

SUSTAINABLE DEVELOPMENT, ANCIENT WISDOM AND SRI LANKAN TECHNOLOGY

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Abstract: The world is facing many problems due to the improper exploitation of its resources and lopsided developments with total disregard to the environment during the last few centuries. To overcome these problems sustainable development is advocated and many concepts have been introduced recently. However the examination of the history and religions of the world reveals that many of these concepts were embedded in the wisdom of ancients, and they practised sustainable development for thousands of years. In Sri Lanka, Buddhism had a strong influence on the lives of people and ancient Sri Lankans developed a hydraulic civilization, in harmony with the environment, and achieved significant progress in engineering and technology. This paper deals with ancient Sri Lankan technologies related to irrigation and water management, architectural and structural engineering and metallurgy.

Keywords: *Sustainable Development, Ancient Wisdom, Sri Lankan Technology*

1 Introduction

Tremendous advances in science and technology over the past hundred years or so have uplifted the quality of life for many people in the world. However these also have created many problems, such as pollution, global warming, nuclear weapons, etc. which are now threatening the very existence of the mankind.

One of the main reasons for this sad state of affairs is the exploitation of natural resources with total disregard to the environment by various organizations. Wrong notions held early times that human beings are supreme in this world and that they can exploit the natural resources in anyway they want, have also contributed to this situation. The power struggle between countries - especially between industrialized ones, and the lack of effective means to control the advances in technologies also are contributing factors.

To come out of this crisis all nations of the world should unite and decide on common strategies, which should be accepted and implemented by all, but unfortunately this does not seem to be happening. Many "solutions" proposed have also come from industrialized countries, the creator of most of the problems.

In this scenario it is important to look at the philosophy of our forefathers, their technologies and the way they came to terms with the environment they lived in. We may not be able to use their solutions directly, but we can learn much from their ancient wisdom, in finding solutions to these global problems.

2 Sustainable Development

In the recent past, dangers faced by the humanity due to wrong and over exploitation of natural resources have been discussed in many forums, and in 1983 the United Nations appointed the Brundtland Commission on Environment and Development [1] to address growing concerns about the accelerating deterioration of the human environment and natural resources and the consequences of that deterioration for economic and social development. Having studied poverty in the world, concerns about the acute pressure of population growth, modern technology and demands on the

planetary fabric, global warming, depletion of world's natural resources, etc, the Commission delivered its report on *Our Common Future* in 1987 [2].

The Commission found that population growth, most of which is among the world's poor, was not the major threat to the harmony of the planet. It was not the poor who were consuming most of the Earth's supply of fossil fuels, warming the globe with their carbon emissions, depleting its ozone layer with their CFCs, poisoning soil and water with their chemicals, or wreaking ecological havoc with their oil spills. In fact, their consumption of the world's resources was minute compared to that of the industrialized countries. Brundtland declared that poverty in the developing world was less cause than effect of environmental degradation, and only sustainable development could blend the fulfilment of human needs with the protection of air, soil, water and all forms of life - from which, ultimately, planetary stability was inseparable [1].

Thus the concept of *sustainable development* was introduced, as a pattern of resource use that aims to meet human needs while preserving the environment so that these needs can be met not only in the present, but also for generations to come. The Commission defined it as *the development that meets the needs of the present without compromising the ability of future generations to meet their own needs*. It contains within it two key concepts: the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given, and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs [2].

With the introduction of the concept of sustainable development, many related concepts came into prominence. Of these sustainable architecture is directly relevant to this conference theme. Sustainable architecture describes an energy and ecologically conscious approach to the design of the built environment, and seeks to minimize the negative environmental impact of buildings by enhancing efficiency and moderation in the use of materials, energy, and development space [3].

Energy efficiency over the entire life cycle of a building is a primary goal of sustainable architecture. Architects use many different techniques to reduce the energy needs of buildings and increase their ability to capture or generate their own energy. This is very important for Western countries where energy cost, for heating and cooling, is considerable. Other considerations are sustainable building materials and the use of recycled or second hand materials, waste management, water management and reducing water demand by means such as grey water reuse and rainwater harvesting.

It should also be pointed out that a universal solution to fit all countries of the world is not possible. Different countries should find their own solutions based on their environmental, cultural, political, economic and social factors.

