# Tanks and Anicuts of South India
## Examples of an Alternative Science of Engineering

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## Abstract

*In the past several decades, the harmful side effects of science and technology have become painfully clear. This can be traced to modern science which concerns itself solely with the study of "facts" (devoid of value) and hence, its method is necessarily reductionist and vivisectionist. An alternative science of engineering must be inherently free of side effects and yield solutions/systems that would perform their stated function without unduly harming the rest of creation. There is considerable evidence that concern for and preservation of all life was the underlying primary objective of traditional science within India and without. If we are able to unearth the principles and method of an alternate science of engineering, it could be applied to present day problems and needs.*

*A few significant results from our study of traditional irrigation systems are presented here. Although, at this stage we do not claim to be anywhere near the long-term goal. Hampered by lack of data or any textual sources to go by, the study was based on archival search, field investigations, physical survey and flow data availability. Two examples of traditional irrigation are discussed.*

*1. A side weir : The Grand Anicut*
*2. A network of 200 tanks : Tank System on Palar river*

*It is heuristically argued that the oddly shaped Grand Anicut was designed to increase the sediment transport to the distributary, the Coleroon. The investigation of the tank system showed that it is located in a region of high rainfall variability both temporally and spatially. In such a semi-arid region, under unreliable rainfall conditions, the tank system diversity was found to optimize food security.*

## Introduction

For the past several decades, the harmful side effects of science and technology and of the rapid "development" during the 20th century have become painfully clear. Even a cursory inspection of these problems (air/water pollution, ground water depletion, deforestation, salinity ingress at river mouths because of the construction of large dams…) reveals that they are not mere accidents, nor merely due to improper use of technology, but emerging from the fundamental presuppositions of modern science and its method. As a matter of self-definition, modern science concerns itself solely with the study of "facts" (devoid of value) and its method is necessarily reductionist and vivisectionist.

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Our long-term quest is to try and rediscover the principles and method of an alternative science of engineering that would be inherently free of side effects and would yield solutions/systems that would perform their stated function without unduly harming the rest of creation. It is a project of rediscovery because there is considerable evidence that concern for and preservation of all life was the underlying primary objective of traditional science within India and without (c.f. Mayamata, 1985, Uberoi, 1984, Seathl, 1855 etc.). Thus, our interest in traditional engineering systems does not stem from a need to celebrate a "glorious past" nor from a concern for heritage preservation but from the hope that through a study of these works of engineering we would be able to unearth the principles and method of an alternate science of engineering, which could then be applied to present day problems and needs.

While at this stage we do not claim to be anywhere near the long-term goal stated above, we wish to present a few significant results from our study of traditional irrigation systems, which we feel clearly provide the impetus for further study in this direction.

The methodology adopted in our investigation is outlined below. Essentially there are two approaches. One is to read the old texts and look for principles mentioned in them. Then examine traditional irrigation networks and show how these principles were adopted in them and how effective such principles were in practice. Such an approach was not possible, given the state of the textual sources. Indeed, there is no textual source known for irrigation structures per se.

Instead, the study focussed on particular structures with a view to uncovering general principles. Traditional irrigation structures are first defined as those originally built prior to British intervention. Structures built after 1830 AD are seen to be distinctly different from those built earlier and are hence described as "modern". (It is the distinction and not merely the date that separates the "traditional" from the "modern".) The historical functioning of traditional structures and the problems encountered owing to modifications is traced where possible. Evidence from engineering literature is collected to support the hypothesis.

## The Grand Anicut (Kallanai)

The first example considered here is the Kallanai or Grand Anicut. This is a stone masonry structure, about 6 m high and 330 m long, situated in the Cauvery river delta. Said to have been built in the $2^{nd}$ century AD by the king Karikaal Chola, it is a side weir lying along the northern bank of the Cauvery. The Cauvery delta begins at the point where the undivided river (i.e. Akhanda Cauvery) divides into two branches, the northern branch called Kollidam and the southern branch that retains the original name, Cauvery. The Grand Anicut is situated 28 km downstream from this bifurcation. A sketch of the river in the vicinity of the Grand Anicut is shown in Figure 1.

