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Engineering Expansion:

Irrigation, Population and the State in Pre-modern South India[1]

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The effects of technological innovations are typically overrated in the short run, but underestimated in the long run.

-- Arthur C. Clarke

Introduction

The Cholas figure prominently among the regional dynasties of South India, being mentioned both in the edicts of the Maurya king Ashoka (3rd century BC) and the literature of the Shangam period (early centuries CE). After the 5th century CE, however, the Cholas were reduced to a minor role, being sandwiched between two dominant neighbours, the Pandyas in the south and the Pallavas in the north. But when the Pallava dominance over the region was removed by a campaign of the Rashtrakutas in the mid-9th century, the Cholas ascended in a manner almost unparalleled in Indian history, not only occupying the territories of their former overlords, but also expanding into Bengal, conquering Sri Lanka and even launching a maritime attack against the ports of Sri Vijaya, the sea-borne empire in southern Sumatra and the Melaka Straits.

Historians seeking to provide an explanation for this sudden and phenomenal rise have given a variety of answers and suggestions, without reaching an agreement. The most basic answers sprang from the assumption that big men make big history, that is, men excelling in charisma and

military skills (combined with an bit of luck occasionally) are crucial in founding empires, or at least in laying the foundation stones. This view of history as being made by gifted rulers can be found especially in the writings of a school we term “nationalist”. Within this school, the doyen of historical studies of South India, Nilakanta Sastri, is perhaps the most prominent and influential representative.[2]

This focus on the leaders and rulers has been advanced by two studies from the United States, which have identified a kind of military-commercial complex underlying the expansionist wars of the Cholas, which shed more light on the mechanisms of war and its underlying economic motives. Of the two, George Spencer has shown how the wars of the Cholas were suited to support further wars, in what he has called a “tax – tribute – plunder continuum”. While the Chola state remained financially dependent on the land revenue and tribute collected from neighbouring rulers (*samantas*), the raiding of Bengal, Sri Lanka and Sri Vijaya provided additional wealth which the Chola rulers could distribute among their followers and thus secure the latter's support for further campaigns.[3] In a complementary line of argument, Kenneth Hall has drawn attention to the strategic alliance between the various commercial groups of South India and the Chola rulers. As these merchants (or guilds, as they are often styled) were significant contributors to the imperial war-chest, the motivation for the strike against Sri Vijaya may not only have been financial in terms of plunder and booty, but also politically expedient to secure the Tamil merchants' position vis-à-vis the monopoly of the Sri Vijayan rulers in the trade between India and Southeast Asia.[4]

While these studies, by and large, concentrated on the kings and high politics, recent research has shifted the focus towards structural elements that formed the stepping stones for the rulers setting out on military campaigns. The first of these elements is the possible advances in military technology and the transformation of warfare resulting from it. As far as can be seen from the sources, however, this factor played no role, or at best a minor one, in the expansion of the Cholas. Naval warfare certainly was a novelty, but it seems that king Rajendra I, who directed the campaign against Sri Vijaya, did not “invent” a navy, but made use of the ships (as well as ship-

builders) that were available along the Tamil coast to transport warriors to the ports on the other side of the Bay of Bengal. The battles were then all fought on the land, not on the sea. Another change in military tactics that became apparent in South India is the use of horses and mounted archers. Their spread over India resulted from the success of the Sultans of Delhi - whose military power rested on cavalry - in conquering northern and, after 1300 CE, southern India.[5] Horses indeed make an appearance in South Indian epigraphy, but hardly before c. 1200 CE and therefore, at a time when the predominance of the Cholas was waning again. The spread of cannons and gunpowder in South India can similarly be dated to the late 13th and early 14th centuries; again, the Delhi Sultans seem to have been both the major reason and source for their proliferation even though the Chinese too, were active in supplying arms to Southeast Asia from around the middle of the 14th century.[6]

Besides military technology, the demographic factor of warfare has become an important object of historical research. The existence of sizeable armies to follow a charismatic ruler is no longer taken for granted, but analysed for its number, social composition, equipment and strategy. With the exception of the Velaikkaras, a group of specialised soldiers who also gained fame in Sri Lanka,[7] the study of the Chola army has hardly begun.[8] As far as numbers are concerned, this may be due to the fact that even rough estimates of population anywhere in pre-modern South and Southeast Asia run the risk of misrepresentation by a wide mark. Accordingly, there's a general tendency in historical literature to avoid clear statements or even to exclude demographic factors altogether.[9] On a very general level, there seems to be agreement that early states were short of people but nevertheless, kings were occasionally able to rally considerable numbers of soldiers for their campaigns.

The agriculture of the Chola empire has long been seen and discussed as an annex to the empire's administrative structure (land revenue collection, village autonomy, feudalism).[10] In such discussion, the agricultural system was seen as basically static and unchanging. However, in the 1980s, this picture was revised by scholars like Nitz and Heitzman. Looking at the ancient field marks, Nitz could show that during the Chola period a significant expansion of the cultivated area took place

in peripheral parts of the Kaveri delta. Wherever possible, the new fields were demarcated in the same manner as the old fields in the heart of the delta, while fields farther out were of more irregular sizes and shapes.[11] At the same time, Heitzman published the results of his reconsideration of the *nadus*, the socio-economic units of which the Chola state was composed. On the basis of five selected *nadus*, Heitzman disproved their uniform pattern and emphasised instead that they varied considerably with regard to their natural and climatic conditions and therefore, in terms of their economic value as well. *Nadus* in the vicinity of the Kaveri were generally well-irrigated and suited the cultivation of wet rice (padi). In contrast, *nadus* in the outlying parts of the delta, and even more so in the hilly areas away from the valley, tended to be much larger but less well-endowed with water or irrigation facilities, not infrequently consisting mainly of jungle land. Heitzman confirms that in the course of the 10th-12th centuries, attempts were undertaken to improve the economic value of these *nadus* through the construction of irrigation works, either by extending existing irrigation systems into these districts or by introducing, as far as possible, suitable new facilities.[12]