3 Ancient Wisdom

Human beings have been in existence in the world for about 200,000 years, reaching full behavioural modernity around 50,000 years ago. Until around 10,000 years ago, most humans lived as hunter-gatherers, and about 6,000 years ago, the first proto-states developed in Mesopotamia, Egypt's Nile Valley and the Indus Valleys. The late Middle Ages saw the rise of technologies, and the Industrial Revolution in the 18th–19th centuries promoted major innovations in transport, energy development etc. With the advent of the Information Age at the end of the 20th century, modern humans live in a world that has become increasingly globalized and interconnected.

Although interconnection between humans has encouraged the growth of science and technology, it has also led to conflicts and wars and the development and use of weapons of mass destruction. During the last few centuries so called human developments have led to environmental destruction and pollution, producing an ongoing mass extinction of other forms of life that has been accelerated by global warming. According to some worst case scenarios we are not sure of the existence of human beings for another millennium.

In the ancient world the human beings have lived in harmony with the environment for thousands of years. The Australian Aborigines were able to maintain a stable life style, although primitive from our standards, for more than 40,000 years in a very hostile environment. Ancient Egyptians maintained a civilization for more than 3000 years, and produced engineering marvels, some of which we still fail to understand fully. Ancient Chinese were the masters of invention and discovery for three millennia, and many of the greatest inventions have their foundations in China. Hence it is useful to look at the wisdom of our ancients which embodies many concepts which we think are modern.

Judge Christopher Weeramantry, former Vice-President of the International Court of Justice, has referred extensively to sustainable development and ancient wisdom in many of his writings [eg. 4], speeches [eg. 5] and judgments [eg. 6]. His latest book, *Tread Lightly On The Earth* [4], deals with the environmental wisdom contained in the teachings of some great religions of the world; Buddhism, Hinduism, Christianity, Islam, and Judaism.

Referring to Buddhism, he points out that “its basic teachings integrate with concerns for the future and the case of future generations, and that the respect for all living things – including plants and animals, is an integral part of its attitude towards the environment”. He refers to the sermon of the Buddhist missionary Thera Mahinda who brought Buddhism to Sri Lanka from India in the 3rd century BC, preached to the King Devanampiyatissa of Sri Lanka (this is given in Mahawamsa – the Great Chronicle of Sri Lanka [7]). “O King” said the Thera, “you may be the king of this country but you are not the owner of this land. You are its trustee and you hold this land for the benefit of all those who are entitled to use it both now and the generations to come”. Weeramantry points out that “here succinctly stated over two thousand years ago, was a cardinal principle of environmental law which we moderns tend to think we have recently invented or discovered”

Referring to Hinduism, Weeramantry points out another example of the relevance of ancient wisdom regarding the legality of weapons, such as nuclear weapons, which go beyond the purpose of war. He points out that “in the Indian classic Ramayana this was expounded in the context of the availability of a hyper-destructive weapon which could decimate the population of the enemy and devastate his landscape. In a far more civilized manner than is now the case, Rama, the prince to whom the weapon was offered, was told that before he used such a weapon he should consult the sages of the law. The sages of the law advised Rama that he could not use this weapon in his conflict with Ravana, King of Sri Lanka, because the purpose of war is to subjugate your enemy and live in peace with him thereafter – not to massacre his population and ravage his countryside”.

The Buddha has specifically referred to recycling in giving instructions to his monks regarding the preparation and the use of the robe. Visuddhimagga or The Path of Purification [8] gives details regarding the preparation of a robe from refuse material such as; a rag dropped on a charnel ground, a cloth thrown into a place for rubbish, a rag thrown away after wiping up blood stains, etc. Cullavagga [9] gives a conversation between the King Udena and Thera Ananda regarding the use of the robe. The Thera told the King that once the robe is worn thin after use, it will be used as a bed spread. When it is also worn out it will be used as a mattress covering, afterwards as a ground covering, then as a door mat until it is worn out. Afterwards it will be shredded, kneaded with mud, and used for plastering.

The above is only a few examples where the ancients, all over the world, in the past have adapted environmentally friendly and sustainable solutions in their developments. We will not be able to use these solutions directly, but we can learn a lot from them in tackling current environmental problems faced by the world.

