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CONDITION MAPPING OF TANK CASCADE SYSTEM IN MADURAI USING GIS

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Abstract: Tank cascading refers to a process in which multiple tanks are arranged in series. The flow of water is tracked from the start of the river with covering the tanks through a canal system which the water flows. The total length, area and volume of the tanks are calculated using QGIS. Two types of data are collected viz. current data and old data. The two data are compared to find the difference in the area and the volume of the tanks in order to identify the difference in the capacity of the tank. Also, the canal system is visited and the current conditions of the canal system is noted. Structures like weirs, culverts, sluices are also visited and their condition of working is also analyzed. With the conditional data of the canal and the structures an asset map is created which indicates the conditions with different color notations which helps to easily identify the current conditions. By examining the Tank cascade system, we can come to a conclusion that more than half of the canal system is in poor state which has to be taken care in order to make the flow optimum. Also, the volume and the area of all three tanks are reduced, particularly the Paravai and Thenur tanks are in really bad state in terms of volume reduction which will affect the cultivation in that command area of those tanks. Old data were collected from the year 2010, in which the capacity of Thenur, Thodaneri and Paravai tanks were found to be 1.522357×10^8, 9.807259×10^5 and

9.284027 x 10^9. Similarly, the current data of these tanks were collected from the year 2022 and the capacities of these tanks were 1.186328 x 10^8, 9.403456 x 10^5 and 7.955615 x 10^9.Therefore, the difference in percentage of the Thenu, Thodaneri and Paravai tanks are found to be 22.07%, 4.11% and 14.30%. With the data collected and the asset map, a re-habitation suggestion is made in order to recreate the optimum working of the cascade system and maintain proper working.

Keywords: Tank cascade system, field survey, volume calculation & analysis, QGIS, Rehabitation suggestion.

I. INTRODUCTION

Tank cascading refers to a process in which multiple tanks are arranged in series. The flow of water is tracked from the start of the river with covering the tanks through a canal system which the water flows. The total length, area and volume of the tanks are calculated using QGIS. Two types of data are collected viz. current data and old data. The two data are compared to find the difference in the area and the volume of the tanks in order to identify the difference in the capacity of the tank. Also, the canal system is visited and the current conditions of the canal system is noted. Structures like weirs, culverts, sluices are also visited and their condition of working is also analysed. With the conditional data of the canal and the structures an asset map is created which indicates the conditions with different

colour notations which helps to easily identify the current conditions. With the data collected and the asset map a re-habitation suggestion is made in order to recreate the optimum working of the cascade system and maintain proper working. In a typical irrigation tank cascade system, water is collected from a water source, such as a river or rainfall, and stored in a primary tank located at a higher elevation. From there, water is released into secondary tanks or channels, which are situated at progressively lower elevations. Each tank or channel in the cascade system is strategically placed to serve specific areas of land or crops at different elevations. The water flows from one tank to another via gravity, without the need for pumps, which makes the system energy-efficient and cost-effective. Additionally, by distributing water evenly across various terrains, the cascade system helps in maintaining soil moisture levels and promoting uniform crop growth.This method of irrigation is commonly used in hilly or sloping terrains where traditional irrigation methods like surface irrigation or sprinkler systems may not be suitable. The design and layout of the cascade system are tailored to the topography of the land, maximizing water efficiency and minimizing erosion.

II. LITERATURE SURVEY

Water management using traditional tank cascade systems: a case study of semi-arid region of Southern India (Aman Srivastava, Pennan Chinnasamy, 2021): This study says that it is aimed to study the spatial and temporal aspects of the Vandiyur Tank cascade system to highlight the importance of water balance and other features.

Sustainability of village tank cascade systems of Sri Lanka: Exploring cascade anatomy and socio-ecological nexus for ecological restoration (Sujith S Ratnayake, Lalit Kumar, Punchi B Dharmasena, et, al., 2021): This study says that the Spatial and temporal features of the Vandiyur Tank cascade system is obtained by processing with modern software by Digital Elevation model, topographic maps and Google Earth Photos to analyze its sustainability.

