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The Ancient Hydraulic Civilization of Sri Lanka in Relation to its Natural Resources

New Series Volume XXVII Special Number

by

A. Denis N. Fernando

The purpose of the Society is to institute and promote
inquiries into the History, Religions, Languages
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of the present and former inhabitants of the
Island of Sri Lanka, and connected cultures
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FOREWORD

This work is a follow up of the earlier publication on Major Ancient Irrigation Works of Sri Lanka that was read by Mr. Fernando before the Royal Asiatic Society in 1979 and published by the R.A.S. as a Special issue in 1980.

Mr. Fernando has discovered a number of Ancient Archaeological sites using the new techniques of Photogrammetry.

In this paper which was presented to the Royal Asiatic Society in February this year he has used his wide knowledge to distinguish the different types of hydraulic structures in the different parts of the country and to interlink them with the country's Natural Resources, and has presented new facts on the Yakkha Civilization of ancient Lanka which are of significant importance.

Professor M.B. Ariyapala, Ph.D.
President
ROYAL ASIATIC SOCIETY
(Sri Lanka Branch)
30th July 1982

PREFACE

We in Sri Lanka are fortunate in having written records of our history which are among the oldest in the world. The ancient Chronicles, namely the Sihalavathuppakrama, Dipawamsa, Mahawamsa, all of which were set down before the 4th century A.D. provide a continuous recital of the story of the nation from the 6th century B.C. onwards.

It is an astounding achievement for the Buddhist monks who wrote the Mahawamsa to have been able to record not only the inspirational story of Buddhism, but also to provide a wide spectrum of information about the lay culture.

Erudite scholars among whom stand out such names as Sir James Emerson Tennent, Dr. Ananda Coomaraswamy, Dr. Senarath Paranavithana, Mr. Henry Parker, Dr. R. L. Brohier found both inspiration and information in the ancient chronicles when they set out to produce their outstanding work on our culture which is based on a unique Hydraulic Civilization.

They worked however, without the modern tools now available such as Aerial Photography which has been used today most effectively to discover ancient Archaeological sites around the world, to study the land and water resources and to see the interrelations between them.

It was my good fortune to have been able to use the latest methods of Aerial Photography for these twin purposes and to establish that our ancients created a remarkable system of hydraulic structures varying according to the natural endowments of land and water in the different parts of the country.

For over two decades the methods of Aerial Photo-interpretation that I have used have helped to bridge several important gaps in the historical records, and to answer elusive questions. In fact these discoveries made through the use of aerial photographs have again and again established the basic accuracy of what has been recorded in certain puzzling sections of the Mahawamsa.

My latest experience of this nature was in the discovery of the site of the oldest capital of Sri Lanka, namely, Vijithapura, which was established in the 6th century B.C. It is described fully and with remarkable accuracy in the Mahawamsa.

My reading of the Mahawamsa over the years and my use of Aerial Photo Interpretation have not only served me well but also to reveal an earlier epoch of our Hydraulic Civilization belonging to the Yakkhas. Their dominance was prior to the 4th century B.C., therefore predating the Buddhist Hydraulic Civilization, Dr. Senarath Paranavithana who in his early work in 1929 states: "that they were beings worthy of offerings". It is in this same spirit that I dedicate this book to the Yakkhas, to whom we owe a greater debt than is still realized.

This book therefore takes the Yakkhas' story from the point where Paranavithana left off and attempts to show that the Yakkhas had developed an advanced technology prior to the 6th century B.C.

The Mahawamsa states that the Yakkhas helped in constructing the 4th century B.C. city of Anuradhapura and the ancient irrigation works in the centuries following the 4th century B.C.

This evidence from the Mahawamsa along with the other relevant discoveries I have made showed that the Yakkha hydraulic culture had already paved the way to receive the supreme gift of Buddhism. It has been well said that the Buddha always preached his philosophy with its intellectual appeal to civilized nations which were capable of understanding it and were already at a stage of development to accept it.

I must recall with gratitude the assistance and encouragement given by Hon. Gamini Dissanayake, Minister of Mahaweli Development and the Royal Asiatic Society. I would also wish to record here the encouragement given me by my many friends specially Mr. V. N. Rajaratnam, former Director of Irrigation and Past President of the Institute of Engineers, Sri Lanka; Mr. Dudley Fernando, presently Business Editor of Gulf News U.A.E., for having gone through the script and to Mr. Neville Gunasekera, who assisted me in preparing the type script. Finally, I wish to thank Crippen International Ltd., Vancouver, B.C., Canada, who provided the generous offer and grant to print the book.

A. Denis N. Fernando
Ist August, 1982

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by

A. Denis N. Fernando

1. SUMMARY

This paper will highlight the evolution of Sri Lanka's Ancient Hydraulic Civilization in the context of the Island's Natural Resources and Environment mainly from the aspect of science and technology. This interrelation is best understood when it is studied silhouetted against our early history.*

The Natural Resources of Sri Lanka and their co-relations have been mapped out on a small scale over the past two decades by the author either alone or in collaboration with other specialists using the method of Aerial Survey Interpretation supplemented with available information and field verifications. The more important aspects of these natural resources, that have a bearing on the development of our hydraulic civilization will be presented here, so as to bring out a direct co-relation between these natural endowments and the development of our ancient hydraulic civilization.

When we examine our different natural resources namely, the water resources, geology, hydrogeology, land forms, bio-climates, soils, natural vegetation and topography, we see clearly that the ancients were aware of these parameters. Though they did not use the same technological terms or jargon, used in modern times, it is very apparent that they appreciated these same concepts in the construction of the hydraulic structures. It was fortunate that in Sri Lanka our ancients were able to find the different and highly contrasting environmental conditions within close proximity of each other that were akin to entirely different laboratory conditions needed to perform experiments on hydraulics, so that the experience in one environment could be adapted with suitable variations to the other environment.

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* Note:

Since I have already addressed the Royal Asiatic Society on the 16th March, 1979 on the subject of Major Irrigation Works of Sri Lanka (which has already been published, in 1980, as a Special Number in the New Series), it is not my intention in this Paper to go into these details that I have already discussed earlier, except only to highlight the more salient aspects of history that are pertaining to the subject presented here.

The hydraulic civilization based as it was on the harnessing of the water resources in the different environments having distinct land systems, gave rise to the evolution of different hydraulic structures to meet the needs of a particular environment that was distinct in both resources of water and land.

When man moved from the hunting and gathering stage to rainfed agriculture, possibly with wells or ponds for drinking water, he moved to a state of settled agriculture, so that the well could be considered as the first hydraulic structure for use by man. Thereafter, the next stage was the construction of the simplest hydraulic structure for irrigation, viz. the amuna (anicut) with a delivery canal, which is a simple structure across a stream or river, where part of the stream flow was diverted without storage using a canal directly to irrigate the fields. This was in all probability his first major step.

Our ancients chose suitable sites on the river bed that had generally a rock out crop going across the river and by adding simple stone masonry structure to this foundation, they built the amuna or anicut.

The next stage was the construction of the wewa or reservoir by building the "bemma" or bund or dam across a river so as to impound water for subsequent use. The water was stored in the reservoirs and sent to the fields under a controlled system of issuing water with a controlling device, namely, the Bisokotuwa or sluice; to the fields with the help of canals. This construction required real genius to evolve; to construct a device to control the issue of water from the reservoir. This device was the key to the development of reservoirs. This innovation set the stage for the great leap forward.

This invention was followed by the integration of anicuts, canals and reservoirs for the maximum development of the water resources in the system. It is also noted that there was the predominance of specific hydraulic structures in specific areas of the country in relation to its natural endowments.

We see clearly the predominance of minor anicuts in the wet zone mantled plain, with distinct minor anicuts irrigating terraced paddy fields in the ridge and valley and hill and valley systems of the wet zone. We also observe the minor irrigation reservoirs dominating the mantled plains of the intermediate climatic zone. The intricate and integrated irrigation systems of major anicuts across perennial rivers, interlinked with major reservoirs with their networks of canals dominating the dry zone plains with minor irrigation reservoirs scattered as well. In contrast there is the absence of these hydraulic works in the limestone rolling plains of the dry and arid climatic zones where we see the dominance in the use of subsurface water from ordinary wells as well as tube wells today for irrigation that reflect the high porosity of the terrain unsuitable to sustain surface water in reservoirs for surface irrigation. Beyond this barrier as it were in the littoral plain of the dry and arid zone we once again notice the preponderance of minor irrigation reservoirs fed by an irrigation system interconnected with the Giants Tank in the Mannar District.

With the discovery of the ancient fortress of Vijithapura in the vicinity of Polonnaruwa in 1979, Vijithapura stakes its claim as a city older than Anuradhapura, as it is mentioned in the Mahawamsa to exist contemporaneous with Upatissagama, Ujjeni, Uruwela and Anuradhagama, in the 6th century B.C.

The plains of Bintenna or Mahiyangana were occupied by the Yakkhas, according to the Mahawamsa. The presence of a series of stupendous anicuts and reservoirs in the plains of the Mahaweli whose dates of construction are lost in the mists of centuries and which surpassed the hydraulic structures of the Rajarata (in Anuradhapura), again points their antiquity to pre-Vijaya times.

The discovery of the most ancient city of Vijithapura in the plains of the Mahaweli near Polonnaruwa points to a civilization that preceded that of Anuradhagama before it was developed by King Pandukabhaya in the 4th century B.C., which he did with the assistance of the Yakkhas with whom he had excellent cordiality and friendship. No doubt with the development of Anuradhagama, the ancient capital Vijithapura of the 6th century B.C., yielded place to the new capital of Anuradhapura. Then in the Buddhist era from the 3rd century B.C. to the 13th century A.D., the capital oscillated between Anuradhapura and Polonnaruwa. When ultimately Polonnaruwa fell due to natural disasters as well as invasions, the capital shifted from the dry zone to the intermediate and wet zones to Dambadeniya, Yapahuwa, Kurunegala, Sitawaka, Kotte and finally Kandy.

The present evidence points to the identification of three distinct epochs of development:-

i. Megalithic pre-Buddhist Hydraulic Civilization with associated Yakkha artifacts (from pre-Vijayan times up to 3rd century B.C.).

ii. Megalithic Buddhist Hydraulic Civilization with associated Buddhist artifacts like Dagobas (circa 3rd century B.C. to circa 1300 A.D.).

iii. Modern Hydraulic Civilization with hydro-electricity, concrete and rock fill dams (from circa 1300 A.D. in reality commencing circa 1800 till today up to ?).

	Epoch I		Epoch II		Epoch III	
? pre-Vijayan		circa 3rd cent. B.C.		circa 1300 A.D.		to?
	Yakkha Hydraulic Civilization		Buddhist Hydraulic Civilization		Modern Hydraulic Civilization	

2. HISTORICAL SETTING

The geographical position of Sri Lanka is such that its position and its proximity to the sub-continent of India makes it one of the terminal points of constant immigration from the sub-continent. With every onslaught, the inhabitants in the northern, north-western and north-eastern seaboard either overcame the invaders or retreated southwards to the plains or took to the hilly parts that were safer. It is also well known that the island was on the main sea routes across the Indian Ocean from the Middle East through the Malay Straits to China from the most ancient times. There are ancient seaports like Mantota near Mannar and Lankapatuna (whose identity is not yet known) and many others in our country, which were on these routes.

In this context one has also to note that Sri Lanka was in communication with the hydraulic cultures of Egypt, Mesapothamia, Persia, Syria, India, China and the little known but important south-east Asian regions of Indo-China, where rice culture is known from ancient times.

The topography of the Island with valleys and mountains suitably placed well above the plains and the generally undulating nature of the land and its varying natural endowments of rainfall and climate within its narrow confines provided the unique setting for the innovative and constructive genius of our early settlers. It is in this overall context that the ancient chronicles, legends, epics, folklore, dances and other cultural manifestations have to be interpreted.

Historical records indicate that three tribes called Rakshasa, Yakkha and Naga were living in Sri Lanka when Prince Vijaya, the founder of the Sinhala nation landed in Sri Lanka in the 6th century B.C. When he disembarked from his ship, he saw the Yakkha Princess Kuweni at the spinning wheel, seated beside a tank. At this point it is worth mentioning that Sri Lanka's great chronicle, the Mahawamsa, attributes the construction of the first tank to King Pandukabhaya in 307 B.C. However, there are plenty of clues in the Mahawamsa itself which contradict the view that tank building developed only after Vijaya's arrival. The Mahawamsa states that Yakkha kings were given a respectable place in society by King Pandukabhaya and they sat on the same stage together to witness the annual celebrations of the populace.

It was King Pandukabhaya who brought the country together into a single entity, with the appeasement of the Yakkhas. According to the Mahawamsa, the claims of the original Yakkha chiefs to the land of their birth were equitably settled. The Yakkhas no doubt were one with Pandukabhaya and Pandukabhaya was in turn beholden to the Yakkhas for their help from his early childhood and for their assistance and total support in unifying Sri Lanka. With the aid of their Yakkha technology he planned and executed the construction of Anuradhapura. It is also stated in the Mahawamsa (page 207 - vs. 89/92) that when Ruwanweliseya was built gold images of 4 great kings, 32 maidens, 28 Yakkha chiefs, devas, dancing devatas playing instruments, devas with mirrors in hand and a host of other devas with flowers, lotus, swords and pitchers were mentioned. This clearly shows the knowledge of using and sculpturing from different metals and the close affinity the Yakkhas had with the more recent immigrants to the country.

The Mahawamsa also records that the great kings of Sri Lanka with the assistance of Yakkhas constructed many large dams and channels. It is the traditional belief that the Yakkha chief, Bulatha in 150 B.C. built the engineering masterpiece, the Soraborawewa, without the king's permission and paid the supreme penalty. It is evident from this episode that the tradition of tank building and channel construction had been mastered by the Yakkhas. One could therefore attribute the techniques of dam building and channel construction to the inherent genius of the people of Sri Lanka from the most ancient times. There are also scattered in the jungle many monoliths at the foot of Bodhi and Nuga trees which were the Arsanagaras of the chaittya cult of the Yakkhas of the early times.

Even when one examines the colossal quantities of earth work in these ancient dams that have been attributed to the earlier great kings of Lanka, we can rationally come to the conclusion that some of these works were of an earlier era.

Some of the constructions attributed to the great kings would have been constructions of an earlier period, only restored by them, thus requiring the time of construction to be backdated.

One must not forget that the author of the great chronicle, the Mahawamsa was the able and pious Buddhist priest Mahanama, who was the uncle of the great king Dhatusena who reigned in circa 459 A.D. Most of the works attributed to King Dhatusena involved such large volumes of earth work that all these works could not have been done by him during that short space of time, if they were entirely new constructions. Some of them would have been restorations of an earlier era. Then the question would arise which era? The same is the case with the works attributed to King Mahasen (275 A.D.). Several works have also been attributed to King Mahasen which also could not have been done in his era for the same reason. It would appear that King Vasabha (65 A.D.) was the king who really started repairing and constructing the major hydraulic structures, with Mahasen taking a great leap forward by repairing much more than King Vasabha did and King Dhatusena who followed doing the rest. This does not mean that the great kings Mahasen and Dhatusena only did repairs, for they also constructed several very large works attributed to them. King Dhatusena was followed by the greatest of them all, King Parakrama Bahu, the Great (1159 A.D.), who repaired all these works and also constructed new ones.

One must not forget that the Mahawamsa, the great chronicle is essentially a Buddhist chronicle and is like the Bible to the Christians. In its writing sometimes a stand is taken to suggest that everything began with the Buddhist era, just as the Christians like to think that it all begn with the chosen people. We therefore have to make an allowance for such views. In the context of today's knowledge of the past we have to attempt to interpret the data through the scientific methods available. It is along these lines that these facts are presented.

2.1 Introductory Note By Well Known Authors

Some of us scientists and technologists are not fully aware who the Yakkhas were, except for the derogatory way in which they are referred to today in current literature. I would like to quote from Dr. S. Paranavithana, Sri Lanka's preeminent Archaeologist whose paper on "Pre Buddhist Religious Beliefs" was read before the Royal Asiatic Society in 1929. Some excerpts from that Paper refer to the Yakkhas and their cults as well as their assimilation into the religious lore of Hinduism and Buddhism and are quoted by me so that we could view the genius of the Yakkhas in their correct perspective. Says Dr. Paranavithana:

> "As the Abhayavapi had its guardian spirit in Cittaraja, so had the Tissavapi an unnamed genius as its protector. For we are told in an inscription of the tenth century, that Isurumuni Vihara was situated by the side of the Tissa Tank, the waters of which formed the dwelling place of a genius (rakus) who was converted by Saint Mahinda and was made to be of service to the religion as well as to the world.
>
> This spirit is here called rakus, but the word Yaksa and Raksasa are applied indifferently to the same being and hence the genius of Tissawewa is mentioned here in dealing with Yaksa cults."
>
> "Vibhisana, Kalasodara and Dhanesvara are said to be tutelary yaksas of Ceylon. Of these, the first, Vibhisana, the brother of Ravana is still worshipped at Kelaniya and is supposed to be one of the four guardian deities of the Island. Dhaneswara is another name of Kuwera Vaisravana who we have seen above, was worshipped in ancient Anuradhapura in the time of Pandukabahaya. This god was, at a later time, incorporated in the Mahayana Buddhist pantheon and several images of him have been found in Ceylon. The second names Kalasodara ('pot-bellied') may be another name of Vaisravana. Though, from the very beginning, the yaksas were more feared than loved and were supposed to cause great calamities unless propitiated in time; there was originally very little difference between the Yakhas and the devas. In fact, one of the names of the yakhas as a class, was Bhummadeva 'the gods of the earth'. The god Sakka the king of heaven is, in one place, styled a yakkha; and in one of the earliest Buddhist books, the Majhima Nikaya, the Buddha himself is given this epithet in a hymn of praise. In the Mahamayuri, Visnu, Siva and Karttikeya, the most popular of the Puranic Hindu gods are mentioned as the tutelary yakkhas of different cities. In an inscription on a statue of Manibhacra, discovered at Pawaya in the

> Gwalior state, that yaksa is called a bhagavat, one of the most familiar of the epithets of the Buddha as well as of Visnu."
>
> "The word yaksa is derived from the root yaj, 'to offer', and means a 'being worthy of offerings'. The degeneration in the meaning of this word finds parallels in the history of the word asura, in India, and that of deva in Persia.
>
> Some of the principal features of the yaksa religion recur in the popular aspects of Buddhism. The worship of the caitya, so characteristic of popular Buddhism in many countries including Ceylon was originally connected with the yaksas. The Pali pitakas mention several cetiyas which existed in the Buddha's lifetime at Vesali, Rajagaha, Alavi and other places. Buddhagosa in his commentaries informs us that they were dedicated to yaksa worship and after the advent of the Buddha, the people converted them into Buddhist Viharas.
>
> The conditions, in pre-Buddhist Ceylon, of the yaksa cults appear to have been exactly similar to those in North India in the time of the Buddha; and, in spite of the adoption of Buddhism as the national religion, the earlier yaksa worship flourished side by side among the masses and has persisted down to modern times. The word yaksa is now generally rendered into English as 'demons', but the conception of yaksas as evil spirits is of later growth."

