Introduction to Ancient Indian Technology
Professor D. P. Mishra
Department of Aerospace Engineering
Indian Institute of Technology Kanpur
Module 6
Lecture No 28

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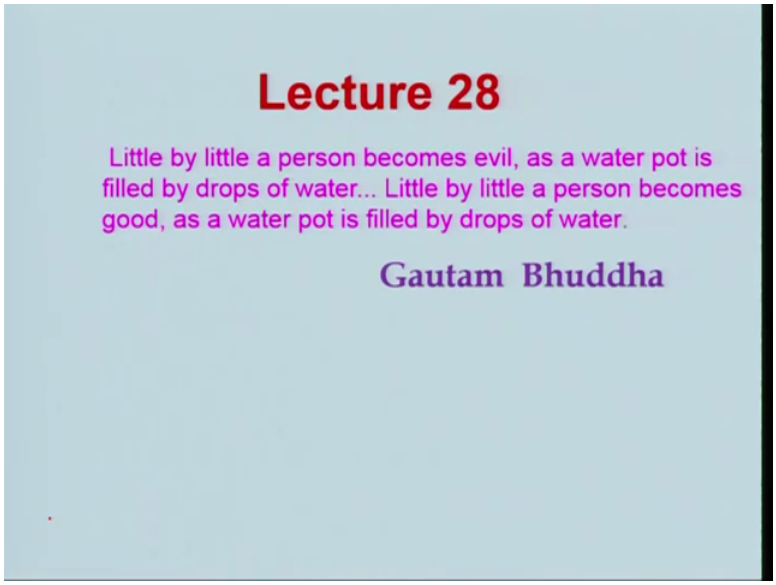

Let us start this lecture with a thought process by Gautham Buddha, “Little by little a person becomes evil as a water pot is filled by drops of water, little by little a person becomes good as a water pot is filled by drops of water”. In the last lecture we had initiated certain discussion on temple tank system whichever where there in ancient India. If you look at, temple plays a very important role in our life particularly in ancient time it was the centre for propagation of education, heritage, culture and also the technology to larger extend, which control the life of common human beings. And therefore the temples were having water tanks which were not being used for everyday usage rather it being utilised for vital purposes for recharging the underground aquifers, reducing the runoff, enhancing the water stagnation time thus ensuring sufficient water in the domestic wells during the summer months.

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Let us look at one example where we will see that lot of water bodies around a temple that is Jagannath temple in Puri of Odisha. This is a beautiful temple I have shown here, but if you look at, we are discussing not about the temple structure rather about the water bodies around this temple. The one tank which is known as Narendra sarovar was constructed basically during this temple construction, but however the history says, that this pond was created during 13th century by Narendra Mahapatra, the minister to Kavi Narasimha Deva in 13th century at a distance around 1 km on the north side of Sri Jagannath temple. And the size is 873 feet long and 743 wide, this is quite huge tank I have shown here in this picture, which you can see at the centre of this huge sarovar or what we call in English Pond, it is having a small temple also.

And which is having a utility maybe for the architectural beauty, one is, but other things it would be that it will be acting as a measure of water in the tank. Besides these, not in this sarovar or the pond, but in other places some step wells are being used to recharge the water inside. And here very interesting thing, if you look at this is the bridge which is there for people to move around and this is the (())(3.29) system is being used if you look at and that similar structures are there in the, various other bridges which were being built in ancient time. Besides these, there are several other water tanks like Indradyumana tank located near Gundicha temple, which is around 3 km away from Jagannath temple and Rohini kunda is a sacred well located within the Jagannath temple premise.

And the Markandeya tank is around 4 acre in size in the Markandeswar temple, which is located south west of the Jagannath mandir in Markandeswar sahi area and Swethaganga tank is located to the South of the temple. And these are the tanks which are existing, but there might be several other tanks which are not associated with the temple but will be around. Some of them might be acquired by the people because today there is a mania for grabbing the land across the country.

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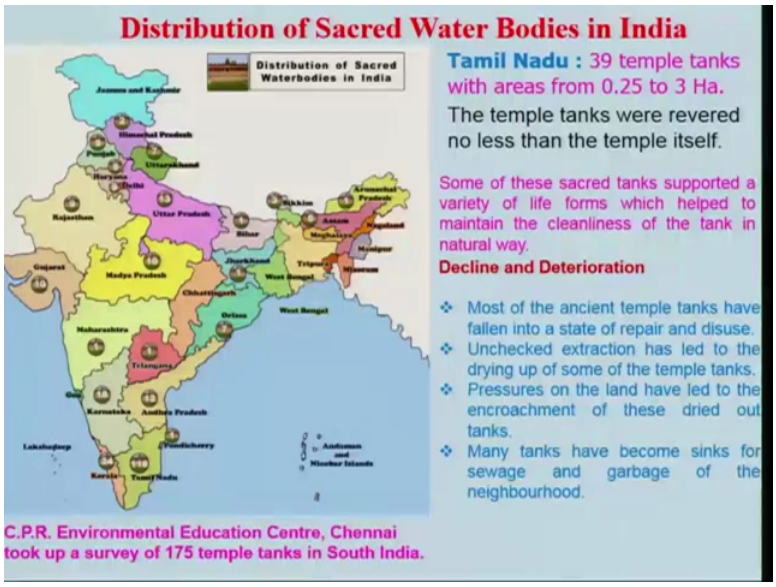

Let us look at actually research work is being done by CPR environmental education Centre Chennai who took up survey of something 175 temple tank in the South India and they have also made a very nice map here, which you can see. But their work was mainly concentrated on the Southern side particularly Tamilnadu, where you can see 116 water bodies associated with the temple you know they could locate a few years back. And besides these of course Andhra, Karnataka and then Kerala but in other places the numbers are very meagre. It cannot be, according to me the numbers will be much higher so far the sacred water bodies are concerned.