The above reappraisal of agricultural dynamics inevitably begs the question of whether advances in irrigation technology were a factor in the expanding irrigation networks and increasing areas of cultivation. In Sri Lanka, which by and large shares the climatic and geographic conditions of South India, a new feature had come into existence in the first quarter of the first millennium CE as tanks and reservoirs built for irrigation purposes grew tremendously in scale. This enlargement of the water storage facilities was made possible by an innovative sluice technology, which enabled the control of water flow without exposing dams to the risk of breaching under the pressure of the water. The Sinhalese historian, R. A. L. H. Gunawardana, has suggested that in the course of time, this new technology may have spread to the subcontinent.[13] Indeed, it appears that both the Pallavas and the Pandyas (the immediate mainland neighbours of the Sinhalese) began to experiment with more sophisticated sluices and larger tanks by the 7th century at the latest.[14] Sitting between the Pallavas and the Pandyas, the Cholas will certainly have come to know about the new irrigation technology by the time of their rise to power.

In an attempt to re-assess the various components that contributed to the expansion of the Cholas, this paper will link the factors outlined above in a more systematic manner. As indicated in the title, a share of the success story will be attributed to the irrigation engineers who built the dams, sluices and channels that changed the agricultural landscape of South India. Their advances in hydraulic technology provided for a relatively stable food supply, which in turn could have allowed a slow but steady growth of population. As the new sluices, wherever they functioned, required less human (especially male) labour to irrigate the fields, more men were available for non-agricultural activities such as military service. This was already the case in the Pallava and Pandya empires like it was in Sri Lanka, so in investigating the peculiar success of the Cholas we will also have to take further factors into account in order to explain what happened. This comparison between the Sinhalese and the Cholas will be addressed at the end of the paper.

Rice, water and labour

South India, albeit part of Monsoon Asia, is relatively dry. The monsoon sheds most of its water while crossing the Deccan plateau, so there is little rain left for the coastal strips of southeast India, especially Tamil Nadu. Agriculture in this area therefore depended (and still depends) on facilities to store and distribute water, the more so when wet rice (padi), the highest yielding food grain and staple food of Asia, is to be grown. Normally, padi fields are prepared at the end of the dry season and sown before the beginning of expected rain. After a few weeks, the young shoots have to be transplanted from the nursery fields to the rice fields proper. Harvesting commences after about four months, in late November. Where favourable conditions prevail, a second rice crop can be grown. The second crop requires less water and time to grow, which also means lower returns, so the fields can, in theory, be used for a third crop.

Water is obviously a crucial factor in wet rice cultivation. Hence, the monsoon rains, which are unreliable and often insufficient, are as often a source of trouble as they are a source of help. Peasants are thus forced to secure the irrigation of their fields, and can obtain water from two

potential sources: reservoirs and perennial rivers. Of the two, the latter can be managed with more ease as the works necessary to divert the flow of water, such as stone embankments, wooden posts, planks and weirs, could all be constructed without much knowledge of physics or hydraulics. Identifying suitable sites for the construction of a weir or the current of a river were easy tasks for experienced peasants, and even if they were inexperienced, trial-and-error promised quick positive results. Naturally, the heartlands of the major South Indian dynasties were all located in the lower parts and deltas of South India's perennial rivers – the Vaigai, Kaveri and the Palar.

In contrast to this comparatively easy method of irrigation, the alternative method of obtaining water requires a considerably higher degree of knowledge and experience. It clearly exceeded the capacities of a peasant household and may even have pushed the capacities of a peasant village to its limits. A peasant may be in a position to identify a suitable site for a dam, but to raise and strengthen even a small one would have required the participation of a substantial work force, which would have had to be instructed and coordinated. More sophisticated hydro-technical devices such as culverts and spillways had to be constructed by experts.

The most vexing problem arising from tank-based irrigation is the need to regulate the outflow of water. This can generally be achieved by two different methods, bailing and conducting. Bailing has the advantage of minimising the risk of harming the embankment but it is very slow, ineffective, and human and/or animal labour-intensive. A very common and ancient method in India involved the construction of a lever.[15] A bucket was attached to a pole, the longer end of which was handled by a peasant, while a second peasant would then pour the water into the feeder channels. The lever made the lifting of the water bucket less exhausting but on the whole, this bailing method is very slow and involves much human labour in relation to the amount of water that eventually reaches the fields. To replace human labour, cattle (mostly buffaloes) were employed in India. Walking slowly down a ramp leading down from the bund, the bullocks pulled the bailing bucket over a wooden scaffold so that a second person could then pour the bucket into the feeder channels. Although this method saves human labour, it is still ineffective and time-consuming.

Alternatively, the water from the tank can be conducted by way of natural gravity. As simply cutting a breach into the dam might have washed the whole dam away, an outlet had to be built into the dam. Given that the suction of the outflow combined with the pressure on the dam can easily wash away the whole dam,[16] these outlets had to be reinforced. Normally, the bottom of the conduit and its flanks were covered with brick, while planks of stone or wood could be put onto the spillway from the inside of the dam to regulate the outflow. This was still a relatively imperfect method, as the brickwork could still break or be torn out by a flood, while the regulation of the outflow depended on the skills of the person who handled the planks. Without due care, excessive water might run down the channels resulting in the loss of water for irrigating the fields.

In addition to the main outlet, dams normally had at least one further outlet at the point where the bund joined the natural elevation (normally a rock or hillock). These lateral outlets served mainly as safety valves to prevent the overflowing (and potential destruction) of the main bund in case of a flood. If the length of the bund and the natural depression permitted it, further outlets could be built into the bunds of larger dams, which could then irrigate still larger areas. However, the risk of breaching grew along with the potential benefits. At the same time, the distribution of water had to be agreed upon in order to avoid quarrels about the amount of water that was to be run through which conduit and into the various feeder channels.