Henry Parker, a former Director of Irrigation in Sri Lanka who devoted over thirty years from 1873 to 1904 studying the ancient irrigation systems visited every part of our country, recording not only the ancient irrigation works, but also the ancient folk tales of our country for the first time. He is the author of the great work "Ancient Ceylon" (1909) and has the following to say:-

> "I am of the opinion that several other embankments of considerate size had been constructed in Ceylon before the works of Abhayawewa (built by Pandukabhaya in 307 B.C.) were undertaken....".

Sir Emerson Tennant, LL.D., F.R.S., was a British Civil Servant who held the office of Colonial Secretary of Ceylon from 1845 to 1850. He was a renowned world historian and the author of a famous book "Ceylon", published in 1860, from which I quote:-

> "The stupendous ruins of the reservoirs are the proudest monuments which remain of the former greatness of

> the country.....excepting the exaggerated dimensions of lake Moeris of Central Egypt and the mysterious 'Basin of Al Aram', the busting of whose embankment devastated the Arabian city of Mareb, no similar construction formed by any race, whether ancient or modern exceeded in colossal magnitude, the stupendous tanks in Ceylon...".

Henry Parker further states that the subtle art of controlling the water issues from irrigation reservoirs had been mastered in Sri Lanka before the 3rd Century B.C. To quote again:-

> "It must have been no easy task to control the outflow of the water at reservoirs which had a depth of thirty or forty feet, as was the case of several large works. Yet the similarity of the design of the Bisokotuwas (valve pits) at all periods prove that the engineers of the 3rd Century B.C., if not those of an earlier period had mastered the problem so successfully that all others were satisfied to copy their design. It was this invention alone which permitted the Sinhalese to proceed boldly with the construction of reservoirs that still rank among the finest and greatest works of its kind in the World."

The late Dr. Richard Leslie Brohier, a former Deputy Surveyor-General who worked in the Survey Department in Sri Lanka for forty years and with whom I was very closely associated as student and friend, in his celebrated works of 1934 says:-

> "Legend tells us that the Sinhalese workers of the 5th Century B.C. found irrigation works formed by the aborigines, who preceded them."

Prof. Joseph Needham, who is an authority on China recently made a special comparative study of irrigation systems in India, China, Egypt and he too came to the same conclusion as Parker had some 70 years earlier, that the art and science of irrigation in Sri Lanka were unique in the World. To quote Prof. Needham from his "Science and Civilization", Volume 4, Part 3, published in 1971:-

> It will be evident even from the roughest sketches that the achievements of Indian Civil Engineers in ancient and medieval times are quite worthy to be compared with those of their Chinese colleagues, though not to win the palm. Yet, it was never in India that the fusion of Egyptian and Babylonian patterns achieved the most complete and subtlest form. This took place in Ceylon, the work of both Sinhalese and Tamil, but specially the former.....".

It is therefore clear that the hydraulic civilization of Sri Lanka has an ancient history which I shall examine soon, after having mentioned some of the major hydraulic works indicated in the ancient chronicles (see map in R.A.S. Publication XXII of 1980).

There were many great kings in our country, who fostered and developed the art and science of irrigation engineering down the ages. Of Sri Lanka's tank and channel builders, the greatest were King Vasaba (65 A.D.), King Mahasen (275 A.D.), King Dhatusena (459 A.D.), King Moggallana II (531 A.D.), King Aggabodhi (575 A.D.), King Aggabodhi II (608 A.D.) and King Dappula II (815 A.D.) who covered many parts of our country at various times with great irrigation works. It is recorded in history that in the 9th Century, the help of engineers from Sri Lanka was requested by Djayapida, the king of Kashmir, in Northern India, to build a lake. The grandest and greatest king of them all was Parakrama Bahu, the Great (1153 A.D.) who not only united the country but renovated almost all the existing tanks in his time and constructed new ones all over the country. His famous words were:-

> "It is not meet that men like us should live and enjoy what has come into our hands and not care for people:
>
> In a country like this, not even the least quantity of rain water should be allowed to flow into the ocean without profiting man:
>
> Let there not be left anywhere in my kingdom, a piece of land though it be of the smallest dimensions that does not yield some benefit to man."

The chronicle Chulavamsa gives an account of Parakrama Bahu's military expenditure and his achievements in the field of irrigation. It says that in 1153 A.D., Parakrama Bahu united Sri Lanka into one kingdom and reigned till 1186 A.D. During his reign, he constructed or restored 165 dams, 3910 canals, 163 major tanks and 2376 minor tanks. This prodigious achievement was unmatched by any other king and was all done in his reign of 33 years. His achievements were also that he did not limit his activities to Sri Lanka alone, but had a navy which went across to India and Burma as well.

It could be said that by the 13th century we had reached the zenith of our hydraulic civilization and of development in agriculture. In the period immediately after this great renaissance, tragedy struck, devastating the country, bringing disease, famine and misfortune.

It would be apposite here to record that the great Parakrama Bahu, during his 33 year reign, spent half of his time in war and the other half in reconstruction of our ancient irrigation works and constructing new ones. If we take just a few of his works and attempt to compare what we are trying to do in the context of the Accelerated Mahaweli Programme (the largest hydraulic project now being constructed with international assistance) we could judge for ourselves the magnitude of that operation.

Parakrama Bahu constructed in around 15 years of peace (in addition to his other works all over the country)

the equivalent of 320 miles of major channels in the Mahaweli basin,

the equivalent of 240 miles of major channels in the Kalawewa basin.

In other words, he did the equivalent of 200 miles of major channels and its dependent structures, dams and downstream development in five years, which is more than what we are attempting to do under the Mahaweli Accelerated Programme in six years. He did this work with the help of his people, the skill of his artisans and the power of the elephant. His example and techniques of mobilization and of ensuring people's participation, discipline and management would be a good example for us to follow. The people participated actively, and inherited the product of their labour.

Besides the great achievements attained by the ancients in the field of irrigation, which has already been elaborated on, the consolidation of Buddhism in 250 B.C. in Sri Lanka, during the reign of King Devanampiyatissa, caused a revolutionary change. Buddhism became a new motivating force that was reflected in the construction of large Dagobas (Relic Chambers), architectural forms, the arts and craft which superimposed and superseded all that went before. In short, Buddhism inspired all art forms in this era and erased what was left of the earlier hydraulic culture. The tank, the temple and the village symbolized this new integration to satisfy the spiritual and temporal needs of the people.

Like the great hydraulic works, the Dagobas that were constructed in the ancient capital cities were enormous and unique, built as far back as the 2nd century B.C., some of them were larger than most of the Pyramids of Egypt. This is clear proof of the scientific, technological and engineering skills that were available in the 2nd century B.C., and supports the thesis that very large works could have been done prior to the 2nd century B.C.

3. NATURAL RESOURCES SETTING

In discussing the natural endowments, it is necessary to present the different parameters that go to form the natural resources. These maps have to be prepared with the objective of representing the different natural resources in the same level of detail so that meaningful comparisons and correlations could be brought out at the same level of detail.

The landforms and their relationship to the Hydrogeology and the drainage pattens and river systems, the bioclimate and their impact on the formulation of soils, natural vegetation and finally the evolution of land systems depending on the above parameters are discussed.

It is on this resource base that the ancient hydraulic civilization in Sri Lanka evolved from a state of nomadism to civilized settled agriculture from the most ancient times till today.

3.1 Main Landforms

The Island comprises: three major physiographic units that are distinguishable on the basis of elevation, viz. the lowlands, the midlands and the highlands. They constitute the first, second and third peneplains (levels of erosion) respectively, first identified in 1920 by the Canadian geologist Frank Dawson Adams, who was associated with the Minerological Survey of Sri Lanka. He was of the opinion that the highest peneplain was the oldest and that the Island had been progressively rising in steps throughout its geological history. However, the Indian Geologist, Dr. D.N. Wadia, who was the Ceylon Government Mineralogist in 1941, was of contrary opinion and postulated that the highlands were formed comparatively recently by vertical uplifts of large blocks of crust along large faults by block uplift, thus making the highest peneplain the youngest. Further attempts are now being made to explain their formation based on plate tectonics. Be that as it may. There is no doubt that these peneplains have been formed by uplifts and their landforms by differential erosion and weathering transportation and deposition.

Each of these peneplains rises somewhat on as we go inland, toward the next higher peneplain. The lowland plain has a general elevation of around 100 feet which has eroded down from a general elevation of the first peneplain which is around 300 to 400 ft. M.S.L. This first peneplain constitutes the major part of the country.

The midlands and the highlands are surrounded by the lowlands. These offer a great contrast in relief and comprise a deeply disected high core that rises to over 8,000 ft. M.S.L. that is flanked on all sides by plateaus in a stepwise fashion at different levels.

From the first peneplain there is an ascent stepwise to the second and third peneplains. The first step or escarpment is an ascent of about 1,000 ft. to the second peneplain which is about 1,400 ft. M.S.L.

The second peneplain or the midland is at level of 1,400 to 2,500 ft. M.S.L. Some examples of the rocky masses of the 2nd peneplain that have been relatively resistant to weathering and rising about 2,000 ft. M.S.L. in elevation and are isolated in the lowland plain between, are Ritigala (2,515 ft.), Galgiriya (1,677 ft.), Dimbulagala (1,750 ft.), Kataragama (1,390 ft.), Sigiriya (1,193 ft.), Kokagala (2,241 ft.), Friars Hood (2,148 ft.), and Westminster Abbe (1,829 ft.).

This would show the extent of the 2nd peneplain before erosion brought these down to lower levels. In some places they stand like sentinels in the lowland plains. But by and large the midlands extend from above the centre of the Island to almost the southern parts. From the 2nd peneplain the highest peneplain rises abruptly like an impenetrable fortress-like escarpment by a steep rise almost one mile (4,000 ft.) to the sky, to the third and highest peneplain which is about 6,000 ft. M.S.L.

The third peneplain is at a general level of 6,000 ft. M.S.L. rising to 8,000 ft. M.S.L. Unlike the 1st and 2nd peneplains, this peneplain which comprises the highland, is least like a peneplain and is more a complex of plateaus, mountain chains, massifs and basins within each of which a general erosion level can be recognized. From the surface of the highland rise the great peaks which crown the Island taking the form of an anchor laid down facing north.

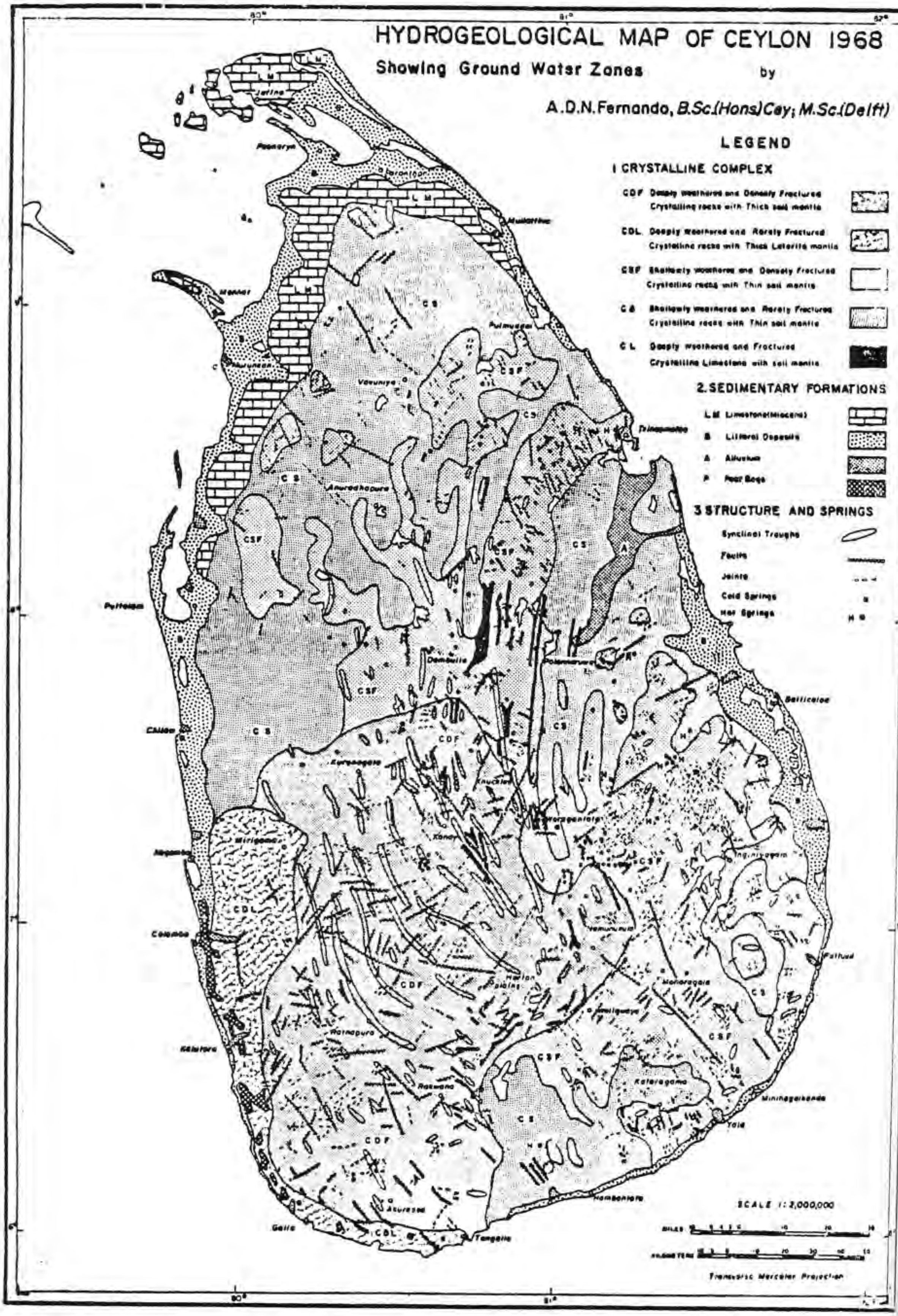
A sweeping arch of the anchor forms the southern wall starting from the sacred mountain of Adams Peak (7,360 ft.) in the west to Kirigalpotha (7,857 ft.) in the base of the anchor to Namunukula (6,360 ft.) in the east. Running north from the centre of the southern wall is the highest plateau from Kirigalpotha to Pidurutalagala (8,292 ft.), the highest mountain of Sri Lanka. Two giant basins of Uva and Hatton flank the eastern and western sides of the highest peak Pidurutalagala.

Two massifs, separated from the main part of the central highland, of smaller extent, also form part of the 3rd peneplain; they are the Knuckles massif which lie to the north of the central massif, with several high mountains over 5,000 ft., the highest being 6,284 ft. M.S.L., while the other is the Rakwana massif to the south-west of the central massif which has a general elevation of 4,000 ft. M.S.L., and has several fine peaks, the highest being Beragala (4,545 ft.).

3.2 Hydrogeology

The hydro-geological map of Sri Lanka was produced in 1968 using aerial photo-interpretation methods and field verification. The Island is divided into ten major hydrogeological units based on the genetic characteristics of all the geological formations on the basis of its lithology and geological structure and the erosional and weathering sequences. They also reflect the infiltration rates. The high infiltration rates cause more seepage and less runoff, while low infiltration rates cause less seepage and more runoff.

The greater part of Sri Lanka consists of the hard rock formations of crystalline rocks that belong to one of the most ancient and stable parts of the earth crust. They are weathered mostly in varying thickness depending on the climatic regions. The rocks themselves have very little inherent pore spaces in the rock textures except in the metamorphic rocks that contain strata like quartzites and limestone or other formations that become permeable by differential weathering. This area comprises 21,340 square miles or nearly 80% of the country's area while the rest of the 4,200 square miles of the Island comprise the rocks of sedimentary origin; of miocene, jurassic and quarternary age.


