Managing Water for Sustainable Agriculture

2022

ICID•CIID

ICID News

1st & 2nd Quarter

Message from the President

Dear Colleagues and Friends,

Sustainability is an intrinsic characteristic of Heritage of any kind whether it is physical or non-physical. Mainstreaming science and engineering heritage in our education, policy, engineering designs, and community governance could be the best multi-disciplinary solution for our prevailing sustainability challenges in various walks of life. Heritage is not for the sake of only heritage appreciation; on the contrary, it has important sustainability lessons for our future survival and overall continued development. Current civilizations benefited and built on the past heritages. For example, the water wheel and shadoof or shaduf for lifting water have led to the evolution of various water-lifting devices through the centuries up to the invention of solar lifting pumps.

Accordingly, water heritage is not discrete but a continuum whether humans are around or not because water itself has no past, present, or future. As a matter of fact, water does not need humans at all as it can create biological life of its own choice, which it has done before, too if we ignore the temporal aspect of our evolution. It is the other way around that humans need water for their sustainability or survival.

Since the dawn of human civilization, water has been an essential ingredient or enabler of societal development so much so that we started believing "Water is Life," a common phrase in most languages. Moreover, life is multi-dimensional involving not only a purely physical aspect but also economic, social, cultural, political, religious, and spiritual aspects too. Heritage encompasses all of these. Early human settlements emerged around natural water availability and continued to do so for thousands of years. Early Civilizations (Egyptians, Mesopotamians, Chinese, and Indians), were developed where the necessary water for agricultural development was readily available, i.e., close to springs, lakes and rivers. During the course of the civilization process, the water bodies became integral parts of human communities and societies and their economic, social, cultural, political, religious, and spiritual activities. Historically, we have always assumed that water is not a limiting factor for human development, however, as our numbers grew from millions to billions, we started to see the finite dimension of water that we now term as "water scarcity" and once a life-critical natural resource becomes limiting our attention is automatically diverted to its value, its use or misuse, its criticality to our survival and its conservation. We have started feeling constrained and questioning our early assumptions of the infiniteness of water, and more importantly, exploring ways to overcome this scarcity as climate change coupled with the over-stretched carrying capacity of our ecosystem and its services have exacerbated the human development situation at present.

Fortunately, water is now being discussed in many domains which have a diverse worldview of water. Water is not owned by just one discipline of human existence, its multi-dimensionality needs to be put in a holistic perspective facilitated by a dialogue among the stakeholders having asymmetric knowledge contexts, capacities, beliefs, socio-economic backgrounds, cultural and spiritual visions.

ICID's World Heritage Irrigation Structures (WHIS) program aims to do just that by bringing together on one platform all the diverse stakeholders so that they are able to understand each other's viewpoints, positions, and arguments based on a common recognition of the physical, socio-economic, cultural and worldviews/constructs of water that the ICID-recognized WHIS represent generally beside a physical manifestation in the form of an intentionally constructed structure.

This issue of ICID News summarizes the 16 recently recognized (during the 72nd IEC Meeting) World Heritage Irrigation Structures that document the tests of time which these structures have undergone over hundreds, if not thousands, of years and demonstrate important lessons for water security, food security, and sustainable agricultural water management for our future generations using all possible human faculties.

Wishing you all the best.

Prof. Dr. Ragab Ragab
President, ICID

INSIDE THIS ISSUE

Recognized World Heritage Irrigation Structures – 2021: An Inspiring Example

During the 72nd International Executive Council Meeting held at Marrakech, Morocco in November 2021, a total of 16 World Heritage Irrigation Structures were recognized for inclusion in the ICID Register of World Heritage Irrigation Structures (WHIS). With this addition, the WHIS Register now comprises 121 structures from 17 countries. This issue covers a brief description of the structures recognized at the Marrakesh meeting. For more information on the Register, please visit: <https://icid-ciid.org/award/his/44>.

1. Li Canal-Gaoyou Irrigation District - China

The history of the Li Canal could be traced back to the Hangou Canal built by Fuchai, the King of Wu, in 486 BC. Hangou Canal connected the Yangtze River and Huaihe River and later became an essential part of the Grand Canal connecting Hangzhou and Beijing. It is because of the characteristics of Hangou Canal and the good irrigation function that the local economic, military, and administrative status has become prominent. As a result, later King Ying Zheng of Qin built a high platform and a post office here in 223 BC, which is the origin of the name of Gaoyou ('Gao' is high in Chinese and 'you' post). This reflected that the Gaoyou region had good irrigation agriculture at that time, which provided a solid economic foundation for the establishment of the Post Office of Qin. Three years later, Qin Shi Huang built a road to the seaside in Gaoyou, which can better reflect the local economy and agriculture.

The New Book of Tang records that the Li Canal has the function of irrigation. Li Jifu, the prime minister during the Yuanhe Period (806-820) of the Tang Dynasty, built the Pingjin Weir to regulate the canal's water level. This principle of "preventing insufficiency and releasing excess" has since become the guideline in the water conservancy construction of Gaoyou. The Old Book of Tang records: "When Li Jifu served as the governor of Huainan region, he embanked the Gaoyou Lake for irrigation, benefiting tens of thousands of hectares of farmland; in addition, he built another two ponds named Furen and Guben; together, these projects not only ensured that Shanyang Canal had sufficient water but also increased the irrigated area by

more than 30,000 ha." Also called the Three Ponds of Gaoyou, these three projects laid the foundation for large-scale irrigation in this region. After the Yellow River changed its course and flowed into the sea through the estuary of the Huaihe River, Gaoyou Lake became a lake that lies above the surrounding land, making gravity irrigation possible along the Li Canal.

Using the lake and canal for water storage, the gates, culverts, and dams for water distribution, and the main canal, branch canals and sub-lateral canals for water delivery, the heritage of the Li Canal and Gaoyou Irrigation District has formed a complete irrigation system that has achieved two dynamic balances: the balance of water levels during droughts and floods as well as the functional balance between water transport and irrigation.

In the Gaoyou Irrigation district, gravity irrigation is adopted by diverting water from the Li Canal. At present, the irrigation district has 8 water division culverts along the Grand Canal, with a total designed water diversion capacity of 150 m3/s, irrigating 39,260 ha of farmland of 10 towns and 135 administrative villages. Excavation of Li Canal provided a stable water source for regional irrigation, and irrigation reliability was further ensured by the lake-canal-gate dam-channel in the later period, which provided a strong guarantee for regional grain growth. The ancient people constantly improved the land by building water conservancy facilities, which greatly enhanced the land fertility. According to the Records of Northern Tour written in the Qing Dynasty, Gaoyou was a rich agricultural base because of the water conservancy projects.

After long-term construction and development, Li Canal - Gaoyou Irrigation District has established a complete system of irrigation, drainage, blocking and lowering facilities, forming the irrigation system of trunk, branch and ditch and the interconnected drainage system of large, medium and small ditches. The Li Canal was listed on the World Cultural Heritage list by UNESCO as early as 2015.