When sufficiently supplied with water, the cultivation of rice tends to produce relatively stable societies, with the parameters of food security and population size mutually influencing each other. Irrigation, regardless of whether it was done by bailing or with the help of low-tech weirs, was labour-intensive. Agricultural growth was therefore doubly arrested by the amount of human labour needed for irrigation and for ploughing. In this situation, the population could grow only very slowly, unless additional labour was procured from outside, that is, by way of raids and abduction. On the other hand, population growth was frequently interrupted by natural calamities such as floods, droughts and epidemic diseases (plague, malaria, etc.). Seen on the whole, the land-labour ratio

therefore remained relatively stable over long periods, forming one element in the perceived 'stasis' of Asian peasant societies.[17]

A technological revolution: Pistons and sluices

As described thus far, the level of sophistication in irrigation technology has been relatively low, which means that the hydraulic devices could be constructed, maintained and operated by an average peasant community or a village. Knowledge and experience, acquired by way of trial and error, gradually grew and over the course of time, the methods to conduct water became more sophisticated. This process went along with a further division of labour or rather expertise, as stone-cutters and master masons gradually refined their skills and turned into hydraulic engineers. The major improvement came when the traditional outlet that cut through the dam was replaced by a covered culvert, made of dressed stones or brick that led under the dam. In its simplest version, a straight pipe was built into the bund slightly above the natural bottom of the tank. The new device solved the earlier problem of suction destroying the embankment, but created two new problems. The first concerned the regulation of the flow of water, made possible only with the help of a kind of wooden stop-lock, which blocked the pipe from the outside. This necessitated a pipe with a small diameter, which in turn meant that the amount of water that could be conducted remained quite small. A more important concern was the location of the pipe: if it was built too close to the bottom, it could easily become blocked by the mud and dirt sediments from the bottom of the tank; if the pipe was built too high, the water below the level of the pipe would remain inside the tank unless it was bailed. In addition, the area around the inlet of the pipe had to be carefully protected, as the suction accompanying the outflowing water could perforate the dam. With the amount of water that could be conducted being still rather small and the principal problem of protecting the bund against the action of the waves and suction, the incorporation of simple pipes in the embankment could not fully satisfy the irrigation needs and did not really represent a progress in irrigation technology.

The real solution to the problem was found at some point in the first half of the first millennium CE, with the invention of a new type of sluice. The crucial innovations were first, to detach the inlet of the conduit from the dam and, second, to regulate the inflow of water inside the tank rather than at the point where the water left the conduit on the outside of the dam. According to current research findings, a mainland and an insular solution can be distinguished.[18] The version on the South Indian mainland, of which the oldest surviving examples date from the Pandya-Pallava period (c. 6th-9th centuries), consist of a culvert made of dressed sandstone laid through the bottom of the dam to a point some metres inside the tank – often near the lowest point of the tank bed – where a kind of piston mechanism consisting of two upright stone pillars (occasionally brick pillars were employed as well) holding cross-beams were constructed. The cross-beams in turn supported an upright wooden beam, which could be raised and lowered so as to open or close the inlet of the culvert. The inlet of the culvert, usually consisting of a large plate of stone with a hole in the centre, was protected by a low brick wall to prevent mud and dirt from entering the spill. The diameter of the culvert could be considerably increased, though the crucial bottle neck determining the amount of water that could be conveyed was determined by the size of the hole of the inlet together with the piston regulating it. As a result, the capacity of the piston sluice was still relatively low.[19] The human effort necessary to operate the sluice mechanism was insignificant, though a boat was needed to reach the pillars of the piston.

The version of the cistern sluice found on the island of Sri Lanka is even more sophisticated. The flow of water was controlled by way of a brick-made cistern built into the embankment, which held a set of stone slabs that could be removed according to the water level inside the tank. To let the water flow, the slabs were removed by two men who could enter the cistern by way of stepping stones built into the walls of the cistern. As a major advantage, the amount of water that can be conveyed by this mechanism is in principle unlimited, and neither pressure nor suction can do much harm to the embankment (apart, of course, from the harm caused by the action of the waves in

general, against which the inside of the embankment had to be protected with stone boulders). Human labour was also reduced to a minimum.

Though the development, as presented here, appears to suggest that a new technology was invented in South India and elaborated in Sri Lanka, the transfer of technology seems to have worked exactly in the opposite direction. Survival in the dry zone of northern Sri Lanka was possible only on the basis of universal irrigation, and proverbially Sinhalese civilisation was composed of the village, the monastery and the tank (an assumption that was again heavily exploited by Sinhalese nationalists in the 19th century).[20] In the first centuries CE, this hydraulic system based on unconnected village tanks was gradually turned into a supra-local (or perhaps imperial) system, which connected the village tanks with large reservoirs through long, sophisticated channels. According to the Sinhalese chronicle *Mahavamsa*, a monastic record written around 500 CE, the first ruler of the island to be famed for completing several large-scale dams was king Mahasena, who reigned in the second half of the 3rd century CE.[21] It is obvious from what has been said above that an indispensable prerequisite for the construction of these huge reservoirs was the availability of sophisticated methods to conduct water from the reservoir to the distributaries.[22] No dated examples are known from Sri Lanka, but as the South Indian piston sluice was obviously known on the island but never used,[23] it appears a logical conclusion that the Sinhalese knew a better way to tackle this problem. This transfer of technology is quite probable, as the relations between the island and the mainland were quite intensive throughout. As an island, Sri Lanka formed a geographically separate unit but politically, it was part of South India. Ethnically, socially and economically, the two regions had much in common, and the short distance across the Palk Straits – less than 50 kilometres at the narrowest point – facilitated intercourse and interaction. Buddhist monks and communities, for instance, were in close contact,[24] and the network of Tamil merchants that was spun across the Bay the Bengal also included Sri Lanka. This is illustrated by the presence of the Nanadeshis, a Tamil traders' corporation, in the south of the island.[25] Besides these peaceful forms of intercourse between Sri Lanka and South India, military struggle prevailed almost permanently.