HYDROGEOLOGICAL MAP OF CEYLON 1968
Showing Ground Water Zones
by
A.D.N.Fernando, B.Sc.(Hons)Cey; M.Sc.(Delft)
LEGEND
1 CRYSTALLINE COMPLEX
CDF Deeply weathered and Densely Fractured Crystalline rocks with Thick soil mantle
CDL Deeply weathered and Rarely Fractured Crystalline rocks with Thick Laterite mantle
CSF Shallowly weathered and Densely Fractured Crystalline rocks with Thin soil mantle
CS Shallowly weathered and Rarely Fractured Crystalline rocks with Thin soil mantle
CL Deeply weathered and Fractured Crystalline Limestone with soil mantle
2. SEDIMENTARY FORMATIONS
LM Limestone(Miocene)
B Littoral Deposits
A Alluvium
P Peat Bogs
3 STRUCTURE AND SPRINGS
Synclinal Troughs
Faults
Joints
Cold Springs
Hot Springs
SCALE 1:2,000,000
Transverse Mercator Projection
80°
81°
Jaffna
Pooneryn
Elephant Pass
Mullaittivu
Mannar
Pulmuddai
Vavuniya
Trincomalee
Anuradhapura
Puttalam
Dambulla
Polonnaruwa
Batticaloa
Chilaw
Kurunegala
Knuckles
Kandy
Wattegodera
Negombo
Mirigama
Colombo
Inginiyagala
Pottuvil
Horton Plains
Monaragala
Wellawaya
Ratnapura
Kalutara
Rakwana
Kataragama
Mininnagalkanda
Yala
Hambantota
Akuressa
Galle
Tangalle
CS
CSF
CDF
CDL
LM
B
A

The geological structure plays a dominant role in the evolution of the landscape of the Island in the crystalline complex. The hydrogeology features follow closely the geomorphological units, each reflecting the other almost like twin brothers.

Crystalline Complex

(a) Deeply weathered and densely fractured crystalline rocks with thick soil mantle.

This formation is found in the wet zone of Sri Lanka in the highland, the midland and the wetter part of the lowland plains. In this formation the ground water is found especially in the valley bottoms, where there is the accumulation of alluvium and colluvial materials, in the quartzite, crystalline limestone bands and the physical rock partings, viz. the faults, joints and sheer plains and the weathered zone. In the overall assessment, the infiltration is around 10% of rainfall. Since the rainfall is high in this region there is correspondingly more infiltration. The annual run-off is also high in these areas as the rainfall is high.

(b) Deeply weathered and rarely fractured crystalline rocks with thick laterite mantle.

This formation is in the wet zone and in the lowland plain in the south-western seaboard. These laterites have been formed by weathering of the pre-cambrian rocks, they are deeply weathered and have a honeycombed structure, their porosity and permeability is moderate and the infiltration is around 10% of the rainfall. Since the rainfall is high in these areas the annual runoff is also high.

(c) Shallowly weathered and densely fractured crystalline rocks with thin soil mantle.

This formation is in the Eastern foothills in the midlands and the lowlands in the intermediate and dry zones in a highly dissected Inselberg landscape. They also exist in the north central region and conform to the low ridge and valley land systems which are highly dissected. Since this formation is well faulted and jointed, their overall permeability is moderate and the infiltration could be taken as 10% of the rainfall and also runoff is high.

(d) Shallowly weathered and rarely fractured crystalline rocks with thin soil mantle.

This formation lies exclusively in the dry zone, in the north-western, north central, north-eastern and southern parts of the country. The permeability and porosity is considered low and therefore the infiltration is taken as 5% of the rainfall. This would mean that the runoff factor is very high. Our ancients no doubt knew that the annual runoff in these areas was large and they would have to be conserved if man was to survive in that environment. Strangely enough most of our ancient major irrigation works are located in these areas in addition to those in the alluviums.

(e) Crystalline Limestone

These occur in the crystalline complex in all the climatic zones. The differential weathering that has taken place in contrast to the country rocks have been due to the climatic regimes they are situated in. Solution cavities and stalaglites and stalagmites occur in caves in their vicinity. Their porosity characteristics are better than the country rocks. Transbasin underground stream flow has been noticed in the vicinity of their outcrops and are a dam construction engineer's dilemma.

Sedimentary Formations

(a) Miocene Limestone

These are located in the northern seaboard from Puttalam to Pulmoddai, including the Jaffna peninsula, the Island of Mannar and the offshore islands in the north. They extend around 20 miles inland. They vary in depth from near the surface at the contact with the crystalline rocks about 20 miles inland, and are to a great depth near the coast. The pre-Cambrian basement slopes towards the coast. The permeability and porosity in this formation is good and therefore the infiltration is between 20 to 15% of the rainfall and therefore the runoff is low.

Often one comes across streams that virtually vanish below the ground to solution cavities in this karst landscape. This is an area where there are sink holes that look like reservoirs because they contain water in the depressions where there is an impervious clayey layer. This is an area where major ancient irrigation schemes are absent.

(b) Littoral Deposits

These littoral deposits encircle the island and are found in all climatic zones. These are the coastal sands that have been formed in the recent and pleistone times. They include the sandy beaches, sand spits and dune sands of varying composition. Sometimes lacustrine silts and clays form the lagoon floor and the surrounding flats, sometimes flooding by rivers make them relatively impervious. More often than not these are highly porous and permeable formations.

(c) Alluviums

These comprise the river alluviums in the deltas of large rivers and they comprise one of the best water bearing formations. The largest patch of alluvium is on the Mahaweli basin. There, infiltration is high around 20% of rainfall. These aquifers are charged not only from rainfall but also from the river itself.

(d) Peats

The peat bogs occur in the wet zone of the western seaboard. Their characteristics are similar to the alluvium. However the water quality is poor due to its acidity and the presence of organic matter that makes its use restricted.

Structures and Springs

These geological structures also play an important part in the Hydrogeology. In the crystalline complex the synclinal valley bottoms would be conducive for the accumulation of water. Differential weathering in the bedding plains and weathering of some rock types would cause the accumulation of water in the weathered strata. There are possibilities for artesian conditions. They are generally good aquifers. Faults and joints in the crystalline complex are also special areas for the accumulation and the concentration of ground water. The hot and cold water springs are nothing but evidence of ground water coming to the surface.

3.3 Drainage Patterns and River Systems

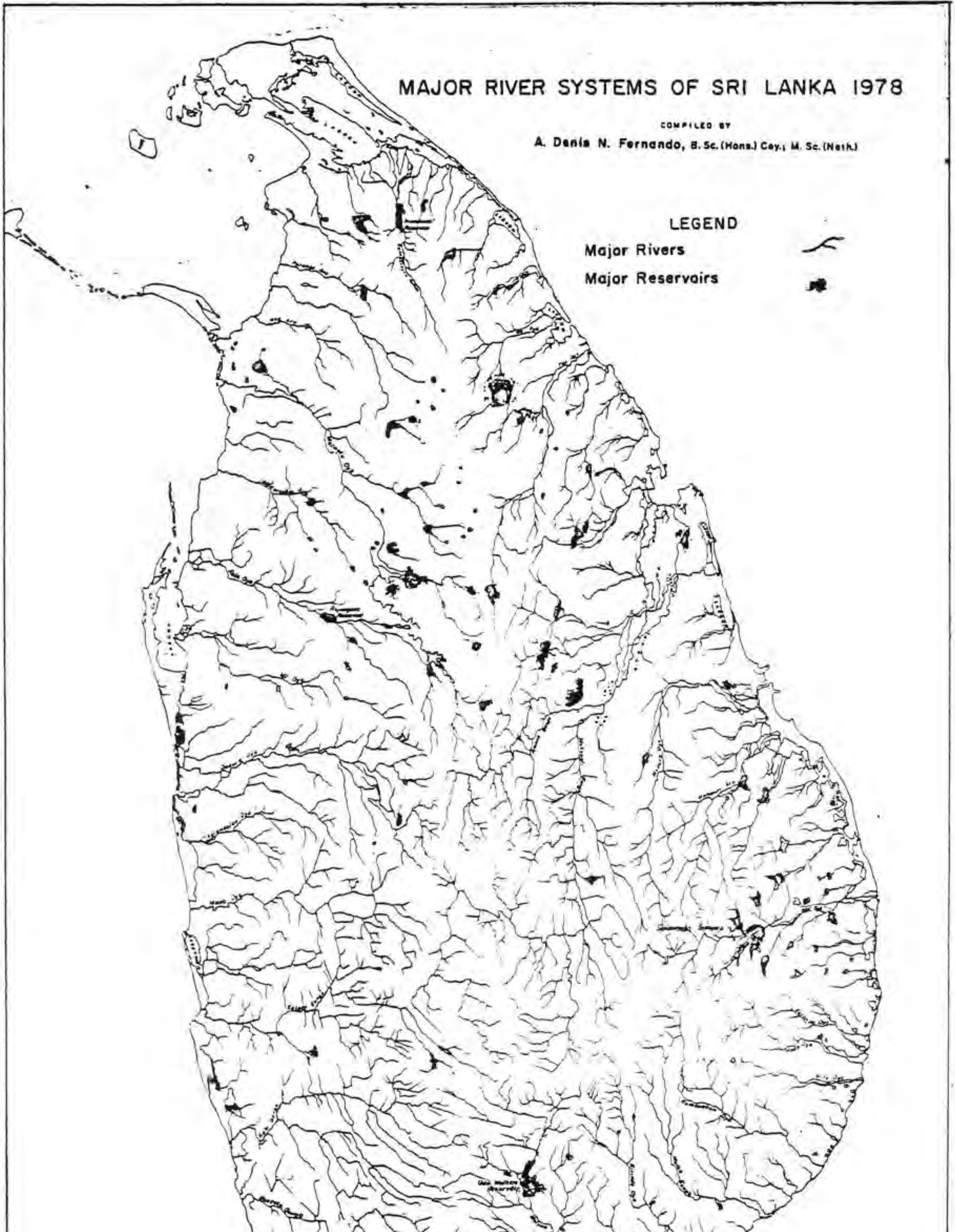
The cycle of erosion from the most ancient times has been responsible for the detailed land forms within the three peneplains. Rivers have developed depending on the erodability of the land and the rocks. The rivers are controlled by the major structural patterns in the course of their evolution. The river systems developed in the island reflect these drainage patterns and all forms of landscape exist ranging from the young deeply incised landscape, the varying stages of maturity and old age, till they reach their base level in the deltaic plains. The accompanying map shows the major river systems and drainage patterns of Sri Lanka.

The major drain patterns are radial in the highland peneplains where most of the major rivers start; they radiate outwards. While from the central part of Sri Lanka northwards, they start along a north south axis and flow eastwards and westwards respectively.

These rivers exhibit varying patterns of river systems, trellis patterns of drainage largely controlled by dips and strikes, joints and faults, while in the north, we find a few rivers suddenly vanishing in the karst formations of the miocene limestone into the ground.

Waterfalls are normally found on the minor nick points along the river profile, but they are most prominent in the 1st and 2nd escarpments that lie between the peneplains. The major falls forming cascades are on the 2nd escarpment between the middle and the highest peneplains and are the most beautiful and highest in the island which are used today for hydro power development.

The weathering process in the crystalline complex is mainly physical while the soil formation is both physical and chemical. The limestone bands



MAJOR RIVER SYSTEMS OF SRI LANKA 1978

COMPILED BY

A. Denis N. Fernando, B. Sc. (Hons.) Cey.; M. Sc. (Neth.)

LEGEND

Major Rivers	〰
Major Reservoirs	●

which are partly weathered are redeposited in the caves and caverns as stalatites or stalagnites which are mainly chemical in nature. There is also chemical weathering in the miocene limestone areas, where the weathering is reflected in the karst land form which appears with scattered water holes.

Rivers control to a large measure the development of the areas they traverse. The harnessing of these rivers by man created a revolution in transforming man from his nomadic hunting life to a settled agricultural life in Sri Lanka.

3.4 Bioclimates

The sequence of erosion, weathering, transportation, deposition from the most ancient times have been responsible for the detailed landforms within the three peneplains. The presence of land forms like inselbergs in the present dry zone and the remains of Hippopotamus and Rhinoceros in the alluvium of the wet zone near Ratnapura would imply that there was earlier a much wetter climatic phase.

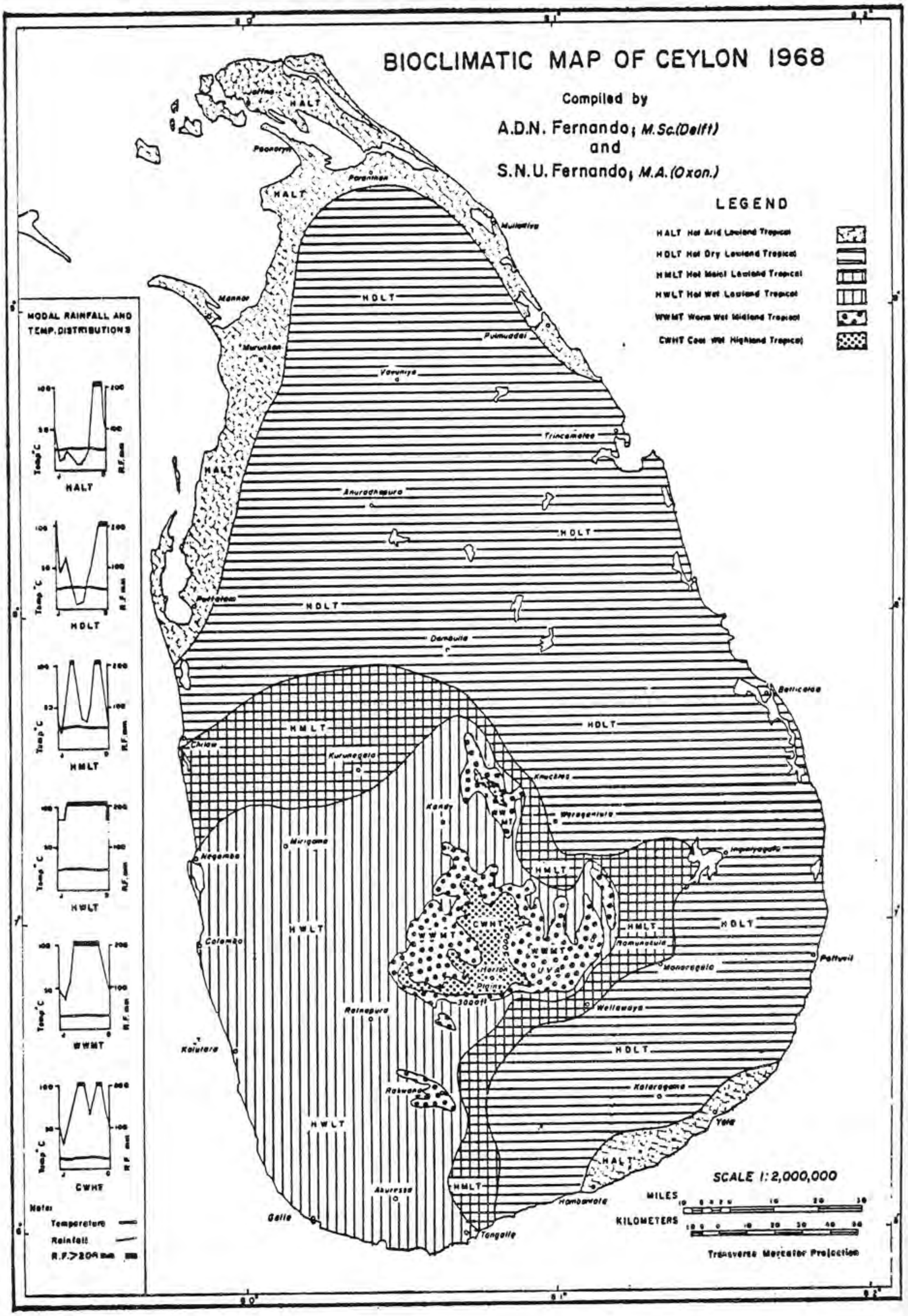
The climate of Sri Lanka is tropical being close to the equator. The temperature of the lowland plains is around 80° F.

Since the temperature drops by 1° F. per every 300 ft. in elevation, there is a temperature difference of 3.3° F. for 1000 ft. Accordingly the highest regions over 6000 ft. MSL enjoy a distinct mild temperate climate of around 60° F. The highest mountain Pidurutalagala is 8292 ft. MSL which is below the snow line and therefore we have no snow. Frost is a rare occurrence in the highest altitudes and it lasts only a few hours at a time around January.

Relative humidity is high and variable and is between 70 and 80. It is more dry and pleasant in the dry lowland plains, and more humid in the wet highland where the rainfall is high. Dew is common in the upland and it can be in important supplementary source of water. Mist and clouds, too, are present in the highlands.

There are two prominent rain-bearing winds, viz. the South West Monsoon and the North East Monsoon which blow in opposite directions to each other in two different seasons.

The South West Monsoon brings rain from May to July and deposits its heavy rain in the south-east quarter of the country, including the hills, while the North West Monsoon is more widespread and brings heavy rains mainly to the rest of the country from about November to January. Since the Island lies in the doldrum zone in the inter-tropical convergence region of warm and cold winds, rains occur during these Intermonsoonal periods and these bring rain commonly called intermonsoonal rains especially around March to April and September to October. Of these two the latter intermonsoonal rains are heavier.



BIOCLIMATIC MAP OF CEYLON 1968

Compiled by
A.D.N. Fernando; *M.Sc.(Delft)*
and
S.N.U. Fernando; *M.A.(Oxon.)*

On the basis of the annual rainfall the island has been divided into two major rainfall zones, the wet zone and the dry zone having an annual rainfall of 80 to 210 inches and 70 to 40 inches per annum respectively. The wet zone is in the south-west quadrant of the island encompassing the mountain region, while the dry zone is in the lowland plain.

An intermediate rainfall zone, with bimodal rainfall peaks with an average rainfall 70 to 80 inches per annum lies between the wet zone and dry zone. This forms an arch from Chilaw in the west and goes round eastwards to the foothills conforming approximately to the second peneplain, ending finally in the south, near Tangalle. There are two arid zones with an annual rainfall of 25 to 40 inches per annum, one in the north-western sector near Mannar and Murunkan and the other in the south-east section near Kataragama.