And we need to do research on this and let me just tell you give some data from them. The Tamil Nadu 39 temple tanks were with area from point 0.25 to 3 hectors, it is very huge. These temple tanks were revered no less than the temple itself that means they consider this as device as the temple that much of importance were given to the water bodies at that time, of course not today because we are using the water from the, in a pipe and supplied by the government or local bodies and we are not careful about the water usage and it is you know, considering it as divine.

Some of these sacred tanks supported a variety of life forms, which helped to maintain the cleanliness of the tank in the natural way, but in modern time we are using mechanical way. We will be putting some kind of you know water purification system which is there in a market but their nature does the purification, that is the thing we need to learn, so that we need not pay money to the people and which is unnatural, lot of chemicals are entering in the process of purification of water into our body and it is spoiling also. But unfortunately this system which was there in the ancient India, and associated with the temple and other sacred structures those are being declined and deteriorated over the years and because of that, most of the ancient temple tanks have fallen into a state of repair and disuse, because most of the technologies in ancient India needs the regular maintenance which we did not do.

Ancient extraction has led to the dying of some of the temple tanks, because people were using sparingly the water, but today people use profusely right. They do not have concern for that, and pressure on the land which I had told earlier that today people what to grab the land and have led to the encroachment of this dried out tanks. And not only these sacred tanks, also the other tanks which are being used the secular tanks which are being used earlier by the people are being taken over by the builders and then other people and many tanks have become sinks for the sewage and garbage of the neighbourhood. Now you know like water system is fall apart, if you look at the water system is basically in the turmoil today, whatever are existing in the ancient India.

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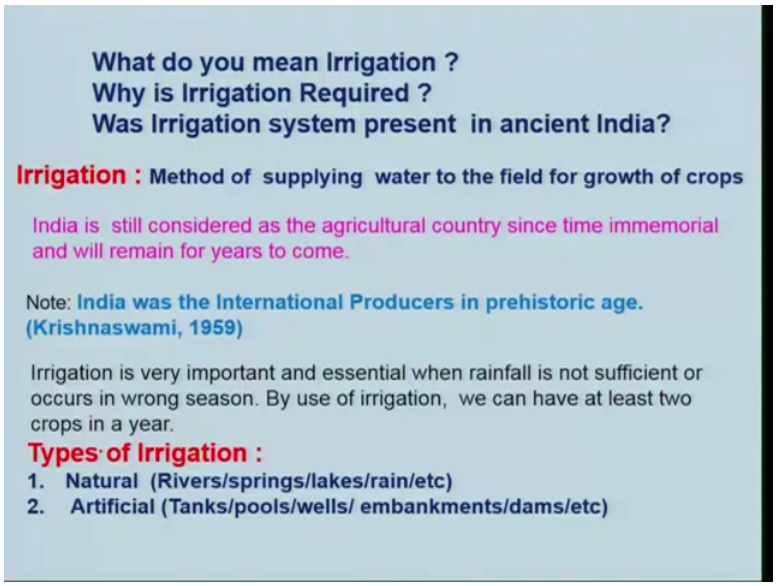

And let us now talk about irrigation system in ancient India, a question might be coming to your mind, what do we mean by irrigation, why is irrigation required and was irrigation

system present in any ancient India? If you look at irrigation is basically method of supplying water to the field for growth of crops because crops you know is very important for the life and I consider that it is the primary wealth, right. Agriculture is the primary wealth or the crops are the primary wealth of us and the rest of us are secondary wealth, but unfortunately the entire wold including India is running after secondary wealth.

But still India is considered as the agricultural country since time immemorial and also remains for years to come because India is a populous country and food is essential. Our scriptures says, “aana pratista deva” that meins without food you cannot really do anything. So therefore we need to produce food and for that irrigation is essential, keep in mind that according to Krishna Swami, India was international producer in pre historic age, unfortunately today also we are producing but using chemical fertilisers and other things. But we need to go back to the, our natural way of farming which I had discussed earlier.

For that irrigation is very important, and essential when rainfall is not sufficient or occurs in the wrong season because you know like there is a climate change. Therefore the rain fall is very very erratic and we need to now learn how to face to challenges created by the climate change and the global warming, and by use of irrigation system in ancient India, and also we can improvise it. We can have at least two crops in a year to meet the demand of the food in this country, the irrigation system can be divided broadly into two categories, one is natural other is artificial. Natural means basically with the help of reverse springs, lakes, lakes means natural lakes and rain water and others. Artificial means, we will have to use tanks pools and then wells, embankments, dams, etc so that we can you know, store the water, rain water and also the flowing after, so that we can utilise for the irrigation.

