An Ancient Hydraulic Engineering Technology in Sri Lanka

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Abstract:

The ancient water engineering technology stands out as a robust construction that underscores the excellence of Hela culture. Ancient societies endeavored to manage water for agricultural purposes in response to climate change, even predating civilization. While the early micro-water industry emerged for limited purposes, it is evident that later, expanded-purpose, and marine irrigation industries developed. The uniqueness lies in how the technology was manipulated to create a canal, serving the functions of a long river. This research aims to explore the water engineering technology of the Yodha Canal and its environmental balancing concepts. The research problem focuses on ascertaining the contribution of the geophysical environment to Yodha Canal water engineering techniques. In conducting the research, the study area served as the core area, spanning from Kala Lake to Tisawewa, with 3 miles on both sides as the left and right bank serving as the peripheral area. Geographical location information and formal survey methods were employed for data collection, while Geographic Information System and laboratory research methods facilitated data analysis. The research revealed sluices supplying water to the lakes on both sides of the Yodha Canal, silt control technology, groundwater conservation methods, bank technology, and water engineering technology. This can be identified as a unique irrigation engineering technology, aptly nicknamed a "long river."

Keywords - Irrigation, Hydraulic Engineering, Water Management, Groundwater.

Among the canals identified in the Sri Lankan irrigation industry, Anuradhapura's ancient “Yoda Ela” is considered a special irrigation design. All canals, except Minipe, Kalinga, and Elahera, are crucial as they are designed to distribute water in a managed routine. These canals were constructed in connection with Amuna (Anicut), crossing the Mahaweli River. For instance, concerning the starting point of the Minipe Canal, Brohier highlighted that "a narrow canal was formed by an island on the edge of the bank at a bend in the Mahaweli River. A large body of water was drawn from the river into the canal, and at the other end of the stream are two stones. The water of the canal falls back from these two stones, so the water is somewhat trapped there; these two stones are connected by a dam (Brohier, 1935:10). Anuradhapura's ancient “Yoda Ela” originates from a sluice located at a high altitude in the Kala Wewa and traverses the upper valley of the Kala Oya, crucial for settling the inter-region. Water has flowed up to Tissa Wewa by providing water; beyond the concept of "canal inter-canals," created to provide water to the inter-region from the "giant canal." Therefore, it is evident that the “Yoda Ela” is not merely a means of water transport designed to meet the water needs of the capital but also an irrigation industry designed to provide water to the settlements in the inter-region.

The classification of irrigation includes tanks: village tanks of medium and large sizes, and the initial stage of this practice dates back to the prehistoric period or early Iron Age (1000–500 BC). Confirming cultural phases vertically at a depth of about 10m from the surface of the excavation in Anuradhapura, artifacts related to agriculture, such as cattle and horses, were discovered. According to the radiocarbon dating of the silt deposit, it has been established that these findings belong to the period of 700 B.C (75 Radio Carbon dates). Based on these factors, Deraniyagala concludes that the initiation of water management activities in Sri Lanka may have occurred in the prehistoric period (1000–500 BC) (Deraniyagala, 2002:8-XX). The most advanced stage of this development takes place during the Anuradhapura era.

In the early stages, there was no need for inter-canals for water management and the supply of water to other areas around the rural tanks spread throughout the country, given that the tanks were networked according to the topography.

However, by the middle stage of Anuradhapura, with the emergence of medium- or large-scale irrigation, more water capacity had been provided in the tanks through canals. The Samantapasadika Commentary mentions the distribution of water by canal (Samanthapasadika, 1967:316). Vinayatta katha is mentioned as Udakavahaka and Matika in the story (Samanthapasadika, 1967:330–331). Udakavahaka means big canals, and Matika means small canals from the mention of Khuddakamatika (small canals). A canal is an inter-channel that carries water from a large reservoir to a stream or tank. In the inscriptions, canals are referred to as "Mathera, Matira, and Matara" (Priyanka, 2015:138). Generally, this indicates a stream or water system, and in this connection, two meanings are associated with "Mathera Majibaka," commonly used in the inscriptions. That is, the income from the fish caught in the canals (Paranavithana, 1958, pp. 129–137). The second opinion is that it is the fee charged for water in the canal that supplies water to a lake from a river, brook, large tank, or other main waterway (Priyanka, 2015:138). It is plausible to think that canals were constructed in the 1st–3rd centuries to supply water to distant areas. Confirming this, inscriptions from the 3rd century AD to 50 BC and in inscriptions from the 1st century AD to the 3rd century AD refer to canals with names such as "Adi and Ali" (Priyankara, 2015: 167). Chula Namara Ali (Muthugalla), Va(na)ka Ali (Kotaweheragala, 10.2), Kalaha (na)kara Ali (Duvegala, 15.2), Girikahothi Ali (Vehera Udamalai, 30.2), Ulibikala Ali (Habassa, 57.3), and Thotagamaka Ali (Nelugala, 79.8). According to these inscriptions and the study of the expansion of settlements around the ancient "Yoda Ela" in Anuradhapura, the need for an irrigation industry in ancient society arose early through the historical factors of "Avarana, Dakapati, Karakadaya" (Abhayagiriya, 96:9) mentioned in the inscriptions of Ruwanvelisaya and Abhayagiriya, belonging to the central area of the study. It is confirmed that.

The unique feature is that the ancient giant canals do not flow in connection with the tank; instead, they are designed to pass over the tanks. A key consideration in this design is to control silt or other soil deposits carried by the canals into the tank. In this context, the research conducted by the Geological Survey in 1963, titled "Tentative Classification of Alluvial River Channels," is crucial. It pointed out that the method of water release and the structural size of the canal are the primary factors influencing the transport of silt or deposits (Schum, 1963:1). The water speed of the canal is determined by the shape of the canal bank, as indicated in the research paper on the Concept of the graded river (Mackin, 1948: V: 59, p.463-512). M. Church extensively studied the structural condition of canals in the book "Channel Morphology and Typology" published in 1992 to identify the structural representation of canals. Others have also researched the shape of canals (Church, 1992), showing a direct impact on sediment deposition. Accordingly, the meandering form indicates that regular flow, turbulent flow, undulating flow, long-form flow, etc., affect it (Kellerhals et al, 1976).

The Channel bars in gravel-bed Rivers, as explored in the research on Gravel-Bed Rivers by Church and Jones in 1982, demonstrate how deposits are collected on the banks of the canals based on the directions of the location of those banks (Church and Jones, 1982). These directions include the semi-circular column system, the cross-column system, the media column system, the diagonal column system, and the lateral column system. It can be observed that the shape of the bottom of the "Yoda Ela" is more complex than these methods.

The canals are classified into five main types based on flow methods: turbulent flow, irregular flow, coherent flow, and direct flow (Horrocks, 1998). Despite drawing widespread attention to the current effects of the "Yoda Ela" (Awsadahami, 2015; Karunarathna, 2018; Karunarathna, 2021), it does not appear that the geographical and environmental factors influencing the inception of its irrigation technical features have been given sufficient attention.

In the research, several unique irrigation technical features were identified in the Anuradhapura Ancient "Yoda Ela." These include inter-canals that provide water to upland settlements, sluices, the operation of the Diyakaliya, and the design technology of the right and left banks. The position of the contour lines of the land was confirmed by placing the sluices, and special attention was given to irrigation's technical features. Geophysical environmental characteristics that influenced the construction of these technical techniques based on the "Yoda Ela" were discovered by examining the location of its irrigation features. The slope of the land was determined based on the contour lines of the "Yoda Ela" flow path.

The research focused on revealing the complexity that canal design technology has brought to water management compared to other giant canals.

Methodology

"Yoda Ela" route was revealed in relation to the relevant areas and the land was prepared-taking into consideration the destroyed parts of the it and the current situation, the area where the canal traveled was divided into three main parts, using the survey plans and inch map, the ancient.

- The canel is active from Kala Oya to Mahailupallam
- The ancient canel is in ruins from Mahailuppallam to Batuwatta.
- The ancient canel is an active part from Batuwatta to Tissa Tank.

The path of the "Yoda Ela" from Mahailuppallam to Batuwatta has been completely destroyed, so measurements should be taken to confirm the form the "Yoda Ela" quantitatively in the exploration, according to these parts. Another difficulty faced in taking the measurements was the correct identification of the left bank of the canal. A current explorer of the Giant's Canal can see the different forms of the canal's structural features depending on the different regions through which the Giant's Canal flows. In some parts of the canal, the left bank can be clearly identified, and parallel to it, parts of the sloping land with waterlogged land to the south cannot be clearly identified. In the study, the banks of the canal act as the main transporter of water management, which led to accurate confirmation of the bank segments in the survey. The methodology adopted in confirming the quantitative form of these banks can be divided into two main parts, that is, the canal where the left bank can be identified. The parts of the road and the south bank can be identified as parts of the canal bank- for this purpose, the mean sea level heights of the respective regions were calculated to confirm the slope form of the affected land.