On the mainland, a constant struggle for supremacy was going on between the Pandyas, the Pallavas and (later) the Cholas, which repeatedly also affected the island. As immediate neighbours, the Pandyas seemed to pose the bigger threat to the Sinhalese kingdom at Anuradhapura, so it became a question of political expediency for the Sinhalese kings to side with the Pallavas. Instead of keeping the island out of the conflict, this alliance drew Lanka deeper into the conflicts on the mainland. Since crossing the sea posed no real problems to an army, the island was repeatedly invaded, its army conquered and its capital, Anuradhapura, plundered. Occasionally, victorious invaders would occupy the Sinhalese throne for longer periods. On at least three occasions, this conquest resulted in the establishment of a Tamil dynasty ruling over Lanka from the capital city Anuradhapura. The first of these dynasties, founded by a Tamil conqueror, was established in the 2nd century BC, the next one during the 5th century CE, and the last and most important one, around 1000 CE. The last-mentioned occupation was different in character as the Cholas, who had superseded both the Pallavas and the Pandyas as the supreme power in South India by the 9th century, did not reside at Anuradhapura after conquering the city. Instead, they returned to their own capital in India and turned Lanka into a province of their empire, administered by a governor.

Irrigation and state formation on the mainland

Although classical literature of India is replete with references to tanks, conduits and other irrigation works allegedly built since antiquity,[26] archaeological and epigraphical data suggest these are much younger. Among the earliest constructions, we find the Sudarshana lake of Gujarat, whose origins may go back to the 1st century BCE, but which breached on more than one occasion. No trace of it has survived.[27] Quite recently, a reservoir of considerable size has been discovered in the vicinity of Sanchi, an ancient Buddhist site on the north-western Deccan (in Madhya Pradesh). It appears to be contemporary with the stupas, which are generally assigned to the period between the 2nd century BCE and the 1st century CE.[28] The descriptions and pictures so far available show that the inner side of the bund was carefully reinforced with rocks, a necessary measure to counter the

wave action against the dam, and a water spill, which resembles the one at Vanagiri tank near Kaveripumpattinam.[29] Though the facing suggests that the builders of this tank had advanced knowledge of irrigation, there is no obvious sign of a more sophisticated sluice mechanism.

The earliest epigraphic reference for a sluice comes from southern Orissa and dates from the year 87 of the Ganga Era or 585 CE.[30] This reference is quite interesting, as the area – generally known as Kalinga (approximately the region of southern Orissa and northern Andhra) – was in close contact with Sri Lanka in the early centuries CE. Although the inscription gives no clue as to the type of sluice, it is not entirely improbable that a cistern sluice was meant.

By the time this inscription was written, the construction of tanks and irrigation works was fully under way all along India's east coast.[31] Again, it took some time until irrigation works found mention in written documents. In the inscriptions of the Pandyas, sluices and sluice-gates called *tumbu* are regularly referred to from the beginning of the 8th century. The earliest Pandya record mentioning a kind of irrigation device dates from the year 720 CE, though the term *madugu* may not necessarily denote a sluice.[32] Proper sluices (*tumbu*) are in fact mentioned only a century later, when a Pandya king recorded repairs to several tank bunds and sluices.[33] In the 9th century, the number of references to sluices increases markedly in the epigraphy of the Pallavas.[34] By then, advanced hydraulic engineering and construction had apparently become quite common in South India. The inscriptions occasionally give a hint as to the type of sluice by referring to boats.[35] Boats were of course instrumental in removing the silt from the tank, which could block the inlet of the simpler types of water pipes, but they were also needed to operate the piston that regulated the flow of water through the cistern sluices.

Social meanings of a new technology

Small-scale artificial irrigation had prevailed in India since ancient times, but the construction of tanks and sluices became widespread in South India during the 6th to the 14th centuries, as is suggested by both archaeological and epigraphic evidence. No other Indian region displayed a

similar density of irrigation tanks as the coastal area of Tamil Nadu and the adjacent regions, Andhra Pradesha and Karnataka on the Deccan.[36] This spread and proliferation of tank-based irrigation was built on an increasing experience in hydraulic engineering, which includes everything from determining suitable locations for a dam to deciding on the gradient of canals and improving the outlets and control mechanisms of the waterspills. It seems that the most sophisticated of these sluices, the piston sluice, was developed in Sri Lanka, where it was used rather frequently from the 8th or 9th centuries, after which it spread to South India, where the earliest examples may date from the 11th century.[37] While it may have still been in progress by experimentation during the Pallavas and the Cholas, the piston sluice came into full use under the Kakatiyas of Warangal, who succeeded the Cholas on the Deccan between the 12th and the 14th centuries. The Kakatiya kings commissioned numerous large irrigation tanks, and the famous inscription from the Porumamilla tank (mid-14th century) describes, in a poetical manner, the constituents of a good tank as well as the things to avoid in its construction.[38]

The technological change had social and political consequences. To begin with, a new group of artisans, the master masons who were capable of constructing a sluice gate, rose socially and economically. Occasionally, they are even mentioned by name – a privilege otherwise reserved for members of the royal family, high courtiers and religious masters – together with the special rewards and payments they received for their craft.[39]

Secondly, the surplus of water that could be distributed to the fields may have led to an increase of the acreage under cultivation and/or higher yields. The secure food basis stabilised society and could even accommodate natural population growth. It would also have allowed an increase of the population by ways of forced migration and enslavement. As mentioned previously, people appear to have been a rare commodity in pre-modern South and Southeast Asia, and thus military conquests regularly resulted in the abduction of humans.[40]

Thirdly, it has been argued that as the rural economy becomes more settled and access to irrigation becomes a prerequisite for wealth, society would eventually become more stratified with the emergence of a lower social stratum of landless labourers, who might end up as serfs permanently attached to the fields they workon.[41]

Finally, the ability to regulate the outflow of water from a tank by sluices instead of bailing it with buckets had a tremendous impact on the amount of labour needed for agricultural work. As generally two men could operate a sluice mechanism, regardless of whether this was a shutter of logs tied together or a piston valve or cistern sluice which both had to be reached by boat, and conduct any required amount of water into the fields, a considerable portion of male labour lay idle in the period between ploughing in May/June, and the harvesting and threshing in December. Of course, a huge amount of labour was still needed, as men had to look after the embankments of the channels and remove the silt, but these tasks and responsibilities were organised well enough to minimise the demand for labour.[42]

So how did the men utilise this additional spare time they had with the introduction of 'modern' technology into their daily lives? One possible answer seems to lie in South Indian culture, in which physical exercise and martial arts were held in high esteem, and which linked masculinity almost inextricably to heroism and martyrdom.[43] An early display of this feisty attitude was cattle theft, which seems to have been a major pastime in coastal South India and the Deccan in ancient times, at least if judged by the hundreds of hero stones that were erected to commemorate those who had lost their lives either when caught stealing or in pursuit of a cattle thief.[44] Increased spare time may have amplified that disposition as well as it could have enabled the emergence of social groups specialising in military activities such as the Velaikkaras.[45] At any rate, it would seem that population growth, an emerging class of landless peasants and decreasing demand for labour spent on irrigation, in combination with a predilection for physical exercise and martial arts, would have benefited the military expansion of the Chola rulers.

