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Role of Lateral Tanks in Improving Water Management Under the Dry Zone Cascade System

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ABSTRACT

The best water management has existed since ancient period in the dry zone of Sri Lanka because of the cascade system. Tanks are inter connected to carry water tank to tank and water circulate longitudinal along the cascade from upstream to downstream in the cascade system. But, sometimes water circulates among parallel lateral tanks. Localized rainfall and dry spells have been highly increased as a result of changed rainfall patterns because of climatic change. The aim of this study was to identify the role of lateral tanks in improving water management under the dry zone cascade system. Muriyakalla - Perimiyankulama tanks in Muriyakalla cascade and PahalaAmanakkattuwa, Pahalawewa and Thorapitiya tanks in Mahakanumulla cascade was used for the study. The primary data were being collected using questionnaires, check lists, focus group discussions, key informants and Global Position System (GPS). The secondary data were collected from Department of Agrarian Services, Divisional Secretariats and Topographic maps at the scale 1: 50,000. The difference of elevation in every tank was 00 to 04 meters. Breaches of tanks and the cascade had been because of there was not regular maintenance. The lateral tanks can be introduced as "A tank system which water circulates as parallel among tanks which are located parallel elevation in a cascade system". Also, there is a relationship between present condition and maintenance with breaches of tanks and cropping intensity of paddy fields. And, lateral tanks are the best solution for the drought and flood as a water management method.

KEYWORDS: *Cascade, Dry Zone, Lateral Tank, Water Management*

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1. Introduction

A best water management has been since the ancient period in the dry zone of Sri Lanka because of the cascade system. The dry zone is located in the lowest peneplain in the island. And the annual rainfall of the dry zone is 1000 – 1250 mm. Generally there is a water scarcity in the dry zone. The scant water resource of the dry zone could be used with the best manageable techniques because of the tank system. Most of the researchers were studying about the tank system in the dry zone in the near past. The basic and excellent characteristics were found in the system and called it as the cascade system by them.

The cascade system means "connected series of tanks organized within the micro (or meso) catchments of the Dry Zone landscape, storing, conveying and utilizing water from an ephemeral rivulet" (MaddumaBandara 1985, Panabokke 2002).

Tanks are inter connected to carry water tank to tank and water circulate longitudinal along the cascade from upstream to downstream in the cascade system. But sometimes water circulates among parallel lateral tanks. A lateral tank can be generally defined as tank share water among the other parallel tanks at the same elevations. According to the MaddumaBandara, Yatigammana and Paranavithana (2010) there are lateral connectivity tanks in Ethdathkalla, Katukeliyawa, Aliyawetunuwewa and Pandigama tank systems in the dry zone.

The lateral tanks are the best technique of water management in the dry zone in Sri Lanka. Because of water flows one side in a season of the year and water flow other side in the other season in the year in some lateral tank systems. Therefore the lateral tank system can be used for water management in the dry season.

2. Statement of the Problem

There is a water scarcity in dry zone nowadays. Especially it could be seen in North Central Province in Sri Lanka. The important reason of it is the destruction of tank systems in that area. When new water and other projects are being built, most of the tanks were accumulated. As a result, inter connections of tanks were destroyed. Therefore the ability of water management in tank systems was cracked.

A Climate of Sri Lanka has been changed since the near past season. As a result of climatic change rainfall patterns have changed. Also localized rainfall and dry spells have been highly increased. The lateral connectivity tanks are the best solutions to overcome that problem. The aim was of the researcher to do this study identifies the role of lateral tanks in improving water management under the dry zone cascade system.

3. Objectives of the study

The objectives of the study can be divided as general objective and specific objectives. The general objective of the study was to identify the role of lateral tanks in improving water management under the dry zone cascade system.

Also there were several specific objectives of the study. They were to find out what are the lateral tanks, to examine how locate the lateral tanks in a cascade system, to examine the performance of the lateral tanks in the different seasons, to find out the role of lateral tanks in improving water management.

4. Review of Literature

Sri Lanka can be divided two major climatic zones as the wet zone and the dry zone. At the base level dry zone was defined as that "part of the island receiving 1270 – 1905 mm of rainfall" (MaddumaBandara, 1985). And generally the dry zone covers over 60% land area of Sri Lanka.

The dry zone of Sri Lanka can be defined as the lying in room of the ancient hydraulic civilization in monsoon Asia. There was a high level of water resources management in dry zone since the ancient times because of the tank system. The ancient hydraulic civilization grew with its three salient components; i.e. the tank, paddy field and the dageba (MaddumaBandara, 1985). According to the register of Irrigation Projects (1975) there are 3119 minor irrigation tanks have spared in the dry zone. MaddumaBandara (1984) estimate that the total number of tanks in use and in abandoned state exceeds 12,000. Also minor

irrigation schemes in Sri Lanka closer to 200,000 and it is 40% of the total minor and major irrigation schemes (MaddumaBandara, 1985).