The accompanying Bioclimatic Map of Sri Lanka was compiled by the author in collaboration with Mr. S.N.U. Fernando, Principal, Ceylon Forest College, in 1968. Rainfall is the chief determinant factor in the general climate of the island while its temperature is variable in the upland areas. Therefore climatically rainfall and temperature are the two main factors that control the natural vegetation and consequently the associated fauna. For biological life, the temperature, rainfall, their range, their intensity and distribution and frequency are important for survival of different species. This map delineates the main areas that have dominant bioclimatic modules which are easily recognizable at a macro scale using climatic factors and the distribution of the natural vegetation as an indicator. This does not reflect different edaphic (soil) factors that can also differentiate the environment like riverine communities, swamps, mangrove or littoral, which have their own fauna and flora.

The bioclimate has been divided into six regions:

1. Hot Arid Lowland Tropical
2. Hot Dry Lowland Tropical
3. Hot Moist Lowland Tropical
4. Hot Wet Lowland Tropical
5. Warm Wet Midland Tropical

and 6. Cool Wet Highland Tropical.

The wet climates are differentiated into three types on the basis of temperature, that is the Hot Wet Lowland, the Warm Wet Lowland and the Cool Wet Highland Tropical types. The temperatures correspond to the altitude above sea level and accordingly the suffix (lowland, midland and highland) to name the climatic regimes. Distinct regions cannot be delineated in the lowlands on the basis of temperature because it is constant in those areas. The moist, the dry and the arid climates are distinguished on the basis of the annual effective rainfall and its distribution and not on the temperature differences and accordingly they are Hot Moist Lowland, Hot Dry Lowland and Hot Arid Lowland Tropical Regimes.

In general, the climate is variable from place to place. Further, one type of climate grades gradually into its neighbour with transitional zones in-between. These transitional zones are wide in the plains often between 5 to 10 miles wide and narrow in the mountains, where they may be within a few thousand feet in height.

It is seen that these bioclimates not only affect the flora and fauna, but they had an effect on early man as he was a victim of his environment when he had no control over it and had to sustain himself on the natural environment. In later years when he settled on the land, we note that because of good rainfall he constructed the minor anicuts to divert water to his terraced fields in the Hot Wet Lowland Tropical zone. In the Hot Moist Lowland Tropical Zone as he had the advantage of two short rainy seasons, he built his minor irrigation reservoirs, while he built the larger anicuts across perennial rivers and large reservoirs in the Hot Dry Lowland Tropical Zone as he had only one rainy season and had to conserve more water for his use throughout the year.

3.5 Geomorphology Based On The Land Systems Classification

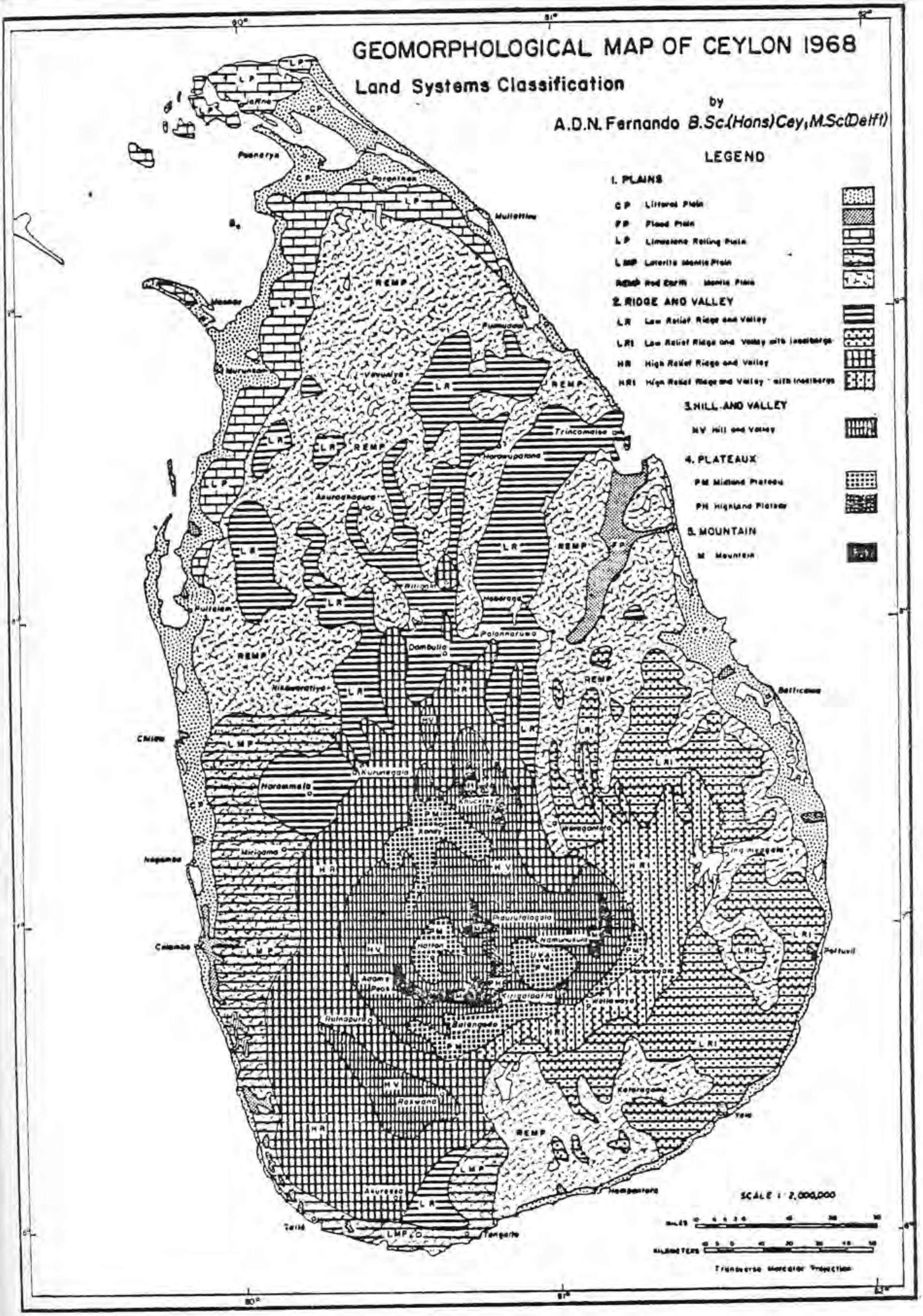
The Geomorphology of the Island has been mapped based on a land systems classification. At this scale of mapping the smaller geomorphological units cannot be mapped and therefore the units adopted are associations of the sites with closely related water resources, physical properties and genesis. They are characterized by a high degree of co-relation between the lithology, land form, soil and vegetation. These land systems units have been mapped by interpreting aerial photographs and field verification from which details were transferred as in the other maps, to mosaics and thence to a map of the scale of 1:500,000 and thence to 1:2,000,000.

The different aspects of the major physiographic units, of the lowlands, the midlands and the highlands have already been discussed including the climatic aspects that reflect weathering and erosion. The effect of hydrogeology in the infiltration of rainfall to ground water bodies and the extent of runoff in relation to rainfall and the formation of drainage patterns and river systems have also been dealt with earlier. This chapter on land systems will further elaborate first on the dynamic aspects that have not been amplified before, viz. Soil Formations and the type of Natural Vegetation, that the different land systems units sustain and the present land use and bring out the composite pattern of the land systems that go to form the Geomorphology of Sri Lanka.

The land systems have been first divided into the major geomorphic units of:

1. PLAINS
2. RIDGE AND VALLEY SYSTEMS
3. HILL AND VALLEY SYSTEMS
4. THE PLATEAUS

and 5. THE MOUNTAINS.


GEOMORPHOLOGICAL MAP OF CEYLON 1968

Land Systems Classification

by

A.D.N. Fernando *B.Sc.(Hons)Cey, M.Sc(Delft)*

The plains comprise the lowest peneplain, while the ridge and valley systems form the higher parts of the first peneplain and the entirety of the second peneplain. The hill and valley systems, the plateaus and the mountains constitute the highest or third peneplain, viz. the Highlands.

These major land systems are further divided into sub systems on the basis of the lithology, landform, water resources, soil and vegetation.

In the pre-cambrian crystalline complex, the geology is sub-divided on petrographic characteristics as the stratigraphic units are difficult to distinguish. For this reason several geologically different types of crystalline rocks give rise to the same soil groups under similar environmental conditions. The major factor that influences soil formations in this crystalline complex is the climate as the parent geology plays a subordinate role. Due to varying rainfall conditions of varying intensity and duration, laterization of varying degrees occur.

In the crystalline complex of the dry zone due to relatively less rainfall, there is partial laterization. These soils are fertile though rich in minerals and are better known as the reddish brown earths; while in the wet zone podsolic soils are formed as laterization of varying degrees occurs.

In the crystalline complex of the first peneplain of the wet zone laterization is complete and we have red yellow podzolic soils with well developed laterite, while in the midland or the 2nd peneplain we have very strong lateritic soils and in the highlands or 3rd peneplain we have weakly developed lateritic soils. Both these soils in the midlands and highlands can be classified as red yellow podzolic soils.

In the sedimentary formations in the miocene limestone areas we have the calcic red earths or the latosols. In the littoral deposits, in the arid parts, there are alkaline and saline soils or solodized solonetz and solon chaks, while in the dry and wet zones we have regosols. In the alluvium we have alluvial soils and in the peat deposits of the wet zone we have bog and half bog soils.

The natural vegetation of the island follows clearly the biotic, climatic and edaphic factors, both in the lowland plains and in the crystalline complex. In the crystalline complex they are determined by climatic and edaphic factors. The dominant controlling influence in the wet zone is the formation of rain forests in the lowland, midlands and highlands. The reddish brown earths are in the monsoonal forest of the hot dry lowland tropical bioclimatic regions.

In the lowland sedimentary we have in the latosols a mixture of thorny scrub jungles and monsoonal forests. In the solodized solonetz and solon chaks, we have thorny scrub jungle; while in the littoral areas inundated by the tides we have the mangrove swamps. The alluvial soils have riverine forests and in the fresh water, bog and half bog soils there is swamp vegetation.

The major land systems indicated earlier could be further divided into sub classes of land systems which are now dealt with. All the plains and the low relief ridge and valley systems belong to the 1st peneplain, while the high relief ridge and valley system belong to the 2nd peneplain. The hill and valley systems, the plateau and the mountain area belong to the 3rd or the highest peneplain. The sub classes of the land system are as follows:

Littoral Plains

These are in all climatic zones and are the quatanary and pleistocene deposits in the coastal plains below 100 ft MSL in elevation and comprise fossil beach sands, sandstones, sand beaches and sand spits, dune sands and clays. The soils that lie over this parent material reflect the action of climates on them. In the Hot Arid Lowland Tropical regions are solodized solonetz and solon chaks, the permeability of which is relatively poorer in comparison to the rest of the area which is comprised of regosols.

The natural vegetation in the solodized solonetz and solon chaks is monsoonal scrub jungle and associated grass lands which are also known as thorn forests and the major part of the island's principal wild life sanctuaries are in these park lands, while in the regosols we have maritime vegetation. In the areas affected by the tides we have mangrove vegetation. The present land use in the solodized solonetz and solon chaks is mainly rice cultivation, while in the regosols are coconut and homestead gardens.

Flood Plains

These are the river deltas having alluvium and the areas of peak deposits in the wet zone and are below 100 ft. MSL in elevation. They are in all climatic zones.

Their soils comprise alluvial soils and bog and half bog soils respectively. In the alluvial soils we have the riverine forests and in the bog and half bog soils we have swamp vegetation while in the areas affected by the tide we have the mangrove vegetation. The present land use is mainly rice cultivation.

Limestone Rolling Plains

These are the areas of miocene limestone in the Hot Arid Lowland Tropical Bioclimatic zone less than 100 ft. MSL in elevation. Their permeability is high and the soils are latosóls. The vegetation is a mix of thorny scrub jungle and monsoonal forests. The present land use in areas where the ground water table is high is in coconut with isolated rainfed paddy and lift irrigated cash crops and associated home gardens and homesteads.

Laterite Mantle Plains

This is in the lowlands in the 1st peneplain of the Hot Wet Lowland Tropical Bioclimate. The parent material is pre-cambrian crystalline rock which is deeply weathered and rarely fractured with a laterite overburden in the wet zone with an elevation of below 200 ft. MSL. The soils are red yellow podzolic soils with well developed laterite and bears rain forests. The present land use is mainly coconut and homestead gardens with paddy in the valley bottoms of the rolling plains.

Red Earth Mantle Plain

This is in the lowlands in the 1st peneplain at an elevation of 100 ft. MSL. This is in the Hot Dry Lowland Tropical Bioclimatic zone. The parent material is the pre-cambrian crystalline rock that is shallowly weathered and rarely fractured with a thin soil mantle and has a low permeability with a high run-off factor. The soil is reddish brown earths and sustains a monsoonal forest. The present land use is mainly rice cultivation, homestead gardens and associated human settlements with the major irrigation systems, comprising large reservoir canals, large anicuts in addition to slash and burn (chena) cultivation, with minor reservoirs and paddy in the valley bottoms of the mantle plain.

Low Relief Ridge and Valley

This is in the lowlands, in the 1st peneplain and is well dissected at an elevation between 100 to 300 ft. MSL in the Hot Dry Lowland Tropical Bioclimatic zone. They are in the crystalline complex and are shallowly weathered, densely fractured crystalline rocks with a thin mantle of soil. The soils are reddish brown earths and the natural vegetation is monsoonal forests. The present land use is rice cultivation, homestead gardens and associated human settlements with minor irrigation systems predominating, while they are the physical location of major irrigation reservoirs and the start of large anicuts in the beginning of the plains. In addition to chena cultivation being practised, in the Hot Wet Lowland Tropical and Hot Moist Lowland Tropical Bioclimatic zones we have minor works and paddy in the valley bottoms and coconut in the higher elevations with associated homestead gardens.

Low Relief Ridge and Valley with Inselbergs

This is in the lowlands in the 1st peneplain of the island's eastern section of the Hot Dry Lowland Tropical Bioclimatic zone. Its elevation is below 500 ft. MSL with scattered inselbergs. They are in the crystalline complex and are shallowly weathered and densely fractured crystalline rocks with thin soil mantle.

The soils are reddish brown earths and the natural vegetation is monsoonal forests. The present land use is mainly slash and burn (chena) and associated scattered human settlements with minor irrigation systems which are largely in ruins, with location of major irrigation reservoirs nearer the plains.

High Relief Ridge and Valley Systems

This is in the midlands or 2nd peneplain and its elevation is about between 500 and 2000 ft MSL and well dissected. They are in both the wet and intermediate rainfall zones; in the Hot Wet Lowland Tropical and Hot Moist Lowland Tropical Bioclimatic zone. They are deeply weathered and rarely fractured crystalline rocks. The soils are red yellow podsols and natural vegetation is rain forests. The present land use is mainly in rubber and mid grown teas where rainfall is high with rainfed paddy in the valleys and minor hydraulic structures, mainly anicuts supporting irrigated terraced paddy with homestead gardens and associated human settlements. In the Hot Moist Lowland Tropical, the perennial crop is mainly coconut with paddy on hill sides and the valley bottoms.

High Relief Ridge and Valley Systems with Inselbergs

This is in the midland or 2nd peneplain and its elevation is about 500 to 200 ft. MSL with inselbergs, in the eastern sector of the island and is well dissected. They are in the intermediate rainfall zone in the Hot Moist Lowland Tropical Bioclimatic zone and are shallowly weathered and densely fractured crystalline rocks. The soils are reddish brown earths with rain forests and savanna grasslands. The present land use is mainly chena with rainfed paddy in the valley bottoms.

There are many scattered minor irrigation works most of which have not yet been restored. Traditionally known as the land of thousands of paddy fields, today these are not yet restored. In addition there are isolated tea and rubber plantations.

Hill and Valley Systems

These are in the highland or 3rd peneplain and above 3000 to 6000 ft. MSL elevation in the wet rainfall zone in the Warm Wet Highland Tropical Bioclimatic zone with deeply incised valleys. They are deeply weathered and rarely fractured crystalline rocks in the wet zone. The soils are red yellow podzelic soils and the natural vegetation is rain forests. The present land use is the high grown teas for which Sri Lanka is world famous. In the valley slopes sometimes terraced paddy is grown as often the valley bottoms are too narrow to find levelled land for paddy cultivation. Homestead gardens and associated human settlements are generally in the valley sides as the rainfall is fairly high. The minor hydraulic structures are mainly anicuts supporting terraced paddy fields.

Midland Plateau

These are the plateau formations within the Highland and have their own levels of erosion within 3rd peneplain. While the Kandy plateau is in the Hot Wet Lowland Tropical zone, all the other plateaus are in the Warm Wet Midland Tropical Bioclimatic zone. They are in the deeply weathered and rarely fractured crystalline rocks. Their topography is of a rolling nature at its own level of erosion. These plateaus have been identified as belonging to this category, viz. the Hatton Plateau: 3,500 ft. MSL, the Uva (basin) Plateau: 3,000 ft. MSL, the Balangoda (platform) plateau and the Kandy Plateau: 2,500 ft. MSL which is the lowest of them all. Their soils are red yellow podzolic soils with unincorporated humus. The forests in these areas could be classified as Highland rain forests with associated grasslands. The present land use is teas with scattered homestead gardens with cash crops mainly vegetables. Paddy is also grown in the valley bottoms.

Highland Plateau

This plaeau is like a table land in the highlands in the higher elevation or the 3rd peneplain. It is in these regions that periodically there is frost for short spells. The level above MSL is around 6000 to 7000 ft. Here we have a Cool Wet Highland Tropical Bioclimate. They are in the deeply weathered and rarely fractured crystalline rocks. Their soils are red yellow podzolic with unincorporated humus. The natural vegetation is mountain forests with associated grass lands. The present land use is where the best of the high grown teas and exotic vegetation that have a very high demand are grown.

Mountainous

These are the highest mountains in the highlands in the highest or the 3rd peneplain. It is in this area that frost occurs occasionally in the higher reaches of the mountains. Here we have the Cool Wet Highland Tropical Bioclimate. The soils are red yellow podzolic soils with well incorporated humus. The natural vegetation is very distinct and are mountain forests. These are very rich in flora with moss, lichens and orchids. The present land use in the mountain sides is tea and natural forest reserves on the ridges.