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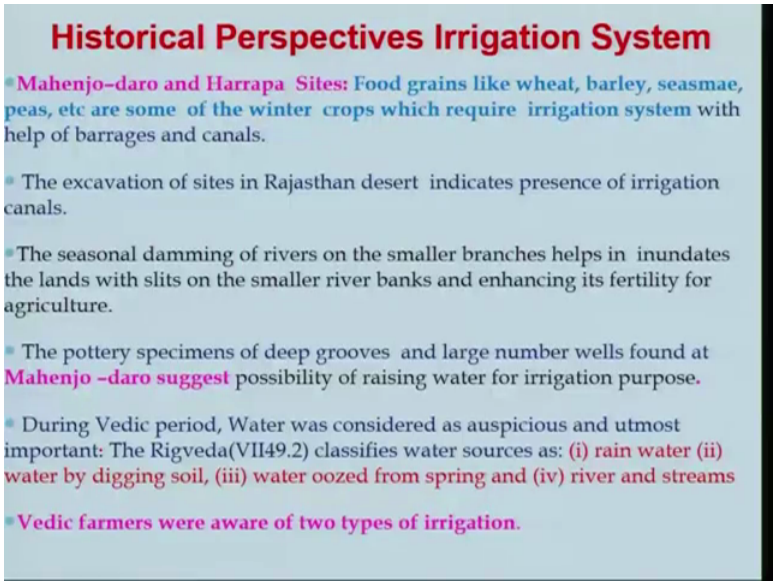

So let us look at historical prospective of irrigation system and if you go back to the Indus valley civilisation to the Mohenjodaro and Harappan sites you will find that also the evidence of the food grains like wheat, barley and sesame, peas etc were some of the winter crops right, which require irrigation with the help of barrages and canal. And you remember that I had shown you that people were having particularly in Mohenjodaro sites, there is a way of utilising the canals for the irrigation purposes and the excavation sites in Rajasthan deserts indicates presence of irrigation canals.

Seasonal damming rivers on the smaller branches helps in inundates the lands with the silts on a smaller river banks enhancing its fertility for agriculture. In modern dams there is problem always the silt is big problem getting you know deposited on the dam itself or the canal also blocking the portion? But earlier day's people were using these silts as a fertiliser in the land by the method of inundate irrigation system which we will be discussing let bit later on. And the pottery specimens of deep brooks and large number of wells found at Mohenjodaro suggest possibility of rising water for irrigation purposes. During Vedic period water was considered auspicious and utmost important component of life and according to RigVeda, the water sources can be classified as rain water, water by digging soil, water oozed from a spring and river and streams.

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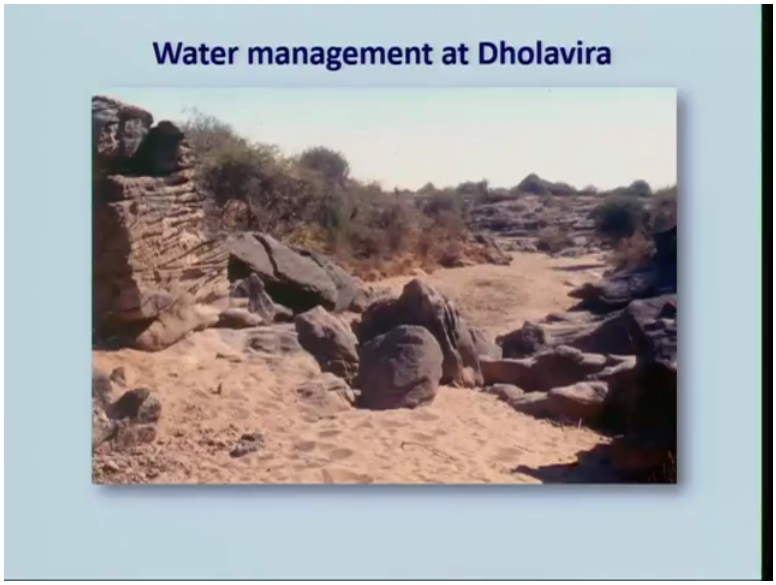

So if you look at it can be basically two types of irrigation system what we had discussed earlier were known to the Vedic farmers that is natural and artificial. If you look at the water management at the Dholavira you can see that this is the remnant of a dam on one side there is a Nullahs basically a canal you can say or a drain canals, so that it is given some of this portions, people are saying it was might be a dam kind of thing.

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And besides these people are conjectural also how they could have a structure to strengthen the dams. They were thinking palisade fences of the wood or metals these are the wood kind of things, horizontal and then these are vertical being placed inside the soil so that it will give

a structural support to take the water load due to the, you know during the floods and other things on the channel.

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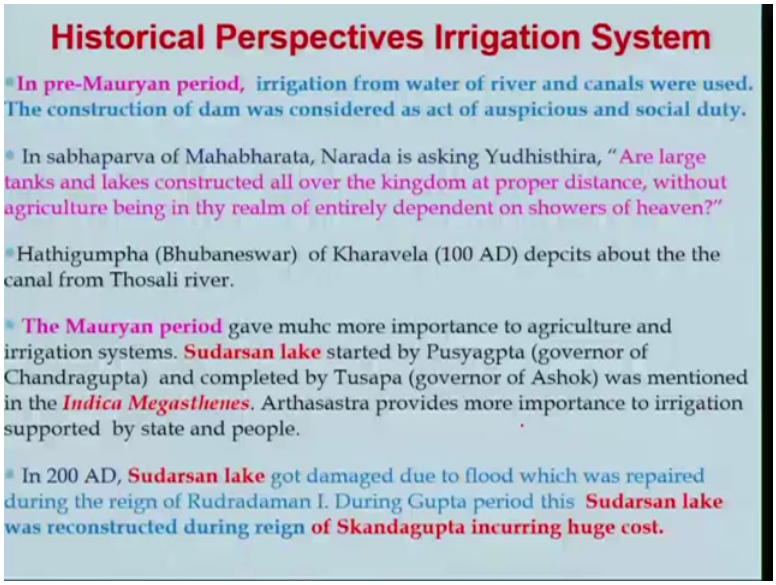