An important technique in the study of irrigation techniques is to identify the location of canal contour lines. According to previous studies, it has been shown that the canal has travelled along the same contour line. The method used to confirm this was to record the locational information values of the ancient road where the "Yoda Ela" travelled from Kala Oya to Tissa Tank. In addition to this, the structural form of the ancient "Yoda Ela", the places showing the changes in the canal, the physical and structural changes that have occurred in the places where the ancient "Yoda Ela" and the New Jayagaga run parallel, to report for research work with special attention in the field exploration. The contour line spread of the canal was identified by superimposing the relevant position values (GPS) on the contour map using the data survey software of contour lines obtained by the surveying department from the area belonging to the "Yoda Ela"route from Kala Oya to Tissa Tank.

The variation of the banks according to the topography is important among the detected functions. In investigating the factors affecting the changes in the bank landscape, the sea level heights were obtained at the places where the changes in the giant canalanicutfactors could be identified. Here, the actual sea level heights were obtained from the mileposts set up by the Survey Department parallel to the area of the "Yoda Ela"route.The actual sea level heights of the respective area were recorded as the sea level heights were taken from the mileposts used along the "Yoda Ela" to the area belonging to the relevant geographical region. Thus the elevations were obtained along three main lines established by the Surveyors Department with mileposts. That is, the places where the values related to the mileposts belonging to the Puttalam Anuradhapura route are marked ^Point&, the places where the values related to the Kandy Anuradhapura route are marked ^Point&, and the places where the values related to the mileposts belonging to the Halawata Anuradhapura route are marked ^Point& had to be used. In obtaining these values, the sloping nature of the land was confirmed by obtaining the values of the parts belonging to the "Yoda Ela" upstream as well as the parts belonging to the "Yoda Ela" basin.

Thus, while obtaining data, the types of data possessed by the survey department should be considered. Here, there are three types of data as PL-IX" SL-IV" TL-IX, Okha-shadha. Among these data, the most reliable data is PL-IX can be iden tified.The acquisition of this data was done by focusing on two specific places belonging to the coastal region and SL-IV" TL-IX are the sea level differences which have been divided by those values and taken to two other places. The first data was obtained for this research because the values of SL-IV" TL-IX are less reliable than those of PL-IX.

Results

Ancient “Yoda Ela”is an inter-canal designed to carry water up to Tisawa, but its construction is unique in a land area with the highest elevation. It was revealed that excellent irrigation technical techniques have been used to provide the necessary water to the settlements in the Yodha Ala inter-region, which stretches from Kalawewa to Tisawewa, between the upper valley of Kala Oya and the lower valley of Malwatu Oya. Due to these complex structural design features, it was possible to confirm that “Yoda Ela” is not just an inter-canal but a long canal.

The Sluice

The sluice design can be recognised as a great irrigation feature of the “Yoda Ela”. This shows a good relationship between the sluices and the canal bank design, and the canal water is distributed to the tanks and paddies in a managed way. According to field studies, Gonapathirawa, Maradankadawala, Ulagama, Kuttikulama, Aluthwewa, Amunukolaya, Konwewa, Kiralogama, Tirappanaya, etc. are important sluices that can be identified in the Kala Oya upper valley region from Kalawewa to Nambadewa Bridge.

Table No. 01, Sea level values at Yodha Ala sluices and locations

No	The tank belong to Region	Sluice	Mean See Level
1	Kalawewa-Kekirawa	Yes	N 8.12 TBM-39 /E 4+800
2	Ganthiriyagama-Mahailluppallama	Yes	N 8.12120/E 80.46960
3	Maradankadawal- Mahailluppallama	Yes	N 8.42538/E 80.58210
4	Thalawewa- Mahailluppallama	Yes	N 8.13557/E 80.45220
5	Kuttikulama-Thalawa	Yes	N 8.15281/E 80.40152
6	Aluthwewa-Thalawa	Yes	N 8.14906/E 80.44310
7	Madagama-Thalawa	Yes	N 8.13251/E 80.13251
8	Amunukole-Thalawa	Yes	N 8.15172/E 80.42430
9	Konwewa-Thalawewa	Yes	N 8.16163/E 80.42430
10	Kiralogama wewa-Thalawa	Yes	N 8.27132 /E 80.49820
11	Thirappanewewa-Ihala Nuwaragama Kalaviya	Yes	N 8.22152/E 80.52612

Resource: Field Survey

The first factor indicating that water was supplied to a tank from the "Yoda Ela" can be identified by the sluice connected to the Gonapathirawa tank. The sluices that supply water to Kuttikulamaveva and Ulagamaveva from the "Yoda Ela" can be identified, and the structural form of these deviates from the original constructions (photo no. 10). Although the ancient sluice used to supply water to Aluthwewa from "Yoda Ela" can be identified, the sluice built during the colonial period was identified nearby (100-02371 B). Due to the location of Aluthveva and Kuttikalameva at the same height, it is possible to think that the Kuttikulameva sluice and Alutheva sluice should be located at the same place (98-16732 A, 98-52321A, 97-95324A) (photo no. 11). Both the ancient sluice and the Kuttikulama sluice are placed at the same elevation. But since the new sluice of Aluthweva is slightly above the ancient sluice, it can be concluded that the lower sluice can be definitely the ancient sluice when considering the height of the sluice belonging to the Kuttikulama tank.

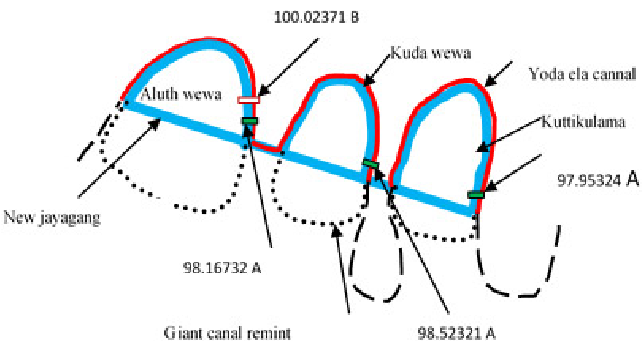
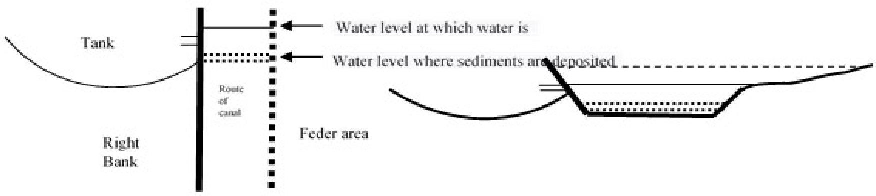


Figure 01(1), Location of Sluices
Resource: Field Survey

The sluice that supplied water to the Amunukolaya tank and almost half of the tank was caught by the encroachment of the new Jayagaga built with the Mahaweli development movement, and the landscape has changed beyond recognition today. As the "Yoda Ela" flows covering a large area around the Koon wewa, it is clear that more water must have been released from the "Yoda Ela" into it. Here the elements of two sluices used to release water could be identified and new sluices were established in the same places where the ancient sluices were located during the colonial period with various interventions.

Through the establishment of these sluices, water was not only distributed in a managed manner, but it was also possible to confirm the concepts of environmental conservation and their understanding of the nature of the land. Each sluice is located at the point where the canal begins to meander and where the canal meanders and rejoins a downstream valley. Here, if the sluice channel and the tank are placed at the same level as the water from the canal to the tank, there is a possibility that silt mixed with the tank water would enter the tank with the waste water.



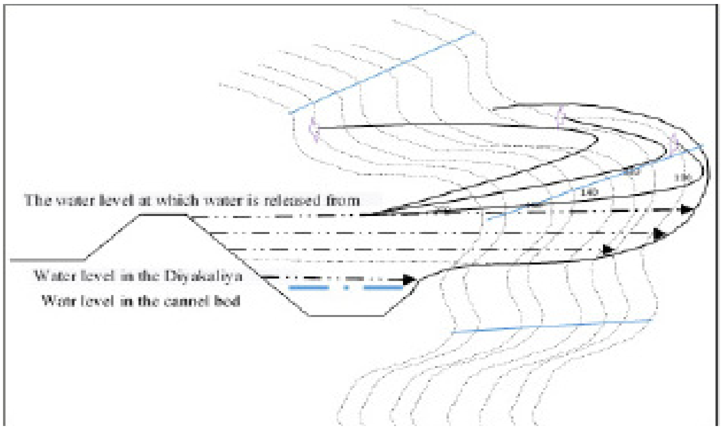
Plan: 01, Placement of sluices in the canal
Sourse: From field studies

It can be observed that careful consideration has been given to the elevation in placing the sluices, ensuring that the sluice opening is established in a way that releases water into the tank only after the canal's water reaches a certain level. The field survey uncovered additional sluices, apart from those connected to tanks, which are utilized to supply water to agricultural lands. These sluices are strategically located in high topographic regions to provide water to tanks from canals, while sluices in lower elevation regions supply water directly to agricultural lands. The presence of agricultural land near the basin area of the remaining ancient sluices indicates the application of alternative canals by the New Jayagaga movement in these areas. Such stone sluices can be identified near the Eppawala phosphate deposit and other locations like Mahailuppallama, Chhedagala, Konvewa, Giant Canal village, Yakallegama, Batuwatta, Tirappanaya, Amunukolaya, etc. It's important to note that these sluices do not supply water to tanks but directly irrigate paddy fields.