4. Ancient Sri Lankan Technologies

Sri Lanka has a recorded history dating back more than 2500 years. The ancient Chronicles Mahawamsa [7] and Chulawamsa [10] cover the period from around 6th Century BC to 12th century AD. Foreign visitors to the Island and officers from occupied forces, especially the British, have

As a result a Hydraulic Civilization heavily dependent on irrigation systems for its agriculture systematically developed in the country from about 6th century BC to form a large and complex system to exploit land and water resources. “It is a system which, while recognizing the need for development and vigorously implementing schemes to this end, at the same time specifically articulated the need for environmental protection and endured that the technology it employed paid due regard to environmental considerations”[6].

Chronicles [7, 10] and others writings [esp. 12, 17] give wealth of information on the irrigation works carried out from time to time by ancient rulers of the country. King Pandukabaya (5th century BC) is credited with the construction of the Basawakkulama reservoir, which is still used at present. From then onwards the construction of reservoirs and irrigation systems continued up to the end of the reign of King Parakramabahu I (1153-1186 AD), the great reservoir builder. His Parakrama Samudra, or the Sea of Parakrama (Fig. 2) is the largest ancient tank, covering a water spread area of 2100 hectares, with an embankment 14 km long having an average height of 12 m. In all around 30 large reservoirs (Fig. 1) and more than 25000 small ones have been built during this period.



Fig. 2 Parakrama Samudra (Sea of Parakrama)

King Parakramabahu had declared that “no drop of water should flow into the sea without serving the interest of man”. Chronicles also have records such as “this irrigation system was undertaken for the benefit of the country and out of compassion for all living creatures”. These statements have notions of optimal use of resources for the benefit of all living things, and demonstrate that ancient Sri Lankans had practised sustainable development. In his separate opinion on the case concerning the dispute between Hungary and Slovakia over the use of waters of river Danube [6], Judge Weeramantry has used Ancient Irrigation System of Sri Lanka as an example of sustainable development some 2500 years ago.

Ancient Sri Lankans have used much originality and ingenuity in developing their irrigation systems. Rainwater which fell on a catchment was collected in a cascade of small tanks (Fig. 3), and used and re-used many times before coming to a large reservoir, thus giving expression to the royal dictum of Parakramabahu [18]. In addition to supplying water for cultivation of paddy, the water stored in the cascade system was used for domestic bathing needs, livestock needs, inland fisheries, etc. These series of small tanks also reduced the silting problem in the large reservoir, and they were maintained collectively by the villagers.

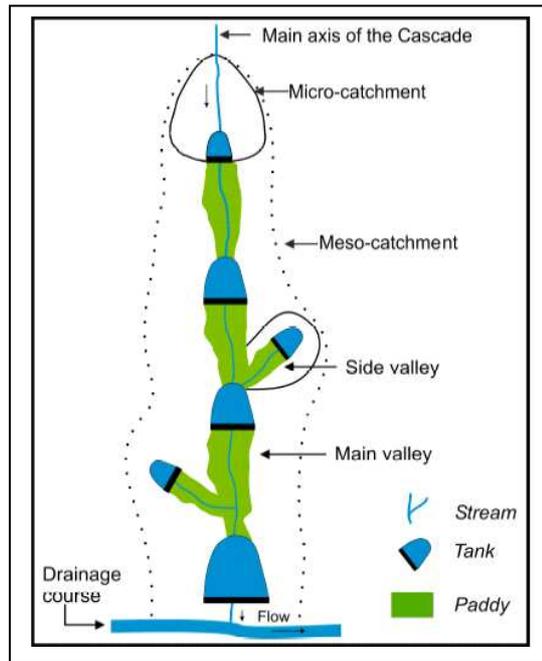
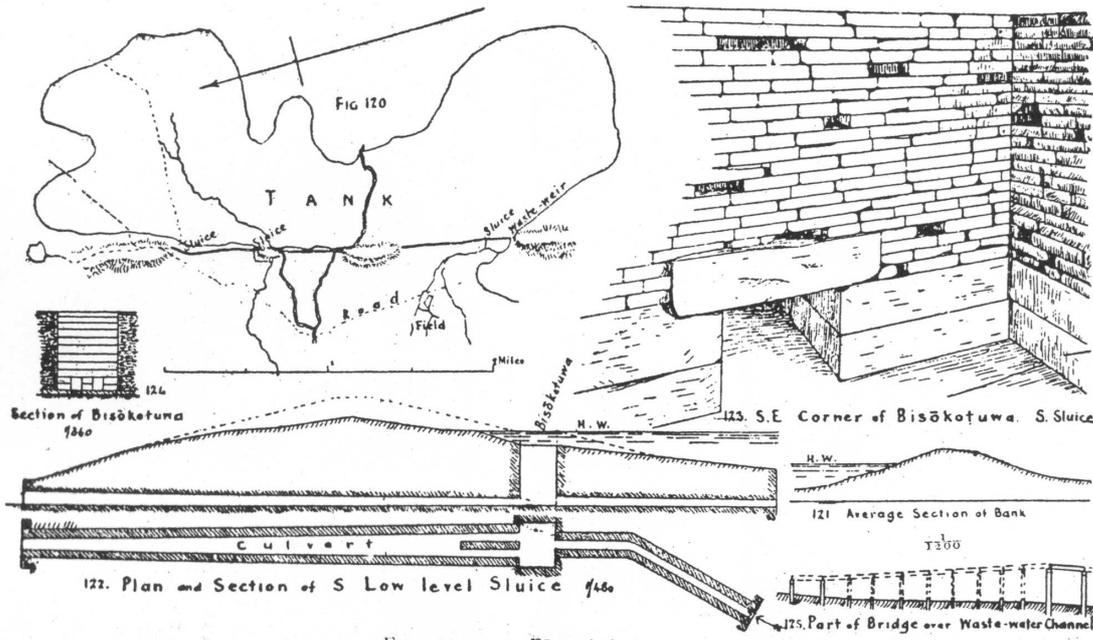