So these are the things people are thinking it might be having and let us look at some more historical perspective of irrigation system. In pre-Mauryan period irrigation from water of river canal were used profusely and construction of dam was considered as an act of auspicious and social duty. It is even today also we feel that kind of social obligation particularly if you talk with the old people in the villages, remote villages not modern villages right, you will find that it is very important to have a wells to be done by the people. And that is the practice which they were having earlier days. And even if you go to the Sabhaparva of Mahabharata, Narada is asking Yudhishtira "Are large tanks and lakes constructed all over the kingdom at proper distance without agriculture being the thy realm of entirely dependent on showers of heaven", that means if you go to the story of Mahabharata it also very clearly say that, they were not relying on the rain for the crops they were having irrigation system in place.

And which was the duty of a king to provide and so also maintain by the people. And Hathigumpha of Bhubaneswar of Kharavela around 100 AD depicts about the canal from Thosali River. If you look at the canal system was there in 100 AD that is the evidence we are having, and Maurya period game much more importance to agriculture and irrigation system. Sudarshana Lake started by Pusyagupta the governor of Chandra Gupta and completed by Tusapa, the Governor of Asoka was mentioned in the Indica Megasthenes, the book written

by Megasthenes and Artha sastra provides more importance to irrigation supported by the state and people.

In 200 AD, the Sudarshana Lake was constructed by Pusyagupta got damaged due to the flood which was repaired during the reign of Rudradaman 1 and during Gupta period this Sudershan Lake was constructed due the reign of Skandagupta incurring a huge cost. That means you know if you look at this kind of lake and water bodies, artificial water bodies were also constructed used and maintained well by the kings and local people as well. In South India irrigation were carried out using small tanks and lakes during even Iron Age.

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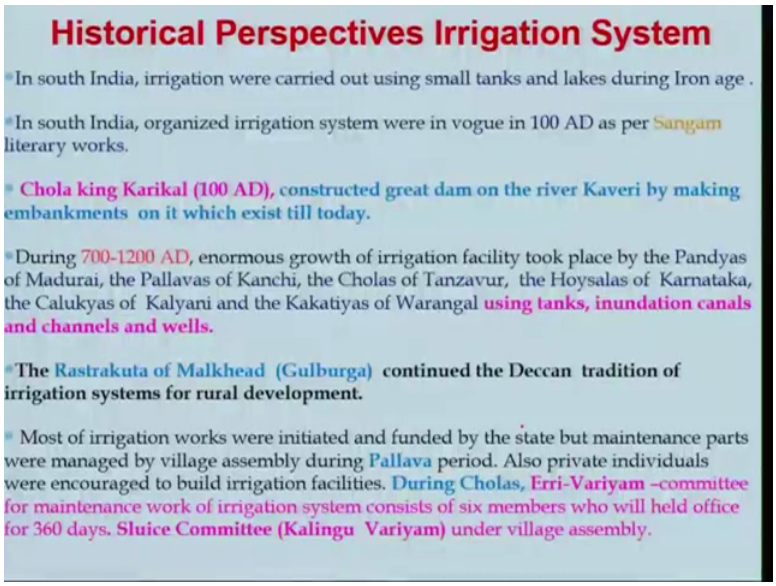

In South India organised irrigation system were in work in 100 AD as per the Sangam literary works. Chola king Karikal who was famous for building constructing a great dam on the river Cauvery which exist till today of course that has been changed a lot, but however it is still being used by the people. And during 700 to 1200 AD, the enormous growth of irrigation facility took place by Pandyas of Madurai, Pallavas of Kanchi, Cholas of Kanjeevara and Housel of Karnataka, Chaukuyas of Kalyani and Kakathiyas of Warangal using tanks, inundation canals and channels and wells. So if you look at there is a great you know, something around 500 years of history are there, who indicates the historical evidence of 500 years indicates that irrigation was priority of the you know rulers in the southern India.

And Rastrakuta of Malkhead in Gulbarga district of Karnataka continued the Deccan tradition of irrigation system for rural development. Most of the irrigation works were initiated and funded by the state, but the maintenance part was managed by the village assembly during

Pallava period. And you can see also similar things are mentioned in Artha Sastra that it will be initiated by the king, but however it has to be managed by the local people. There are two systems during particularly Cholas period, one is 'Erri Variyam' a committee for maintain works of irrigation system which consists of 6 members will held office for 360 days of course after that there will be change of the guard for the people.

And besides this there is another separate committee which is known as Kalingu Variyam and which is English if you look at it, it is a Sluice committee under the village assembly, which will be taking care of the closing of the sluice, maintenance of the sluice gates and other things, for controlling the water to the fields and other places. So therefore it very clearly indicates that there is a system which plays in Southern India for the governance of water bodies as well, not only the construction but governance of those bodies and how to control that.