The Chola expansion

Even under the assumption that the expansion of the Cholas in the 10th and 11th centuries was by no means a linear development – dynastic squabbles over succession and invasions by the Rashtrakutas in the second half of the 11th century, for example, vitiated most of the earlier successes -- can this period be regarded as one of the classical Asian examples for 'imperial expansion'? The foundations for this expansion were laid by king Parantaka (907-55 CE), whose reign brought the conquest of the Pandyas as well as repeated attempts to invade Sri Lanka. The invasion of the Rashtrakutas in the closing years of Parantaka confined Chola power to their heartland around Tanjore again, but it seems to have done even greater damage on the Pallavas, the northern neighbours of the Cholas, as they vanished as a regional power. In this situation, two outstanding kings-cum-military leaders, Rajaraja I (985-1016 CE) and Rajendra (1012-44), appeared on the scene and exploited the power vacuum left by the Rashtrakutas. Rajaraja, having subdued both the Pandyas and the Pallavas in the early years of his reign, led a campaign against Sri Lanka in 998 CE, in the course of which he took the Sinhalese king prisoner and plundered the capital, Anuradhapura. Rajaraja's son and co-regent Rajendra failed with a second attempt to subdue the whole island in 1017, but launched two more successful campaigns immediately thereafter. In 1023 CE, the king marched along the Indian east coast into Bengal and the lower Ganges valley, from where he brought back water with which he filled a temple tank in his new capital.[46] Two years later, he sent a fleet against several ports and emporia in the Malayan-Sumatran area with the probable aim of breaking the trade monopoly of Sri Vijaya. This maritime raid apparently had no lasting effects, but even without evidence of such, the expedition can be regarded as an outstanding achievement by a king who managed to mobilise the resources of his kingdom to the fullest.

As has been suggested in this paper, advances in irrigation engineering, from simple weirs across rivers to small-scale tanks and finally to large reservoirs with sophisticated sluice mechanisms, lay at the beginning of this remarkable expansion of the Cholas from the early 10th century. When they had conquered the neighbouring dominions of the Pallavas and the Pandyas, they also took

over the latter's already respectable hydraulic system which they integrated, extended and elaborated with technology probably imported from Sri Lanka. It does not appear to be incidental that king Karikala, a semi-mythic figure from the early centuries CE who supposedly 'invented' artificial irrigation in South India by building a stone weir in the Krishna river, is regularly praised in Chola epigraphy.[47] The Chola kings, it seems, recognised that their political power, to a considerable degree, was derived from and depended on the empire's irrigation system.

Surely, to suggest a linear nexus between advances in irrigation technology and the extension of agriculture and population growth, and then to assign this as the factor responsible for the final military success of Rajaraja and Rajendra would clearly overstretch the argument. These factors came in addition to other structural components such as esteem for and exercise in martial arts, and the alliance between trading communities and the kings. Of course it also took visionary rulers determined to make the most of these opportunities in terms of military conquest and expansion. But while the other factors have long been identified and investigated for their contribution to the Chola success story, the contribution of hydraulic engineers to agricultural expansion has not. It may be futile to search for a single most important or overriding factor for it seems to have been a combination of them all. But among these, hydraulic engineering should not be forgotten.

A final question that remains to be answered, at least tentatively, is how it is that agrarian expansion in South India, combined with other factors, could have created such a powerful expansionism among South Indian dynasties (most notably the Cholas), while the Sri Lankan kings, who commanded an older and apparently more sophisticated hydraulic system, became instead the victims of that early form of imperialism. Several answers to that seem possible. At the outset, it must be noted that the Sinhalese kings were not completely and not always inferior to their neighbours. Mention has been made above of the campaigns of king Gajabahu, and in the 12th century it was a general of Parakkama Bahu I who invaded South India and held the conquered territory for a considerable time. However -- and this may be one reason why the rulers of

Anuradhapura had to more often defend their territory rather than expand on the mainland -- topography put a natural limit on the expansion of agriculture on the island. The sea coast formed a natural external border, and the mountains covered with rainforest in the south-western part of the island formed an internal frontier that could not be conquered. Sri Lanka's hydraulic system may have been older and more sophisticated, but it had reached its limits by the time irrigation works in South India were expanded and integrated. Though there is no firm linear correlation between expanding irrigation works, agricultural production and population growth, it seems that the island's population and, along with it, the number of recruitable soldiers were stagnating at a time when they were growing on the mainland. Frequent hiring of South Indian mercenaries by Sinhalese kings can be regarded as an indication of this development.