Diyakaliya,

Traditionally considered a micro water source for water retention, reveals an excellent aspect of water management and environmental concepts through design technology and utility. The main functions of Diyakaliya, in connection with the "Yoda Ela," include generating power for water flow, controlling silt, managing agitation and temperature, maintaining high soil water levels, and serving as a unit providing water for agricultural activities. The average depth of the Diyakaliya, resembling a small tank, is approximately 35 to 40 feet, with an oval structural shape influenced by contour lines and geophysical factors. About 50 dams built in connection with the "Yoda Ela" were discovered during the field survey, contributing to changes in the landscape. The Yodha Canal is supplied by water released from Kala Oya, water received from reservoirs, and rainwater. Given the consistent water supply to the canal throughout the year, the tank remains consistently full. Noteworthy Diyakaliyas include Wetakolu Diyakaliya, Ranhami Diakaliya, and Little Banda Diakaliya.

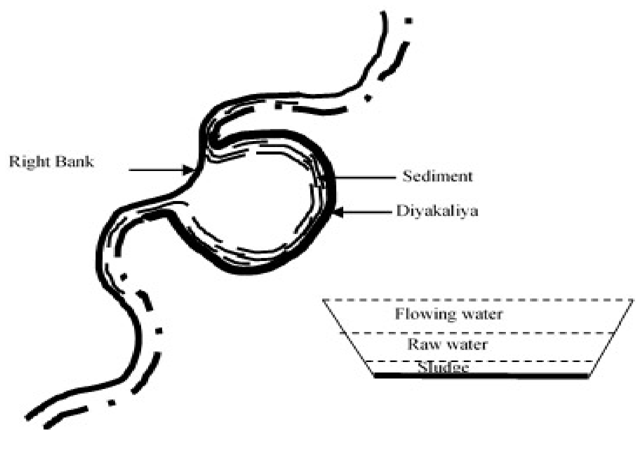
While both Diyakaliya and the tank operate in connection with the Yodha Canal, Diyakaliya is directly linked to the canal, whereas the tank exhibits an independent relationship. Bounded by the left bank of the Yodha Canal, the canal flows above the tanks, and sluices on the banks, determined by elevation, release water into the tanks. The Yodha Canal's design avoids a direct connection with other water sources in the inter-region because the south side functions as a catchment area. This design prevents silty water from interfering with the water circulation process of the tank by depositing on the tank's surface.



Plan: 02, Contour lines of the Giant's Causeway region

In the topography of the Yodha Canal flow area, a contour line stretch with a slight elevation open to the canal on its left side can be identified. The canal is additionally supplied with water from Kalaveva, contributing to a higher presence of silt in the canal's soil water. This raises the question of whether the silt carried by the canal travels up to a distance of 54 miles, or if there was a formal technical method in place to collect it. Consequently, a breakwater has been strategically created in a zone with equal elevation to control the impact of silt on the water circulation process and acquire the kinetic energy needed for the water to flow forward. Before crossing higher ground, the water flows forward, creating pressure as if a high water capacity is stored in the dam.

The process of silt deposition in the lagoon is directly related to the distribution of contour lines in the respective region. After flowing for about 1 1/2 miles (Mahailuppallam and Upper Tank lagoon), the water is stored in the lagoon, exhibiting three water levels. These include the lowest water level (approximately 2 feet from the lowest level of the canal to the annular lump bordering the right side slope), the first water level from the left bank water level, and the water level that releases water from the breakwater (Plan No. 01). The first and second water levels constantly oscillate around the pond, during which silt gradually settles on the pond's bottom. In the third stage, the ancient water level rises with a new surge, and the water flows forward with the pressure created by this surge.



Plan: 03, The function of Diyakaliya

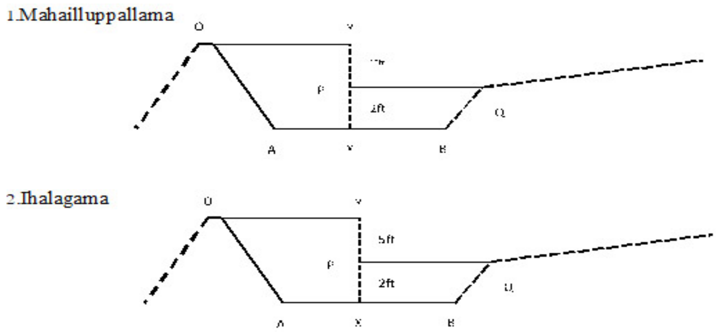
Another crucial aspect of creating a waterfall lies in its provision of a technical means to supply the kinetic energy required for propelling water forward. Spanning approximately 54 miles from Kalawewa to Anuradhapura city (Tisawewa), the canal transports water across varying elevations of the land and diverse geophysical positions, including mountains, valleys, rough slopes, and gentle slopes. In response to this challenging topography, Diyakaliya has been strategically placed adjacent to the Yodha Canal, aiming to facilitate the crossing of diverse geophysical locations.

Groundwater level control techniques have been implemented to ensure water supply to every piece of land in the region where the ancient "Yoda Ela" of Anuradhapura once flowed, both on the surface and underground. The technical methods employed to elevate the underground water level are evident in the organized design of the canal space. The "Yoda Ela" is engineered to flow from the Kala Oya to Tisawa through a landscape of flat valleys. In areas with slight slopes of the land, the power required to propel the water forward has been obtained by structurally preparing the banks according to the topography of the respective region. This is manifested in the creation of high banks in topographic regions of lower elevation and the establishment of banks at a minimum height in areas with topographical features of high elevation.

Table No: 02, Depth and width of old "Yoda Ela"sections

No	Location	X-P	P-Y	Total
01	Mahailluppallama	2ft	10ft	15 ft
02	Ihalagama	2ft	5ft	7 ft
03	Aluthwewa	2ft	7ft	9 ft
04	Eppawala	2ft	5ft	7 ft
05	Amunukolaya	2ft	7ft	9 ft
06	Yakallegama	2ft	6ft	8 ft
07	Endagala	2ft	6ft	8 ft
08	Giant canal Village	2ft	5ft	7 ft
09	Baturwaththa	2ft	6ft	8 ft
10	Thirappanawa	2ft	5ft	7 ft

Sourse: From field studies

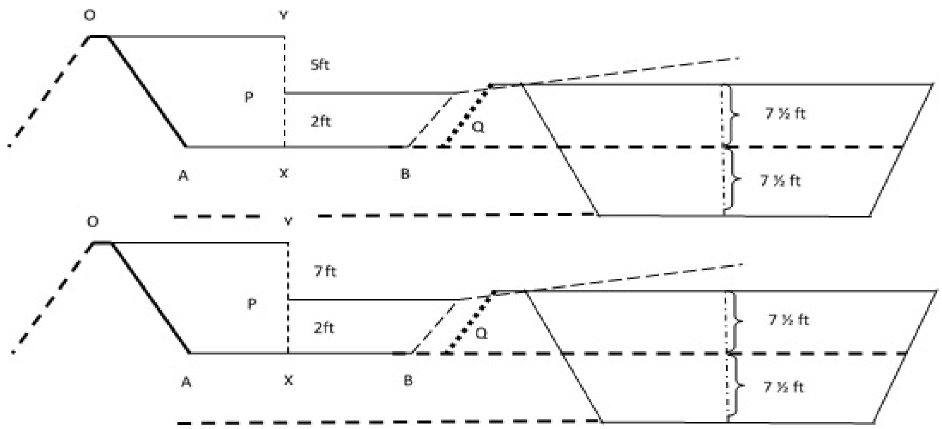


Plan No: 04, Depth and width of old "Yoda Ela"sections
Sourse: From field studies

A-X= Distance from right bank to center of stream " X-B= Distance from center of stream to left bank " X-P= Height from left bank to center of stream " P-V= Height from the center of the canal to the right bank " A-O= Slope form on the right bank " B-Q= The slope of the land on the left.