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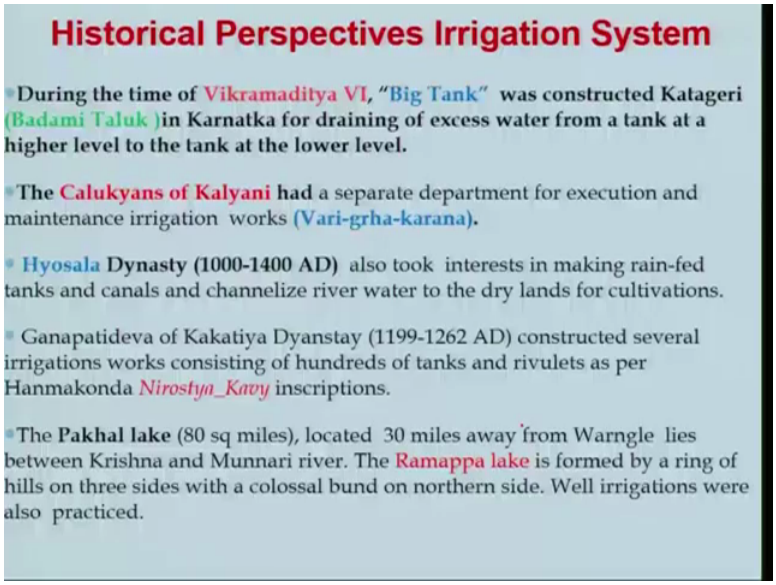

And during the time of Vikramaditya 6, the Big Tank was constructed Katageri, Badami Taluk in Karnataka for draining of excess water from a tank at higher level to the tank at the lower levels. And Chalukyans of Kalyani had a separate department for execution and maintenance of irrigation works. They were having a separate department like a, as of today and Hoysala Dynasty which lasted around something 1000- 1400 AD, also took interest in making rain fed tanks and canals, channelize river water to the dry lands for cultivations.

Ganapathy deva of Kakatiya dynasty constructed several irrigation works, consisting of 100 tanks, rivulets as per the Hanmakonda Nirostiya Kavy inscriptions people got during this

period, which talked about this irrigation system carried out by this Kakatiya dynasty. Pakhal Lake which is around 80 square miles it is a very huge lake located 13 miles away from Warangal lies between Krishna and Munnari River. Ramappa Lake is formed by a ring of hills on three sides with colossal bund on the northern side, if you look at they were choosing the natural you know places for example like hills and other things, and they were also joining the rivulet such that you can have a very easily store the water without much constructional work unlike in the modern system. Well, irrigation were also practised at that time. What do you mean by dam?

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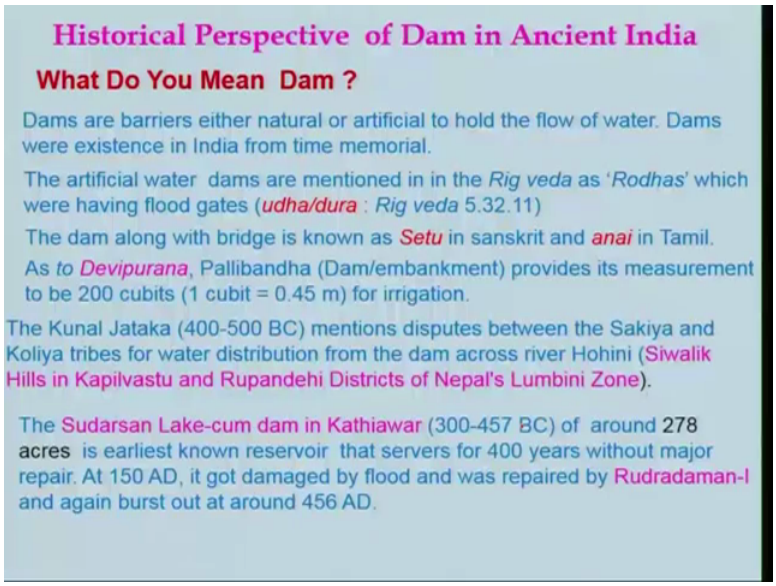

So if you look at dams are the barriers, either natural or artificial to hold the flow of waters. And dams were in existence in India from time immemorial, the artificial water dams was mentioned in Rig-Veda as Rodhas which were having flood gates like Udha or dura. That is the term what they use and you can think of using the sluice gate in modern time. So the dam along with the bridge is known as 'sethu' in Sanskrit, Anai in Tamil and as to Devi Purana the pallibandha or the dam provides its measurements to be around 200 cubits for irrigation system. Kunal Jataka, which is around 400 to 500 BC mentions disputes between the Sakiya and Koliya tribes for water distribution from dam across the river Hohini.

And if you look at today also we are having dispute among the states like your Karnataka and Tamil nadu about the Cauvery water distribution. Similarly, in future also we will be having because water is going to be a very precious thing. Therefore it very much clearly indicate that there is a concern for water and how to save it in ancient India and also the related technology. And the Sudarshana lake cum dam in Kathiawar, which was built around 300 to

457 BC which is very large like around 278 acres is earliest known reservoir that serves around 400 years without major repair. Of course at 150 AD it got damaged by the flood and was repaired by Rudradaman 1, and again busted around 456 AD, this we have already discussed.