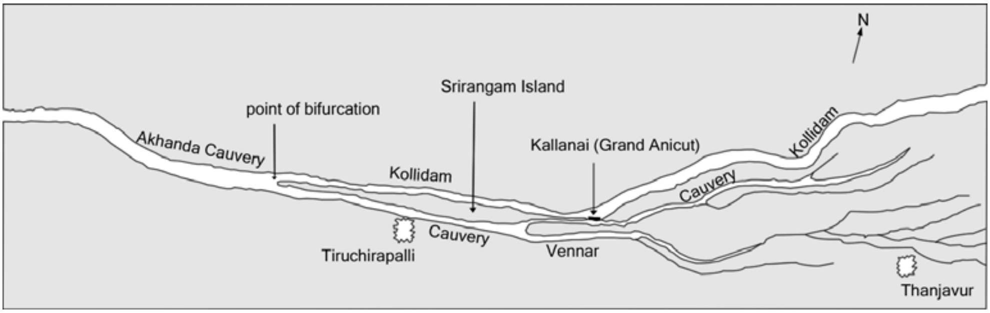


**Figure 1. Map of a small section of the Cauvery as it was in 1854 AD. The section includes the beginning of the delta (i.e. point of bifurcation) and the Grand Anicut, 28 km downstream. It also includes the towns of Tiruchirapalli and Thanjavur.** ***(Adapted from a map drawn in 1854 in Baird Smith, 1856.)***

The Cauvery is the primary river for irrigation in the region. Even in 1800 AD, it irrigated 6,00,000 acres***. The main function of the Grand Anicut was to keep the waters of the Cauvery away from the faster and steeper Kollidam (Coleroon) during normal times, while allowing floodwaters to be safely transported from the Cauvery to the sea via the Kollidam. The Grand Anicut apparently performed its function adequately for nearly two thousand years without the aid of any other structure in its vicinity.

When the British arrived on the scene in the early years of the 19th century, the Grand Anicut was in a state of disrepair owing to political upheavals in the region (the wars between 1740 and 1790 AD). There was severe aggradation††† in the Cauvery branch, threatening to choke water supply to the 6,00,000 acres irrigated by the Cauvery. The British struggled with the problem for decades. As one British engineer wrote (Baird Smith, 1856)

> "For nearly 25 years, from the time at which Captain Caldwell's works were completed (i.e. 1806), an incessant struggle was maintained against the increasing tendency of the river-bed to silt up –- the head and many parts of the channel were periodically cleared of deposits by manual labour – long and expensive embankments were carried across the bed of the main stream, so as to force a larger supply of water into the Cauvery branch. All these efforts however, were ineffectual – the bed continued to rise, the supply to diminish, the extent of land under irrigation yearly decreased, the revenue was falling off, and the condition of the people was visibly becoming worse and worse. About 1829-30 the crisis had been reached…"

*** Today it irrigates about 11,00,000 acres, yet the problems of this river reach are far from satisfactorily solved.

††† Aggradation refers to the rise in river-bed level owing to deposition of sand there. The flow, unable to carry more sediment than its "capacity" drops any excess sediment leading to "aggradation". The opposite situation, *viz.*, "degradation" occurs when the flow is carrying less sediment than its "capacity", it then picks up sediment from the river-bed reducing the river-bed level.

To resolve the crisis, drastic modifications were made after 1830, adding hydraulic regulators upstream and downstream of the Anicut etc[##]. The Grand Anicut Complex existing at present is shown in Figure 2. It is quite clear that the British engineers undertook all their modifications without fully understanding the original system. In fact, the first modification itself (done in 1806 AD) may have been to the detriment of the functioning of the structure. This was to level the top of the structure and raise it by about 2 feet.