4. PREDOMINANCE OF SPECIFIC HYDRAULIC STRUCTURES IN SPECIFIC AREAS

The topography of the island with valleys and mountains suitably well placed above the plains and the generally undulating nature of the land had the unique setting for the innovative and constructive genius of our early settlers.

The ancients had all the conditions: considerably varying topography and land forms, comprising the flood plains; the mentled plains; the low ridge and valley systems; the high ridge and valley systems; varying rainfall regimes and run off; catchment sizes that provided streams of varying sizes and of varying stream flow; climatic regimes from the arid to dry and warm to cool to choose from. Sri Lanka was then and is even now an open laboratory with all these varying conditions. It was no doubt this varying environment that triggered the genius required to evolve the construction of different types and ranges of hydraulic structures that made it possible to evolve the hydraulic civilization of Sri Lanka.

Even from the agroclimatic aspects, the dry zone was more favourable for the seasonal grain crops, compared to the wet zone that was more favourable for perennial crops. Since man's sustenance depended on grain, the population concentrated in the valleys of the dry zone where water was available or could be harnessed.

It has been found more often than not, when the modern engineer or surveyor decided on the most appropriate site for irrigation works, he stumbled on ancient irrigation works built at that very site many centuries ago by our ancients. These were mainly earth dams of enormous height and length, with enormous stone masonry placed suitably to control the issue of water and also of ponding them with suitable large stone spillways. The recent discovery of the ancient Maduru Oya dam (4th century B.C.) is yet another example of what I have just stated.

Similar discoveries could be expected when the other areas of development are opened up. The jungles which have protected and preserved the legacies of our past for centuries are waiting to reveal more secrets of our irrigation practices and our ancient hydraulic culture.

In the map of the Major Ancient Irrigation Works of Sri Lanka that I have already presented to the Society in 1979, the ancient irrigation works prior to the end of the 12th century, which have been mentioned in inscriptions, chronicles and folklore and have been indicated in sources of modern writing have been used. It is not in all cases that the dates of construction has been indicated, but they have been indicated wherever they are available. Constant revision will be needed as more information becomes available.

In the case of irrigation works before the Christian era, I have taken care to date them only where they have been recorded, though in many cases the tradition goes back to pre-Vijayan times and I have taken the precaution to date them as only B.C.

Very often these feeder major hydraulic works also functioned as feeder tanks to the minor hydraulic works with extensive canal systems. In addition to the major and medium hydraulic reservoir works, there were also minor hydraulic reservoir works with the associated human settlements and agricultural production.

These minor reservoirs were the nucleus of every village in the intermediate and dry zones, comprising the village (minor) tank and paddy, the homestead and the chena. These were all within range of the homestead and constructed and maintained by the small communities themselves.

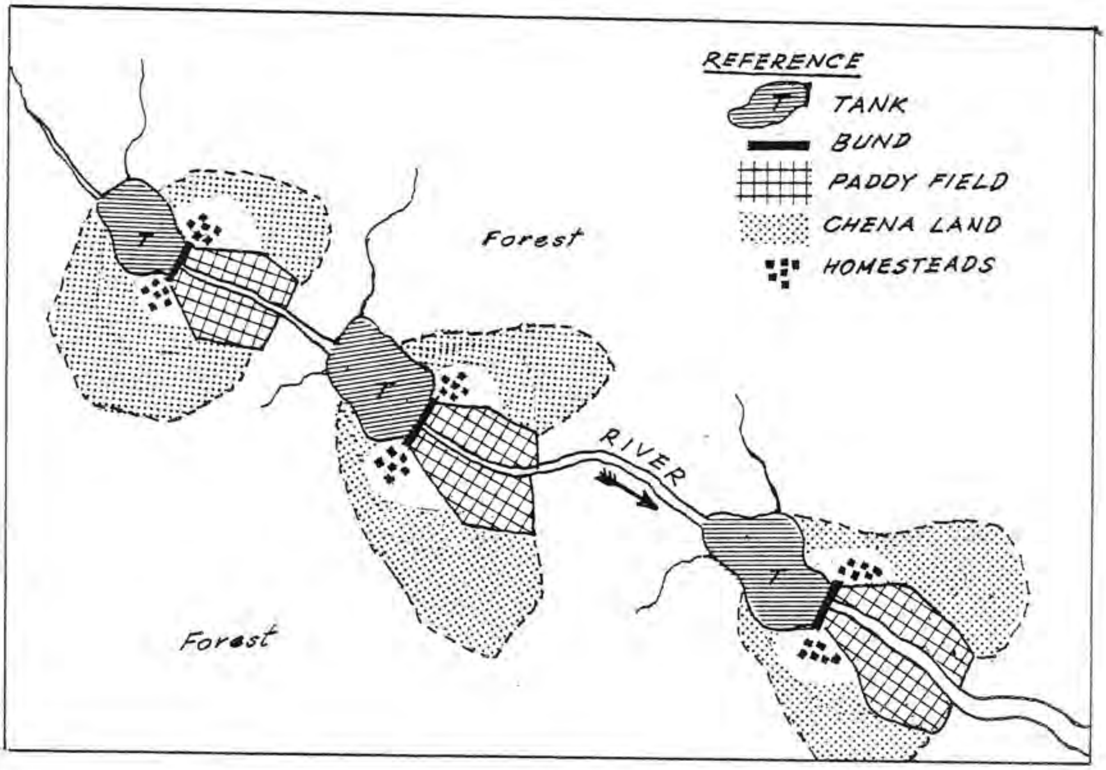


DIAGRAM I - Minor Irrigation systems in a small river valley, with homestead, paddy and chena.

The fall in fertility with constant cultivation made the villagers abandon their field and the shift up and down the valley system, even with the extreme care in choosing proper seed materials which they have developed.

The chena (slash and burn) had a cycle of use of around 7 - 15 years, an averge of around 12 years. Similarly the villagers, too, shifted when the fertility of the paddy fields was reduced to such an extent that it became uneconomic to continue to stay as it did not even provide sufficient food for their sustenance. In fact, this was the reason for this agrarian economy, based on the hydraulic structures, to have a shifting village pattern, moving up and down the small stream while having permanent citadels. This was in fact the reason for the construction of semi-permanent houses for the peasants that would last around 5 years, which soon after abandonment went back to nature with no trace of their existence, while hydraulic structures, the temples and the king's palaces which were permanent remained. Remnants of these modes of living still prevail in the remote areas and are reflected in the houses of these peasants.

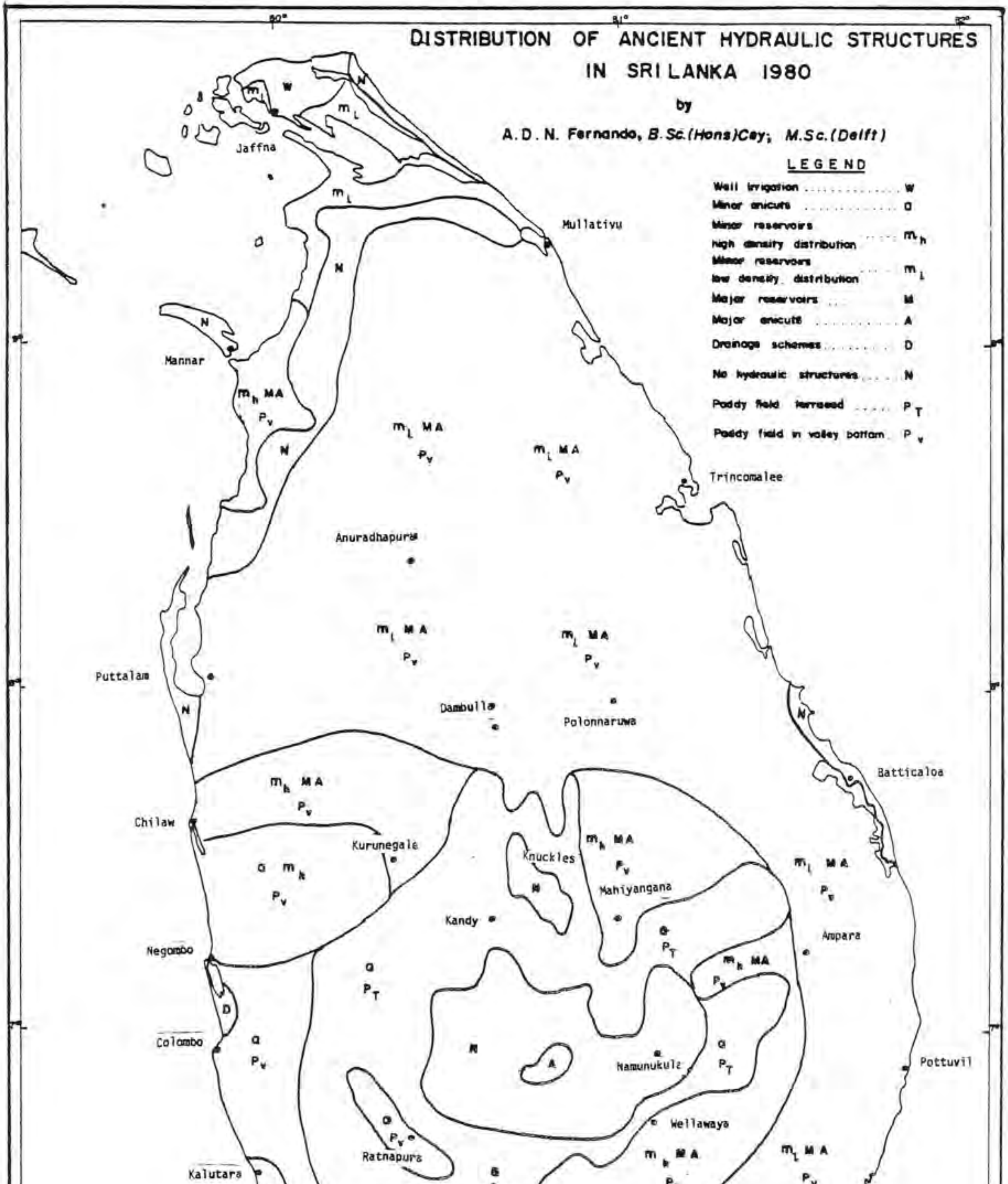
It could, therefore, be concluded that at any one time for reasons of fertility of the soil, the minor reservoirs were wilfully abandoned periodically. In addition to this conclusion, it is also confirmed by the water resources limitations in the catchments that at any one time around 1/3 of the minor tanks, or a maximum of half were occupied and operational, the people abandoning and shifting in about every 5 years. Therefore, we could reasonably presume that two or three adjacent minor tanks in a river system formed a village community with a cycle of occupancy of about 12 to 15 years or so.

In the flood irrigation systems of ancient Egypt, there was constant annual replenishment of fertility with the flow of nutrients with the annual flood waters from the river Nile, directly to the fields. Such conditions did not prevail in Sri Lanka except in the flood plains. The water was ponded in reservoirs and issued when required to the fields. Where there were small streams in the wetter parts they were diverted to the fields direct; where there were large river flows in the drier parts, the large anicuts were controlled by elaborate spills along the channel to prevent excessive flows. These works would necessarily have had less minerals and nutrients in suspension and therefore less fertilizing properties from these waters, unlike those in Egypt. The major hydraulic works no doubt would have been constructed, maintained and managed by expert engineers and managers of that era.

In ancient and medieval times fertilizer in the form of bone, ash and cowdung was known and was limited in application, because of its limited quantity. It could therefore be reasonably deduced that most irrigation schemes went into disuse besides poor maintenance, wars, natural disasters and floods intervened so that the dams were breached. There was also periodic abandonment because of fertility problems and consequent low productivity in the fields below the reservoirs.

The practice of allowing flowing water to pass through paddy fields may have been an old cultural practice to trap fertilizing materials in the fields and increase the yields. In addition flooding the paddy fields was an old cultural practice quite effective as a weedicide. Though these old cultural practices are yet being used today, sometimes we as scientists and engineers tend to scoff at these practices without knowing that the new developments of fertilizer and weedicides are only about 5 decades old. If they are cheap, the farmer would use them; if they are expensive, I suppose he would flood his field to kill the weeds. If the water is free, who would not?

A close study of the numerous sites of the Brahmi Inscriptions which are of the era 2nd centure B.C. to 2nd century A.D., which were the first signs of lithic record, clearly indicates the distribution and presence of settled and associated cultural activities in that period. These sites were almost exclusively in the Hot Dry Lowland Tropical and the Hot Moist Lowland Tropical zones or the Dry and Intermediate zones, in the Low Relief Ridge and Valley systems, both with and without inselbergs and in the flood plains of the first peneplain and also in the lower reaches of the 2nd peneplain in the hill and valley systems and in the valleys close to rivers. There were inscriptions of a post 2nd century A.D. era in the same climatic zone in the Red Earth Mantle Plain. Meanwhile it should be noted that the ancient cities of Sri Lanka were all in the Red Earth Mantle Plains.



DISTRIBUTION OF ANCIENT HYDRAULIC STRUCTURES IN SRI LANKA 1980

by

A. D. N. Fernando, *B. Sc.(Hons)Cey; M.Sc.(Delft)*

After the Hydraulic Civilization reached its climax in the 13th century, the system went to disarray. The population could not sustain itself and moved from the Dry Zone to the Intermediate and Wet Rainfall Zones, the Low Relief Ridge and Valley and High Relief Ridge and Valley systems to start once again the cycle of construction from minor hydraulic structures. After the 13th century A.D., the capital also shifted to Yapahuwa and Dambadeniya (both in the Intermediate zone in the West of the Island) and thereafter to the Wet Zone in Sitawaka and Kotte. The shift of the capital to the Kandy Plateau was mainly due to external factors of aggression by the Western world. Kandy was an excellent refuge on the lowest plateau of the third peneplain, naturally well fortified and served its purpose well.

In the study of the distribution of minor hydraulic works, we note that in the wet zone or the Hot Wet Lowland Tropical Zone, there are minor anicuts in the Laterite Mantled Plain, minor anicuts with terraced paddy in the High Relief Ridge and Valley Systems and also in the Hill and Valley systems. Sometimes we find also temporary anicuts made with tree stumps to divert a season's stream flow to small paddy lots as well. The minor reservoirs dominate in the intermediate zone or Hot Moist Lowland Tropical where their density is high with continuous tank paddy systems in the valley bottoms of the Low Relief Ridge and Valley Systems. These minor reservoirs also exist in the Dry and Arid Zones though at a much lesser density in the Reddish Brown Earths as well as in the Littoral deposits.

There are at present recorded about 35,000 such minor reservoirs in the island and more are being discovered. Their density per square mile is more in the Hot Moist Lowland Tropical Bioclimatic zones where they are best suited. (Please see Map showing the distribution of Ancient Hydraulic Structures.)

What is most amazing is that the major and medium ancient hydraulic works are exclusively in the Dry Zone or Hot Dry Lowland Tropical Bioclimatic zones, in the Red Earth Mantle plains and also in the Alluviums of major rivers.

In the Hot Dry as well as in the Hot Arid Lowland Tropical Bioclimatic Zones in the Littoral Plains with soils comprising solodized solonetz and solon chaks near Mannar, there also exist major works with medium works as well, which is a happy anomaly. This region is a place apart separated by a barrier as it were from the major clusters interior by a belt of limestone rolling plain between, which is highly pervious.

It is most noteworthy to know that there are no major works in this belt comprising limestone rolling plains which have karst formations and latosols, because of their high permeability which obviously our ancients knew and avoided.

The lifting of water by using leather buckets was known. In the alluvial areas water was lifted from rivers and in the limestone rolling plains ground water was extracted using dug wells with cultivation on a limited scale. In the wet zone alluviums there are a number of drainage schemes.

There are however isolated medium works in the highest peneplain in the highland plateau of the Cool Wet Highland Tropical Bioclimatic zones. One is called Mipilimana Tank and has been attributed to the legendary King of Lanka, Ravana (2nd to 5th millennium B.C.) while the Drainage and Reclamation works in the Wet Zone of the country were works of the Parakrama Era.

5. RECENT DISCOVERIES RELEVANT TO THE HYDRAULIC CIVILIZATION

It would be necessary at this stage to present the more recent discoveries that have a direct bearing on the ancient hydraulic civilization.