From this data, it is evident that the giant stream's maximum depth does not exceed 2 feet, despite its significant width of 40 feet. The design technology employed to facilitate the 54-mile flow is noteworthy. The irrigation strategy implemented here involves maintaining the sloping nature of the land as an open area, without constructing a bank on the right side. On the left side, corresponding to the highest slope of the flat valley on the right, the canal's bank design is apparent. When the water level in the Yodha Canal rises, the pressure on the right bank diminishes, causing the water to cascade toward the left plain valley. Consequently, in addition to the 2 feet depth prepared in the canal, the landscape on the left side of the canal has been inundated, covering a large area of the valley.

These irrigation techniques have played a crucial role in sustaining a high underground water level in the Yodha Canal and its upper reaches. The elevated groundwater level has created favorable environmental conditions for agriculture in the surrounding region. However, it has been confirmed that the current underground water level of the Yodha Canal has diminished due to the construction of the new Jayagaga parallel to it, replacing the ancient Yodha Canal with an environmentally unsuitable design.



Plan: 05, The underground structure of the New Jayaganga and Old Yodha Ala works in Ulagama

Sourse: From field studies

The depth (vertical) values of the ground measurements obtained at two locations, New Jayagaga Ulamagama and Amunukolaya, running parallel to the ancient Yodha Canal, have been configured in a way that the water flows at a depth of 7 feet per square meter compared to the ancient Yodha Canal. This has resulted in reckless interference with the land and settlements on both sides, leading to these areas having a very dry nature due to the rapid decline of the underground water level caused by digging the land deeper than the ancient Yodha Canal. The entire ecological system, including the system tanks fed by Yodha Ala, is gradually fading due to this situation, disrupting social, cultural, ecological, interrelationships, and Hela irrigation culture, water management, and established environmental conservation methods.

Inter-canals fed by Yodha canal

It is evident that the Yodha Canal, surpassing the function of a mere canal, represents an excellent irrigation design, catering not only to areas with lower elevations but also to those with higher elevations through the creation of inter-canals. Three such inter-canal routes were identified through the canal from Kalawewa to Tisawewa:

1. From the giant canal bank crossing the upper half of Maradankadawala tank (the canal leading to Upper Land).
2. From the giant canal bank crossing the lower half of Amunukolaya (the starting canal).
3. Konitthi Canal (Inter Valleys) constructed from Eppawala to the Katiya region.

This canal design technique aims to supply water to the upper contour line region without constructing through the lower contour line region. It was confirmed that these canals were created with consideration for the contour lines of the land during the construction of the Yodha Canal. Checking the actual sea level at the places where these inter-canals are used revealed that the "Yoda Ela" route was constructed through the highest points on the land, with a contour line extending gradually to both sides. This confirms that the settlements were widespread in the regions where these inter-canals are spread, and these inter-canals must have been created from the Yodha canal to provide water for that purpose.

In this scenario, social, cultural, environmental, inter-relationships, Hela irrigation culture, water management, and established environmental conservation methods are gradually diminishing. The canal starting above Maradankadawala weva, going up to the upper Amankattua, also moves forward, providing water to the upper Gamawewa. This can also be identified as the canal used to supply water to the Upper Amankattua System Tank (Cascade System). The functioning of this system can be identified as follows.

Table No: 03, Inter canals starting from Yodha Canal

The system tank is fed by inter canal route starting from Yodha Canal				
No	First tank	Second tank	Third tank	Four tank
01	Amane	Ihala Amanne Siwalagala	Pahalawewa Walagambahuwa Marikkakulama Paindikulama Mawathwewa	Mahakanumulla Wagayakulama Kudakanumulla

The Yodha Canal not only supplies water to the lower system tanks but also feeds extensive settlements and system tanks across the high-elevation land. It is noteworthy that the canal, originating from the bank of the "Yoda Ela" created through the upper part of Maradankadawala tank, serves as a driving force to nourish the Mahakanumulla Cascading.

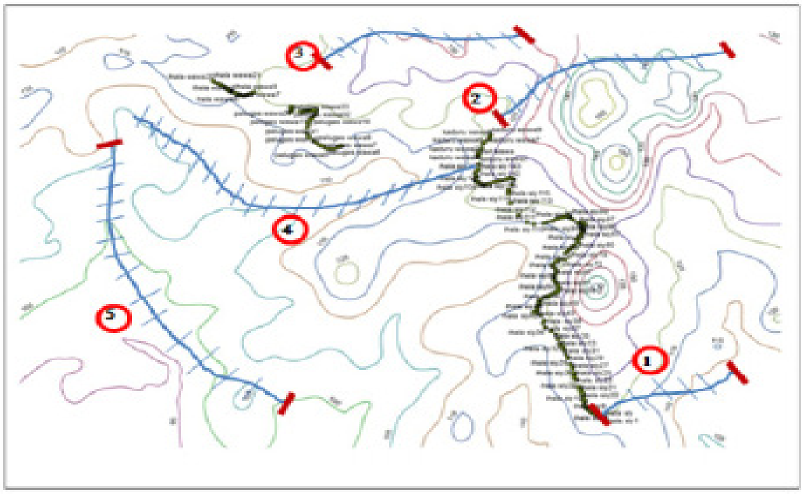
The second canal is the inter-canal that starts from Amunukola and feeds Nallamudawa Cascading. Here, it is a horizontally expanding system tank, and its spatial organization helped reveal the topography of the respective region.
Table No: 04" Inter canals and tanks starting from Yodha Canal

Table No: 04, Inter canals and tanks starting from Yodha Canal

A system tank fed by a canal that originates from above Amunukolayawewa				
No	Cascade I	Cascade: II	Cascade: III	Cascade: IV
01	Siyambalagas wewa Kuttikulama Thammennagala Kodarikulama Halmillewa	Nallamudawa	Mawatha wewa Kudawewa	

Sourse: From field studies

This system tank is more complex than other tanks. The inter-canal route starts from the right bank of the Yodha canal which passes above the Amunukolayaveva and connects to the Nallamudavaveva. But the water required for the Radagamava River, which is the main tank feeding the Nallamudava River, has also been provided by a canal from Ulankulama to Radagamava River.



Map:01 Inter canals fed by Yodha Canal
Sourse: From field studies

The canal system created in the upper part of Yodha Canal reflects a thorough understanding of the topography. Although there was a belief that the "Yoda Ela" was formed through the area with the highest elevation, it was observed that the canal was constructed across the highest land, with canals applied along the contour lines sloping on both sides. A clear observation revealed the limitation of such canals. If there were available spaces to apply this technology in other areas, ancient irrigators would not hesitate to adopt it. The key lies in the widespread practice of land reading by ancient irrigators.

The distribution of system reservoirs and the calculation of land sea levels are crucial factors detectable through geodetic practices in canal creation. This was evident as the system tanks connected to both these canals starting from the Yodha canal exhibit a counterclockwise distribution, while parallel to it, they spread in a clockwise direction from the south. Therefore, canal construction stands as an outstanding irrigation industry that considered the sloping nature of the land. Another confirmed aspect is the calculation of the actual sea level extending from the canal to both sides.

The Banks of the Giant Canal

A significant challenge encountered in the Yodha Ala field survey was the discovery that the left bank created from Kalawewa to Naodewa Bridge crossed the right bank from Naodewa Bridge to Tisa Tank. Aerial photographs taken before 1971 were examined to conclusively confirm this fact. To understand the factors influencing the change in bank configuration, sea level heights were obtained in the land area sloping to Kala Oya from Kalawewa to Nambadewa Bridge (left bank) and from Nambadewa Bridge to Tisawawa (right bank) to Malwatu Oya. Actual sea level elevations (peaks) were also obtained in the sloping land area. The distribution patterns of actual sea levels established here are as follows.