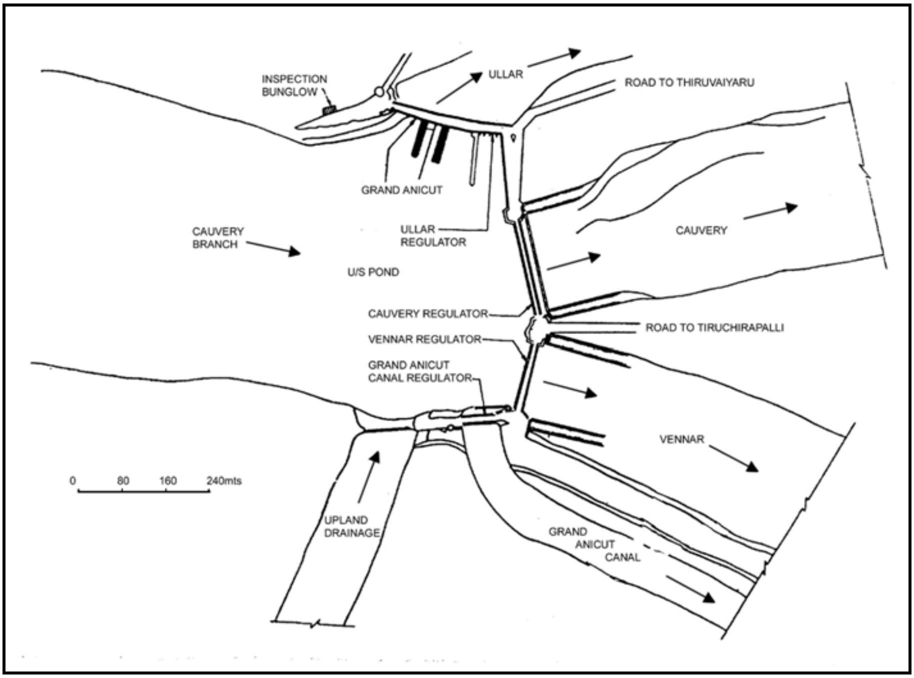


**Figure 2. The Grand Anicut Complex at present**
***(Source: Mohanakrishnan, 1990)***

Fortunately, a picture of the Kallanai prior to modifications can be imagined, from a record dating back to 1776. Peculiar features of the anicut are mentioned in the record. It was curved, i.e., "making two or three waves from one end to the other". Its crest was not level but sloping; higher at the western end than the eastern end. It had a transverse slope too, "a descent from the front to the rear… which makes in some parts a regular and smooth slope and in others irregularly by 3 or 4 steps". Lastly, "overall is spread about ¾ inch thick of a very fine and smooth chunam to prevent the water from making the smallest impression...". This plaster probably needed to be replaced every five years. Further, the front was ragged and uneven, which, however, was said to be an advantage as it "threw up a bed of sand in perpetual suspension for its defence" (Figure 3).

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## There have been several major alterations to the structure and river reach since 1800 when the British took over the region. Since 1934, upstream dams have controlled flows to this reach. All these have greatly changed the discharge and river condition here. As a result the importance and effectiveness of the Kallanai has changed.

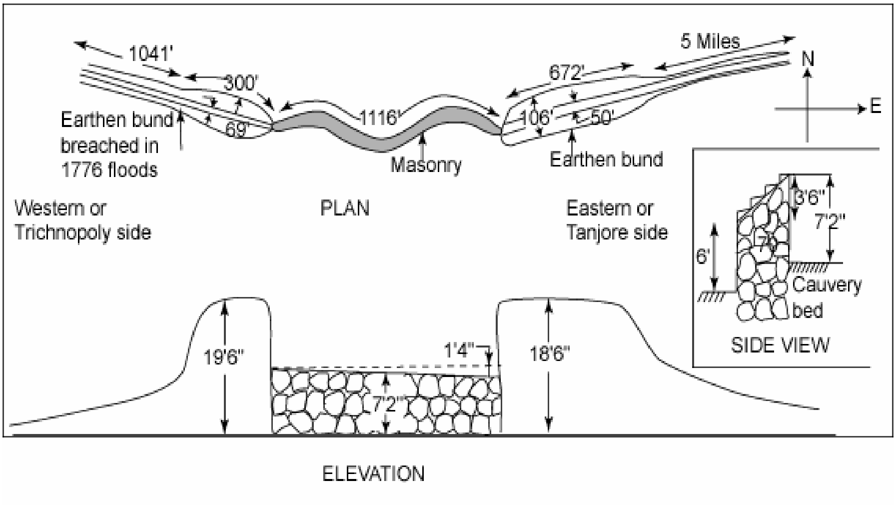


**Figure 3. Plan and elevation of the Kallanai based on the 1777 report (not to scale)**

These curious features may help explain the effectiveness of the Grand Anicut in the centuries prior to 1800. A heuristic argument can be made. As Leliavsky (1957) noted during tests in Egypt, the slope of a side weir influences the sediment transported over it. A hypothesis is elucidated in Krishnan (2003), but in brief, the Grand Anicut's undulating plan form and the transverse and longitudinal slope of its crest etc. transported a significant fraction of the bed sediment over the anicut during floods. Thus, the overall bed slope (from the point of bifurcation shown in Figure 1) in the Cauvery branch is increased, thereby, increasing the speed of the flow and hence its sediment carrying capacity and preventing any net aggradation.

Future work could involve modelling the "curious" features of the Grand Anicut, but it presents a very difficult condition to scale down and model. Also, data for calibrating the model are not there, given all the modifications done to this river reach over the past 200 years. Yet, this is an important, albeit complicated, example. This is because some idea of the original structure, as also some details of its performance, could be pieced together. This information is not known for any other traditional anicut. Indeed, this was the very first irrigation structure that the British tampered with in India.

## A tank system

The second example concerns the Palar, a seasonal river that originates in Kolar district (Karnataka) and flows predominantly east into the Bay of Bengal midway between Chennai and Pondicherry. More than 1500 tanks have been built in the basin of this river of which the Chillapanahalli Subseries (consisting of 198 tanks) of the Ramasagara Main Series was chosen for detailed study. On the basis of long rainfall records, runoff measurements, physical survey and examining old tank registers, an analysis was made.

A schematic drawing of the tank series under study is shown in Figure 4, on the basis of information obtained from the tank registers of 1907 AD. In this figure, the areas of the rectangles correspond to the capacities of the respective tanks and the lines indicate interconnections (inflow and outflow). As can be seen, the connectivity is quite complex and the variation in sizes is considerable. The 11 large tanks (capacity over 1 $Mm^3$) can hold 60% of the total storage, while the remaining 187 tanks can hold only 40%. This begs the question as to why so many small tanks were constructed.