5.1 Ancient Vijithapura

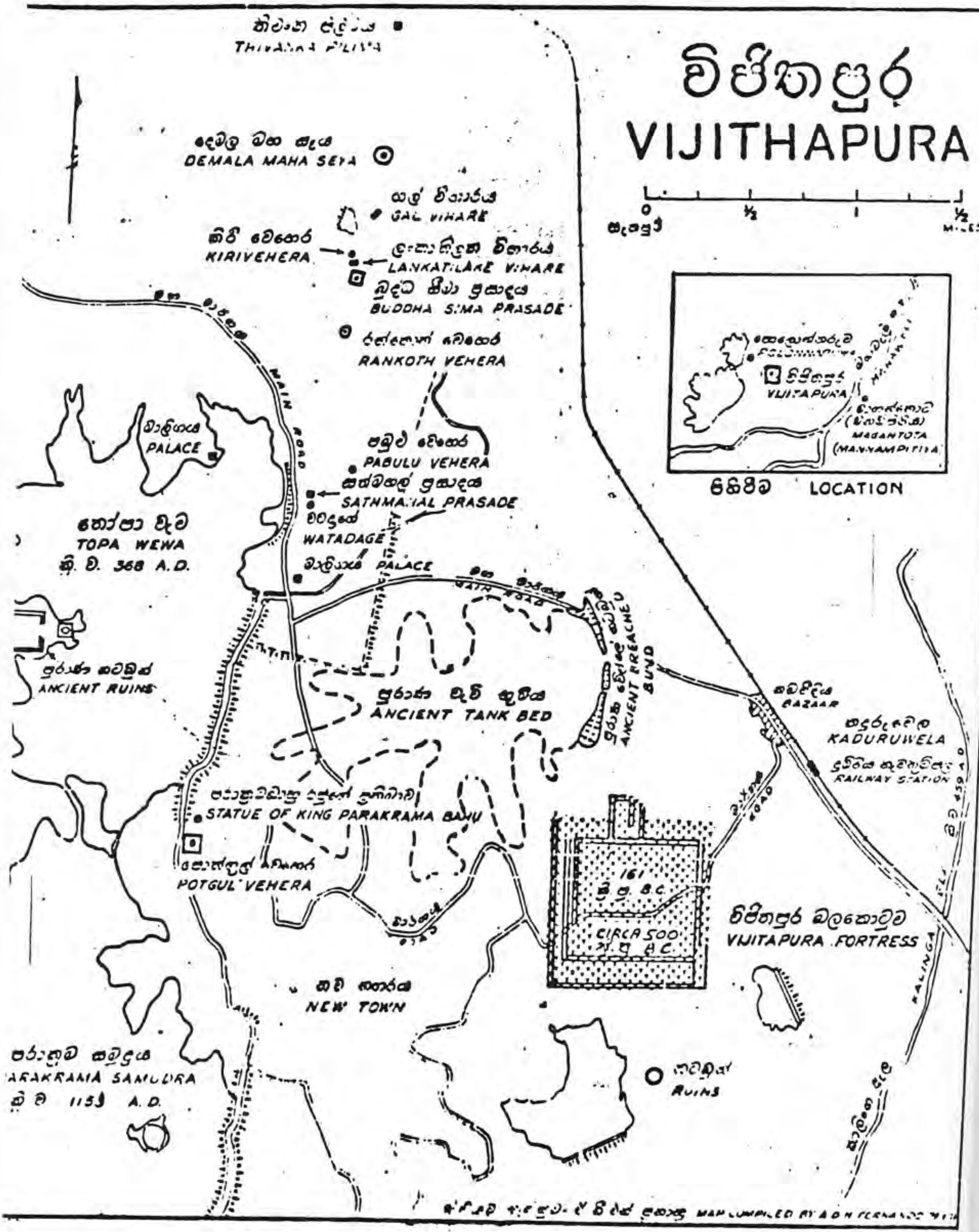
In 1979 I was engaged in a detailed study of the area that comes under the Mahaweli Project and I came across what appeared to be a distinct cultural feature in the shape of a large square surrounded by three consecutive moats yet visible on the aerial photographs, the area within the central moats being around 250 acres.

This was indeed the fortress of Vijithapura, that was mentioned in the chronicles, though many had searched but could not find. This find fitted in detail to the description as it was mentioned in the chronicle, in the 2nd century B.C. (see Aerial Photo). This was the fortress where a great battle took place in the 2nd century B.C. This discovery would have to be taken in the context that in the 6th century B.C., the North Indian Adventurer, Prince Vijaya, an Aryan Prince conquered Sri Lanka and established Vijithapura as the metropolis. The siege of Lanka was similar to that of Troy: the Yakkhas who were a civilized race, were engaged in revelry and gaity to mark the marriage of the king's daughter in his palace, when Vijaya struck.

It is said that Prince Vijaya established five townships, Upatissagama, Ujjeni, Uruwela, Anuradhagama and Vijithapura (which was the metropolis) named after his chief Generals. It would appear that like all adventurers, the conquerer would have taken over existing towns and given them new names, of which Vijithapura was the foremost as it was a city (pura). Vijithapura was the foremost metropolis of ancient Sri Lanka and is today in the outskirts of the famous ancient capital city of Polonnaruwa (see map for their relative positions).

It must also be recalled here that the chronicles mention that the ancient city of Sri Lanka in pre-Vijayan times was Lankapura whose location is not known. One could therefore speculate whether the ancient city of Lankapura could be the city of Vijithapura, now in the outskirts of Polonnaruwa? The present evidence supports the view that they are one and the same. Be that as it may. The ancient metropolis of Sri Lanka in the 6th century B.C. was Vijithapura which is today in the outskirts of Polonnaruwa.

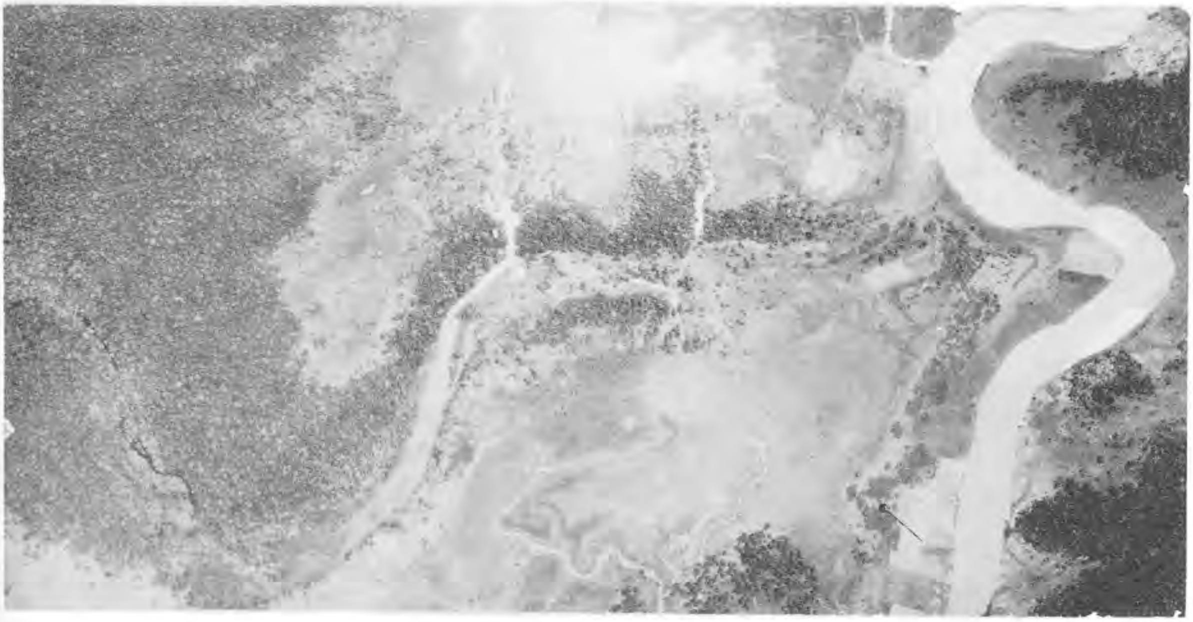
Aerial Photograph of Vijithapura on Scale 1 : 10,000, showing the moats of the fortress as described in the Mahawamsa Chronicle.


විජිතපුර
VIJITHAPURA
0
½
1
1½
සැතපුම්
MILES
පිහිටීම LOCATION
POLONNARUWA
විජිතපුර
VIJITAPURA
MANNAMPITIYA
MAGANTOTA
(MANNAMPITIYA)
THIVANKA PILIMA
දෙමළ මහ සෑය
DEMALA MAHA SEYA
GAL VIHARE
කිරි වෙහෙර
KIRIVEHERA
LANKATILAKE VIHARE
BUDDHA SIMA PRASADE
RANKOTH VEHERA
MAIN ROAD
PALACE
පබුළු වෙහෙර
PABULU VEHERA
SATHMAHAL PRASADE
WATADAGE
PALACE
තෝපා වැව
TOPA WEWA
ක්‍රි. ව. 368 A.D.
ANCIENT RUINS
MAIN ROAD
ANCIENT BREACHED BUND
පුරාණ වැව් පතුල
ANCIENT TANK BED
STATUE OF KING PARAKRAMA BAHU
POTGUL VEHERA
ROAD
BAZAAR
KADURUWELA
RAILWAY STATION
ROAD
161
ක්‍රි. පූ. B.C.
CIRCA 500
ක්‍රි. පූ. B.C.
VIJITAPURA FORTRESS
KALINGA ELA
නව නගරය
NEW TOWN
RUINS
පරාක්‍රම සමුද්‍රය
PARAKRAMA SAMUDRA
ක්‍රි. ව. 1153 A.D.
MAP COMPILED BY A D N FERNANDO

Later, Anuradhagama (gama is village) became the capital and was known as Anuradhapura in the 3rd century B.C. With the incursions from the Western seaboard from India, the capital oscillated between Anuradhapura and Polonnaruwa, up to the 13th century A.D.

5.2 The Ancient Mahaweli

In 1965, when I was associated with the mapping of the entire Mahaweli basin for an F.A.O. Study, I was fortunate to discover the old and ancient course of the Mahaweli Ganga by using aerial photographs (see photo). From the Manampitiya Bridge, three miles downstream of the Mahaweli, there is a large island which the Mahaweli Ganga engulfs. On the left of this island is the old dried up course of the Mahaweli. Ancient temples (dagobas) such as Somawathiya, Kombanachchiya and Seruwila are along the old course stretched out like a string of pearls. It is an astounding revelation that the ancient Buddhist temples were beside the old river course while there is none today on the present one. (Please see map.)



Ancient Mahaweli flowing from West to East and
Present Mahaweli flowing from South to North at
Somawathiya

In ancient times, the river abandoned its old course and ploughed its way along the new course that we see today. Just two miles from where the river changed its course, the river partly submerged a huge life-size elephant carved out of rock, which is part of a large living rock outcrop that once formed part of the sculpture of an ancient monastery that was well above the ground. Beyond this point, the present river crosses the old river at right angles and thereafter divides itself into two, the main river flowing north to the Kodiyar Bay and the branch flowing to the east coast.

It has been said that Sri Lanka lies outside the major earthquake prone regions of the world and that it is thus spared the horrors and disasters that accompany them. However, I present to you a map showing the distribution of earthquake epicentres recorded recently in and around the environs of our island, from the National Earthquake Information Service of U.S. It is clear that though we are not within the major earthquake-prone area, earthquakes do hit our country and the environs.

The first earth movement and submergence of the coast by which Sri Lanka is alleged to have been separated from the mainland of India is said to have taken place, according to chronicles, in the Ravana epoch (between 5th and 2nd millennium B.C.). The second is ascribed in the period of Panduwasa, 4th century B.C. and the subsidence of Colombo is said to have taken place in the period of Kelanitissa, 2nd century B.C.

It could, therefore, be reasonably deduced that there have been three earthquakes. There is no doubt that one could be fixed near Kelaniya and I have used my judgement and placed one near Mannar (making the physical separation of India and Mannar) and the other near Kaduramalai (on the basis of folklore in the Kaduramalai area). There is also a reference in the "Sasanawamsa' to an earthquake when the last Arahath Maliyadeva attained Pari Nibbana around 1000 years after the Buddha which is around King Upatissa's time (368 A.D.).

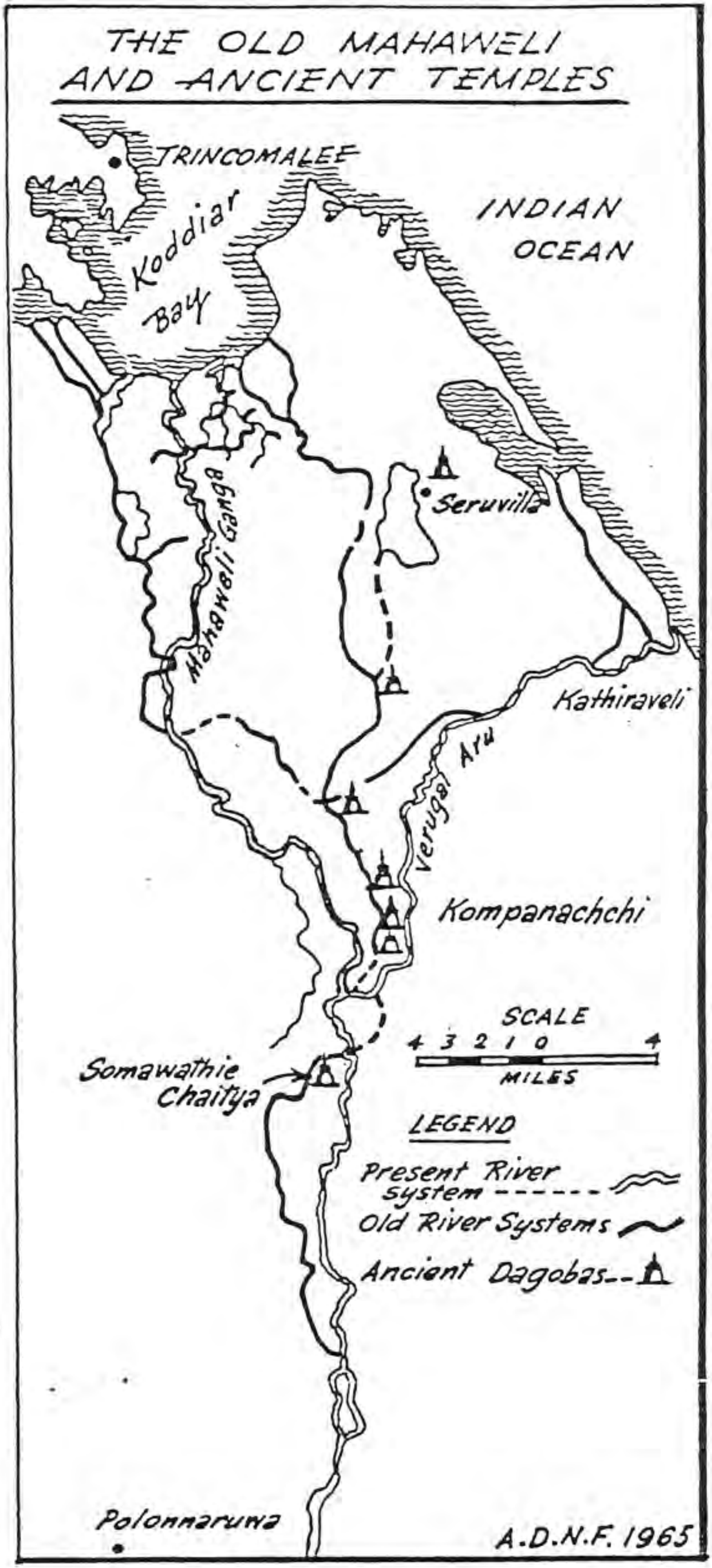
I would also locate another earthquake, which I shall explain, south of Trincomalee that caused the river to change course. These earthquakes are depicted in the accompanying map. The frequency of these earthquakes that hit the land appears to be once in a millennium.

The change in the Mahaweli ganga course was due to an earthquake that could have depressed a vast area and diverted the river suddenly. An interesting question to ask is, when did this disaster take place? Let us look at four clues!

First, there is a stone inscription beside the old river, near Somawathi Chaittiya which has been found to be about 2,000 years old. This inscription mentions a crossing point (ford) which was on the old course at which money was collected for crossing. The money was to be given to the temple. We can therefore say that the river changed course within the last two thousand years (and also that at that time money was used).

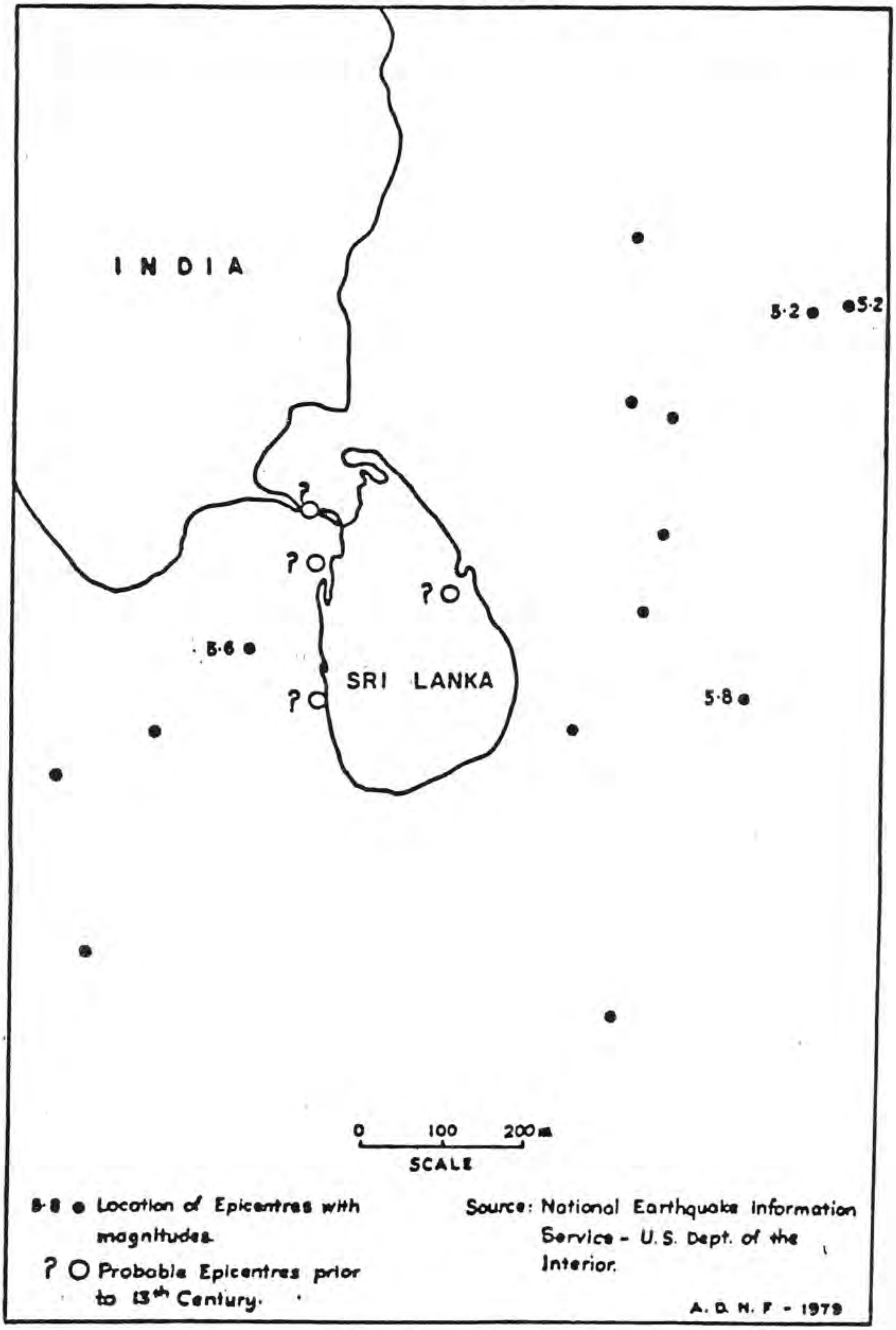
The second clue is the submerged elephant of the monastery which I have referred to earlier, which appears to be similar to the Pallawa art like at Mahabalipuram in South India. Cave inscriptions indicate that the monastery was flourishing till 700 A.D. or less than 1300 years ago.