2. Liao River Irrigation District - China

Liao River Irrigation District is located in Fengxin County, the northwest of Jiangxi Province. It belongs to the Liao River Basin, a tributary of the Xiu River. Liao River is the largest tributary on the south bank of the lower reaches of Xiu River Liao River Irrigation District has been developed based on three weir water conservancy systems, namely, Pu Weir, Wushitan Weir and Xiang Weir. It is a large-scale irrigation district with the functions of flood control, drainage and soil and water conservation. It is also the earliest multi-dam gravity diversion irrigation district built in Jiangxi Province, with an irrigation area of 22,400 ha.

With a long history, the irrigation district originated in the Tang Dynasty. According to the literature available, the Pu Weir project, located on the North Liao River beside Chexiachen Village, Xiangtian Township, Jing'an County, is a weir built of firewood and soil by local villagers in the Taihe Period (AD 827-835) of the Tang Dynasty. It is the earliest irrigation water conservancy project in the irrigation district. In the 12th year of the Chenghua Period in the Ming Dynasty (1476), people of Congshan Township in Fengxin County built Wushitan Weir on the bank of Wushi Lijia Village, about 3 km upstream from the Pu Weir. They led the villagers to chisel the stone mountain spur, dredge the river, and divert the water in the pond to Yanghao Weir, about two li (1 li = 0.5 km) away, where they built the south and north ditches to channel water to irrigate the farmland of Fengxin and Jing'an counties; in addition, the local people in the Ming Dynasty built Xiang Weir on the bank of Macao Lake, Xiangjia Subdistrict, about 1 km upstream from Wushitan Weir.

After multiple times of renovations and reinforcement, the water conservancy projects of the three weirs have reached their current scale, capable of irrigating 3593 ha, 1040 ha and 1753 ha of farmland, respectively. Liao River Irrigation District was gradually developed and expanded based on the above three water conservancy systems. There are 7 trunk canals in Liao River Irrigation District, with a total length of 152.0 km, 213 branch canals, with a total length of 540.1 km, and 853 structures in the main canal system. The multiple-cropping index of crops is 2.12 with the main crops in the irrigation district being rice, cotton and rape.

The project site selection is scientific and reasonable. They are all water diversion projects using weirs, typical in the southern hilly areas. Their planning and design are scientific, as the local water flow environment and actual conditions of irrigation of farmland were taken into full consideration. The weirs were built at the river bends, with slow water flow, to reduce the impact on the weirs, thus ensuring the effective and consistent operation of the facilities. In addition, the weirs are located at the hard riverbed in the upper and middle reaches of the river, with a stable dam foundation and less sand sediment on the dam, so desilting is scarcely needed, and less damage will be caused to the dam foundation, to extend the service life.

The ancient weirs in the irrigation district are steeped in rich water conservancy culture, having a profound influence on the local communities. Having been in continuous operation for over one thousand years, the irrigation district has promoted the local economic development, maintained social security and stability, and played an important role in flood prevention, irrigation, navigation, reasonable utilization of resources, as well as an indispensable role in handling regional flood, drought, deterioration of water environment and other problems, contributing significantly to safeguarding the security of grain output, water use, ecological environment and sustainable development of agriculture in the area.

3. Sakya Water Storage Irrigation System - China

Between the Himalayas and the Gangdise-Nyainqentanglha Mountains, there is a valley plain. The Chongqu River, which originates in the northern foothills of the Himalayas, flows through this valley before entering the Yarlung Zangbo River. In the 11th century AD, on the hillside above the northern bank of the Chongqu River, a Buddhist monastery was built. It was named "Sakya", meaning pale grey earth in Tibetan.

Sakya is located on a plateau with a temperate, semi-arid monsoon climate. The plateau boasts an average altitude of more than 4,000 m, an average annual temperature of 5 to 6 ▯, and an annual rainfall of about 150 to 300 mm. To make full and effective use of the limited water resource, the people of Sakya started the construction of a water storage irrigation system along the Chongqu River no later than the 13th century. Because of complex terrain, most of the water pools were built near the Chongqu River. Some are natural pools embanked with stones; some are man-made water storage facilities using weirs, and some are excavated to store water diverted from the Chongqu river. The water storage capacity of a single pool is about 30,000 to 50,000 m3 during the wet season. In addition to water storage, the pools have another important function: to increase the temperature of the irrigation water. The water of the Chongqu River is mainly meltwater from the surrounding snowcapped mountains around 3°C, but because of the pools, the temperature of irrigation water could be raised to around 13°C, which could promote crop growth and increase yields. At present, there are more than 400 pools still irrigating farmland in Sakya County. At the forking point, the river is controlled by a three-gate sluice after which the water runs to three pools respectively. The pools, also equipped with sluices, provide water for downstream canals and then farmland.

Apart from its unique location and structures, it also features a unique irrigation management system. The Sakya Water Storage Irrigation System has promoted regional social and economic development, and at the same time led to the rapid rise of Sakya's political status. The Sakya Water Storage Irrigation System, high atop the roof of the world, has been in operation for centuries and still irrigates thousands of hectares of highland barley. On the Qinghai-Tibet Plateau, the natural conditions are extremely harsh. Despite that and the rudimentary engineering equipment and building materials, local people have managed to build a marvellous project, leaving the field of hydraulic engineering and human civilization with a formidable legacy.

On the premise that the construction equipment and materials were relatively backward at that time, the natural terrain and existing conditions were fully used, favourable conditions were skillfully created to fend off natural disasters that modern water conservancy projects strive to achieve, and the comprehensive functional requirements of irrigation and drought resistance were met, without too much transformation and damage to the natural environment; the sustainable development of the local social economy was ensured, and the wisdom of ancestors in controlling waters was fully embodied; different water storage irrigation systems were chosen according to local conditions and terrain conditions

The establishment and development of the Sakya water storage irrigation system greatly increased the regional grain output and population growth, making Sakya the capital city of the Tibet region at that time. Sakya water storage irrigation system is the hub gathering regional folk customs, religion and water architecture culture. Even today, Sakya Temple boasts the richest collection of books in Tibetan Buddhism, so it is known as "the second Dunhuang".

4. Kalingarayan Anicut and Kalingarayan Channel System - India

The Kalingarayan channel in Erode Taluk is one of the oldest channels of the Bhavani River and it takes off from the right side of the Kalingarayan Anicut. The Kalingarayan Anicut is also the oldest Anicut constructed across the river Bhavani just above its confluence with river Cauvery near Bhavani town in 1285 AD ago in the pre-British era by one Kalingarayan Gounder a native chief. This is the second and the last Anicut across the river Bhavani below the Bhavanisagar Reservoir.

The Kalingarayan Anicut consists of three parts Main Anicut, Central Anicut and Murian Anicut. The main anicut consist of a length of 231 m, Central Anicut consists of a length of 260 m and the Murian Anicut consist of a length of 411 m. The maximum flood discharge of Kalingarayan Anicut is 126771 cusecs occurred on 09.12.1972. The High Flood Level of Anicut is +167.035. In sand vent, there are 3 vents the size of each vent is 6'x4' + 2' semi-circular arch and the sill level of the sand vent is +161.825 m.