A second explanation can be gleaned when one checks how the material wealth and the excess human labour gained by introducing sophisticated hydrotechnology were used. The most concise answer to this question is that the Sinhalese, from king to peasant, invested in works of merit. Again, this behaviour is also found in South India where the Cholas became champions of the Hindu reform and revival movement, and built large temples,[48] but the scale was certainly different. By the time the Chola kings began to furnish their residential cities with monumental temples, the Sinhalese could look back upon a century-old series of huge, elaborately constructed religious monuments at Anuradhapura.[49] This began with the construction of the first major stupa, the Mahathupa, and the Lohapasada, an assembly hall several storeys high, which were both built by king Dutthagamani in the 2nd century BCE. In the following centuries, several more higher stupas were added until in the 3rd century CE, King Mahasena – not coincidentally the first "hydraulic king" of Anuradhapura credited with the construction of several major irrigation works – built the stupa of the Cetavana monastery. Measuring about 120 metres in height and more than 300 metres in circumference, this stupa surpassed all other stupas in Anuradhapura and indeed, until now, all stupas in the whole of Sri Lanka. The mass of its body is comparable to the Egyptian pyramids. The construction of these monuments not only required a reliable logistical network for the supply of

major building materials such as bricks, mortar, wood, stones, sand, limestone and the like, but also considerable architectural knowledge regarding, for instance, the preparation of the construction site which had to bear the weight of the building.[50] The construction of these large stupas, it should be noted, came in addition to the construction of numerous other religious monuments such as monasteries, libraries and hospitals all made of wood and brick, as well as the cutting of natural rocks for monasteries and monumental sculptures such as the image of a standing Buddha at Avukana. Obviously, the production of all these religious works of merit not only consumed the material resources of the kingdom, but also utilised a large amount of human labour. Seen on the whole, the Sinhalese may not have been less warlike than the Tamils from the subcontinent, but their cultural disposition turned their activities in another direction. Ultimately, the comparison between Sri Lanka and South India can therefore be reduced to the problem of religious ethics: it seems that this-worldly activities such as martial arts and warfare were forms of worship for the Tamils, whereas the Sinhalese were more interested in leaving this world behind by way of generosity (*dana*) and contemplation.

Notes

[1] This paper is part of an ongoing research project on the role of irrigation in the formation of states in premodern South and Southeast Asia, which was begun at Manchester Metropolitan University (MMU) in 2004. I would like to thank Dr Nawal Prinja on behalf of a group of donors for sponsoring the initial phase of the project, as well as numerous colleagues for their comments and discussions at various stages of the project.

[2] K. A. Nilakanta Sastri, *A History of South India*, 4th ed. 1976 (Madras: Oxford University Press, 1955). See also K. A. Nilakanta Sastri*, The Colas* (Madras: University of Madras, 1955). T. V. Mahalingam, *Kancipuram in Early South Indian History* (London: Asia Publishing House, 1969) also follows a strictly chronological pattern based on the succession of kings.

[3] George W. Spencer, "The Politics of Plunder. The Chola Conquest of Sri Lanka and Sri Vijaya", *Journal of Asian Studies*, 35, 3 (1976): 405-19, and George W. Spencer, *The Politics of Expansion. The Chola Conquest of Sri*

Lanka and Sri Vijaya (Madras: New Era, 1983). Cp. also Georg Berkemer, "Structure and Process in the Early Kingdoms of South Asia", in *Explorations in the History of South Asia*. *Essays in Honour of Dietmar Rothermund*, ed. Georg Berkemer (New Delhi: Published by Ajay Kumar Jain for Manohar, 2001), pp. 132-3.

[4] Kenneth R. Hall, *Trade and Statecraft in the Age of the Cholas* (Delhi: Abhinav Publications, 1980).

[5] For a general overview, see Simon Digby, *War Horse and Elephant in the Delhi Sultanate: A Study of Military Supplies* (Oxford: Orient Monographs, 1971) and more recently, Jos Gommans, "War Horse and Gunpowder in India, c. 1000-1850", in *War in the Early Modern World, 1450-1815*, ed. Jeremy Black (London: UCL Press, 1999), pp. 105-29.

[6] Gommans, "War Horse and Gunpowder", and Alam Iqtidar Khan, "Origin and Development of Gunpowder Technology in India, AD 1250-1500", *Indian Historical Review*, 4, 1 (1977): 20-9; both agree that guns and gunpowder became important with the Mughals, i.e. around 1500 CE. For developments in China, see Sun Lai-chen, "Military Technology Transfers from Ming China and the Emergence of Northern Mainland Southeast Asia (c. 1390-1527)", *Journal of Southeast Asian Studies*, 34, 3 (2003): 495-517.

[7] S. Pathmanathan, "The Velaikkarar in Medieval South India and Ceylon", *The Sri Lanka Journal of the Humanities*, 2, 2 (1976): 120-37.

[8] But see Daud Ali, "War, Servitude and the Imperial Household: A Study of he Palace Women in the Chola Empire", in *Slavery and South Asian History*, ed. Indrani Chatterjee and Richard Eaton (Bloomington & Indianapolis: Indiana University Press, 2006), pp. 44-62 (esp. pp. 49-50). For general views, see Dirk H. A. Kolff, *Naukar, Rajput and Sepoy: The Ethnohistory of the Military Labour Market in Hindustan, 1450-1850* (Cambridge: Cambridge University Press, 1990), and the studies of Seema Alavi.

[9] For a possible approach to the topic see Anthony Reid, "Low Population Growth and Its Causes in Pre-colonial Southeast Asia", in *Death and Disease in Southeast Asia: Explorations in Social, Medical and Demographic History*, ed. Norman G. Owen (Singapore: Oxford University Press, 1987), pp. 33-47.

[10] A ddiscussion of this debate, which concerned the nature of the Chola state as centralised and bureaucratic (Nilakanta Sastri), segmentary (Burton Stein), South Indian feudalist (Veluthat) or a mixture of all these, would require more space than is available here. For summaries, see Hermann Kulke, "The Study of the State in Premodern India", in *The State in India, 1000-1700*, ed. Hermann Kulke (Delhi and New York: Oxford University

Press, 1995), pp. 1-57, and Kesavan Veluthat, *Political Structure of Early Medieval South India* (Hyderabad: Orient Longman, 2001), pp. 246-71.

[11] H.-J. Nitz, "Order in Land Organisation: Historical Spatial Planning in Rural Areas in the Medieval Kingdoms of South India", in *Explorations in the Tropics* (K. R. Dikshit Fel. Vol.), ed. V. S. Datye, *et al*. (Pune: Prof. K.R. Dikshit Felicitation Volume Committee, 1987), pp. 258-79. Also see Hans-Georg Bohle, "Spatial Planning and Ritual Politics: The Evolution of Temple Towns and Urban Systems in Medieval South India", in *Explorations in the Tropics* (K. R. Dikshit Fel. Vol.), ed. V. S. Datye, *et al*. (Pune: Prof. K.R. Dikshit Felicitation Volume Committee, 1987), pp. 280-9.