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Let us look at the grand Anikut, Kallanai which is I had mentioned was mentioned basically built on the Cauvery rivers to irrigate the fertile delta region of Cauvery and Kallanai was constructed with a uncut stone with 329 meter long and 20 meter wide and 5.4 meter high across the main stream of the Cauvery. If you look at this figure what I have shown here, it is the modern dam system in the river Cauvery it is not the old one, because it was already been changed a lot by the Britishers and later on by the Government of India. And this Grand Anikut which is known as Kallanai was built by Chola king Karikala around the first century AD.

It is one of the oldest water irrigation systems in the world which is still in use. The main function of Grand Anikut as I tod earlier was to keep the waters of Cauvery away from the faster and steeper Kollidam, I will be showing a picture of Kollidam in the next slide. During times while allowing the flood waters to be safely transported from the Cauvery which is at higher elevation to the sea via the Kollidam. Kollidam is the river.

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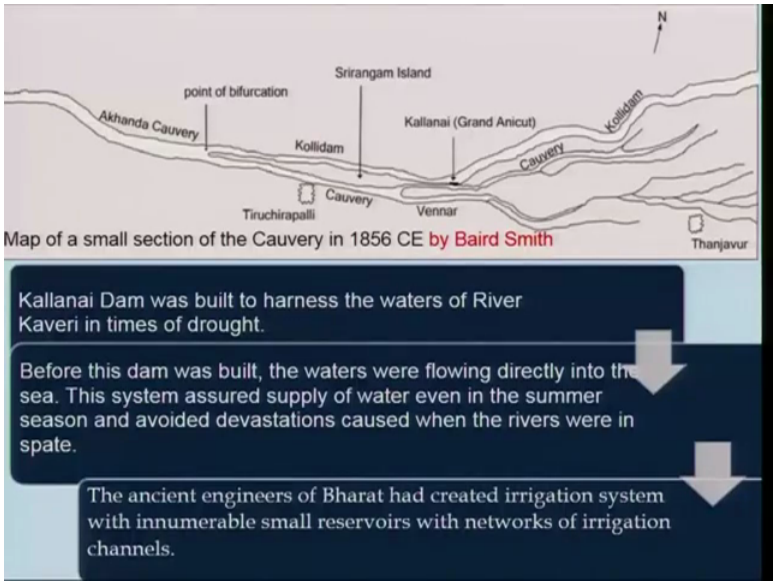

So if you look at this is the topology of the Cauvery River, this is the ahkand Cauvery and it gets bifurcated at this point here and this river which is the fast stream is known as Kollidam which goes to the sea. The other portion which is known as the Cauvery like its having several branches here and this is the Delta region. And this is the Grand Anikut which was built by the Chola King Karikala and this is a you know is a very important because this is at a higher elevation and it will be, water will be flowing through this what you call (())(25.00) to the fat moving Kollidam river. And as I told earlier kalliani was built to harness the water of the river Cauvery in the times of drought, right. Water will be there in Cauvery but during the flood or the water excess what will happen.

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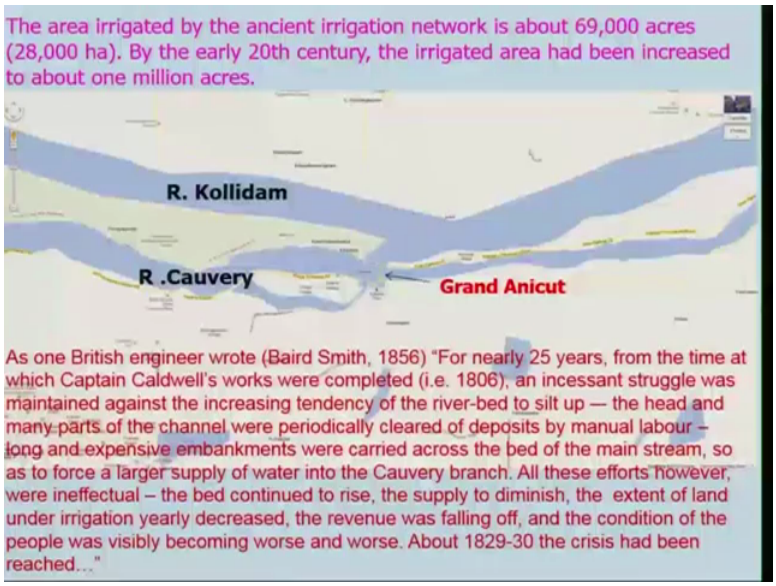

This will, excess water will be moving from this Cauvery river to the Kollidam thus avoiding the devastation caused due to the flood. Ancient engineers of Bharat had created irrigation system with innumerable small reservoir with networks of irrigation channel, which I will be discussing little later on. And the area irrigated by ancient irrigation network is around 69000 acres. But by the early 20th century the irrigation land had been increased to about 1 million acres, as I told earlier this is the river Kollidam and this is the river Cauvery.

Of course bifurcation is somewhere upstream which is not shown in this figure and today the modern time these are the, you know all places were being placed but earlier times it was a dam or what you call the dam was earlier in this region and nowadays people call the entire region as the Grand Anikut. But let me tell you that when the Britishers came into repair this dam which was not being used for years together due to the war and other things, then they found it was quite difficult. According to one of the British engineer Baird Smith in 1856, he has given some evidence, writings. He says that for nearly 25 years from the time at which Captain Caldwell's work were completed around 1856 incessant struggle was maintained giant increasing tendency of the river bed to silt up. They were finding the problems of silting up and then in the process what happens they try, they could not understand what the design is.