The Kalingarayan channel head sluice has a maximum discharging capacity of 584 cusecs in 6 vents the size of each vent is 5'10" x 4'6". The sill level of the head sluice is +162.350 m. The Kalingarayan channel runs for 91 km and irrigates about 15743 Acres of land in Erode, Modakkuruchi and Kodumudi Taluks of Erode District. In

the Kalingarayan channel, there are three branches namely the Malayampalayam branch, the Periyavattam branch and the Avudayarparai branch. The crops raised in the Kalingarayan channel ayacut areas are mainly wet crops such as paddy, Turmeric, Banana and Sugarcane.

The Kalingarayan Anicut is one of the old Anicut of its kind. Only two anicut systems were in existence around 735 years back in the Bhavani River. In earlier days a provoking thought which created by the then local chieftain Mamannar. Kalingarayan Gounder, who constructed the anicut across river Bhavani. The width of anicut is 902m. A channel named the Kalingarayan channel takes off from the right bank of anicut to a length of 91 Km, which is an earthen channel. This channel serves an ayacut of 15743 Acres. The irrigation channel carries water for a period of 10½months in a year. This channel caters for the needs of nearly 4000 farmers. The Kalingarayan channel finally confluences in river Noyyal. It is one of the ancient rivers linking projects.

(a) Length of the Main Anicut: 230.73 m (757 ft); (b) Average Crest level: +164.93 m (541.13 ft); (c) Length of Central Anicut: 260.3 m (854 ft); (d) Average Crest level: +165.85 m (544.13 ft); (e) Length of Murian Anicut: 411.48 m (1350 ft); (f) Average Crest level: +165.475 m (542.9 ft)

The anicut is located at LS 92 km from the Bhavanisagar Dam. Since the local farmers and public of the vicinity are treating this anicut as part and parcel of their livelihood, they all are of spiritual importance to the anicut. The anicut and channel serve well and fulfil the needs of the farming community efficiently. In the head reach of this channel from mile 0 km to 25 km, there are a lot of tanneries, dyeing industries and textile factories functioning near the right side of the Kalingarayan channel. These factories are either directly or indirectly discharging their effluents into this channel. The Erode Corporation domestic sewage water is also directly let out into the channel by residents dwelling nearby the channel. Due to this polluted water, the agriculture fields of this command are very much affected with the resulting yield of crops from these agriculture fields are going on decreasing year by year.

5. Grand Anicut Canal (Kallanai Dam) - India

The Kallanai Dam was built during the 2nd century AD by Karikalan, a king of southern India's old Chola Dynasty and is also one of the oldest irrigation systems in the world that is still in use. Kallanai Dam is the fourth oldest dam in the world, and first in India. It is a rock-solid project that has survived 2,000 years. The purpose of the dam was to divert the waters of the Kaveri across the fertile Thanjavur delta region for irrigation via canals. The Kallanai is an anicut of unhewn stone that stands in the Kaveri parallel to the riverbank; it is more than 300 m long, 20 m wide, and 4.5 m high. It is believed that Kallanai initially irrigated about 69,000 acres, though it now irrigates close to 1 million acres (13,20,116 Acres).

The Kallanai was built to divert floods from the Kaveri branch of the river into the Kollidam branch via a short connecting stream when the water level in the river rose above its crest. The Kollidam was the wider (also the steeper, straighter, and hence faster) of the two river branches and the flood carrier. It was barely used for irrigation. Almost all of the 600,000 acres irrigated by the river in 1800 were delta lands south of the Kaveri branch. So the Kaveri branch was the lifeline for delta farmers, while the Kollidam was of little consequence for them. Once the floods were diverted to the Kollidam, they flowed directly to the sea, causing minimal damage to agriculture. The construction of the dam proved to be beneficial for the farmers of the Cauvery delta region.

Modernisation works during the British Period:

- In 1804, Captain Coldwell repaired the Grand Anicut and provided dam stones 0.69 m in height on its crest and at the same time, raised the river embankment above, ensuring additional water to the Cauvery.
- In 1829, Major Sim proposed under sluices in the Cauvery with outlets

into the Coleroon to prevent the accumulation of silt in the upper reaches.

- Improvements were made to the dam in the 19th century by Arthur Cottons, a British general and irrigation engineer. The Lower Anicut built by Sir Arthur Cotton in 19th century AD across Coleroon (Kollidam), the major tributary of Cauvery, is said to be a replicated structure of Kallanai.
- The word, `Kollidam', means a place that can contain or fit things. It can fit 300000 to 400000 Cusecs of water.

The dam is fast emerging as a tourist spot in the region. It is also home to a large variety of flora and fauna. The bird lovers can observe the birdlife in the basin and can take photographs of these beautiful creatures. The dam flaunts a magnanimous panoramic view of the water all around. You will feel relaxed and refreshed in the cool and pleasant climate in the surroundings. People mostly visit the place and have an escape from busy urban life.

In her pioneering study, Dr. Chitra Krishnan combined historical studies of old descriptions of the anicut from a variety of archives with archaeological and anthropological field surveys and original hydraulic research. This enabled her to piece together a picture of the Kallanai. Krishnan's reconstruction suggests that the original Kallanai had some very peculiar design features: the curved shape of the masonry section, a sloping crest, and an irregular descent from front to rear.

The Kallanai dam across the Kaveri River is 329 m long, 20 m wide and 5.4 m high and is constructed from unhewn stones. The anicut was constructed on inter-locking technology without cementing material. The unique structure of the Kallanai dam involves large stones sunk in the Kaveri River to divert the water flow to the fertile delta.

6. Dhukwan Weir - India

Dhukwan weir was constructed across river Betwa in district Jhansi of Uttar Pradesh during the years 1905-1909. In the Jhansi, Jalaun and Hamirpur Districts of the Bundelkhand Region (Uttar Pradesh), the water has always been at immense depth, rainfall is scanty, irregular, and uncertain, and wells are brood at an expense that is prohibitive for irrigation purpose. People, therefore, had to migrate on any signs of upcoming drought. Apropos a necessity was accepted by the British Government towards the end of the 18th century to construct a catchment for fulfilling the water requirement of the region. After a detailed study by the experts, the area of Dhukwan was selected for the weir. Betwa River was a key tributary of river Yamuna in the Ganga basin. Betwa River had a vast catchment area of 8140 sq. miles from its origin at Bhopal to the location of Dhukwan weir. To fulfil the objective of subsidiary storage for Parichha weir, a masonry weir of 3845 feet length was constructed to store 3759 mcft water submerging 5000 acres of land. The maximum height of the weir above the deepest riverbed is 50 feet.