Nature of small tank cascade systems and a framework for rehabilitation of tanks within them(Ramaswamy Sakthivadivel, Nihal Fernando, et, al., 1996): This study says that, in situations where data on hydrology and water consumption is insufficient, it offers a methodology for organizing the repair and enhancement of

small scale irrigation systems.

Water quality variation in a tank cascade irrigation system: A case study from Malagane Cascade (Kushani Mahatantila, et, al., 2011): The study looked at the role of hydrophytes in the upper periphery (Thaulla) and the fluctuation in the quality of the water in the cascade system.

Are cascade reservoir systems sustainable agroecosystems? (S Sirimanna, KKPN Kahathuduwa, et, al., 2022): According to the study, by comparing the aforementioned parameters in the chosen cascade system, the study evaluated the effectiveness, efficiency and resource footprint of village tank cascade system.

III. DATA COLLECTION & PROCESSING

There are two types of data that has to be collected to assess the cascade system, they are

- Tank Data
- Field survey data

Tank Data:

Firstly, the cascade system has to be delineated to obtain the length of the syatem then to assess the tank tanks we need several data of the tanks such as area, volume, depth in order to compare the data to conclude the suggestions to improve the working. Tank data of two different periods has to be collected to compare the features of the tanks. Current data of the tank and old data such as tank data before 10 years in time has to be collected to find significant differences in the tank features.

The Tank data can be either collected from the government through Public welfare department or it has to be acquired through web by using various softwares and tools such as QGIS, Google Earth Pro, Etc. The second option is carried out in the project to acquire the tank data. The data has to be collected only during the dry period since only when the exact depth and contour of the tank can be formed precisely and the tank data will be legit to carry out the process. If the data is collected with water or vegetation present inside the tank then the data will be not reliable and will produce uncertain results that cannot be used to produce proper suggestions at the end.

Tank data like the volume, area , depth, etc, are needed to be collected to compare the those with the current condition and the condition of the tank before atleast 10 years before to detect the changes in the topographical nature

and the opearaing changes of the cascade system. This is crucial in the part to give the rehabitation suggestion to improve the working of the tank and the cascade system.

To collect these data several softwares and tools have been used like QGIS, Google Earth Pro, TCX converter, etc. Firstly, using the Google Earth Pro the cascade system is delineated and the feartures like tanks were marked in the map. Then using the polygon tool, the tanks are delineated and the approximate area of the tanks are found. After that a random grid lines are formed over the tank area and the file is saved in KML format. Then in the GPS visualizer Website the KML file has to be selected then the file is converted into GPX File format and downloaded to the local system. The downloaded GPX file is the selected in the TCX converter and chose to be converted into CSV file format so that it can be added as a layer in the QGIS for further processing of the data. In the QGIS the CSV file is added a delimited file to import the elevation data accumulated from the Google Earth Pro. Initially it is formed as a csv layer then it has to be exported as a Shapefile (SHP) layer so that it can be processed using the plugins. Using the IDW Interpolation plugin available default in the QGIS the shapefile is chosen and converted into DEM analysed format which can be used to find the contour, Volume and area of the selected tank. Using the contour plugin the interpolated layer of the selected and the contour lines are generated which gives the idea about the structure of the tank with the elevation points mentioned over the contour lines this also helps to find the maximum depth of the tank system.

Finally, Using the Raster Surface Volume plugin the interpolated layer is selected and the base value of the tank is given as the input the volume of the tank is calculated and saved as a HTML file which gives the information about the Volume, Pixel Count and the Area of the tank. The intel is collected and used to compare with the previous or old tank data to find the changes in the nature of the tanks.