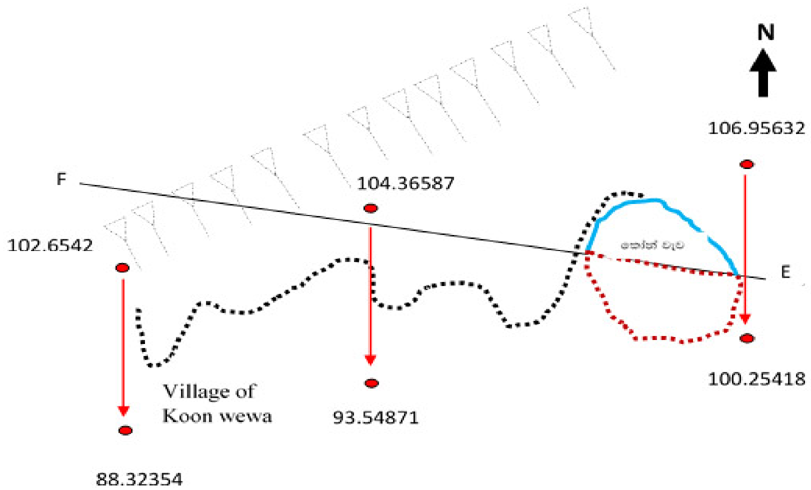
Table No: 05, Giant's Causeway Mean Sea Levels

From Kalawewa to Naodewa, the land area has slopes on the south bank				From Nowawa Bridge to Tisawawa, the terrain slopes to the left bank			Tisava region		
No	Miles. Stone	Point of Value	MSL	Miles. Stone	Point of Value	MSL	Miles.S tone	Point of Value	MSL
1	5½	43	103.74690	5	44	105.09959			
2	6	42	11.68560	4½	45	101.2101	44	10	99.504m
3	6½	41	105.36684	-	-				
4	7	40	105.59693	2	50	85.5767	45	-	92.787
5	7½	39	103.89659	2 ½	47	90.60527			
6	9 1/2	35	103.44583	3	48	95.6875			
7	10	34	97.33880	Seconary Level					
8	11	32	95.49369	12	23	119.72184			
9	12	30	99.63267	12 1/2	20	108.85895			
1	10								

Source: Sea-level elevations derived from source field studies

Comparing the actual sea levels, it becomes evident that the southward shift of the Yodha Canal from Nodawa Bridge to Tisawawa on the south bank is influenced by the slope of the land. As the actual sea level in the area sloping to Kala Oya (left bank) from Kalawewa to Nambadewa Bridge ranges between 99 and 105 feet, the slope towards the left bank from Kalawewa to Nambadewwa takes a higher value. Given this scenario, the south bank was created, and the actual sea level value of the south bank slopes from Nambadewa to Tisawewa is confirmed to be between 105 and 85 feet, depending on the slope's shape. This clarifies that the left bank sloping to Kala Oya from Kalawewa to Nambadewa has functioned to supply the necessary water for the Yatawata Cascading, while the right bank sloping to Malwatu Oya from Nambadewa Bridge to Tisawawa has formed a channel to collect water from the updavata and direct it to Tisawawa. In this manner, the landscape has been manipulated to accumulate a significant water capacity in the Yodha canal inter-region, which then flows to Tisavava.

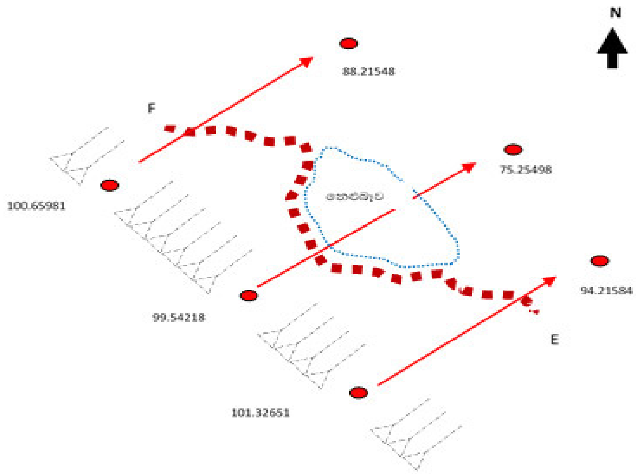
The ancient bank factors along the route of Yodha Canal from Ulawewa to Aluthwewa were clearly confirmed through field surveys, aligning with the mean sea level of the land. The Yodha Canal was completely destroyed between Kalawewa and Batuwatta during the field survey. The left bank of the canal could be identified, and the land elevation was determined by calculating the sea level value of the region. Sea level calculations for the left area of the canal included Upper Tank, Kuttikulama, and Aluth Tank areas, showing sea level values ranging between 103-108 feet. Additionally, in the south bank area where the land slopes towards Kala Oya, sea level values range from 95-98 feet. This confirmed that the left bank of the Yodha Canal was constructed with consideration for the elevation of the landscape. Reporting on-site information about the destroyed parts of the Yodha Canal, the bank parts from Aluthwewa to Konwewa were confirmed. These parts also belong to the area where the Yodha Canal flowed from Kalawewa to Batuwatta, and due to the operation of the New Jayagaga, the ruins were confirmed outside the operation of these parts. To calculate the actual sea level of the region, data from the upper parts of Alutheva, Amunukola, Konveva, and the parallel south bank areas were obtained. In this region, actual sea level values in the left area range between 102-106 feet, and in the south area, actual sea level values range from 96-99 feet. This further indicates that the left bank in this region was constructed for the purpose of water management and storage as the land slopes down to Kala Oya.



Plan: 06. The steep form of the banks of the old "Yoda Ela"at Konwewa village
Sourse: From field studies

From Konwewa to Kanduruwewa, the "Yoda Ela" travels through a region with low topography. Although the "Yoda Ela" passes through tanks from Mahailuppallam to Konwewa, it was found that it covers approximately 10 kilometers across flat land in this area. In comparison to other regions, there are more Diyawangu in this area, indicating that the region's structure is shaped by the forces needed to propel water in this region. The distribution pattern of sea level values, ranging between 88-100, shows that the elevation of the land extends towards Kala Oya. It can be observed that the actual elevation of the land in this region has a rough slope compared to the original parts, and to address this, giant canals with bends and high banks were created. However, the extension of contour lines in this region inclined towards the north, resulting in the creation of the bank on the left-hand side.

Although the left bank can be identified as the main water carrier of the Yodha Canal from Mahailuppallam to Nambadeva Bridge, it was confirmed that the right bank was created from Nambadeva Bridge to Tisavava. To verify the accuracy of this, the sea level height of this region was calculated. The spread of sea level in the left area shows a range between 78-80 feet, while the spread of sea level in the right side area shows a pattern ranging between 85-99 feet. This indicates that the elevation of the land extends towards Malwatu Oya. The fact that the left bank can be identified as the right bank from Nambadewa Bridge to Tisavava is an important finding of the research. The distribution of contour lines in the landscape from this region is designed to enhance water capacity by creating the "Yoda Ela" bank vertically parallel to those horizontal contour lines sloping towards Malwatu Oya. The spread of contour lines in that region reveals that the irrigator was conscious of creating the "Yoda Ela" bank.



Plan: 07,The slope form of the old "Yoda Ela"banks at Nelumbewa Based on field study of sources

Mean sea level values were calculated in the Nelumbewa area to confirm the giant canal bank factors. In this region, the range of land elevation is 99-101 feet according to the sea level values on the left side, and the range of sea level levels on the right side is 75-94 feet. A pattern is also evident, allowing the identification of the way in which the land elevation spreads towards Malwatu Oya. Mean sea levels were calculated in the Ratmalewewa area to further confirm the giant canal bank factors. In this area, the range of sea level levels on the left side is 85-99 feet, and the range of sea level values on the right side is 78-80 feet. As shown, it was possible to identify the direction in which the elevation of the land spreads towards Malwatu Oya. Thus, the creation of the right bank of the Yodha Canal from Nambadewa Bridge to Tisawawa can be recognized, and this was confirmed in the calculation of the actual sea level.

Anuradhapura's ancient "Yoda Ela" is a single-banked canal (Esabataka ibana kabaka), representing an excellent irrigation industry in managing the natural landscape as a singular human construct within a vast area. In the design of other irrigation systems, the placement of irrigation elements was done by focusing on a limited landscape. However, the creation of a single bank in a linearly heterogeneous landscape of 54 miles of the Yodha Canal is a complex process. The critical question here is from which direction the soil was taken for the bank and whether it was obtained from an external area. To address this, 16 soil samples were obtained from three places where the ancient Yodha Canal remains were tested. These conclusions were drawn through the particle size classification of the soil samples taken at locations like Yakallegama, Mahailuppallama, Batuwatta, etc.

Table No: 06, How pressure is distributed on the bank of a tank and the banks of a giant canal

අංක	Hight (before) (g)	2mm	710um	250um	150um	75um	75um<	Hight (after) (g)
				Yakallegama				
1	100 g	27.47	35.40	19.80	6.82	5.60	4.91	100 g
2	100 g	3.88	28.15	34.30	13.88	10.64	9.15	100 g
3	100 g	2.74	27.42	34.98	14.70	11.08	9.08	100 g
4	100 g	4.02	35.52	35.78	12.08	7.65	4.95	100 g
				Mahailluppallama				
1	100 g	1.05	14.75	27.78	15.88	19.30	21.24	100 g
2	100 g	3.45	18.05	32.15	19.58	15.93	10.84	100 g
3	100 g	3.93	18.34	33.30	19.02	15.38	10.12	100 g
4	100 g	2.93	14.50	29.18	20.14	10.65	14.30	100 g
				Batuwattha				
1	100 g	10.06	21.11	28.04	15.57	14.51	10.71	100 g
2	100 g	12.70	26.54	28.10	14.25	10.18	8.25	100 g
3	100 g	2.80	22.42	32.64	17.10	14.80	10.20	100 g
4	100 g	9.06	22.62	30.30	16.50	10.82	10.70	100 g
5	100 g	5.13	21.26	30.05	19.48	13.74	10.34	100 g

Sourse: From field studies

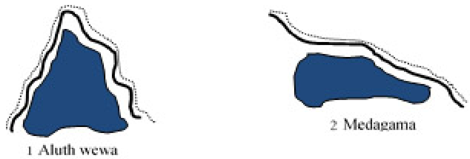
The distribution of particle sizes in the soil samples obtained from Yakallegama, Mahailuppallama, and Batuwatta areas reveals unique characteristics specific to each location. Notably, the disintegration of the grain structures in the soil samples followed a consistent pattern—from the soil sample taken 50 feet away from the area where the canal passed in the internal part of the bank to the section where the internal canal passed, constituting the slope of the bank. Consequently, it is evident that the soil must have been extracted from the left side of the canal during the construction of the ancient 'Yoda Ela' bank in Anuradhapura. The soil conditions in the areas where the soil samples were collected were examined, and the soil color was assessed in Yakallegama, Mahailuppallama, and Batuwatta, where the canal passes.