The weir is constructed with granite stone masonry with a hearing of cement concrete. The weir has been provided with 383 no falling shutter gates of size 10 feet X 8 feet above the crest level 890 feet, making full reservoir level 898 feet. The water from the reservoir is released into the river for utilization at Parichha weir through two upper sluices at elevation 868.50 feet i.e., 21.5 feet below the crest and one lower sluice at 845.50 feet i.e., 44.5 feet below the crest. The sluice gates are operated from the sluice tower located in the middle of the weir. The weir was designed to pass a maximum flood of 6,52,000 cusecs with a water column height 12.75 feet above the crest, RL 902.75 feet. The afflux bund with top-level kept at 907 feet was constructed with black cotton earth placed upstream of core wall with side slope 1:3 and downstream slope with common earth.

Later, with the construction of the Matatila dam and the Rajghat dam operation manual were modified. The water stored in the Dhukwan reservoir and release of Matatila and Rajghat dam is used for Rabi irrigation through upper and lower sluices. Water is also released to Madhya Pradesh through Datia carrier canal, a new off taking structure constructed at the left bank of the weir. Over time, two new dams namely Matatila and Rajghat dam have been constructed upstream of Dhukwan reservoir across the Betwa river. In addition to the initial function of the pick-up weir for the Parichha dam, this reservoir is now utilized for the diversion of water to Madhya Pradesh through the Datia carrier canal. It also acts as the source of water for the 24 MW Dhukwan Small Hydro Power Plant constructed at the toe of the reservoir.

Dhukwan is subsidiary storage for Parichha weir. It provides water for the lone Betwa canal system, the lifeline for

the region off taking from Parichha weir for Jhansi, Jalaun and Hamirpur. It was constructed to provide water for Rabi and Kharif crop which had an original storage capacity of 3,759 Mcft and it enhanced the Irrigated land from 62,000 acres of Rabi in 1899 - 1900 to 6,01,927 acres presently, with average annual irrigation of 6,07,580 acres.

This design was way ahead of its time as such a massive structure (1,194 m long, 50 ft high, 383 falling shutter type gates with cranes and three sluice gates). An astonishing corridor through the weir was provided for communication with the far bank and with the sluice tower during the floods. This massive structure was constructed without machinery in a record time of just five years with high efficacy. It is still functional and fulfilling its obligation for irrigation of the region through its large storage capacity. Dhukwan Weir is one of the key projects that has supported economic development and agriculture in the Bundelkhand region. The water stored in the Dhukwan reservoir is used for Rabi irrigation through upper and lower areas.

7. Veernam Tank - India

The Veeranam tank was excavated during the period of Paranthaga Chola-1 in the 9th century. This tank was excavated by his soldiers during the rest time available after the war. He named it in the name of Veera Naraya Perumal temple as Veeranarayanan Eri and now it is called as Veeranam tank. It is the largest tank in Cuddalore District. The tank was constructed to store the rainwater from its catchment area to irrigate the ayacut downstream of the tank bund. Later, a supply channel was excavated from the Coleroon river at Anaikkarai and this channel is called as Vadavar Channel. Later this tank was connected to the Vellar River through a channel on the northern end of the tank. The excess water is allowed to drain through the Vellar river. And sometimes the water from Coleroon river is taken to Veeranam tank and then from Veeranam tank to Vellar river. The water from the Vellar river is taken to ayacuts along Vellar Rajan Channel during scarcity of water.

The Veeranam tank receives rainwater from its catchment area of 165 Sq miles and Cauvery water from Coleroon River through Lower anicut (regulator) via the Vadavar canal. The water spread area of this tank is 15 sq. miles. Now the capacity of this tank is 1465 mcft and it is irrigating to an ayacut of 44856 acres through 28 nos of sluices along the main bund & 6 nos. in foreshore bund.

The length of the main bund is 16 km. It irrigates the ayacut in 102 Villages in Chidambaram, Bhuvanagiri and Kattumannarkoil taluks of Cuddalore District. The maximum length of the field channel is the Boothangudi channel and is 24.30 km in length. The water is flowing in these channels only by gravitational force. The rainwater from the catchment on the Upstream side of the Veeranam tank is from Ariyalun & Cuddalore Districts. There are 2 surplus Channels to drain excess water during a flood and these surpluses confluence with the Bay of Bengal. It was designed to store the excess water from the Coleroon river during flood time. It safely discharges the excess flood water through drainage canals.

Structure's engineering utility as per its designed utility: Excess flood water is stored by increasing the top of bund level from +45.50' to +47.50'. It receives water from Vadavar and supplies the water to Vellar river and in turn to Vellar rajan channel for irrigation

Structure's engineering utility as per its functional utility: Due to an increase in height of storage, the land in the foreshore bund was submerged. Hence the foreshore bund was formed. The infall points of all foreshore channels will be constructed with the regulator to keep +47.50'.

From 1997 to 2006, the rehabilitation work was carried out. The main bund of Veeranam tank was protected with C.C. block revetment on its upstream side to its entire length. The top of bund was raised in the New Veeranam Project to a height of 2 feet. Due to this, the capacity of the tank was increased from 985 mcft to 1440 mcft. Hence a wave deflection wall was constructed upstream of the bund, to avoid overflow of water due to the wave effect. The supply Channel of Vadavar was protected with a concrete slab on the sides of the Channel and bed concrete is laid with weep holes at the bottom to the entire length of Vadavar. The foreshore of the Veernam tank is constructed with an earthen bund to avoid submergence of land.

The Tamil Nadu Water Supply and Drainage Board constructed a water pump at the left flank of the Veernam tank. The water pumped from the Veeranam tank by TWAD is around 70 cusecs. This water is taken through a pipeline to a length of around 225 km. Then it is supplied to Chennai City, after proper purification. The Veeranam tank is irrigating 44856 acres of ayacut in 102 villages of Kattumannarkoil and Chidambaram taluks of Cuddalore district and supplies drinking water to Chennai city (235 km away) roughly to 50 - 180 million litres of water every day.

8. Hindiya Barrage - Iraq

The heritage dam was established on the Euphrates River, south of Baghdad, at the place where the Euphrates River divides into the Hindiya and Hilla branches, to replace an old (weir) dam called the Shundervarkan Dam, which was established there before the construction of the barrage and the latter began working in 1911 and finished in 1913. The barrage was named Hindiya after Al-Hindiya River south of the dam, whose name went back to Yahya Asif al-Dawla, Bahadur al-Hindi, who was a minister with the King of India (Muhammad Shah al-Hindi) who opened and implemented a stream that took water from the right bank of the Euphrates River to deliver water to the city of Najaf, whose people were suffering from drought and this stream was later on known as Al-Hindiyah River in relation to the Indian Asif al Dawla. The purpose of establishing the barrage was to raise the water level in the head of the dam to secure water to the Hilla branch.

The Hindiya barrage, made of bricks, is similar to the oldest regulators in Egypt in its construction method. The original design of the Hindiya barrage was done by Sir Willem Wilcox. He set the design of the Hindiya barrage in two parts: the first is the main barrage and the second part is the barrage itself plus a submersible dam at its rear.