According to the ancient water management system, it has developed with tank cascade system. "A cascade is a connected series of tanks organized within a micro catchment of the dry zone landscape, storing, conveying and utilizing water from an ephemeral rivulet" (MadumaBandara, 1985). Panabokke, Shkthivadivel and Weerasinghe (2002) indicated "all cascades are located within either a second order inland valley, or a first order ephemeral stream. It should also be borne in mind that there is no dry season flow in these ephemeral streams from February to October except for the first order ephemeral streams which get reactivated for a very short period with the March – April rains. These small tank cascade systems constructed in ancient times could be considered as unique irrigation systems with a distinctive assembly of land uses". Also Dharmasena (2010) has introduced a schematic representation of the physical layout and the various components that make up the small tank farming system in ancient dry zone of Sri Lanka.

MaddumaBandara, Yatigammana and Paranavithana (2010) refer water circulation in a cascade is not only longitudinal along the cascade from upstream to downstream but also it happens sometimes between parallel lateral tanks. MaddumaBandara, Yatigammana and Paranavithana (2010) have done some researches about the role and relationship of lateral tanks (*baendiwew*) in several cascade systems. They have researched at Ethdathkalla lateral tank system, Katukeliyawa tank system, Aliyawetunuwewa tank system and Pandiggama tank system. According to their findings high level lateral tank connections can be identify Ethdathkalla and Pandigama tank systems even today.

Older one inch topographic maps in Sri Lanka indicated Ethdathkalla, MahaHelambawewa and Millawetiya tanks are created by the extend of same tank bund. As well as these all three tanks were located in a same contour line and there are few differences of the spill levels. Therefore in rainy seasons water has would be flowed to Ethdathkalla in rainy seasons. And there is an old lateral cannel between Ethdathkalla and Millawetiya. The difference of the levels of the lateral connectivity canal is 50 mm. So it can be consider as a same level canal between the two tanks.

Pandigama cascade cluster has been created by a system of seven small tanks. Large scale tanks of the system are Mahawewa, KudaWewa and ThalgasWewa. The direction of water flow was from ThalgasWewa to KudaWewa and then to Mahawewa. According to the measurements of critical points the spill levels of these three tanks were less than 15 cm. The aim of these minor level differences would be share the water with parallel tanks. The level difference of the old cannel between Nala Ganga Wewa and KudaWewa is 125mm. Also the spill level difference between KudaWewa and MahaWewa is 90 mm. Also there is a lateral connection between tanks of the Katukeliyawa and AliyawetunuWewa tank systems.

MaddumaBandara, Yatigammana and Paranavithana (2010) indicate lateral flow tank systems may prove valuable for rational water management in the future because of the extremes patterns of localized rainfall and dry spells that are likely to happen now with increased frequency.

5. Methodology

Two study area are using for the study. They are Muriyakalla and Perimiyankulama tanks at Galkulama and Pahala Amanakkattwa and Pahalawewa at Thirappane. According to Panabokke (1999) these study areas situated in the same watershed and sub – waters head. Several causes were based for the selection of these study areas. Malwathu Oya water shead which is situated the study areas, is the watershed with the high density of cascades in the dry zone.

These study areas are situated near by Anuradapura. Anuradapura was the center of the hydraulic civilization of Sri Lanka in the ancient times. Also, many of cascade case studies have done in the Mahakanumulla cascade. But no one has studied the lateral connectivity of the Pahala Amanakkattuwa and Pahalawewa tanks. That causes have motivated the researcher to select these study areas.

The methodology of the study consisted with research design, population, sample and sample techniques, data collection, and data collection instruments and data analysis. This study involved the analysis of the role of lateral tanks in improving water management under the Dry Zone cascade system. The research had been designed survey based.

The target population for the study was included the members of the farmer organizations established in Perimiyankulama and WalagambahuwaGramaNiladari divisions. Researcher used a sample for collecting data from the population. Sample was selected in randomly. 25% selected from the population as the sample. Details of the sample are as following.

Table 01: Details of the sample

Farmer organization	Population	Amount of sample	Sample selection method
Perimiyankulama	86	22	Randomly
Walagambahuwa	42	12	Randomly

Questionnaire method has been used as a primary data collection method. As well as key informant interviews has been used as a data collection method. Office bears of the farmer organizations, Agriculture Research Development Officers (Krupanisa) and yayanoyojitha were the key informants. Both of focus group discussions and check lists used as the data collection methods. And Global Positioning Systems (GPS) used get the GPS points of the study area. And the secondary data collected from several of institutions and maps. Source of secondary data were Department of Agrarian Services in Thirappane, GramaNiladari offices, Thirappane Divisional Secretariat, Topographic maps at the scale 1:50,000 and 1:10,000 and Google satellite images.

The data was analyzed using the computer software known as Microsoft Excel and average, hypothesis testing was the data analysis methods. As well as Arc GIS was used for design the map of the lateral connectivity tanks in the study area.