[12] James Heitzman, "State Formation in South India, 850-1280", *Indian Economic and Social History Review*, 24, 1 (1987): 35-61, and James Heitzman, *Gifts of Power: Lordship in an Early Indian State* (Delhi: Oxford University Press, 1997), pp. 37-54. As the titles of Heitzman's publications make clear, his research investigates the forces that led to the integration (and later, disintegration) of the empire rather than the expansionist phase as such.

[13] R. A. L. H. Gunawardana, "Intersocietal Transfer of Hydraulic Technology in Precolonial South Asia: Some Reflections Based on a Preliminary Investigation", *Southeast Asian Studies* (Tokyo), 22, 2 (1984): 115-42, and R. A. L. H. Gunawardana, "Hydraulic Engineering in Ancient Sri Lanka: The Cistern Sluices", in *Paranavitana Commemoration Volume*, ed. J.E. van Lohuizen-de Leeuw *et al*. (Leiden: E. J. Brill, 1978), pp. 61- 74.

[14] Rajan Gurukkal, "Aspects of the Reservoir System of Irrigation in the Early Pandyan State", *Studies in History*, 2, 2 (1986): 155-64. For an overview of ancient Indian irrigation technnology, see T. M. Srinivasan, "Irrigation and Irrigation Works", in *History of Technology in India*, vol. 1 (From Antiquity to c. 1200 A. D.), ed. A. K. Beg (Delhi: Indian National Science Academy, 1997), pp. 556-90. Note that Srinivasan does not mention the possible Sri Lankan origin of the sluice technology.

[15] Lifting water by a lever was already known in ancient Egypt. A very simple machine, the lever may have been developed independently in India at an unknown time.

[16] In ancient India, dams were indeed broken and washed away, which is shown by several passages in inscriptions. The best known example is perhaps the Sudarshana tank in Saurashtra (Gujarat), which finally broke in the middle of the 5th century CE according to the Girnar rock inscriptions of King Skandagupta, see J.F. Fleet, ed., *Inscriptions of the Early Gupta Kings and Their Successors* (2d ed. 1963), (CII), no. 14, p. 63.

[17] See, for instance, Michael Roberts, "The Hydraulic Society of Ancient Ceylon and Factors Contributing to its Relative Stasis", *Journal of the Oriental Society of Australia*, 14 (1979-80): 23-33.

[18] Much of what follows is based on the research of Gunawardana, "Intersocietal Transfer" and Gunawardana, "Hydraulic Engineering". Gurukkal's "Aspects of Reservoir Systems" is also heavily indebted to Gunawardana's research.

[19] Cp. Gunawardana, "Intersocietal Transfer", p. 125 and p. 133.

[20] See Jakob Rösel, *Gestalt und Entstehung des singhalesischen Nationalismus* (Berlin: Duncker & Humblot, 1996), see esp. ch. 6.

[21] Wilhelm Geiger, ed./tr., *Mahavamsa or, The Great Chronicle of Ceylon* (London: Pali Text Society, 1909/1912), ch. 37, v. 47-50.

[22] Cp. Gunawardana, "Intersocietal Transfer", p. 130.

[23] Cp. Gunawardana, "Intersocietal Transfer", pp. 132-3.

[24] For the religious intercourse between Sri Lanka and Tamil Nadu and Andhra, see R. A. L. H. Gunawardana, *Robe and Plough: Monsaticism and Economic Interest in Early Medieval Sri Lanka* (Tucson: University of Arizona Press, 1979), ch. 7, pp. 262-71. The presence of Sinhalese monks at Amaravati, the centre of Theravada in Andhra, is attested by the inscription of a lady who built a monastery for them in the 7th century. See J. Vogel, "Prakrit Inscriptions from a Buddhist Site at Nagarjunakonda", *Epigraphia Indica*, 20 (1929-30): 1-37.

[25] For a seal of a merchant a guild called *nanadeshis* found at Hambantota, see K. Indrapala, "South Indian Mercantile Communities in Ceylon, c. 950-1250", *Ceylon Journal of Historical and Social Studies*, 1, 2 (1971): 101-13.

[26] Srinivasan, "Irrigation", pp. 556-63.

[27] Fleet, *Gupta Inscriptions* (CII), no. 14, p. 63.

[28] See Julia Shaw and John V. Sutcliffe, "Ancient Irrigation Works in the Sanchi Area: An Archaeological and Hydrological Investigation", *South Asian Studies*, 17 (2001): 55-75; Julia Shaw and John V. Sutcliffe, "Water Management, Patronage Networks and Religious Change: New Evidence from the Sanchi Dam Complex and Counterparts in Gujarat and Sri Lanka", *South Asian Studies*, 19 (2003): 73-104; Julia Shaw and John V. Sutcliffe,

"Ancient Dams and Buddhist Sites in the Sanchi Area: New Evidence on Iirrigation, Land Use, and Patronage in Central India", *South Asian Studies*, 21 (2005): 1-24.

[29] Srinivasan, "Irrigation", p. 573.

[30] Achyutapura copper plate of king Indravarman, in S. N. Rajaguru, ed., *Inscriptions of Orissa*, Vol. Il (Bhubaneswar: Orissa Sahitya Academy, 1960). vol. 2, p. 24. The king ordered that "no-one shall cause hindrance to the opening of the sluice-gate (*udara-bandha*) of the tank".

[31] Srinivasan, "Irrigation", p. 559.

[32] *Epigraphia Indica* Vo.I 28, pp. 27-32; Gurukkal, "Aspects", pp. 155-6. According to the inscription, the *madugu* regulated the outflow from the Vaigai river, so it seems to have been a kind of weir rather than a sluice at a tank.