The specifications of the Hindiya barrage and its submersible dam are given below:

- The width of the barrage: 237.5 m between the retaining wall on the right abutment and the exterior wall of the ship lanes (Lock) on the left side.
- The number of openings equals 36 arches divided into three basins, each of which contains twelve openings (5 m wide each).
- The number of abutments is equal to 33, each of which is 1.5 m wide, and two main abutment piers each of 3.5 m wide, which are the twelfth and twenty-fourth.
- The width of the barrage is equal to 3.85 m between the curtains.
- The ship lane (left bank) is equal to 8 m in width and 131 m in length, and a drawbridge has been erected above it, and there are three pairs of iron gates.
- Floor Level (front and back) = 26.35 m

- Level of the submerged dam's top in the south of the barrage = 27.35 m
- Ground-level in the South of the Submerged Dam = 24.85 m
- Level of the beginning of the Arch = 32.35 m; Crown of the Arch = 33.35 m
- Highest flood level: Head of the dam = 32.60 m; Back of the dam = 32.35 m; Back of the submerged dam = 32.1 m
- Water Level in Summer: Top of the dam = 31.35 m; Back of the dam = 27.85 m; Back of the submerged dam = 26.35 m
- Hydraulic Gradient of the Barrage = 1: 10.4
- Gate Type = Each gate has two movable shutters

Solving the Irrigation Problem: The proposal to build the Hindiya Barrage in its ancient site was a lifeline, as the water was cut off from Shatt al Hilla in the dry season. Presently it irrigates an area of nearly 550,000 ha.

Barrage as a Water Regulator: The barrage was used to regulate the water and distribute it alternately on the streams located in the north of the barrage on one side and the river course located in the south of the dam on the other side, and this shift system differs according to the seasons of the year and the need for winter's and summer's crops, and below is a table of levels, discharges and areas of Hindiya Barrage.

9. Waterwheels of Heet - Iraq

The Akkadians settled on the western bank of the Euphrates River between the region of Aneh and Heet in the fourth millennium BC, where they cracked the streams from the Euphrates to the agricultural lands and practised agriculture based on free-flow irrigation. For hydrological reasons, the bottom of the Euphrates River fell, and the irrigation water receded from its courses, which led to the degradation of agriculture. The farmers faced this problem with the idea of inventing wheels that rotate with the force and speed of the water flow in the river, and they called it Na'oor (singular form for a waterwheel) and Nawa'eer (plural form for waterwheels).

The Waterwheels were constructed over the Euphrates River in Heet City more than 2500 years ago and occupy an area of 2500 m². A waterwheel is a wooden wheel 11.6 m in diameter installed on a structure (constructed from stone and limestone) in the middle of the river called Aldaliya which carries 4 waterwheels. The waterwheel is made of only wood and ropes and no other materials are used. The main goal of their construction is to irrigate agricultural lands and grind grains by connecting the mills to the waterwheels. Waterwheels used to irrigate the agricultural lands of several farmers in the Turbeh Village until the '80s of the last century in a shape of a river strip with dimensions of (1500*150) m² i.e., 90 donum.

A waterwheel consists of the following parts:

- Al ober: Wooden axis around which the waterwheel rotates.
- Al sulban: It is everything in the form of two intersecting lines that connect Al ober to the waterwheel perimeter.
- AlKefaf: Wooden sticks of which the waterwheel perimeter is made and on which Alqawaqa is fixed.
- Alqawaqa: Pottery jars that ladle the water from the river and pour into the water stream.
- AlHufuf: Wooden nails used for binding waterwheels parts together.
- Alsubn: Wide nails, the length of each is two feet, placed between Al'ober and Alsulban.
- Alsadan: Wooden parts on which Al'ober is put.
- Al-karaked: A wooden piece used to complete the cross if it is short.
- Albethora: A wooden square connected to the waterwheel tip to increase its rotational speed.
- Alrabtta: A strong rope to which the waterwheel is tied to stop it for maintenance purposes and not to be swept away by water current during flood season.

The waterwheels certainly existed for more than 2000 years ago, when a mosaic panel was discovered in the city of Anemia dating back to the year 469 BC, confirming the existence of the waterwheels before this period, as the human populations that inhabited these areas, especially between the city of Rawah and Heet, depended entirely on agriculture, which in turn needs the waterwheels to raise water from the river to the agricultural lands, in addition to using them to operate grain mills by connecting them to the wheels to become water mills. These activities require a close link between the groups of the community to manage it, especially the management and evaluation of the irrigation water, which is managed by the beneficiaries and not by the ruling authority, where farmers have become organized in the form of a family or village gatherings to build waterwheels on the river which are managed in a participatory system and within agreed-upon laws. These activities have contributed to the development of the economic situation and the increase in incomes for the beneficiaries by transferring the local surplus of agricultural crops and handicraft industries to other cities via the river and by means of wooden rafts (Aklak) that resemble ships as they descend with the current of the river to the cities of the south to transport these goods. The management of this system was carried out in the past by farmers. However, due to industrial development, these waterwheels were replaced by mechanical pumps and mills.

10. Teragaike Pond and Teragaike Waterway - Japan

Teragaike Pond, located on the Akamine Plateau, is the largest reservoir in Kawachinagano City, Osaka Prefecture. Teragaike waterways run from the Ishikawa River, the water source, to beneficiary areas via Teragaike Pond. Teragaike waterway is a general term for the waterways that are being drawn upon. Among the waterways, the section from the Ishikawa River to Teragaike Pond is referred to as Teragaike Waterway.

Construction of Teragaike Pond and Teragaike Waterway took 16 years, from 1633 to 1649, under a municipal plan to develop new rice fields in Ichimura Village. The original intention was to redirect water to newly reclaimed fields, by expanding a small pond into a much larger one by utilizing the natural terrain. The water source for the pond is the Ishikawa River, which is located 6 km to the south.

It has been stated that a total of 40,000 people worked continuously on the project. The slope of the 8.2-km-long waterway was measured at night under the light of lanterns, while during the day the waterway was dug. The full watered area of the pond is approximately 13 ha with 2197 m perimeter and water storage capacity of approximately 600,000 metric tonnes. The embankment height and length on the north side of the pond are 15 m and 126 m respectively. Upon completion, crop production increased 100-fold. Thus, Teragaike Pond and Teragaike Waterway are public works facilities symbolizing an important historical stage of transformation in the development of irrigated agriculture in Japan.

The three most popular ponds in southern Osaka Prefecture are said to be Teragaike, Sayama and Izumi Kumeda Ponds (in that order). Teragaike Pond is also widely known for its depth. Although the number of beneficiary areas has decreased due to residential development, it still plays an important role in supplying agricultural water to local fields. Furthermore, the zone around Teragaike Pond has been developed as a municipal park and citizens enjoy it as a place to relax in and as an interactive space.

The construction of the Teragaike Pond is an extension of the original small pond. The east and west sides of the pond utilized the hills on both sides as banks. The north and south banks, which are shorter in length, were constructed using soil to form a larger pond. Some village neighbourhoods were submerged due to the pond's expansion, which shows that developing the new rice fields was very much a priority at the time.