Fig. 3. A Small Tank Cascade and a Distribution of Cascades [18]

Issue of water from the large reservoir, which will have water depths in excess of 10 metres was a difficult task. This problem was overcome by ancient Sri Lankans with an ingenious creation called the Bisokotuwa (Fig. 4) built near the point where the water level meets the inner slope of the dam bund. It is an open well with rectangular section having faces lined with stonework and timber flanks, and an inlet culvert and an outlet culvert placed at its bottom. Sluice gates regulated the water inflow and outflow. Bisokotuwa also served as a place where de-silting can be done. Parker [12] states “whatever form the design took, it was a triumph of the ingenuity of the ancient Sinhalese engineers. It was this invention alone, which permitted them to proceed boldly with the construction of reservoirs that still rank among the finest and greatest works of this kind in the world”. Thus the ancient Sri Lankans were the inventors of the valve-pit more than 2000 years before it was used in the West in the 19th century.

In the case of river diversions to feed tanks, the ancient Sri Lankans used oblique dams rather than square dams across the rivers (Fig. 5). Parker observes “ the Sinhalese possessed profound practical knowledge of the best methods of dealing with water, and realized that an oblique dam would have greater stability; and the blow of a log would have much less tendency to displace a stone of an oblique dam” than a square one built perpendicular to the current. To convey the diverted water from the river to the reservoir and from one reservoir to another, canals were used, some of them very long and ingeniously located. Jaya Ganga, the right bank canal of the Kalawewa reservoir conveying water to Tissa Wewa reservoir, is 91 km long and 12 m wide. The canal feeds a number of small tanks on the way, and over its first 30 km, the canal has a gradient of 1 in 10,000 (6 inches to a mile), an accuracy hard to achieve even today.



Figs. 120-125. Pāvāṭ-kuṣam.

Fig. 4. Pāvāṭkulam Bisokotuwa [12]

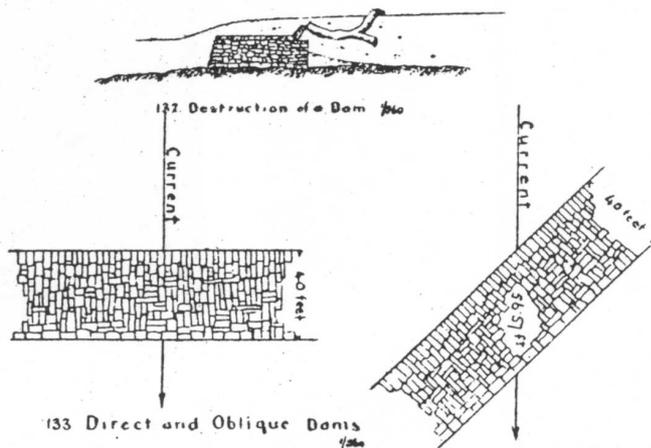


Fig. 5. Oblique Dam at a River Diversion [12]

The location of the reservoirs and their sluices were also done in the best possible way. When the modern engineers, after a thorough study of the terrain selected a place to locate the dam for Maduru Oya Project, they found an old dam and a sluice at precisely the same place!