[33] Srimara Srivallabha's Cinnakkollapatti inscription, *South Indian Inscriptions* 14, no. 43-44 (early 9th c.).

[34] C. Minakshi, *Administration and Social Life under the Pallavas* (Madras: University of Madras, 1938) provides a good overview on this question in ch. 7. Most of the epigraphic references can be found in T. N. Mahalingam, ed., *Pallava Inscriptions*.

[35] For example, see V. Rangacharya, ed., *A Topographical List of the Inscriptions of the Madras Presidency* (Madras: Government Press, 1919), vol. 3, p. 1514, nos. 49-51; inscriptions from the 4th year of Rajakesarivarman Chola made mention of the boat plying the tank and making provisions for the repair of the boat and the removal of silt from the tank. Cp. T. M. Srinivasan, "Irrigation in South India", in *History of Indian Science, Technology and Culture, AD 1000-1800*, ed. A. Rahman (New Delhi: Oxford, 1999), p. 347.

[36] Cp. the map in B. N. Chaturvedi, "The Origin and Development of Tank Irrigation in Peninsular India", *The Deccan Geographer*, 6, 2 (1968): 61.

[37] Cp. Gunawardana, "Intersocietal Transfer", pp. 134-7.

[38] *Epigraphia Indica*, vol. 14, no. 7, pp. 71-97.

[39] E.g. Singaya Bhatta, the mason who constructed the dam mentioned in the previous footnote; and Sonan Ariyan, in T. N. Mahalingam, *Inscriptions of the Pallavas* (Delhi: Agam Prakashan, 1988), no. 268, p. 649 (9th century).

[40] As Anthony Reid has put it succinctly: "Control of men, not land or capital, was both the key and the index of power". See Reid, "Closed and Open Slave Systems in Pre-colonial Southeast Asia", in *Slavery, Bondage and*

Dependency in Southeast Asia, ed. Anthony Reid (New York: St. Martin's Press, 1983), p. 157. Though it is impossible to quantify the population of any Asian region before c. 18th century, examples of abduction of people, especially of skilled artisans and workers, abound. Numerous hero stones all over South India commemorate warriors who died in connection with a raids seeking people (more often seeking cattle, though), and the Sinhalese king Gajabahu is said to have brought back thousands of Tamils from his campaign in South India in the 2nd century CE.

[41] Vivek Chibber, "Breaching the Nadu: Lordship and Economic Development in Pre-colonial South India", *The Journal of Peasant Studies*, 26, 1 (1998): 1-42.

[42] Removing the silt from a tank or the supply channels was normally a community task, assigned to the village adjacent to the tank. The village committee would annually appoint a few men who had to look after the tank during the year. See e.g. T. Mahalingam, ed., *Inscriptions of the Pallavas*, no. 83, p. 279 (Paiyanur CP of Nandivarman II from Paiyanur, Chingleput distr.): two merchants and the villagers agreed that the money from a sale of land was to be utilized for digging silt from the tank; ibid., no. 217, p. 562 = SII 6, no. 325 (Uttaramallur inscr. of king Kampavarman, 884 CE): a gift of 1000 kal of gold by Seyya Aparajitam of Tolurnadu was entrusted to the village committee (*sabhaiyar*) of Uttarameru, who were to use the interest to pay for the removing of silt and the strengthening of the bund; ibid., no 215, p. 559 (Ukkal inscr. of King Kampavarman, 884 CE): members of the village committee were to supervise the strengthening of the bund of the tank.

[43] For modern concepts of martyrdom and heroism in Tamil culture, see for example, Peter Schalk, "The Revival of Martyr Cults Among Ilavar", *Temenos*, 33 (1997): 151-97, and Michael Roberts, "Filial Devotion in Tamil Culture and the Tiger Cult of Martyrdom", *Contributions to Indian Sociology*, 30, 2 (1996): 245-72. A Keralan form of martial arts is described by Philipp B. Zarilli, *When the Body Becomes All Eyes. Power, Practice and Discourses of Kalarippayattu, a South Indian Martial Art* (Delhi: Oxford University Press, 2000).

[44] For Indian memorial stones, see S. Settar and Günter Dietz-Sontheimer, *Memorial Stones. A Study of Their Origin, Significance and Variety* (Dharewad: Institute of Indian Art History, Karnataka University, 1982), especially the contribution by S. Settar, "Memorial stones in South India" pp. 183-97. Some of the inscriptions on these stones are edited by Mahalingam, *Inscriptions of the Pallavas*, passim. For a reference to hero worship in classical Tamil (*sangam*) literature, see Nilakanta Sastri, *A History of South India*, p. 169.

[45] As has been shown, the Velaikkarar, as one of these groups specialising in warfare, were acting on a supra-regional level, as they were repeatedly hired by Sinhalese rulers as well.

[46] The new Chola capital was accordingly named Gangaikondacolapuram, "city of the Cola who took the Ganga".

[47] The analogy of the Cholas as conquerors and hydraulic engineers with Karikala's deeds can be easily discerned from the Leiden Grants of King Rajendra in which it is stated that "King Karikala controlled the Kaveri (…) by means of a bund made of earth thrown in by subdued kings who carried baskets on their heads". The earliest references to king Karikala is however found in Pallava inscriptions, e.g. of king Punyakumara (c. 700 CE). See K. A. Nilakanta Sastri, *Studies in Chola History and Administration* (Madras: University of Madras, 1932), p. 62.

[48] This refers especially to the 'imperial temples' at the Chola's chief cities, Tanjavur and Kancipur. In fact, it has been argued that the Cholas were the first Indian dynasty to engage in monumental religious architecture.

[49] For a connection between economic progress and architecture, see Tilman Frasch, "Religious and Economic Development in Ancient Anuradhapura", in *Sri Lanka Past and Present. Archaeology, Geography, Economics: Selected Papers on German Research*, ed. Manfred Domrös and Helmut Roth (Weikersheim: Margraf Verlag, 1998), pp. 61-81.

[50] The construction process of the Mahathupa, which may be representative for any of the later stupas as well, is described in detail in the *Mahavamsa*, chs. 32-5.