From its construction till present, many renovations have been carried out on Teragaike Pond to maintain its function, mainly around its sluice gates and embankments. As the original metal parts used in the sluice gates were iron and tended to rust quickly, copper ones replaced them in 1744. In August 1854, due to a severe earthquake, about 34 m of the embankment was damaged. About 945 workers took part in the repair work. A sticky soil, known as hagane, was used to reinforce the embankment and resist the high-water pressure.

A structure called a "throwing hole" was adopted for the intake of water to the reservoir, which enables a large pond like Teragaike Pond to take in water according to the height of the water surface. This system is said to have been first adopted in the nearby Sayama Pond in around 1600, and the present-day Teragaike Pond has the same structure.

With recent urbanization, the beneficiary areas of Teragaike Pond and Teragaike Waterway have been decreasing but the current state of the pond is being maintained, with renovations carried out by managers and beneficiaries for generations, and the pond is still providing a stable supply of irrigation water for agricultural lands. The current beneficiary area is estimated to be approximately 25 ha.

11. Usa Irrigation System - Japan

The Usa Irrigation System (UIS) was constructed to develop rice paddy fields in the Yakkangawa River basin. The Usa Irrigation System was designed by Usa Shrine, one of the most powerful shrines at that time. The Usa Irrigation System consists of two irrigation systems: Hirata and Hirose. Since there are contrastive flat areas on either side of the river downstream, progress in developing agricultural engineering and irrigation in Japan is visible through the two irrigation systems. The total irrigated area of the UIS has increased from its original 240 ha to 3,187 ha at present.

Hirata Irrigation System (constructed in 1156 AD): The Hirata Irrigation System was constructed in the low-lying area on the left side of the river. Its irrigated area has increased from the original approximate 140 ha to 1,546 ha at present whereas the main irrigation canal increased from 12 km to 25.6 km long. The irrigation system was smartly designed based on empirical knowledge of the river basin and represents the state of land development in ancient times. In particular, the 12th century is an important transitional period from ancient times to the Middle Ages. The irrigation system was smartly designed based on empirical knowledge of the river basin: the former riverbed was partially transformed into irrigation canals to distribute water efficiently to the low-lying paddy fields, and the weir and inlet (headwork) were constructed to intake water efficiently at the starting point of the alluvial fan. Water distribution was the most important issue in the irrigation system. The distribution was managed by the Hirata family, descendants of Usa Shrine, through the generations. In addition, small shrines have been constructed at the water division points to watch over the water division process. The irrigated area has gradually increased with the development of agricultural engineering.

Hirose Irrigation System (constructed in 1870 AD): The Hirose Irrigation System was constructed to develop the slightly elevated plateau of the right side of the river. The irrigated area has increased from the original approximate 100 ha to 1,641 ha at present. The experience gained during this project enabled the engineers to build other important structures related to the modernization of Japan, including the Asaka, Nasu and Lake Biwa canals. The Hirose Irrigation System was constructed in 1870 to develop the slightly elevated plateau of the right side of the river. Construction of the irrigation system began in 1751. Owing to the application of advanced construction techniques, such as tunnels and aqueducts required to deliver water from the upper point of the river to the plateau, it took about 120 years to complete. As such, advanced construction techniques can be seen in this irrigation system: a 900-m irrigation canal was excavated through the mountainous area; stone arch bridges and inverted siphons were built across valleys; and a 17-km long main irrigation canal was constructed, with a precise slope of 1/1000. The irrigated area has increased from the original 100 ha to 1,641 ha at present. The main irrigation canal is 37.1 km long.

The slope of the river is steep, and the river basin's water-retaining capacity is insufficient to control the river flow because the soil layer in the upstream region is shallow. Therefore, droughts and floods occurred frequently in the river basin. The best agricultural technologies, such as an oblique weir in the headwork and irrigation canals along the geographical contours were used to construct the irrigation system. In an oblique weir, the angle of the weir is arranged to intake river water efficiently, and the height of the weir is set so as not to receive flood flow directly.

The Usa Irrigation System is still an important irrigation structure for rice production. It was designated a Globally Important Agricultural Heritage Site (GIAHS) in 2013 and is one of the important parts of the GIAHS, Kunisaki Peninsula Usa Integrated Forestry and Agriculture and Fisheries System.

12. Khettaras - Morocco

The Khettaras still constitute today, in the oases of southern Morocco, an ingenious system for collecting groundwater from the water table. This hydraulic structure allows the collection of water underground at its end while minimizing losses through evaporation. They are also known in other countries under the name of Foggara or qanât. Its presence spans from the Middle East to Afghanistan, China and Japan in the East and West to the Maghreb, in Sicily (Palermo) to Andalusia (Spain). In Morocco, the first use of khettaras dates several centuries back. In the 16th and 17th centuries, the Almohad dynasty ensured diffusion of the technique of draining galleries in many regions of the Empire.

The Haouz of Marrakech is a high place in the Mediterranean hydraulic history. In a semi-arid plain with an extremely hot summer climate, generations of marrakchis have been able to capture groundwater resources for over nine centuries through the establishment of hundreds of khettara. In Marrakech, the Khettara system is at the origin of the city's water supply, irrigation of gardens and palm grove of the city.

The oases of the Tafilalet Region occupy a central place in the Moroccan civilization of water, the khettaras reflect centuries of human ingenuity to benefit from the floods of the Ziz and the Gheris rivers coming from the High Atlas, and to extract the underground water by draining galleries. By 2000, the number of khettaras in operation in the Tafilalet area were 308 with a length of 1,190 km serving 155 perimeters with a total area of 12,750 ha.

This ingenious groundwater catchment system includes two types of Khettaras:

Khettaras of river (oued) – Originate in a wadi and drain the groundwater from his courses. Length: varies from 500 m to 1 km.

Khettaras of water table – Located at the foot of a "jebl" (Mountain) or on the terraces of a wadi; Length: can go up to 10 km (case of Tafilalet)

The khettaras is a sort of water mine, an underground gallery that intercepts the water of a water table located upstream of the area to be irrigated. The water collected is transferred by simple gravity to the outlet. Many inspection wells are visible on the surface, they allow aeration during construction and maintenance of the structure. The pipes follow a slight slope and run about 5 or 10 m below the surface of the ground. The khettaras themselves has a sufficient diameter (1 to 1.20 m) to allow the movement of a bent man, a worker advancing from downstream to upstream at the time of the drilling, and a worker circulating to carry out maintenance work. The irrigation of oases with underground water resources relies on a whole art of combining wells to extract rare waters and khettaras which provide little water but all along the year. The flow rate of Khettars is variable according to rainfall, annuals upstream, the length of the draining part and the qualities of ground and basement.

The ingenuity of the Khettaras lies in its design and its adaptation to the conditions of life and the Saharan climate. They are designed to serve as a catchment system of rainwater, seepage water. It is an appropriate technology adapted for water supply. They are low-cost structures, built using local labour and know-how. They can supply water for various uses drinking water for populations, irrigation of crops and trees and animal watering. There is no energy cost for its operating since it is based on gravity flow of water. They require periodic control and maintenance and rehabilitation operations as necessary. Khettaras help to fight desertification, the progress of sand in the region and therefore the safeguard of human life and the environment of the region.