Field survey data:

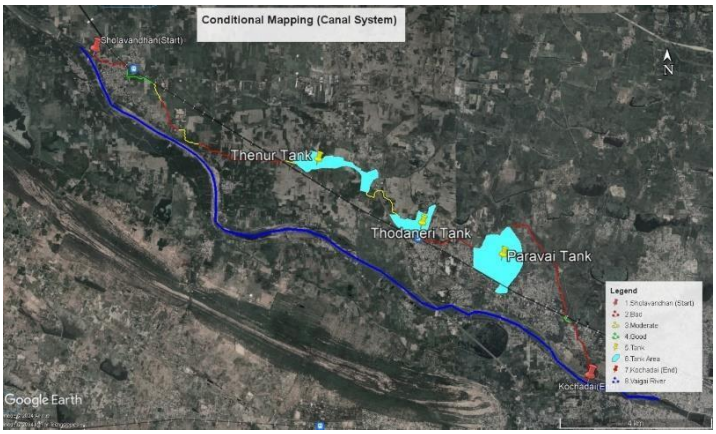
A field survey has to be conducted to get the idea of the condition of the canal system and the tanks. During the survey the condtions of the canal, structures and the tanks are noted in order to present the suggestion to improve the proper working of the cascade system. The intel collected during the field survey is later used to provide rehabitation suggestion and create a assest map contains the working conditions of the canal system and the structures present in the system.

Conditional Assessment:

During the field survey the conditions of the canal system and the structures in the canal system inspected and noted then using the conditional data a table is created with mentioning the working of the structures and their working conditions which helps to get the idea about the conditions of the cascade system and makes easy to identify the spots where intensive care has to be taken in order to get the optimum working rate of the canal system.

Conditional Mapping:

After conditional Assessment those data are used to create a conditional map which contains the information about the current conditions of the canal system and the structures present in the canal system. This comes in handy to know where the working of the canal system is very crucial and where it is well maintained and makes easy to give re-habitation suggestion. Different colour notations are used to indicate the working condition of the cascade system.



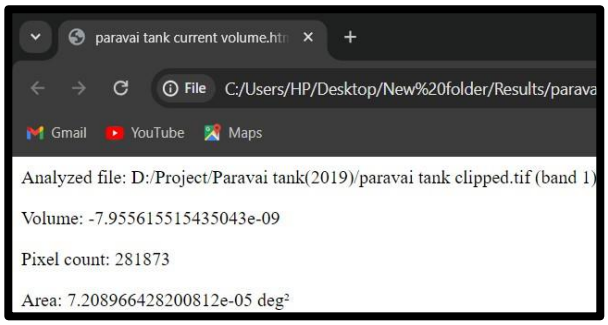
Rehabitation Suggestion:

The Re-habitation suggestion gives the ideas how to repair and maintain the cascade system to work in its full potential. The areas where the cascade system fails are noted down and the suggestion which improves the condition is given according to the problems faced on that particular area. This will improve the flow rate of the water through the canal system and can also increase the amount of water that can be stored in the tanks with minimizing the loss of water due to any structural malfunctions.

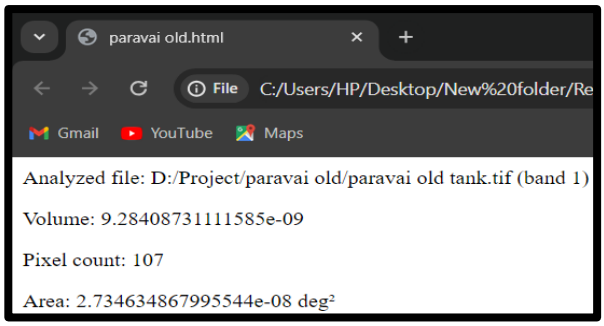
IV. RESULT

After completing the processing to all the current and old tanks the results are compared to conclude the change in the topographical features, like volume, area, depth, etc.