The third clue is the Kalinga Irrigation system itself. It is attributed to King Dhatusena around 459 A.D. It is therefore after this date that the


THE OLD MAHAWELI AND ANCIENT TEMPLES
TRINCOMALEE
Koddiar Bay
INDIAN OCEAN
Seruvilla
Mahaweli Ganga
Kathiraveli
Verugal Aru
Kompanachchi
SCALE
4 3 2 1 0 4
MILES
Somawathie Chaitya
LEGEND
Present River system
Old River Systems
Ancient Dagobas
Polonnaruwa
A.D.N.F. 1965

DISTRIBUTION OF EARTHQUAKE EPICENTRES AROUND SRI LANKA

POSSIBLE EARTHQUAKE EPICENTRES PRIOR TO 13TH CENTURY SUPER IMPOSED



5·8 ● Location of Epicentres with magnitudes.

? ○ Probable Epicentres prior to 13th Century.

Source: National Earthquake Information Service - U.S. Dept. of the Interior.

A. D. N. F - 1979

shattering earthquake took place, destroying the Kalinga Irrigation Scheme, submerging the sculpture of the monastery, changing the river's course and bringing disaster to a large population.

The fourth clue is that Parakra Bahu, 1153 A.D., restored these channels. Since there have been no historical records indicating a cataclysmic event like the earthquake associated with the disrupting of the irrigation channels in the pre-Parakrama Bahu period, it is reasonable therefore to surmise that this event took place subsequently. This argument is further substantiated by the absence of temples along the new course. After the demise of Parakrama Bahu I, in 1186 A.D., in fact within a few decades, the Sinhalese Kingdom began to crumble under civil war and external aggression and by the end of the thirteenth century, the past glory became only a memory. During the intervening period the vast and complex irrigation system went into ruin.

There is no historical or epigraphical record of the construction of any new irrigation works of any major consequence from that time to the Portuguese period in the 16th century, as there is a gap in the continuous recording of the chronicle.

It was in the period of the late Dutch (17th century) and British (19th century) colonial periods and the post independence era that the beginning of reconstruction of these major ancient schemes and restoration took place. Since the history after Parakrama Bahu indicates the crumbling of the irrigation system within a short period, it could be reasonably deducted that this cataclysmic tragedy could also have contributed to it. However, it is only by scientific tests, possibly Carbon 14 or pollen dating, that one would be in a position to arrive at the period of this catastrophic event. Whatever the reason, the fact remains that the channel system of Kalinga went into disuse due to the changes in levels along the channels and the surrounding terrain.

It is clear that in looking for traces of the ancient irrigation structures on the main Mahaweli, we would have to search for them on the old course. Likewise in other rivers, there would have been changes in the river course especially in the delta. One could expect these changes and one would have to interpret the ancient hydraulic systems in relation to the river courses at that time. For example, there is sufficient evidence to indicate a change in the river course at the mouth of the Malwatu Oya. However, no work has been done to trace the former course. The position is similar with other rivers as well. Thus, there is more scope for research in these fields.

In respect of the ancient hydraulic structures on the Mahaweli Ganga, it is interesting to note that the recent NEDECO (Netherlands Engineering Consultants) study on the Mahaweli Ganga (Mid-Term Report, December 1978) indicates that over and above the irrigation of fields under Parakrama Samudraya, Minneriya, Giritale, Medirigiriya and Kaudulla, there is sufficient run of the river water in the Mahaweli to irrigate another 100,000 acres and more. This clearly implies the technical feasibility of the Kalinga Bemma or Anicut, with Gomathi and Kalinga Canal System and other channel systems downstream in ancient times. Therefore all of them could have been in existence contemporaneously, dispelling any doubt which some persons had that all of them were not revived, by Parakrama Bahu, the Great, because of lack of water.

5.3 Ancient Bisokotuwa at Maduru Oya

It was a year ago that the author stumbled to some brick scrapings on the ancient bund at Maduru Oya which was accidentally scraped by a dozer in the process of the construction of an access road, and I identified it as a Bisokotuwa and informed the Archaeology Department accordingly. The author further mapped out the alignment of the barrel of the Bisokotuwa across the bund which was askew (at an angle) and not perpendicular to it. In fact, there is a second lower level sluice on the same side of the river bank which has not yet been excavated. The Consultants were informed accordingly to make sure that when this section of the bund was being cleared for the new Right Bank Sluice, the excavation should be done carefully in this particular section. In mid November last year I was informed that the contractors had damaged part of the ancient structure. With the assistance of CECB Engineers and workmen the author was able to expose the water carrying duct of the Bisokotuwa. This structure surprised many engineers as well as others as they thought that this could be only a retaining wall. Thereafter this entire structure was exposed, and the earth around it was excavated by bulldozer (which I think was used for Archaeological excavation in Sri Lanka for the first time), with the Department of Archaeology supervising it.

The Bisokotuwa has an inlet trough with twin inlets with a central chamber and an outlet. The area of cross section of the inlet is smaller than the area of cross section of the outlet conforming to the well known principle of hydraulics in the construction of sluices. In short the ancients were fully aware of the scientific and technological principles involved in such construction. The controlling device was at the inlet side of the sluice as there is no evidence of its presence at any part along its barrel. The outlet of the Bisokotuwa has two outlets from the same point with a monolith of massive dimensions placed over three vertical stone columns. This single monolith of dressed stone weighs over 15 tons. What is interesting in this Bisokotuwa is that it has been encased in bricks (18" x 9" x 2½") bonded with resin. The inside of the Bisokotuwa is gable arched and constructed with brick. Inside this gable arch is a granite lined water carrying duct of rectangular cross-section. In passing it may be of interest to note that this type of gable arch is very ancient and has been recorded in other parts of the world, as far apart as the Americas, as well as Mycenaean Greece (Pages 361 and 262 Larousse encyclopedia of Archaeology).

During excavation, after some rainwater had soaked through a damaged section in the centre of the Bisokotuwa, a section collapsed (as if purposely done by a hidden hand). What was exposed was an excellent sculpture tool cut and formed on terra-cotta bricks, but now damaged. This was obviously not meant for public view, as it was encased in the inner sanctum of the Bisokotuwa. This sculpture is of Yaksa cult depicting five figures which appear to be dancing devatas. The central figure in all probability had a special headgear (which has so far not been found). Could the central figure be that of Cittaraja the water spirit of the Yaksas? It was as if these dancing devatas were heralding the waters that rushed past beside them to the outer world to feed the rice fields below.

This sculpture with two well ornamented pillars on either side is also cut and formed in terra-cotta. The form of these pillars shows that the anicuts were well versed in the construction of perfect spherical shapes on these pillars. If they are replicas of the architecture of the period, the columns would have been in all probability of wood or brick and unlikely to be in stone, as we do not have any ornate stone carvings here. This again gives clues to their antiquity.

On either side of the Bisokotuwa two similar terra-cotta images of size 6" x 3" were found which appear to have been part of a ritual ceremony associated with a bali ceremony of Yakkha cult.

In the Mahawamsa, it is stated that Pandukabhaya lived with the Yakkhas in these parts on the right bank of the Mahaweli for 4 years. Connected with the Pandukabhaya legend is that of Yakkha Jutindhara whose haunt was the lake named Tumbariyangana near the Mahaweli Ganga in the eastern part of the Island which is again in this area.

Excavated Ancient Sluice Barrel
of the Maduru Oya Reservoir

Twin Inlets With Gable Arch
Containing a Granite Lined Water Duct

Tool Cut and Formed Sculpture
in Relief 4½ x 3 ft
Dancing Devatas on Terra-cotta

Terra-cotta Sculpture on Tile
6" x 3" of Yakksa Cult

These terra-cotta relief figures, though similar to the relief moulded terra-cotta animistic figures at the Ishtar gate of the city of Babylon which is of 7th century B.C. is unlike it. The terra-cotta relief figures at the Maduru Oya Ancient Sluice are executed on bricks laid together with hardly any spacing between and held together with natural resin. The small human figures that are carved are of extremely fine quality. They are neither plastered nor glazed and appear to be tool cut and worked on the brick itself by a Master Craftsman.

The terra-cotta relief plaque appears to have been used in a ritual ceremony, as there is further evidence of chipping of the human figures with a blunt instrument that left impressions about half a centimeter thick and 5 cm wide. It is obvious that the defacement is ritualistic and not with the intention of complete destruction of the plaque. The greater part of the plaque is very clear showing five figures and perfect ornamental pillars on either side of the figures. There is no evidence of any inscriptions, either on terra-cotta or on stone at this ancient sluice.

In the immediate vicinity, within half a mile of this site there are many 3rd century B.C. rock inscriptions in Brahmi script. On the left bank abutment rock outcrop, well above the dam, there are two dagabos in ruins near a pool of water and a giant statue of the reclining Buddha in lime plastered brick in a cave, all in ruins. The valley downstream contains many terra-cotta human figure remnants that recall the fertility cults of the ancient past.

This evidence clearly shows that this valley has been occupied at least from 3rd century B.C. to about the 12th century A.D. The absence of the lithic record at the dam site itself, the very nature of the dam construction and the evidence of Yakkha rituals, both within the sluice and outside it, would place the date of construction before the 4th century B.C. as there is no evidence of Buddhist influence.

Since there is also the evidence that these areas were occupied before the Pandukabhaya period, we can conclude that the antiquity of the sluice at Maduru Oya, goes back to the Yakkha Period. There is the evidence in the Mahawamsa that these parts were occupied by the Yakkhas in the 6th century B.C. The final dating would rest with the scientific method of carbon 14 dating, of which results are awaited.

6. EVOLUTION OF HYDRAULIC STRUCTURES

I shall now proceed to deal with a working hypothesis on the basis that certain hydraulic structures were necessary for the evolution and development of the hydraulic civilization of Sri Lanka.

From the most ancient times, man in Sri Lanka, like his counterparts in the other parts of the world, lived by hunting and gathering in the natural habitat suitable for such activities. Sometimes they lived in caves to protect them from the weather. In areas where the weather allowed it, they lived in the open for long periods, finding shelter during the rainy periods, possibly again in the caves or some rudimentary thatched cover.

There are many caves that show the presence of stone-age man in the Hot Dry Lowland Tropical and in the Hot Wet Lowland Tropical and the Hot Moist Lowland Tropical Bio-climatic regions, in the escarpments of the Balangoda plateau, the Ravana cave in the fringes of the Uva plateau and in Bellan Bendi Pelessa.

There is evidence of urn or pot burial sites with evidence of funerary offerings with associated megalithic monuments which indicate burial practices of a religious nature, near the sea coast and also inland. All of them go to show that man was in Sri Lanka from the dawn of civilization.

Now I shall proceed to deal with those innovations that assisted in the development of the hydraulic civilization. If these innovations were not available at that time, there would not have been the hydraulic civilization. In this context, an analysis can now be made on the evolution of the ancient hydraulic systems that made it possible to have a settled agriculture with its associated hydraulic works, reservoirs, bemmas and channels for rice cultivation and the consequent development of cultural and religious pursuits.

When man moved from the hunting and gathering stage to a rainfed agriculture, possibly with wells or ponds for drinking water, he moved to the state of settled agriculture, so that the well could be considered as the first hydraulic structure for use by man. Thereafter the next stage would have been the construction of the simplest hydraulic structure for irrigation, viz. the amuna (anicut) with a delivery channel, which is the simple structure across a river or stream where part of the stream flow was diverted without storage, through canals directly to the fields. Later the water was diverted from the river along a canal to feed a reservoir in more topographically favourable sites. This was in all probability his first major step. The ancients chose suitable sites on the river bed that generally had a rock outcrop going across the river and by adding simple stone masonry structures to this foundation built the anicut.

These anicuts were of use in perennial rivers as the diversion of the water depended entirely on the behaviour of the flow of the river. Where there was little flow there was less water, where there was no flow, there was no water to be sent down the delivery canal to the fields. Thus, this hydraulic structure was suitable in areas where the rainfall was fairly steady or the flow of the stream steady. This structure would have possibly been the first major hydraulic structure, when man moved out from the hunting and gathering, and rainfed cultivation stage. It would only be natural that he controlled small stream flows at the beginning and thereafter graduated to control larger flows in larger rivers.

The next stage was the construction of reservoirs by building a dam across a river so as to impound water for subsequent use. He stored water in reservoirs and sent them to the fields under a controlled system of issuing water with a controlling device to the fields with the help of canals. All the dams constructed by our ancients were earth dams and conformed to the scientific principles as known to modern man. This construction required a real genius as it called for a device to control the issue of water from the reservoir.

This step was the key to the development of reservoirs. This innovation was the key to the great leap forward. He would no doubt have started by the construction of small reservoirs, having graduated by further experience and proceeded to construct larger reservoirs with their corresponding large structures.

This key was the controlling valve or sluice. This was the master invention that made it possible for the development of the hydraulic civilization in our country. In Sri Lanka, it is called the BISOKOTUWA, a totally indigenous innovation. The vertical shaft with a square cross section was the usual controlling device to regulate the water with a wooden apparatus, by raising and lowering of which the conduit is wholly or partially closed and thus the flow of water is regulated or completely shut off. This shaft with the locking device thus divides the conduit into an inflow and outflow channel that could be fully regulated.

This is illustrated below.

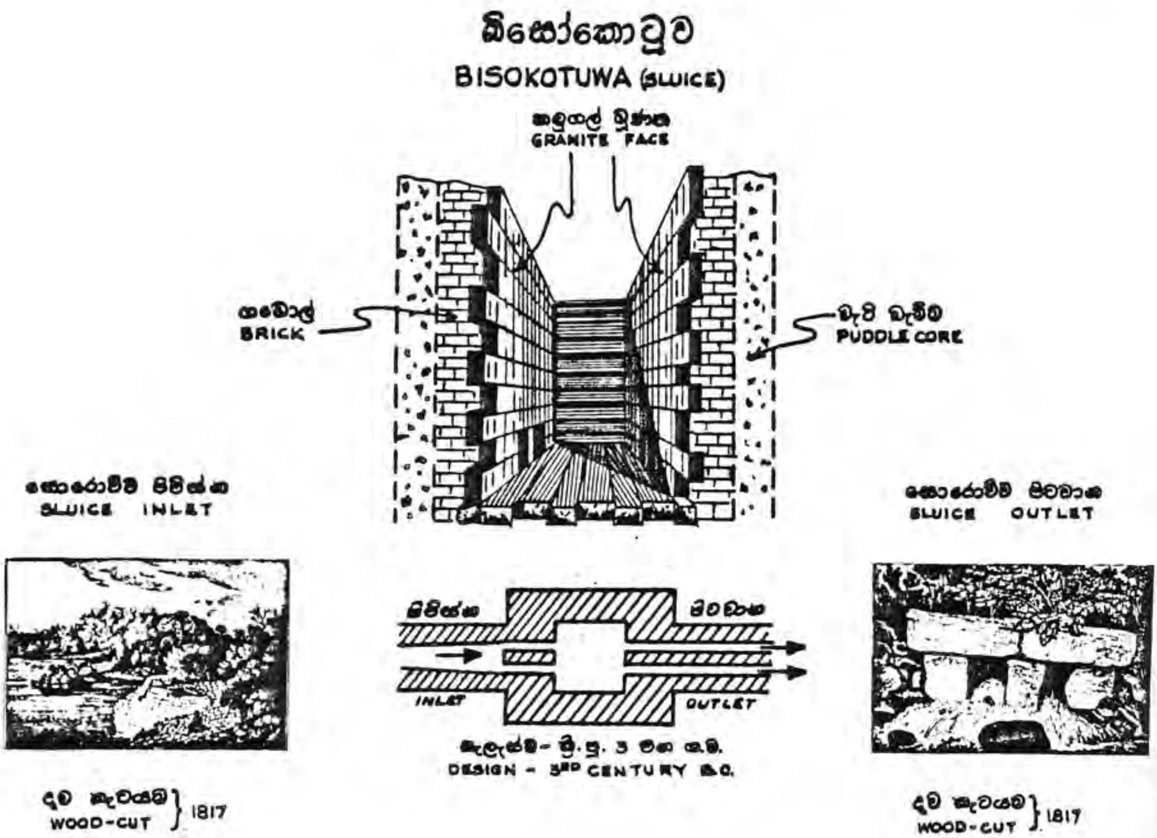


DIAGRAM II - BISOKOTUWA SLUICE

Some are of the mistaken view that only lithic record and epigraphic remains are evidence of the first signs of enlightened civilization. But the oral traditions of cultural, scientific and technological value were usually passed from father to son, from one generation to another, and were not recorded though they existed long before lithic records evolved. Be that as it may. It would appear that the first lithic record with large characters in Brahmi script was on the drip ledges of caves. These were generally statements on granitic gneiss that indicate the presentation of these caves by their former owners to the 'Sangha' (Buddhist monks) 'till the sun and the moon lasts'.