Ancient Sri Lankans not only built colossal reservoirs, river diversion structures, canals and canal structures, but also established procedures and proclamations for proper management of water resources. There were inscriptions regarding good practices, rights and obligations of cultivators, seasons for crop harvesting, etc.

As Weeramantry puts it in his Separate Opinion [6], “This system of tanks and channels, some of them two thousand years old, constitute in their totality several multiples of irrigation works involved in the present scheme”. “They were executed with meticulous regard for environmental concerns, and showed that the concept of sustainable development was consciously practised over two millennia ago with much success”, by ancient Sri Lankans.

4.2 Architecture and structures

Ancient Sri Lankan architecture was significantly influenced by Buddhism, and most of the important buildings are of religious types. Significant constructions are Stupas [19], monasteries and temples [20], palaces and fortresses. Materials used for construction were indigenous and consist mainly of earth, stone, brick and timber.



Fig. 6. Ruwanveli Stupa(2nd century BC)After Reconstruction.

Stupas designed and constructed in Sri Lanka are among the largest brick structures in the world [21, 22]. They are solid structures and house corporal remains of the Buddha or mark an important event or place associated with his life. From the time Buddhism was established in the 3rd century BC, Kings of Sri Lanka built Stupas to honour the Master, and these are venerated by the Buddhists. At the beginning Sri Lankan Stupa was similar to the Indian one, but with the passage of time it changed to a style of its own which later spread to other Buddhist countries like Thailand and Myanmar. Ruwanveli Stupa (Fig. 6), built by King Dutugamunu in the 2nd century BC, is the most venerated Stupa in the Island and it has a height of 103 m and a base diameter of 91.4 m. The Jetavana Stupa (Fig. 7) built by King Mahasen (276-303 AD) attained a height of 122 m making it, at that time, the tallest brick structure in the world, and the third tallest structure in the world (surpassed only by the

two pyramids in Giza). With a total volume of bricks in excess of 300,000 m³ it, arguably, is still the largest brick structure in the world.



Fig. 7. Jetavana Stupa (3rd century AD) After Conservation

Ancient Sri Lankans showed many skills in constructing these mega structures. The bricks used were of very high quality, much stronger than the modern day bricks, and the mortar used was a very thin slurry (butter clay), which did not weaken the brickwork. The structure was water proofed by a thick plaster giving good weather protection (Fig. 8). Much care was taken in selecting the site and preparing the foundations. Ruwanveli Stupa foundation was constructed with layers having crushed stones, clay, cement, brick, metal, and impregnated with chemicals. Hence it is essentially a reinforced concrete foundation with damp and insect proofing. Many Stupas were located on bedrock and the brickwork started from the foundation level. Setting out and raising the structure was done very precisely. For the domes of mega Stupas, paddy-heap shape (ellipsoidal or paraboloidal), which produces no tension under self weight, was used. Mahawamsa also mentions about a device called Vajrachumbata, fixed at the top of the Stupa, to prevent damage to the pinnacle by lightening. This is fifteen centuries before Benjamin Franklin studied lightening in the West.



Fig. 8. Kirivehera (12th century AD) Showing Original Plaster

Some Stupas of small size were provided with a roofed circular structure called Vatadage. This is a construction unique to Sri Lanka, and remains of the stone columns used to support the roof are present in several places. Fig. 9 shows remaining columns of Thuparama Stupa, built in the 3rd century BC by King Devanampiyatissa, and the conjectured form of its Vatadage [19].