The structural forms involved in creating the bank factors are identified as a significant discovery arising from research on Yodha Ala. A structural connection among banks, not identifiable in any other irrigation industry, is discerned through the Yodha Canal. A comprehensive understanding of the geophysical environment is essential to utilizing technology for constructing associated irrigation industries, deemed a social necessity for settlement development. Consequently, the research indicates that the slope of the land may impact the identification of anomalies in the bank factors of the Yodha Canal.

The difference in sea level in the land area from Kalawewa to Tisawewa is 29g726p, signifying that Tisawewa is located 29g726p below Kalawewa. Carrying water from Kalawewa to Tisawewa over the 54 km Yoda Ela with a slope of 29g726w presents a challenging task. In response to this challenge, the Yodha Canal strategically harnesses kinetic energy, navigating the heterogeneous terrain by directing water flow from high to low ground.

This dynamic approach results in the identification of diverse features in the giant canal bank, manifesting across various terrain elevations. Numerous such peculiarities have been discovered through field exploration of Yodha Ela.

- Construction of bank factors to carry the canal over the tank.
- Construction of bank factors for crossing high ground and descending to low ground.
- Design of bank elements suitable for traversing a tank with varying topog raphy.
- Construction of banks capable of handling giant canals in a low-lying area.

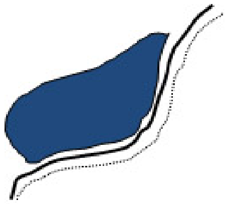


Plan: 08, Dam factors of giant canal passage above tanks in the giant canal interzone

The geophysical location of the relevant area has influenced the determination of the structural form of Yodha Canal's irrigation technical features. An examination of the mean sea level reveals that the first 17 miles of the canal were designed to traverse higher ground than the remainder. The structural design of banks exhibits different shapes due to the canals being designed to navigate around the tanks above them. Consequently, it is confirmed that geophysical factors and previous water management methods have influenced the structural form of the banks, as evidenced by the distribution of tanks such as Thirppanaya, Amunukolaya, Konwewa, and others.

Furthermore, the 'Yoda Ela' also passes above tanks in Gantiriyagama, Maradankadawala, Kuttikulama, Aluthwewa, Medagama, Amunukolaya, Konwewa, Tirappanaya, etc. (Photo No. 19). Since the terrain on which the Yodha Canal is constructed is undulating, extending from a higher to a lower elevation, the work involves channeling natural rainwater from the upper ground and water from the tank through the canal to the tanks and settlements in the inter-region, depending on the extent of the banks.

For the purpose of supplying necessary water to the highest tanks in a cascading manner, the 'Yoda Ela' was created so that the banks flow above the tanks in the first half. This aligns with the way the banks of the canal are utilized below the tanks in the last part of the canal (from Nambadewa Bridge to Tisawewa). Verification of the mean sea level revealed that the contour lines of the region belonging to the end of Yodha Ala extend obliquely to Malwatu Oya, while the contour lines of the first half are created obliquely to the left of Kala Oya.



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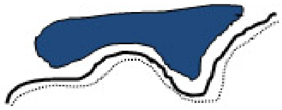
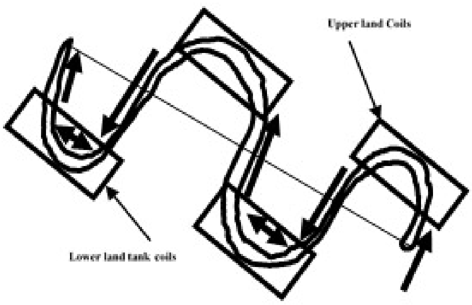


4 Upper Tank

Banks of various structural forms are identifiable along the 'Yoda Ela' route, which runs linearly from Kalawewa to Tisawewa. Despite the challenging task of creating an inter-canal, it was revealed that the 'Yoda Ela' was designed to run parallel to the tank, above the tanks, for the first 17 miles. Consequently, while bank factors can be identified above the tanks in this region, the feeder zones of these tanks have been blocked due to the establishment of bank factors. However, it is evident that these tanks were previously fed by these feeding zones and upstream rainwater before the creation of the Yodha Canal.

It has been confirmed that the water needed by the tanks in this region is supplied by the Yodha Canal, releasing a significant water capacity to feed the system tanks below it. These banks exhibit a curved structural form, shaped according to the upper (Udavata) part of the tank. The construction of the bank did not encircle the entire tank; instead, a giant canal bank was created to cover half of the tank. It was revealed that one or two sluices may have been placed on the bank to supply water to the tanks. Despite these banks being approximately four feet high and feeding the tanks on the left side according to balance factors, the right side of the first half of the Yodha canal can be recognized as an open landscape with a slight slope. Additionally, besides the sluices on the bank, it is clear that this region is also fed by groundwater.

During the first 17 miles, the construction of the 'Yoda Ela' through a region with heterogeneous geophysical factors provided the necessary kinetic force to propel water forward by creating breakwaters. Manipulating the 'Yoda Ela' through topographic zones revealed diverse structural features of the canal banks, as the landscape was engineered to make water flow across higher elevation terrain and back to a lower elevation plain. According to the structural form of this bank, it is recognizable that the upper part always moves around a tank, while the lower part moves at a lower elevation and was created in connection with a tank at a higher elevation.



Plan: 09, According to the structural form of the banks, the "Yoda Ela" Corrodes

The banks created as the canal traverses the lower land are higher than the banks surrounding the tank. Thus, it is clear that because the 'Yoda Ela' passes through lower elevations faster than higher elevations, the bank technology must have been intricately designed to control the pressure caused by a large body of water moving to lower lands simultaneously. Around each tank, Yodha Ala flows on contour lines with high elevation (Kuttikulama, Alutheva, Amunukolaya, Konvewa, Kiralogama, Tirppanaya) and again flows through flat land with lower elevation (Alutheva Village, Konvewa Village, Tirappanaya, Yodha Ala Village).

A curvilinear form can be discerned at the turning points of the banks where the giant stream passes with lower elevation relative to the upper land. The curvature here has also created the structural form of the bank with a wider circumference in the design to control the pressure on the bank. In the field survey, the bank features where this structural form is still present were revealed at places like Kuttikulama, Amunukolaya, Chhazagala, Yakallegama, Eppawala ('Yoda Ela' Village), Ulagama, Kiralogama, Batuwatta, etc.

If the 'Yoda Ela' goes around the tank and the tank is spread over a large area, the bank is designed according to the structural form of the tank. If the 'Yoda Ela' moves around a tank at a higher elevation, it provides more force to push the water forward. That force has helped to move through a flat land with a lower elevation taking into account this situation, the terrain of the 'Yoda Ela' region has been managed so that after crossing each high-altitude region, it spreads again through a lower-altitude region this is confirmed by the fields. As an observation, it was clear that Yodha ela moved around Aluthweva in a larger volume and then again flowed through a larger volume of land in the reclaimed land area Konwewa moved around the upper land and was made to move around Lower Konwewa village, Yodha Ala village, Ulawewa, Epawala, etc. villages. Being the Kuttikulameva is small, so that it flows through a minimal flat area, illustrating that this topographical anomaly was overcome.

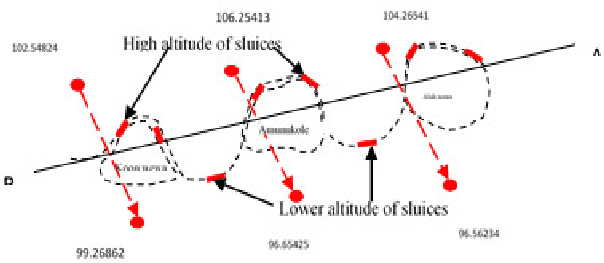
Discussion

Anuradhapura's ancient 'Yoda Ela' irrigation technology features include sluices, the function of banks, inter-canal systems, weirs, catchments, catchment areas, micro catchments, etc. In terms of the function and design technology of these irrigation features, it is similar to the water management process of a tank — the built space of a tank is to store and distribute water in a limited area of land with a valley character, connecting the two streams between two mountains. But Yodha Canal shows an openness compared to the elements of a tank through its irrigation technical features and water management method. In a previous research related to Yodha Canal, it has been pointed out that its structural nature is similar to a 'long tank' (Brohier, 1937; Avsadahami, 2005; Panapitiya, 2010; 22). However, since there was no widespread attention paid to irrigation technical features and water management methods, the irrigation features discovered in the study were investigated in accordance with previous research.

