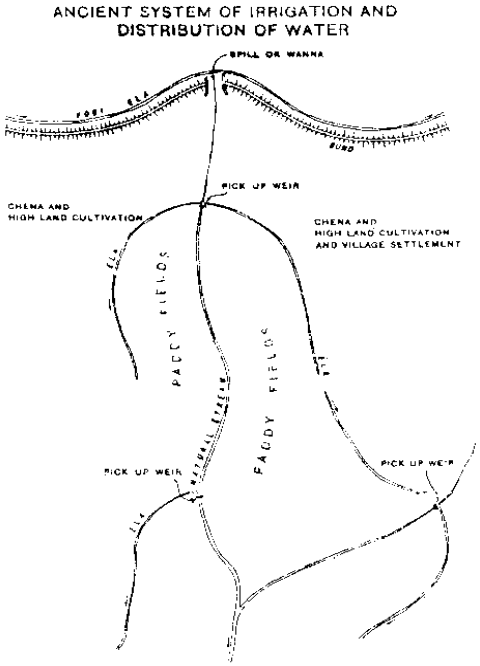
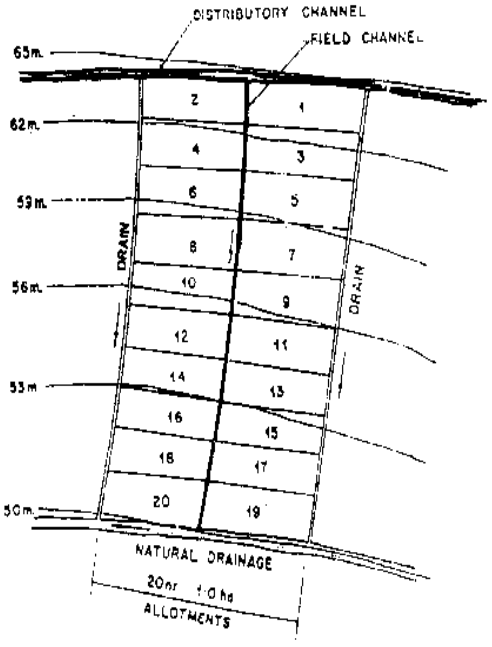


Figure 6





Source: Brohier (1941)

Modern system [Source: Irrigation department]

Fig. 4 Ancient System of Irrigaton and Distribution of water and **Fig. 5. Modern System**

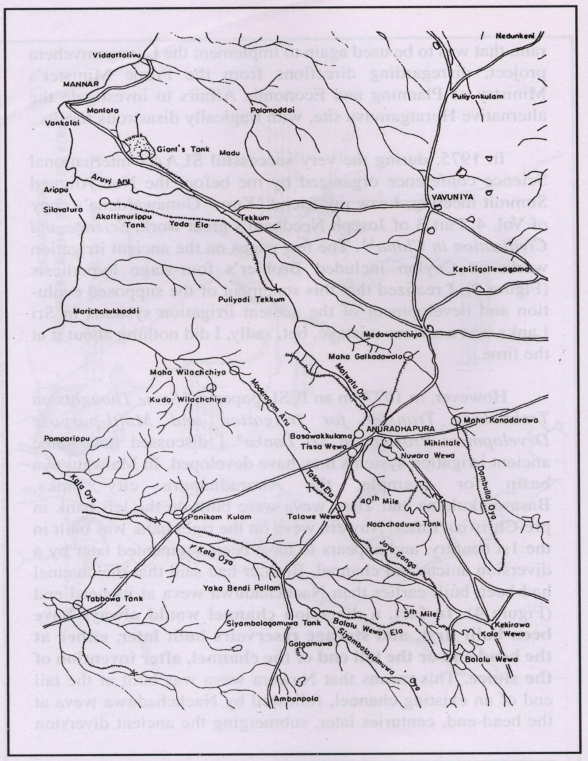


Figure 10
Ancient large reservoirs and channels
in western seaboard of Rajarata. (Source: Brohier, 1937)

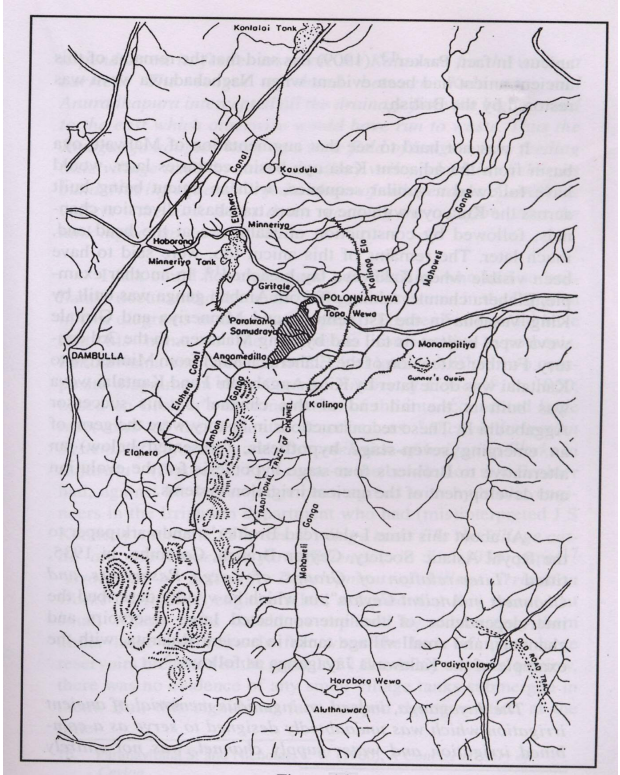


Figure 11
Ancient large reservoirs and channels
in eastern seaboard of Rajarata. (Source: Brohier, 1937)