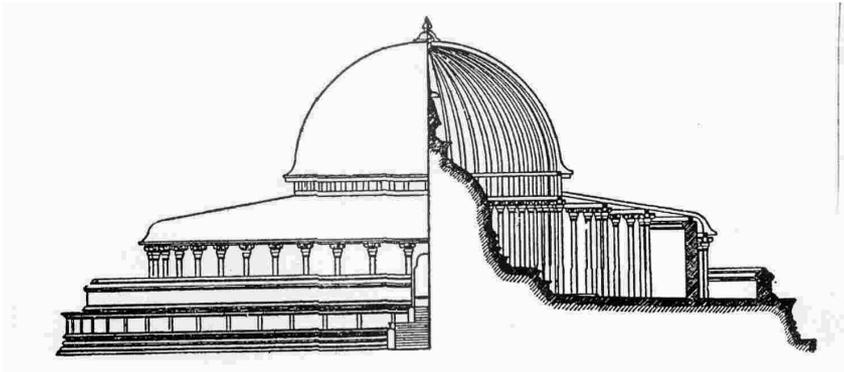
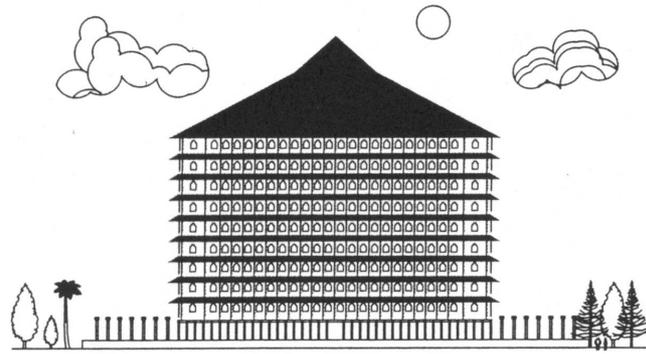


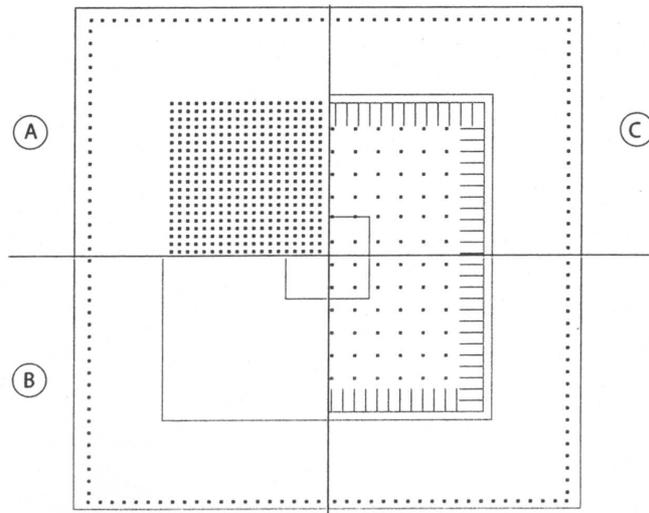
Fig. 9. Thuparama Stupa (3rd century BC) & Conjectured Vatadage [19]

Sri Lanka's ancient monastic architecture [20] displays a rich variety of architectural forms and styles. Monasteries were designed using guidelines given in manuscripts, which outline the layout of various components such as shrines, image houses, assembly halls, etc. They blend well with the environment causing minimum intervention. Efficient and environmental friendly systems were used for water supply and drainage, sanitary requirements, waste disposal etc. Some monasteries were very large accommodating thousands of monks. According to the Chinese monk Fa-Hsien, who visited Anuradhapura in the 5th century AD, there were 5000 monks residing at the Abayagiri monastery and 3000 at Mahavihara.

Mahawansa gives a description of a tall building - the Lovamahapaya (brazen palace) built by King Dutugemunu in the 2nd century BC, and renovated by other Kings. It was used as an assembly hall as well as a residence for monks, and its ground floor was used as a preaching hall too. According to Chronicles it was a 9 storey building built with stone and timber with a copper tile roof. Each floor had 100 chambers, and it could accommodate 9000 monks. With a height of around 49 m, it would have been one of the earliest high-rises in the ancient world. A conjectured drawing of Lovamahapaya [23] is shown in Fig. 10. Presently only the lower stone pillars added by King Parakramabau are remaining.