13. Gangjin Lotus Small Reservoirs Irrigation System – Republic of Korea

Gangjin County is located in the southernmost region of Korea. It is known for its vast fields and four distinct seasons, which gives the region advantageous natural conditions for cultivating crops. The earliest records of rice farming in the Gangjin area go as far back as the 2nd century BC, and agriculture utilizing Yeonbangjuk (lotus small reservoirs) was practised mainly in the northern Gangjin area, where the stream was not developed. The Byeongyeong region of northern Gangjin County has been home to vast fields but was not a place with abundant water. Faced with limited water resources, the Byeongyeong region overcame the challenge of securing water resources for irrigation and Byeongyeong fortress moat, as well as household use, through the connection of five small reservoirs in series. The lotus reservoirs are at the centre of this water storage system. The people of the Byeongyeong region built numerous lotus reservoirs in an all-out effort to store stream water and rainwater.

Bangjuk refers to a dammed pond. The ones in Gangjin County are called yeonbangjuk because lotus (Yeon - continuous) grows wild in the reservoir and five reservoirs are connected through canals. For five lotus reservoirs, a single lotus reservoir is responsible for the irrigation of 150 to 310 ha of farmland and provides water for irrigation purposes to a total area of 1,136 ha.

Bangjuk (small reservoir), as an irrigation system, has been built and utilized in agriculture throughout Korea. However, many Bangjuk have disappeared due to the development of large reservoirs in modern times. These lotus reservoirs have survived because of their essential role in sustaining the cultivation of rice crops. The reservoirs in the Gangjin region have been an invaluable irrigation structure that has made rice cultivation and double cropping possible and has been the driving force behind achieving necessary food production as well as making a living. After each farming season, farmers in Gangjin celebrate the harvest through "garae-chigi" (traditional fishing with fish traps) held at local lotus reservoirs, and this contributes to the development of local community culture.

In an all-out effort by the local farmers to secure water, reservoirs have been built in large numbers and a network of canals was introduced to provide irrigation to the rice fields with the water stored in lotus reservoirs. This is evidence of authenticity in irrigated agriculture practised by our ancestors. The use of lotus reservoirs in Gangjin agriculture has played a crucial role in the livelihood of local farmers and food production for the region.

The Gangjin lotus reservoirs are of a "low-water, high-rice paddy" type. In this design, roads surface slightly above the centre of the flat fields and function as embankments as well. The reservoirs are constructed at places where the water paths gather. The reservoirs are 0.5-3 m deep in water level and 3 to 6 ha in size. The entry point in contact with the farmland is made of a low slope of earth and soil, and there are embankments of consistent heights at the exit. In modern times, this eco-friendly construction method is contributing greatly to the diversity of species. In times of water shortage, the Ganjin lotus reservoirs are able to transfer water to nearby lotus reservoirs through canals to participate in irrigation outside of their normal irrigation zone.

Korea's Important Agricultural Heritage Systems (KIAHS) refers to the agricultural heritage acknowledged by the national government to be worthy of preservation. In this system, the government designates traditional agricultural activities, agricultural landscapes, biodiversity, and usage for conservation and passing on to future generations. The Gangjin Yeonbangjuk (Five Small Lotus Reservoirs) was registered as No. 16 KIAHS by the Ministry of Agriculture, Food, and Rural Affairs of the Korean Government in 2021.

14. Gudeuljang Irrigated Rice Terraces in Cheongsando – Republic of Korea

Cheongsando Island has an area of 41.95 km2, with a maximum east-west distance of about 7.5 km and a north-south distance of 7 km. It is a mountainous area with five mountains among which three mountains are higher than 300 m from the mean sea level, with a maximum of 387 m. There was no adequate area for rice cropping that needs flat farmland and irrigation. Also, no stream was developed due to the small watershed area and steep mountain slope, and most of the soil was mixed with sand and various size of the stone. Rice terrace was the only method to grow rice in such conditions as found in many other rice-growing countries in the hilly or mountainous area.

Gudeuljang rice terraces are composed of Gudeuljang rice fields. The structures began to be built in the 1600s, when villages were expanded in the Cheongsando Island, until the mid-1900s. According to recent studies, upon researching the pottery sherd found in stacked stones of nearby Gudeuljang rice fields, Gudeuljang rice fields are about 700 years old.

Gudeuljang rice fields exhibit a similar structure to Ondol, Korea's traditional floor heating system. Similar to how Ondol transfers the heat from the fireplace via Gudeul (similar to the culvert) laid out under the floor, Gudeuljang rice fields stack stones of varying sizes at the bottom of the rice field and controls water flow through the culvert that sends water to downstream paddy field. The Gudeuljang rice terraces depend on underground stone culvert flow system. The culverts are typically 3-10 m long under the parcel. Each parcel of the rice field was made with a stone layer to get a horizontal surface and boundary wall. The surface was covered with a water leakage prevention layer and then a rice cultivation soil layer. For irrigation water supply, a stone culvert covered with Gudeuljang was installed in the stone layer. Major features of Gudeuljang rice terraces was an underground irrigation water supply system using an underground stone layer and a culvert covered with Gudeuljang stone. This was a very unique method for rice terraces in the sloping area available with stone.

Gudeuljang rice fields embody Cheongsando islanders' strong attachment to land usage and food production. Currently, 72% of Cheongsando Island's land usage is wooded and sloped lands, while rice fields only take up 21.1%. When settlers who came to Cheongsando Island began farming 400 years ago, there were significantly fewer farmlands compared to today (1370 ha). On the Island, Gudeuljang rice fields were the only places to cultivate rice crops that was why they invented Gudeuljang rice fields with an underground culvert irrigation system.

The dolmens from the Bronze Age found in Cheongsando Island can be called the foundation for the island's Stone Stacking Culture. Stones were foundational material in constructing houses, roads, towns, etc. needed for the everyday life of the people. Cheongsanjinseong Fortress was built for defence in the Joseon dynasty. Moreover, Gudeuljang rice fields were developed as a way to solve food problems by developing mountain slope areas as cultivable areas. We can see low and high stone walls between parcels that provide a unique landscape.

Gudeuljang rice field join-cultivators are turning idle farmlands into scenic agriculture areas that farm landscape crops such as rapeseed or buckwheat via restoration and maintenance of fallow land, and they are making effort to transform such land into a tourist attraction. After Cheongsando Island's Gudeuljang rice fields were designated as No. 1 Korea's Important Agricultural Heritage Systems (KIAHS) by the Ministry of Agriculture, Food and Rural Affairs in 2013, it was designated as Globally Important Agricultural Heritage (GIAHS) by the Food and Agriculture Organization of the United Nations (FAO) in 2014.