Fig. 6 Inter-related large reservoirs and channels in western Rajarata (old Figure 10)

Fig. 7 Inter-related large reservoirs and channels in eastern Rajarata (old Figure 11)

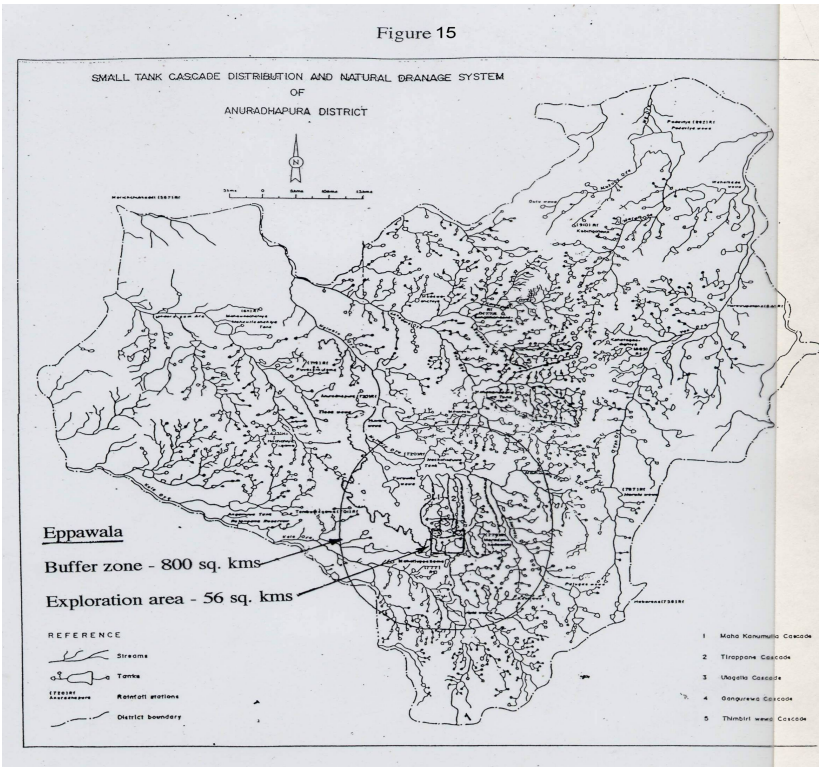


Fig. 8. Eppawala showing chains (cascades) of small tanks in Anuradhapura district

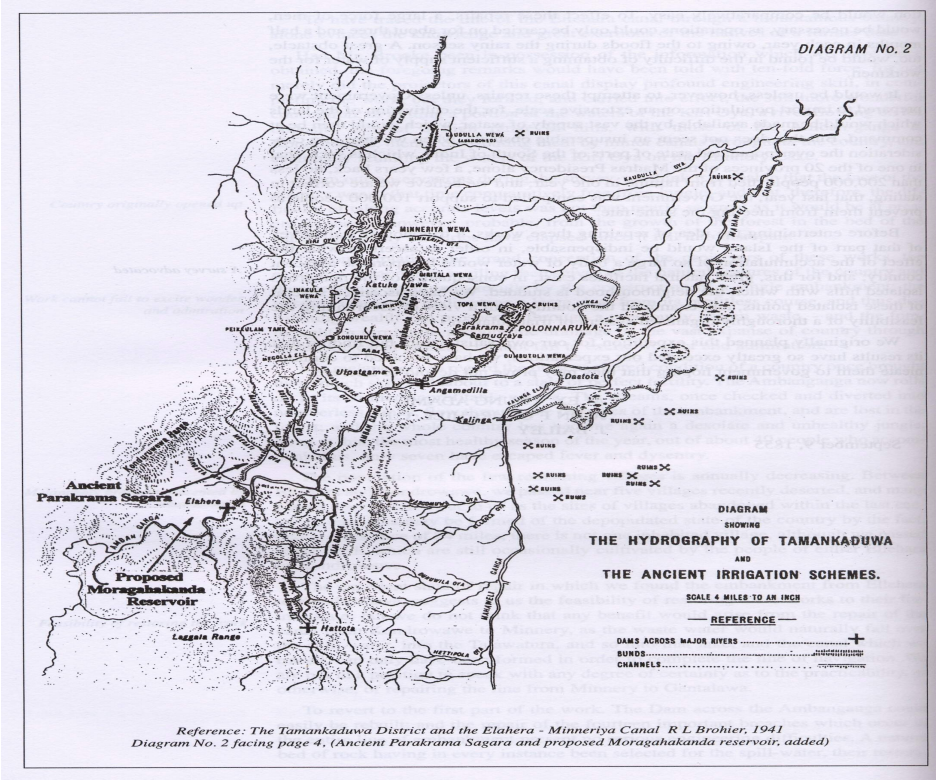


Fig. 9 Ancient Elahera and Parakrama Sagara vs Modern Moragahakande