ELEVATION SHOWING 9 STOREYS
& WINDOWS IN CHAMBERS-HALF IN SECTION.



A-STONE COLUMNS IN SUB STRUCTURE.
B-PLAN SHOWING ROOF
C-LAYOUT OF UPPER STOREYS.

Fig. 10. Lovamahapaya-Conjectured View[23]

Remains of royal palaces are found in the ancient kingdoms of Anuradhapura and Polonnaruwa. The royal palace of Parakramabahu in Polonnaruwa (Fig. 11) was a nine storey building with very thick brick walls. Timber was used for beams as well as for columns.



Fig. 11. Remains of King Parakramabahu's Palace

The rock fortress Sigiriya (Fig. 12), used by King Kassapa (5th century AD) is a meticulously planned royal complex with palaces, water gardens, ponds, and supporting infrastructure. The rock rises 183 m and the palace complex is located on its summit. The water garden in the ground is served with water, conveyed entirely under gravity, using underground conduits made of clay. Its exceptionally engineered hydraulic inflow and outflow conveyance system is a marvel even by today's standards. Sigiriya is one of the oldest landscaped gardens in the world.



Fig. 12. Sigiriya Rock and Water Garden

4.3 Iron and steel manufacture

Historical records show that Sri Lanka was a source of high quality steel, and the presence of slag heaps in many parts of the Island, are evidence of an iron smelting and steel making industry that existed in ancient times. It has been said that Serendib (the name given to the Island by Arabian traders) steels were used for the manufacture of swords in the Arab world [16].

Research by the British archaeometallurgist Juleff [24] has revealed the presence of wind-driven iron smelting furnaces on the hills in the central highlands of the Island, which are exposed to monsoon winds. These furnaces (Fig. 13) are unique to Sri Lanka, and are wind-driven, not wind-blown. It is not the direct wind but the suction created by the wind blowing over the top of the furnace that produces the air blast required to keep the furnace going. Field trials [24] have shown that the furnaces were very efficiently designed and that they were capable of producing high quality steel to sustain a large-scale industry which would have supplied the Islamic world with steel for sword making.

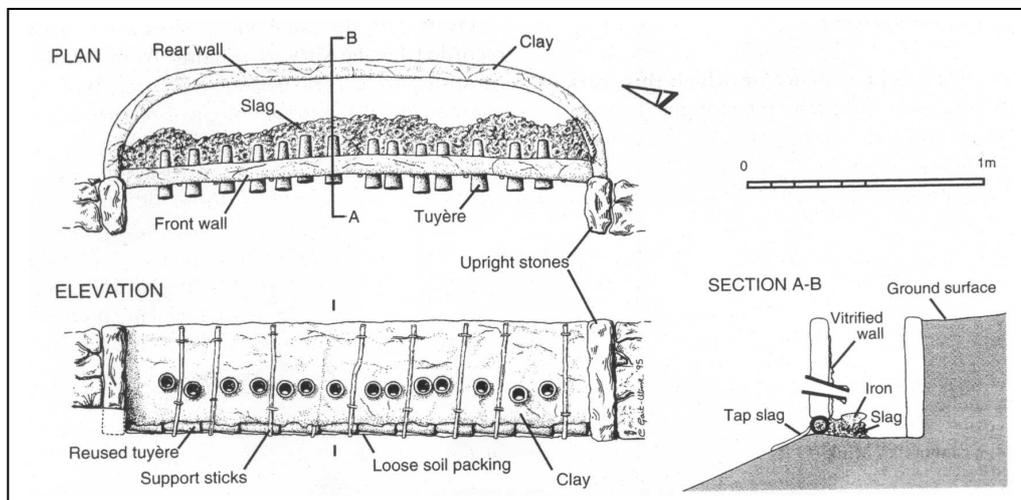


Fig. 13. Wind-powered Iron Smelting Furnace Reconstructed From Archaeological Data[24]

6. Conclusions

Our ancients were much more responsible and wise in dealing with the environment. They respected and protected the environment and practised sustainable development. Many concepts which we think are modern were known to them. In searching for sustainable solutions for development, we should not forget the wealth of knowledge and wisdom of our ancients, all over the world.

While practising sustainable development, ancient Sri Lankans produced significant innovations in irrigation and water management, architectural and structural engineering, and metallurgy.

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