Irrigation features such as banks, sluices, water catchment areas, dikes, inter-canals, etc. have been shown in the research as some of the irrigation features that can directly contribute to the distribution and storage of water in the Yodha Canal Irrigation Industry. With these irrigation features, the Yodha Canal spatially associates watersheds, micro-watersheds, headwaters, brackish channels were also revealed. The four main irrigation features of a tank are catchment area, bank (bank) sluices, outlet, directly affecting the existence of a tank and concerning the utilization of irrigation features and the geophysical environment of the tank. Mud sluice, Bisokotuwa, Ehalawewa, Pitawana, Iswatiya (Porta watiya), Kaligu Bami (Kalingula), Kulawaw, Gantwa, Vad Inamaluwa, Ralapanawa, Vatiwaw, Bisowaw, etc. are important (Tennakoon, 2005; Avsadahami, 2007; Basnayake, 2008; Kumari, 2013; Avsadahami, 2015). In this indication, it can be pointed out that Yodha Ala is a long tank because the technical features of Yodha Ala irrigation show a similarity between the irrigation features of a tank.

Sluices

According to the placement of sluices on the banks of the Yodha Canal, the elevation of the land and the types of sluices were identified in the research. It was shown in the research that the sluices were an irrigation element that directly affected the functioning of the canal and the building of the interrelationship between the settlements. As for the work done by the canal sluices, the canal provides water to the tanks, provides water to agricultural lands and settlements, and provides water to the suburbs of Abhayava and Tisavawa. And the sluices that release water from the canal to the tank are located at a mid-height this was confirmed by the location of contour lines between the sluices connected to the canal and the actual sea level height calculation thus identifying the sluices connected to the tanks that released water from the 'Yoda Ela.' The possible reservoirs are Mahailuppallama, Maradankadawala, Ulaveva, Kuttikulama, Alutheva, Kudaveva, Medagameva, Konveva, Kiralogama, Kuda-amunukolaya, Tirappanaya, Kanduruveva the actual sea level height was calculated to confirm the elevation between these tanks and the sluices. According to the technology of sluice placement, two main topographies can be established high elevation sluices and low elevation sluices — this irrigation feature in a tank is positioned with a dual purpose in view, i.e. the sluice is positioned slightly above the mud sluice to release excess water to distant areas. When the water level of the sluice is low, the function of providing water to the agricultural lands and removing silt is the main function (Basnayake, 1997; 20). But the structure and the breakwater have been created to protect the 'Yoda Ela' from silt, the function of the sluice of a tank has been fulfilled and it is used for agriculture in the nearby settlements. Sluices have also been used to provide water to the lands, this is more confirmed due to the absence of tanks or other water sources in those regions and the fact that a large amount of agricultural land is concentrated in those places the sluices are located in curved places with lower elevation when the stream flows the stream. Although technical methods are used to control the silt on the road.



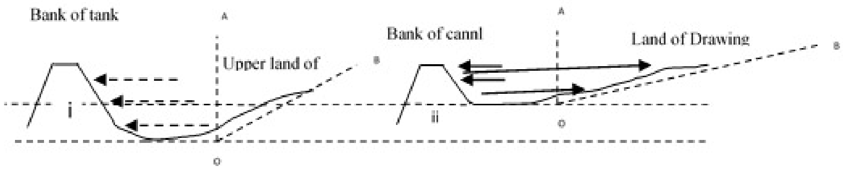
Plan: 10, Yodha Ala sluices and downstream sluices

Bank Techniques

A significant design element of a tank, the "tank bank," can be identified as a bank created by the "Yoda Ela" irrigation industry. The common technical concept involves storing water in a tank by creating a dam connecting two mountains. This process leads to the distribution of water through inter-canals to water catchment areas near the dam and to settlements and agricultural areas far from the main water source (Vijetunga, 2005:15). While this is a normal process in a tank, the 54-mile aqua-linear "Yoda Ela" has banks created to provide ground and surface water across heterogeneous terrain to nearby basins and remote settlements. This involves creating giant canals across high ground in all areas. Considering the function of underground water, it is expected that the lowland region will be developed as a suitable area for settlement. Thus, it is confirmed that during the late prehistoric period or the middle period of the historical period when the Yodha Canal was created, upland settlements gradually migrated to the central area.

In light of this situation, as settlements were centered around rural tanks, the "Yoda Ela" may have been created to flow through the upper land. Avsadahami's research on the tank indicates that creating a tank bank across the upper limit of the valley worked to increase farmland in the lower land (Awsadahami, 2015: 67-68). By directing the "Yoda Ela" to flow through the upper land of each region, the water needs of Yatawata settlements and the establishment of a suitable soil zone have been addressed. This is further confirmed by cultural analysis of settlements in the Udaawata and Yatawata regions. As Avsadahami points out, the Minneriya River has been manipulated with the aim of increasing agricultural land in the basin. It has been emphasized that storing water without protecting settlements in the catchment area is a futile task.

Based on the sloping nature of the land, research has shown that various height levels can be identified in the constructed bank. When the Yodha Canal passes through regions with minimum elevation, banks with minimum height levels are observed, while passing through a geologic region with high elevation results in banks at a higher level. Accordingly, the height of the Amunukolaya bank is 9 feet, the height of banks in Aluthwewa, Yakallegama, Batuwatta area is 8 feet, the height of the Mahailuppallama bank is 12 feet, and the height of the Eppawala bank is 5 feet. It is evident that the left bank of the Yodha Canal from Kalawewa to Naodewa Bridge and the right bank from Naodewa Bridge to Tisawawa can be identified. The inner side of these banks is obliquely designed in comparison to the outer side - the inner side of the bank is designed obliquely to control the pressure on the dam (Awsadahami, 2005). The "Yoda Ela" is designed to flow over a wide area along one contour line. Due to the creation of the canal according to the contour line and the height of the land, it is necessary to control a huge body of water with the water flowing through the Udawatta and the water released from the Kalawewa sluice. Therefore, it can be recognized that the land has been created obliquely so that the sinkhole is in the opposite direction to the bank (this is the natural position).



Plan d the

banks of a giant canal

A tank is centered on a limited valley and the space is organized to store the water in the valley, but to control the pressure caused by applying the kinetic energy of the water to the tank bank, the sides of the valley are designed with a rough slope in front of the bank (Tennakoon, 2005:40). But the Yodha canal is a natural landscape with a slight slope on the right side and the pressure on the left bank has been controlled by making the water level to accommodate the increasing water capacity. The operation of the dam can be pointed out as a case of releasing a large stream of water into the canal - to control the pressure caused by this, the mouth connected to the bank can be recognized as being formed on the basis of a natural rock rise or a valley nature (Mahailuppallama, Amunukolaya) - Minneriya, Kaudulla, Girithale, Maduru This is the result of the creation of the bank of Oya and other tanks based on natural granite rock outcrops (Awsadahami, 2015:68).

Diyakaliya

It is possible to point out the design of "Diyakaliya" and its utility as a technical design element that can be identified in the “Yoda Ela”irrigation work. Diyakaliya can be introduced as a place to store water and provide kinetic energy for the water brought by the canal to flow forward in places with high topography and to collect the silt brought by the giant canal (Karunarathna, 2021). As the research space that has been done in this regard is limited, as a theoretical approach, Small Tank System of Sri Lanka: Their Evaluation, Setting, Distribution and Essential Functions the book is important (Panabokka, 2009). In order to confirm the elevational position of thebankcreated at a higher elevation on the ground, the mean sea levels of the Mahailuppallama bank were calculated- the elevation range of the upstream elevations being 103-108 MSL feet and the downslope elevations being 98-93 MSL feet. Revealed. This location affected the internal workings of the lagoon and in explaining the structural nature and function of the system tanks, Tennakone points out that the water flows from the upper tanks to the lower tanks: water is filtered (Tennakon, 2005, 40). The function and utility of the lagoon created in connection with the giant canals is a more complex process. In the book " Channel Morphology and typology" published in 1992 AD, M.Church has shown that when the slope and winding nature of the canal increases, the stability of the canal decreases and when the stable position of the canal decreases, sediment deposition increases: (Church, 1992). It can be recognized that the silt deposition has a high value as the stability of the canal decreases due to the winding and curved shape of the giant canal. It was shown in the research that silt is deposited very easily due to the water circulation process taking place in it with low stability, like the creation of a circular lagoon at a high altitude (Kellerhals et al, 1976). The research space that emerged here was to conduct research related to the double-banked canals through mean research.But the ancient Yodha canal under study is a single-banked canal. However, in the first 17 miles, the sloping nature of the land in the southern direction opposite to the left bank will fulfill the function of making a canal or a tank according to the water capacity, so it is advisable to use the above theoretical approach for this purpose- In his research,Channel Bars in Gravel-bed Rivers; In Gravel-bed Rivers" which shows that bank design technology affects the control of deposits in canals, Kyamarajya Ba Ndayi has shown how the structural form of the banks affects the formation of deposits. 04 methods of bank strips have been introduced here. That is, Longitudinal and Crescentric bars)" (Transverse Bars)" (Medial Bars)" (Diagonal bars) and (Point of lateral Bars) (Church and Johes, 1982). Among these methods, it can be concluded that the dam connected to the Yodha canal was built with the left side heavy agrathiru method and partial column method. It is clear how the space has been prepared so that the silty water coming from the canal collects in it and then flows forward by placing the water tank on this side.