We find even the Buddhist philosophy passed from generation to generation, from Master to disciple by oral tradition and not as written works till the 4th century A.D. in Sri Lanka. This clearly debunks the mistaken view that literacy and civilization always go together.

Where there are no lithic records on the more elaborate hydraulic structures, we could come to two conclusions:

1. that some of these structures were truly built after the 2nd century B.C. by the kings that followed; which has been recorded in some cases, with inscriptions.
2. that some were only repairs to old structures that went into disuse before the lithic records were evolved; and that as they were repaired and put to use by the kings that followed the 2nd century B.C., these works have not been recorded in some cases.

If the second assumption is correct, there would have to be a lapse of time between the destruction of the earlier civilization and the commencement of the second cycle of development which commenced around the 3rd century B.C. with the advent of Buddhism in Devanampiyatissa's time, which was also when the literary tradition began.

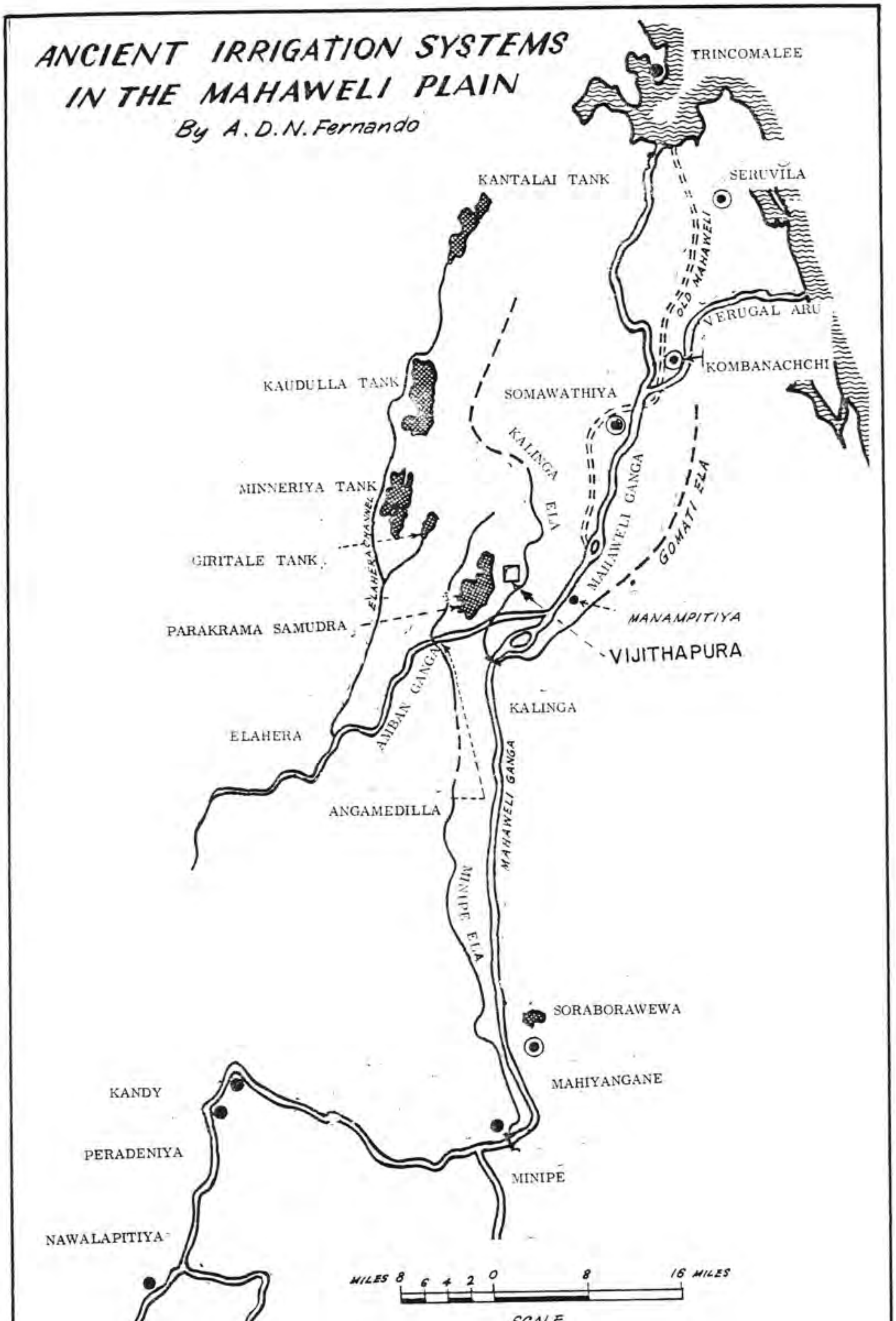
We are living at a time when we are fully aware of the civilization that was built up to a climax in the 13th century, when it reached its peak, went into complete disarray. In the subsequent epoch, the people had once again to commence living through a phase of sustenance, using minor hydraulic structures and renovating and reviving the major ones. Only in 1890 was the first major reservoir restored, while other larger ones are yet being restored. We are also adding new ones altogether when we would reach the zenith of our present civilization.

If we therefore accept the second conclusion, then it would mean that after 1890 we are going through the 3rd cycle of major development. On the other hand, if we only accept that the major structures were only constructed after the 2nd century B.C., then it would mean that today we are going through the 2nd cycle of major development.

Whatever it be, when the great works went into disuse for whatever cause, the civilization was sustained through a phase of using minor hydraulic structures like anicuts and reservoirs that were essential for sustenance and then gradually we moved to the repairing and construction of the larger works to reach its zenith once again almost on a cyclic basis.

We have also seen that there was an enlightened hydraulic civilization in the pre Pandukabhaya period accomplished by the Yakkha chiefs who had the necessary technology to construct large hydraulic and other civil engineering structures. These techniques they passed on, and were the precursors of the Buddhist Hydraulic Civilization which commenced in the 3rd century B.C.

There is also the evidence of numerous hydraulic structures attributed to the early kings who could not have built them in their lifetime, which has been attributed to them. There are some structures in the Mahaweli Basin whose dates of construction are lost in the mists of centuries and cannot be attributed to anyone but the Yakkhas belonging to the dim past.



ANCIENT IRRIGATION SYSTEMS IN THE MAHAWELI PLAIN

By A. D. N. Fernando

The ancients cultivated only one crop a year, and spent the rest of their time engaged in the maintenance and repair, and in building new hydraulic structures and religious buildings. In ancient times from the point of construction and maintenance of hydraulic works went ahead rapidly because land and labour were freely available and evolved from local labour consumptive processes to the more sophisticated systems. Therefore the order of their construction was:

1. Minor anicuts
2. Minor reservoirs
3. Major reservoirs and Major anicuts
4. Integrated systems of Major anicuts with Major reservoirs with link canals.

However today from the modern standpoint where a money economy operates, with limited financial resources and better land and water resources utilization, then the reverse order of priorities is preferred, because labour is expensive for both construction and maintenance of small works relatively.

The management of small anicuts and minor reservoirs as independent entities could be achieved independently with good success by almost any small farmer community independently, where as the construction of major reservoirs, major anicuts and their interconnected canal systems would require better organization, centralization and sophisticated technology for both construction, maintenance and management. Centralization is suited for utilizing the resources of land and water when they are limited.

Therefore it could be deduced that the easier and less elaborate hydraulic works like the minor anicuts and minor reservoirs were constructed by the peasants, where as the more sophisticated major reservoirs and large anicuts with their intricate canal systems, required the use of scientific and technical experts. It is therefore clear that the most vulnerable structures from the point of view of bad management were the larger hydraulic structures. Also when natural disasters like major floods and earthquakes occurred, the larger and more intricate hydraulic structures were the most vulnerable to destruction. Once destroyed the process of reconstruction of all these works was arduous and time consuming and took many centuries to complete.

7. CONCLUDING OBSERVATIONS

Prior to the writings of Sihalavatthuppakarana, Dipawamsa and the Mahawamsa, which are the great chronicles of Sri Lanka, the historical record was of oral tradition. The Mahawamsa was put to literary form in circa 459 A.D. by the learned and pious Buddhist monk, Mahanama, the uncle of King Dhatusena (459 A.D.). He wrote it in the classical Buddhist tradition with all the innuendos one could attach to religion. Others thereafter updated it. All in all it is a true and faithful record except for a few digressions and inconsistencies, which we have in some instances already pointed out.

According to the oral tradition the Mahaweli plain area was said to have been visited by the Buddha in His lifetime, inasmuch as it is belived that He visited other civilized areas in Sri Lanka to preach His new philosophy which has a tremendous intellectual appeal. The Buddha only attempted to present His philosophy to those who were civilized and capable of understanding. The point I am trying to draw here is not of the actual visit, but that the areas mentioned were habited by civilized people. In the Mahawamsa itself, it is said that the Yakkhas occupied this area.

For the people to occupy the plains of Mahiyangana, there should have been some hydraulic structures to sustain them in a settled organization. In short, what were they?

To strengthen the working hypothesis, we would take three major anicut structures (or anunas) on the Mahaweli; one on the branches of the Mahaweli, viz. at Elahera on the Amban Ganga and the other two on the main Mahaweli Ganga, viz. the Minipe Anicut and the Kalinga Anicut.

The Mahawamsa states of the Elahera channel that King Vasabha (65 A.D.) allotted a share of the water of the Elahera channel to a temple, implying that the link canal existed before or was constructed by King Vasabha, though at a later stage in the chronicle, the Minneriya tank is attributed to King Mahasen (275 A.D.), which tank it feeds. However, veddha folklore states that when Mahasen repaired the Minneriya tank, they were given alternate lands to hunt. It is therefore clear that the Elahera canal and the Minneriya tank which it feeds, both existed before 65 A.D., which means that the actual construction is of an earlier era and that reconstruction took place subsequently.

We will now take the case of the Minipe Anicut. Folklore attributes the construction of this to the Yakkhas though it is also said the King Dhatusena constructed it with the assistance of the Yakkhas. Since no mention is made in the Mahawamsa, of the person who constructed it, in all probability it was only repaired later, very probably in King Dhatusena's time.

Then we come to the unique twin channels that start from the Kalinga anicut at Yakkure. The story of the origin of this superb hydraulic structure which is a large anuna or anicut across the Mahaweli Ganga is lost in the mists of centuries. It is built with square hewn blocks of stone of considerable size each weighing around 3 tons. There is a record in the Mahawamsa that Parakrama Bahu (1159 A.D.) repaired this work. It is strange that such a great work was not indicated in the Mahawamsa earlier, though folklore attributes the left bank channel called Kalinga Ela to King Mahasen (275 A.D.) and the right bank canal, the Gomathi Ela, to King Dhatusena (459 A.D.), with no one being attributed to the construction of the anicut itself. Here again evidence points to its construction at an earlier era, with reconstruction possibly by King Mahasen and King Dhatusena, followed by King Parakrama Bahu.

These works were so great that they deserved greater comment in the Mahawamsa, especially when other original works were mentioned like the Kalawewa, which is a newer work. Moreover the Mahawamsa was written in

Dhatusena's time and large works of this magnitude either done by Dhatusena (459 A.D.) or Mahasen (275 A.D.) could not have been missed by the chronicler. Therefore, here again, our conclusion is that these large works were the original work of an earlier era.

Then we take the record from the Mahawamsa that the great King Pandukabhaya (4th century B.C.) before he became Master of Sri Lanka, lived with the Yakkhas in this same area for 4 years on the Mahaweli basin and every year partook in the festivals of the Yakkhas where King Pandukabhaya and the Yakkha chiefs sat on the same platform to witness the annual festivities and celebrations. The fact that the King Pandukabhaya had recognized them as his equals, no doubt showed the esteem he had for them. Moreover for him to have lived continuously with a large population of civilized Yakkhas who were agriculturists, implies that there would have been some hydraulic structures there. We also have the evidence of Pandukabhaya using the technology of the Yakkhas in construction works undertaken by him.

We have it that Wijaya (6th century B.C.) conquered Sri Lanka, overcame the Yakkhas and established five townships one of which was the metropolis at Vijithapura, which would have been an older metropolis of the Yakkhas.

We have the observations here of three well-known renowned experts in hydraulic engineering and historians who again state in no uncertain terms that knowledge of dam construction and channel construction were mastered by the Yakkhas in pre-Buddhist Sri Lanka and that all the Bisokotuwas (sluices) are mere copies of a previous one.

If we visit the old Yakkha settlement and fortress of Ariththa (presently called Ritigala) we find large monoliths, but well carved to perfect rectangular shapes, each single monolith 18' x 6' x 1½' like table tops and well placed as if it were in a conference hall, with absence of any Buddhist religious remnants. The presence of numerous Asanagaras with huge monoliths, the prevalence of Yakkha technology in hydraulic engineering in the 4th century B.C. all point to the advanced state of megalithic culture of the Yakkha in the pre-Buddhist era.

Then we have shown that there were large reservoirs attributed to Mahasen and Dhatusena that could not have been done by them in view of the volume of earth work involved and the time alleged to have been taken for their construction in the time of their kingships. All goes to prove that from the standpoint of known facts the genius of the people prior to the advent of Vijaya (6th century B.C.) had mastered the construction of all forms of hydraulic structures and had developed a hydraulic civilization with its attendant artifacts.

These examples were provided to prove beyond doubt that there was a hydraulic civilization prior to the Buddhist era, and in this era the Yakkhas had reached the climax in respect of building all types of hydraulic structures culminated in the construction of very large anicuts across Sri Lanka's largest river, the Mahaweli Ganga and also very large reservoirs. This was indeed the megalithic pre-Buddhist hydraulic civilization epoch which reached its zenith before Wijayan times (circa 6th century B.C.).

Whether there was another epoch earlier than what I have attributed to the Yakkhas, I could not say, as it would mean speculation. But the only evidence there is to it, is that legend states that the mythical King Ravana, king of Lanka, was a genius who was an expert engineer. There is one reservoir in the hills attributed to him. There is one tank in the south that is attributed to Sita and Rama. There are a number of place names that are attributed to that era which is around 5th to 2nd millennium B.C. However, there is one connecting link that could possibly be the cause for the destruction of all these hydraulic civilizations, viz. when they reached their peak, a cataclysm like an earthquake took place. This has been stated in the Mahawamsa to have occurred in the Ravana epoch (2nd to 5th millennium B.C.) in King Panduwasa's reign (4th century B.C.), King Kelanitissa's reign (2nd century B.C.). I have in addition attributed an earthquake for what happened around the 13th century that was responsible for the destruction of the Buddhist hydraulic civilization.

If we omit the speculative Ravana epoch (though one is tempted to keep it), we can distinctly identify three epochs of development, of our hydraulic civilization, viz.

1. Megalithic pre-Buddhist Hydraulic Civilization
   with associated Yakkha artifacts.
2. Megalithic Buddhist Hydraulic Civilization
   with associated Buddhist artifacts like Dagobas.
3. Modern Hydraulic Civilization with Hydro Electricity,
   concrete and rockfill dams.

When each of the highly advanced hydraulic civilizations was at its peak and when it failed, the people went back from the dry zone to the wet and intermediate rainfall zones in the low relief and high relief ridge and valley systems to start once again the cycle of development from small anicuts, minor reservoirs and once again moved into the plains of the red earth mantle plains in the Dry Zone to re-establish what their ancients had done before them to reach the climax of their civilization, reconstructing old and building new major reservoirs and major anicuts.

What we are trying to do today is just the same as our ancients did, when they were moving to the climax of their epoch. Today we are going to the plains of the Dry Zone to repair and enlarge the works of our ancients and construct new ones, possibly till another calamity occurs. Statistically, however, this would not be soon and even if it does take place it would not be at the same place.

The role that the Natural Resources plays is very clear. Each hydraulic civilization epoch ended and the next began with a major geomorphic event of cataclysmic magnitude, that puts out of gear the hydraulic civilization of that epoch that had developed and reached its zenith.

Within each epoch, there were stages of development which were controlled by the hydrology as well as the characteristics of the land system of the area.

The minor hydraulic structures, like anicuts, continued to be in the High Relief Ridge and Valley system of the wet zone cultivating the paddy in the valley bottoms. They provided irrigation to the terraced paddy in hill and valley systems in the wet zone where rainfall was regular.

Minor hydraulic structures like reservoirs were in the Low Relief Ridge and Valley Systems, in the Laterite mantled Plains and also in the Red Earth Mantle Plains, in the intermediate and dry rainfall zone where the rainfall is intermittent in two seasons.

The major hydraulic structures, like large anicuts, are in perennial rivers in the red earth mantle plains and alluvial plains of the dry zone in the Hot Dry Lowland Tropical Bioclimatic zone while the major reservoirs are physically located in the valleys of the Low Ridge and Valley system with its irrigable command (cultivation areas), in the Red Earth Mantled Plains of the dry zone, in the Hot Dry Lowland Tropical Bioclimatic zones.

The hydraulic structures on the solodized solonetz and solon chaks of the littoral plains have a unique geomorphological setting, on which was possibly superimposed the requirements of an ancient maritime settlement. This sustained the ancient harbour and entrepot of Mantota, which brought in the mariners who settled on the international sea route. It also sustained this strategic outpost.

The drainage schemes in the wet zone, where rainfall is high in the alluviums, appear to be the later works of King Parakrama Bahu, the Great (1159 A.D.) in the megalithic Buddhist hydraulic epoch.

The different hydraulic structures indicated are predominant in the specific land systems having different hydrological regimes. With time and development, and over-population the movement of population took place with epoch starting from the wetter areas (with wet and intermediate rainfall regimes) to the drier parts. The increase in population and the re-mastering of the techniques in the building and repairing of larger works led to the climax of that epoch.

This was in general the cycle of development of hydraulic structures in the hydraulic civilization in each of the three epochs, during which the Natural Resources of the Island were exploited with great genius by the people of Sri Lanka.

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