15. Ethimale (Reservoir) Tank Bund – Sri Lanka

Ethimale tank bund is situated in the Uva province of Sri Lanka across the upper part of the Wila Oya catchment. It was built by Brother Saddhatissa of King Dutugamunu (161-137 AD) using advanced technology. The earthen bund made to retain water was constructed in three sections joining four different mountain hills. The water from the reservoir was not released to the paddy fields directly but to the Wila Oya stream and at an anicut 4.5 km downstream, it was diverted through a canal system to the fields. The main canal still runs 2 km parallel to Wila Oya stream and only after that the water is released to fields through distributary canals. The water thus distributed is retained by few small tanks along the canal and thereafter released to adjoining fields from these tanks.

Ethimale tank has its catchment area of 9.50 sq miles, gets an annual rainfall between 1400 to 1600 mm and stores 5510 Ac.ft (6.8 MCM) of water at its full supply level with 500 Ac.ft as dead storage. This tank bund consists of 3 sections of homogeneous earth fill interconnecting four mountains. The length of the dam is 1100 m and the bund top elevation is 371 ft above MSL. With a catchment area of 2460 ha, the Ethimale tank issues water for 406 ha of paddy fields in the Ethimale irrigation scheme. In addition, this tank is utilized for domestic purposes as well as fisheries and tourism industries.

Ethimale tank belongs to the Monaragala irrigation region, and it is located in Siyambalanduwa divisional secretariat division in the Monaragala district in Uva Province. The main spillway discharges to the Wila Oya stream. This tank is the main water source in this area and gets water during mainly Maha season falling from October to December every year. The full extent is cultivated in Maha season whereas a portion of farmland is selected in Yala season with calculating available water volume. About 60 % of the command area would benefit from the Yala season averagely according to the past records.

According to folklore, King Dutugemunu had entrusted his brother Saddhathissa with the development of the East and South-east areas of the country. Prince Saddhathissa had developed the water resources in the area and had created an environment where people did not have to face food shortages. King wanted to check the progress achieved and had sent a person with a bag full of paddy and wanted him to sell it. The person had walked in the entire area but could not find anyone who wanted to buy and had finally reported it to the King. King has realized all are self-sufficient and had called back his brother with the message "enough brother" which means Ethi Male in Sinhala. After that area has been known as Ethimale and the tank was last built as Ethimale. However, this area had been deserted over many centuries later, until the Irrigation Department commenced the development of the water resources at the beginning of the 1950s. In 1958 restoration work of Ethimale had commenced and 334 families selected from Badulla, Welimada and Moneragala were given land. By 1964 on completion of the canal systems water was released for cultivation.

Ethimale tank is to be rehabilitated and augmented under the proposed Kumbukkan Oya reservoir project funded by GOSL. Identified major rehabilitation are such as raising of spill level, renovation of rip rap, strengthening of the dam, establishment of bathing steps, establishment of tor filter & toe drain, installation of piezometers on d/s slope of the dam, construction of access road for inspection, installation of levelling monuments and installation of boundary stones.

16. Dam and Old Sluices of Parakrama Samudraya – Sri Lanka

Parakrama Samudraya is one of the largest and most famous reservoirs in Sri Lanka situated on the Mahaweli River (Amban Ganga) in Polonnaruwa District. The lake was constructed during the reign of King Parakramabahu (1153-1186 AD), who was one of the most powerful and famous rulers in Sri Lankan history. The lake was mainly constructed by connecting five mini lakes with a proper canal, now named Theppan Ala. The northernmost lake is called Thopa wewa, built by King Upathissa back in the 6th century, the middle one is Eramudu wewa, and the southernmost one is Dumbutulu wewa. There were two more lakes named Kalahagala wewa and Bhu wewa, but they were taken off from the main reservoir in the reconstruction process back in the 1950s.

There are many stories that are related to the Parakrama Samudraya. One story tells that there was a small harbour-like part in the lake where small ships sailed through the Mahaweli River and Kalinga Ala (Canal) as King Parakramabahu is a ruler that conquered many foreign countries. The main feeder canal of the lake is named Angamadilla Yoda Ala, which was constructed by diverting the Amban Ganga. The ancient anicut called the "Raja Bamma" was reconstructed around 1939.

There are a few ancient sluice gates found around the lake and they are known to be some of the best ones in ancient history. The technology, the construction methods and the locations are unbelievable. One can be seen near the Lake Rest House which is located at the beginning of the Thopawewa dam. Another one is located in the Bendiwewa area and it is the one that anyone can investigate the technology well, as it is now separated from the old lake dam. And there is another one located nearly 15 km away from the Thopawewa. It is named "Bhuwewa Sorowwa" and the old Bhuwewa Lake has been filled up and encroached by farmers, as that part of the Parakrama Samudraya had been neglected when the rehabilitating process started back in the 1950s.

During 1937-1944, the lake was rehabilitated; the storage was increased from 98000 ac.ft to 110000 ac.ft, which was further increased up to 116100 ac.ft after the construction of modern spillway gates. The lake's catchment area is 72.52 km2. The dead storage is 15000 Acre ft, the full supply level of the lake is 59.43 m MSL, and the High Flood Level is 59.74 m MSL. The dam is constructed as a homogenous earth-fill embankment. The length of the dam is 12.4 km and the average height is 15 m. The maximum height of the dam is 15.85 m. The lake is mainly fed by the water from Angamadilla Yoda Ala which is constructed by crossing the Amban Ganga at Angamadilla area.

The stone pillars located in the dam were known to be the measurement posts at the time. They are named "Gaw Kanu" and one Gawwa is nearly like 1 km. There are ancient ruins of a castle in the middle of an island located in Parakarama Samudraya. It is known to be "Seetha Maligaya" and folk tales say that there were many castles in the middle of the ancient Parakrama Samudraya. And the ancient spillway was located in Bendiwewa and some remains of the ancient spillway canal can still be seen there. When the lake was founded in the late 1800s, there was just one breach which was about 60 ft in depth and 600 ft in width. It was then named Eramudu Kapolla and there was a canal named Diwulapitiya Ala, which carried a lot of water in rainy seasons.

Parakrama Samudra has irrigates more than 10100 ha and provided livelihood to a large number of inhabitants. Many people benefitted from various employments such as paddy cultivation, cultivation of other field crops, inland fish industry, ornamental fish production, home gardening, fertilizers production and animal husbandry. The Wasgamuwa National Park is considered a major feeding area of the lake. The tourism field is also highly benefited as the National Park is around the Parakrama Samudraya.

ICID•CIID

International Commission on Irrigation and Drainage (ICID) established in 1950 as a scientific, technical and voluntary not-for-profit professional international organization.

The ICID News is published quarterly by ICID Central Office, New Delhi, India.

Disclaimer: The content of each article is the sole expression and opinion of its author, and not necessarily that of the publisher.

Editor-in-Chief: Er. A.B. Pandya, Secretary. General, ICID
Editorial Team: Dr. Sahdev Singh, Director (KM)
Madhu Mohanan, Communication Officer
Ms. Prachi Sharma, Knowledge Officer
Layout: Keshav Dev Tanwar
ICID, 48 Nyaya Marg, Chanakyapuri, New Delhi, India
E-mail: icid@icid.org, Website: http://www.icid.org