Groundwater level control techniques

The water needed for agriculture and settlements under medium-sized or large-sized tanks is provided by sluices or inter-canals- but the water circulation is done underground by means of networked sluices. As the water circulation in the

Cascading, which extends according to the landscape, is underground, the collection of silt into the lower tank is controlled. Since the effect of the ground water of Cascading's upper tank is directly received in the area called Purana Vela, first the harvest is done in the area called "Purana Vela" which is located in a lower landscape- secondly, the other paddy fields are harvested taking into account the water level of the tank. It is pointed out that the size of the ancient market was determined by the water capacity of the tank (Dharmasena, 2009:1-10: Karunarathna, 2018). The Department of Agricultural Services has classified tanks on the basis of the catchment areas of the tank (Agraian Service Act, 1976). According to that classification, it was possible to confirm that the tanks belonging to the study area are small-sized tanks; the underground water circulation process may have affected the formation of the connection between the tank and the settlement; this is also clear from the note by Tennakoon showing the connection between the tank and the settlement related to Cascading (Tennakon, 2005: 45; Karunarathna, 2018; Karunarathna, 2021). It is clear that the water circulation in this region was an underground process, especially since each tank belonged to a Cascading.

The technical method of handling the Yodha canal route worked to keep the groundwater level high. The Yodha canal was designed to circumnavigate the tank through the upstream zone of each tank. Thus two things became clear. That is, to provide water to the tank through the canal and to maintain a high level of groundwater in the region where the "Yoda Ela"belongs. In the research, it was possible to confirm the location of the contour lines in the regions where the "Yoda Ela"traveled, by calculating the height of the mean sea level, and it was possible to confirm how the canal flowed through the areas with high altitude - the other thing is that after crossing a high ground, it was made to flow on the same contour line to a lower ground. By improving the function of underground water, it has become possible to improve the soil condition of a large area.The main geophysical factor that affected this was the slope of the land - the slope of the land was used to the maximum in the construction of the "Yoda Ela"- the effect of several methods could be confirmed to maintain the groundwater level by the "Yoda Ela"- bank designs Technology, structural form, moving in harmony with previous water management means through the design of the banks were discussed that the variability of the banks can be identified according to the elevation of the land. Thus, by creating banks according to the elevation of the land, it has been possible to nourish the soil condition on the surface and underground - for this, the soil condition of the area, the extent of the rock surface and the slope nature have been affected (Dharmasena, 2004:05). Dharmasena points out that the function of this is the function of the exposed aquifer in lithology (Rurapib, 2004:5). Due to this, the distance between the rocks below the humus soil layer is reduced, the slope nature of the land has affected to maintain the water absorption of the soil layer at a high value.

Evidence that Yodha Canal was created by excavating the land is not revealed in connection with the early constructions- The sloping nature of the land created the banks to retain the water by creating perpendicular banks at the highest point- In the study, measurements were taken at several places to identify the depth of the land. There is an average gap of 3-4 feet from the slope opposite the bank to the depth of the canal, thus it is clear that an attempt was made to move the water through the surface land at a shallow depth - and the water level has been maintained at a high level due to the catchment covering most of the left side area. A study was conducted on the soil structure that contributed to maintaining the groundwater level at a high value in the area where the Yodha canal flowed- in which the mean percentage of sand was 05%-40%, the percentage of clay was 55%-70%, and the percentage of gravel was 10%-15%. The addition of surface water to ground water has been controlled due to the presence of high percentage of clay compared to the mean of sand percentage. Since the percentage of sand is high compared to the percentage of clay, the water does not stand constantly and because the water at the soil level leaves the soil, the water circulation process of this soil structure is more suitable for agricultural activities, reseachers have pointed out some of the main points of its function in confirming the internal behavior of underground water (Dharmasena: 2014) In it, it is pointed out that the action of underground water exists through the cracks between rocks, sand and soil and that water storage and circulation takes place very slowly between rock and sand soil through the geological formation (Dharmasena, 2014:1-4) Wijetunga points out that the function of water that affects the retention of underground or soil water can be divided into three main groups, and they are gravity water, capillary water, hypergravity water (Wijetunga, 2015:42). When the microspace is filled with water, it does not contain air and is not suitable for growing crops. But when water is added to a saturated soil in a large space, the water moves down through the soil and joins the ground water due to the capillary force in the soil. This is also not a suitable soil for agriculture (Tennakoon, 2012). The structural space between the soil particles as well as the sloping nature of the land affects the quick absorption of capillary water into the groundwater and this was confirmed in the research through the study of the mean sea level. Due to the undulating nature of the landscape belonging to the North Central Province, water does not remain in the soil for a long time. After the water is removed from the saturated soil, the water contained in the soil microspaces creates a soil that is more suitable for agricultural purposes. Based on that situation, when the amount of water is reduced by the stimulation and evaporation of the plant parts, the water is taken back by the suction force. Thus, the activity of soil water is the activity that takes place up to the level of groundwater on the surface of the soil. Due to this, the structural design technology of the Yodha Canal may have affected the continuous level of activity between the surface soil water and the underground water level by creating the water surface of the Yodha Canal.

Conclusion

In order to confirm that Yodha Canal is not just a canal but a long tank, the design features of Yodha Canal were verified- the main function of a canal is to provide water from a main water source to an area in need of water- Yodha Canal can be identified as an inter-canal and from this water It was possible to reveal the technical characteristics of irrigation that provided water not only for transportation but also for settlements in the inter-region. As the irrigation technical features discovered here, the single, feeder zone, gas gommana, sluice, diyakaliya, inter-canals, diyagilma, kattakaduwa are important- the utility of irrigation features used to manage water in a limited area of a tank is a long area of giant canal. It is special that the execution in can be identified.The sluices are placed according to the elevation of the land and the sluices that supplied water to the tanks from the Yodha Canal are located at higher elevations and the sluices that supply water to nearby settlements are located at lower elevations – for example, Konapathirawa, Upper Tank (Ihala wewa), Kuttikulama, Aluth wewa, Konapathirawa, Amunukolaya, Kiralogama Upper, and lower sluices are important among.

Diyakaliya is an important part of irrigation and is unique to the "Yoda Ela"irrigation industry which cannot be recognized in other Irrigation- This is due to the structural nature of the canal, which is linked to the operation of the canal, thereby maintaining the groundwater level at a high value, providing water for land farming activities, control of irrigation, wildlife. This has accomplished multiple tasks such as providing the necessary water, silt control, getting the kinetic energy required to flow forward in the canal. Nearly 10 such waterfalls can be identified in the Yodha canal and can be seen in the areas near Mahailuppallam, Amunukolaya, Eppavala, Kuttikulam, Ihala wewa (Upper tank) for example, near the Mahailuppallam, a part of the rocky ridge created in connection with the Yodha canal can be identified and the other part is New Jaya canal. The river has been destroyed by design- Bank creation is also an important aspect of water management according to the geologic environment- Only a single bank can be identified here, localized according to the relief of the land. In calculating the mean sea level heights, it was revealed that the left bank area extends to the Kala Oya and the right bank area to the Malwatu Oya. It is clear that the water level has been maintained at a high level due to the design so that it flows over the surface of the land.The structural form of the canal has been created so that the water flows on the surface by creating the banks at a low level and at a high level in the areas with high levels. For example, the height of banks in Mahailuppallam area is 15 feet, Aluthwewa and Amunukolaya banks are 9 feet high and Yakallegama Chhadagala bank area is 8 feet high. This is clear that the left bank of the canal is created and on the other side of the area, from the highest elevation of the right bank to the lowest elevation of the canal, the height of the Jedana Laksh varies and from the Jedana Laksh upwards, the heights vary according to the slope of the land.

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