Paravai Tank:



Current volume



Old Volume

Volume Calculation:

Decrease of volume in percentage:

Formula $= \frac{[\text{Old Volume} - \text{Current Volume}]}{\text{Old Volume}} \times 100\ (\%)$

Paravai Tank:

Old volume of the tank = $9.284027 \times 10^9\ m^3$

Current volume of the tank = $7.955615 \times 10^9\ m^3$

Decrease in volume of the tank

$= [(9.284027 \times 10^9 - 7.955615 \times 10^5)]$

$= 1.328412 \times 10^9\ m^3$

Difference in volume of the tank

Tank Name	Old Volume (m^3)	Current Volume (m^3)	Difference (%)
Paravai	9.284027×10^9	7.955615×10^9	14.30
Thenur	1.522357×10^8	1.186328×10^8	22.07
Thodaneri	9.807259×10^5	9.403456×10^5	4.11

Rehabiattion Suggestion:

LOCATION	SLUICE CONDITIONS	CHANNEL CONDITIONS	FLOW CONDITIONS
SOLAVANDHAN 10° 1'32.43"N 77°57'23.53"E (STARTING POINT)	The sluice is in Proper Working Conditions.	Patch Work Needed for bund walls. There is a Growth of *prosopis juliflora* (karuvela maram) Along the Bunds of the Channel. Removing process need to be done.	The flow in the channel is interrupted by growth of "WATER HYACINTH". Removing process need to be done.
CANAL AT 10° 1'30.46"N 77°57'27.68"E (CP C 1)	-	Vegetation cover along the bunds of canal. Removal process need to be done.	The flow in the channel is interrupted by growth of Water Hyacinth and Greeny Mosses. Sewage water is mixed along the flow of the river water.
THENUR TANK	FARMSLUICE 1: Covered with vegetations. The vegetations should be cleared.	The channel is in proper working condition.	There is a proper flow of water for irrigation purposes.
THODANERI TANK	SLUICE 2: The sluice is in good working condition.	The bunds of channel are not in a proper condition. The bunds should be reconstructed properly.	The water flow is interrupted by vegetative covers and waste materials. Cleaning process is need to be done.

= {[1.328412 x 10^9] / [9.284027 x 10^9]} x 100

= **14.30%**

Volume Table:

	SUPLUS WEIR 1: The surplus weir in damaged in conditions. The weir should be reconstructed.	The channel bunds are in poor conditions. Reconstruction of the bunds is required.	The water flow is interrupted by vegetative covers and waste materials. Cleaning process is need to be done.
PARAVAI TANK	SURPLUS SLUICE 2: The sluice is in proper working condition.	The bunds are not in proper conditions. The bunds should be reconstructed.	The flow of water is interrupted by the growth of greeny mosses. It should be removed To maintain a proper flow of water.
KOCHADAI 9°56'52.09"N 78° 4'28.07"E (ENDING POINT)	-	The channel is not accessible due to over vegetative growth. The vegetative growth should be removed.	The flow of water is interrupted by the growth of greeny mosses. It should be removed To maintain a proper flow of water.

V. CONCLUSION

By examining the Tank cascade system, we can come to a conclusion that more than half of the canal system is in poor state which has to be taken care in order to make the flow optimum.

Also, the volume and the area of all three tanks are reduced, particularly the Paravai and Thenur tanks are in really bad state in terms of volume reduction which will affect the cultivation in that command area of those tanks.

Most part of the canal system does not have a proper route to inspect which shows that the canal system is not maintained properly hence many areas are inaccessible those areas have to be cleaned in order to supervise the canal system effectively.

Throughout the canal system vegetation cover has been found which drastically decreases the water quality which can lead to infectious diseases to those who uses it for consumption and other purposes.

In some parts of the canal system specifically near high human population garbage and sewage water are allowed to mix with the canal this makes the water unusable and can create serious health issues to those live near and who consume the water.

Since the untidy water is allowed to flow through the next tank the fields which use this water to irrigate their crops can also be caught with diseases that could end up in crop dead or even soil nutrition degradation.

The mixing of sewage water and garbage has to be eliminated to ensure fresh water flow through the canal system.Vegetations are found inside Thodaneri and Thenur tanks which has to be removed to prevent waste water consumption and to increase the volume of those tanks. A little rust formation was found on some gates and sluice which can be removed at ease to prevent future failure of those structures.

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