And they made some construction like increasing the height of the dam and they landed in problems and these are the problems which are described in the statements. The head and the many parts of the channel were periodically cleared of depots by manual labours, long expensive embankment were carried across the bed of the main stream so as to force large supply of water into Cauvery branch. They were not knowing , so they started doing all these things and that has spoiled everything. All these however were ineffectual and the bed continued to rise, supply to diminish the extend of land under irrigation year decreased and they were also getting revenue from that because they were supplying water to the farmers the revenue was falling off. And the condition of people were visibly becoming worse and worse, about 1829-30 the crisis had been reached.

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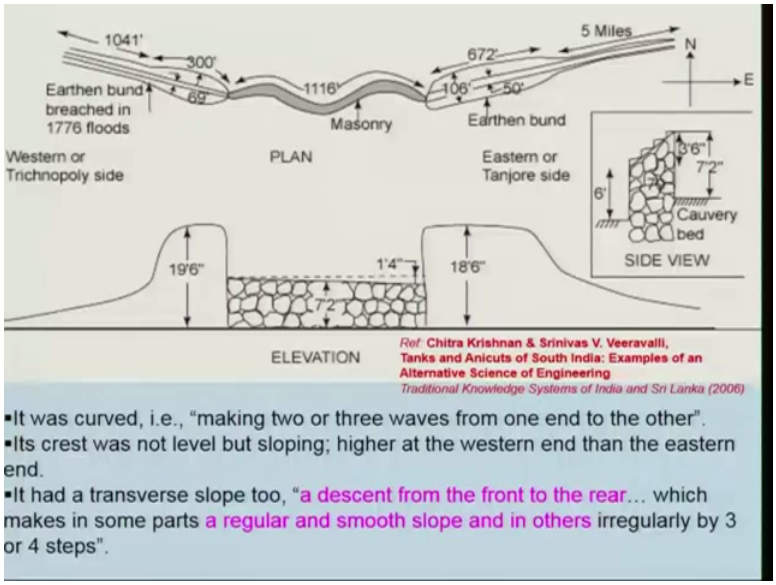

So you know they struggled for 25 years they could not really solve the problems because they did not know the design. So let me just show you how it looks and what are the things, how designed it is, to give you some this thing idea, this diagrams and other things ideas also taken from the paper that is tanks and Anikut of South India, Examples of an alternative science of engineering by Chitra Krishnan and Srinivasa B Veeravalli. And if you look at these are the masonary, which is the actually dam made out of stones, and the shape if you look at it is a wavy shape and these are the earthen bunds which were having and this also if you look at eastern side, this is northern side, western side, there is also a bund, which is a very important for maintaining this things.

And there was a war between the two local kings and they were at loggerhead at that time, they did not allow for it to maintain that is why Britishers came into picture and then they mediated and then do that. So if you look at the Cauvery this is the side view of this you know like Cauvery was having a higher altitude than then Kollidam, the water has to come from here to there this side view. There is another interesting feature of this is that this elevation if you look at there is a slope, right. It has a transverse slope distant from the front of the rear side, which makes in some parts regular and smooth slopes in other irregularly by 3 to 4 steps and is something 1 feet 4 inch kind of difference are there. And people do not understand why it is so. What for it is?

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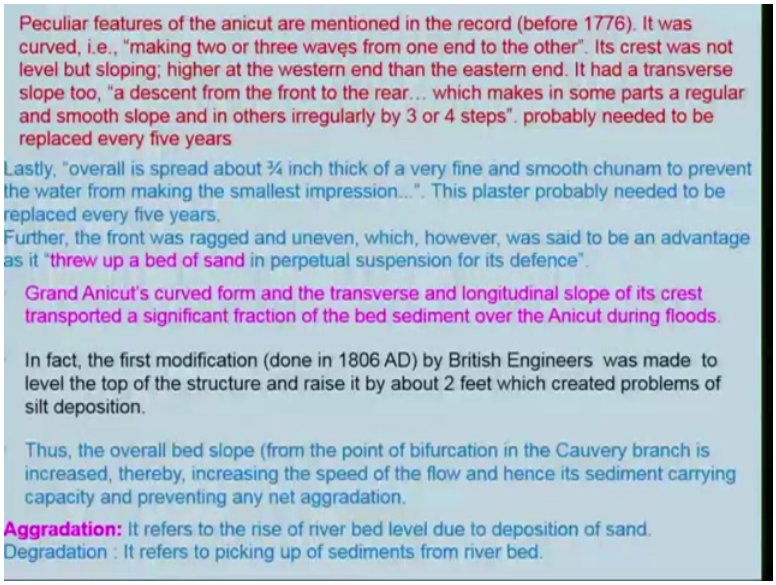

And what they did, they raised this height you know, they raised this heights of this masonary work at the stone work and then they thought that they will you know solve the problem and the problem was what you call worst. As I told earlier this features, what you call making 2 or 3 waves from one and other there is a wavy structure actually its crest was not level but sloppy, higher at the western end than the eastern end that I had shown you, like 1 feet 4 inch kind of thing and it had transverse slope too and at this end from front to rear, which makes in some part of regular and smooth slope in other part regular by 3 to 4 steps. Probably needed to be replaced every 5 years because this maintenance was not being done at that time and this is a very complicated structure and why it was so that the Britishers could not understand but now people are saying it might be due to know, it will be creating secondary flows which will making the silt to be not settled down but suspended in the water.