A couple of important points can be noted from our analysis of this tank system. Rainfall and runoff data for the region indicate that the small tanks would fill up every year, while the large tanks would fill up only once in four years. The small tanks were useful in cultivating an annual rainy season (July to Nov.) crop of paddy, and once in four years, the large tanks ensured a second and very productive crop of paddy in the summer (Jan. to May). Given the variability of rainfall in the region, this arrangement appears to optimize food security. Calculations show that even assuming fairly conservative yields, a population density close to that existing in the 1980s could be supported by this traditional system. As regards maintenance of the tanks, calculations show that even the largest tanks could be desilted by the community it catered to. About 20 people from every village working for a month each year could manually desilt the tanks that fed them, even assuming a high siltation rate. Yet when neglected for decades, the tank desiltation effort becomes unmanageable, as evident today.

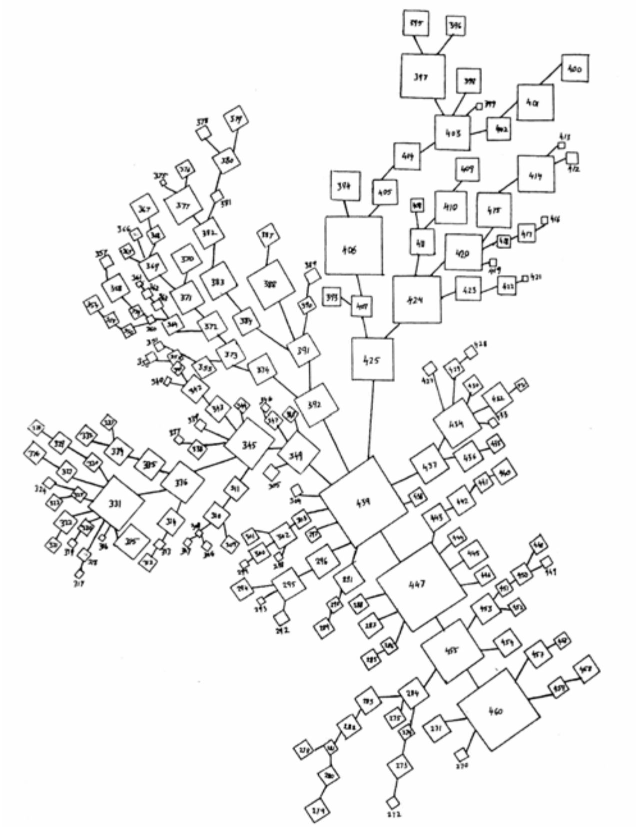


**Figure 4. Schematic drawing of the Chillapanahalli Subseries showing the relative sizes of the tanks and the interconnections between them**

## Conclusion

The short term objectives of such a study are to understand the working of some traditional irrigation structures. The two examples discussed above have provided such an understanding. The challenges of such studies, wherein there are no texts known and when the structures themselves are greatly modified, are clearer. A key point that emerges is that "sustainability" appears intrinsic to the "traditional method". The Grand Anicut functioning for centuries together or a tank system dating back a thousand years and yet functioning are clear indicators of sustainability, especially when contrasted with "modern irrigation" with all its attendant problems.

### References

Anonymous. 1777. *Some enquires into the state of the Annacathy.* Mackenzie Collection: Genera. 59

Dagens, B. 1985. (Translator) *"Mayamata: An Indian Treatise on Housing Architecture and Iconography".* Sitaram Bhartia Institute of Science & Research

Garde, R.J. and K.G. Rangaraju. 1978. *Mechanics of Sediment Transportation and Alluvial Stream Problems.* Wiley Eastern Ltd., New Delhi

Krishnan, C. 2003. *Tank and Anicut Irrigation Systems: An Engineering Analysis,* Ph.D. Thesis. IIT, Delhi

Leliavsky, S. 1957. *Irrigation and Hydraulic Design.* II. Chapman & Hall, London

Mohanakrishnan, A. 1990., *Selected Papers in Irrigation.* Irrigation Management Training Institute, Tiruchirapalli

Raudkivi, A. J. 1993., *Sedimentation: Exclusion and Removal of Sediment from Diverted Water.* IAHR Hydraulic Structures Design Manual No. 6, A. A. Balkema

Seathl. 1855. *Letter to President Franklin Pierce of the United States*

Smith, B. R. 1856. *Irrigation in Southern India.* Smith Elder & Co.

Uberoi, J.P.S. 1984. *The Other Mind of Europe: Goethe as a Scientist.* Oxford Univ. Press, New Delhi