And that need to be researched and as I had told you earlier this over speed of about 3/4 inch thick of a very fine and smooth 'chunam' is to prevent the water from making the smallest impressions, was need of the hour like that might be the reason and this plaster probably needed to be replaced every 5 years. As I had told you earlier this Grand Anikut's curved form and the transverse and longitudinal slope of its crest transported signification fraction of bed sediments over the Anikut during the floods, that was the design what people are anticipating okay, it might be and it may be because if the flow is there, there will be secondary flows. If the secondary flow is there that means re-circulation will be there and that will make the silt to be suspended and it will be carried over from the Cauvery to the Kollidam.

In fact the first modification done in 1806 AD, around by British engineer was made to level the top of the structure, raise it by about 2 feet and they were not understanding, they said let us raise the height and which created problems of silt deposition and thus, you know then they could not find out. What they did over all bed slopes from the point of bifurcation Cauvery branch is increased there by increasing the speed of the flow, hence its sediments carrying the capacity and preventing any net aggradation. Aggradation means basically the rise of river bed due to the deposition of sand, they have done but that is not working. Degradation refers to picking up of sediments from the river, earlier it was doing the degradation it is the picking the silt and taking away.

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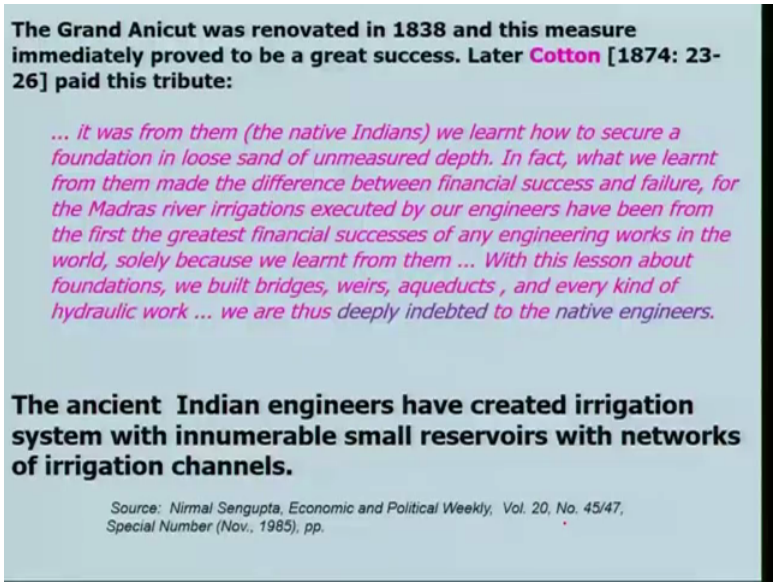

Now that was the design what we are having. Let me tell you that what are this grand what you call Cotton, later on cotton gave a statement he says that, this statement I had earlier mentioned, let me mentioned again. It was from them the native Indians we learned how to secure a foundation in the loose sand of unmeasured depth. In fact, what we learned from them made the difference between the financial success and failures for the Madras river irrigation executed by our engineers have been from the first, the greatest financial success of any engineering works in the world, surely because we learned from them, them means native Indians.

With this lesson about the foundation we built bridges, weirs, aqueducts, and every kind of hydraulic work, we are thus deeply indebted to the native engineers. So if you look at this is the things that will be I will just summarise this.

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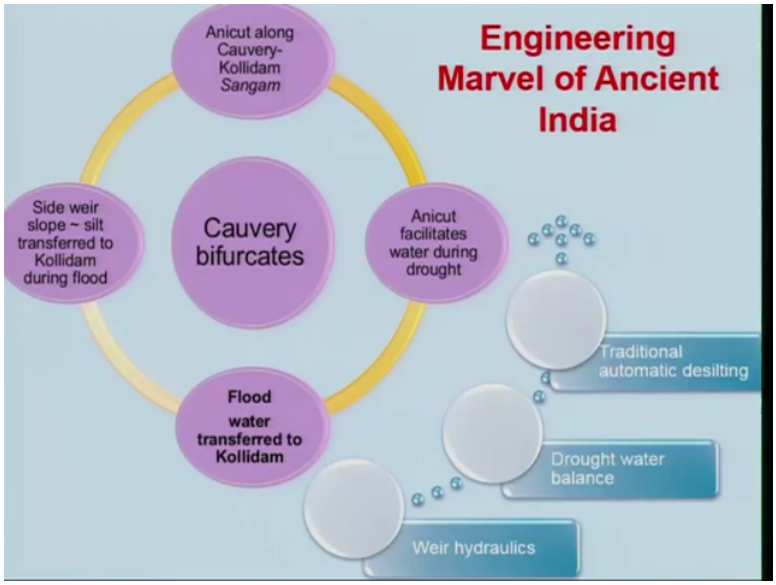

That this is, if you look at the Anikut facilitates the water during the draught and flood water transfer to the Kollidam along with the silt, without silt depositions, right. And the side weir slope silt transfer to the Kollidam during the flood. And if you look at that means, if you summarise it, the traditional automatic de-silting which is very important and we can learn from them and utilise in the modern system and drought water balance and weir hydraulics is also very sophisticated and which need to be looked at. Thank you very much for looking at this lectures and we will stop over here and in the next lecture we will be discussing about different aspects of the irrigation system, Thank you.