6. Results and Discussion

The PahalaAmanakkkattuwa and PahalaWewa tanks are located in a same tank bund. However in another tank which is the Thorapitiya tank has located in the tank bund. Location of the Thorapitiya tank could be identifying in the field survey. As well as the Thoraritiya tank is a small tank and it has not mentioned even 1:50,000 topographic maps. According that the PahalaAmanakkattuwa, PahalaWewa and Thorapitiya tanks have located in "U" shape tank bund. Water of the PahalaWewa tank is circulating to the Thorapitiya tank through a culvert situated under the tank bund. The elevation of the PahalaAmanakkattuwa and Thorapitiya tanks in two sides of the culvert are as following.

Table 02: Elevations of the PahalaAmanakkattuwa and Thorapitiya tanks

Elevation of the PahalaWewa tank	132 m
Elevation of the Thorapitiya tank	132 m
Difference of the elevations	00 m

(Source: Field GPS point data, 2015)

According that it can be see the PahalaAmanakkattuwa and Thorapitiya tanks have located in same tank bund and same elevations.

Also the PahalaAmanakkattuwa and PahalaWewa have located in same tank bund. When the PahalaWewa tank is spilling, the farmers cut the tank bund and the overflow water of the PahalaWewa circulates to the PahalaAmanakkattuwa tank through a plain. The elevation of the spill of PahalaWewa tank and inlet of the PahalaAmanakkattuwa tank are as following.

Table 03: Elevations of the PahalaWewa and PahalaAmanakkattuwa tanks

Elevation of spill of the PahalaWewa	123 m
Elevation of inlet of the PahalaAmanakkattuwa tank	119 m
Difference of the elevations	04 m

(Source: Field GPS point data, 2015)

According to the above table there is 04 meters difference of the spill of the PahalaWewa and the inlet of PahalaAmanakkattuwa tanks. However the two tanks have located in the same tank bund. And the distance from the spill of the PahalaWewa tank to inlet of the PahalaAmanakkattuwa tank are 215 meters.

The PahalaWewa, PahalaAmanakkattuwa and Thorapitiya tanks are located in same tank bund and the importance of that location is the safety of the PahalaWewa because the tank bunds of the PahalaAmanakkattuwa and Thorapitiya has made as fit to the middle part of the tank bund of the PahalaWewa tank. The middle part of a tank is with high pressure of water and it can be breached. But the tank bund of the PahalaAmanakkattuwa is safe and reducing the breaching probability because of above creation. As well as the tank bund has made by the clay of kirala and it reduces the erosion of the tank bund.

Muriakalla and Perimiyankulama tanks are laterally connected. The Muriyakalla tank has divided two parts as right part and left part of a rock plain. In the drought seasons that two parts can be seen clearly because the rock plain is emerging. And in rainy season the tank is filling with water and the two tanks can be seen as one tank. The elevations of the two parts of the Muriyakalla tank are as following.

Table 04: Elevation of the two parts of the Muriyakalla tank

Elevation of the left part of the Muriakalla tank	120 m
Elevation of the right part of the Muriakalla tank	119 m
Difference of the elevation	01 m

(Source: Field GPS point data, 2015)

According that the left and right parts of the Muriyakalla tank has located with 01 meters of difference of the elevation. And the rock plain which is in the middle of the Muriyakalla tank is with 122 meters of elevation.

The overflow water of the Muriyakalla tank circulates to the Perimiyankulama tank along a channel. The channel is about 01 feet deep and it connects the tank bunds of the Muriyakalla and Perimiyankulama tanks. The distance of the channel is 215 meters.

The elevation of the spill of the Muriyakalla and the inlet of the Perimiyankulama tanks are as following.

Table 05: Elevation of the Muriyakalla and Perimiyankulama tanks

Elevation of spill of the Muriyakalla tank	115 m
Elevation of inlet of the Perimiyankulama tank	114 m
Difference of the elevations	01 m

(Source: Field GPS pond data, 2015)

According to the above table the difference of the elevations of the spill of the Muriyakalla tank and the inlet of the Perimiyankulama tank is 01 meters and the tank bunds have connected with a channel.

Analyze the data of the maintenances, changes (breaching and new constructions) of tanks and its cascade because the maintenances and changes are effect to the laterally connected water management. That situation could be seen by this study and it can be summarized as following.

Table 06: Maintenances and floods of studied tanks in last five years

Name of the tank	Maintenances (In last five years)	Floods (In last five years)
PahalaWewa	No	2011, 2012, 2013, 2014
PahalaAmanakkattuwa	2012, 2013	2011, 2012, 2014
Muriyakalla	**No**	**2012, 2014, 2015**
Perimiyankulama	**No**	**2012, 2014, 2015**

(Source: Field survey data, 2015)

According to the above table flood has occurred and damaged paddy lands of PahalaWewa tank in last five years because of there was not maintenance. Also there were not floods and paddy land damages in year of 2013 because of PahalaAmanakkattuwa tank was maintained in years of 2012 and 2013. However there

were not maintenances in both of Muriyakalla and Perimiyankulama and floods were occurred and damaged paddy lands in years of 2012, 2014 and 2015.

Also it was studied the conditions of several importance elements in the tank's reserve as Kattakadwa, Yathruwala, Gasgommana, Perahana, Iswetiya, Godawala and Kiwul Ela in every studied tanks. According to the data of condition of those elements, every element was weak and has faced for distraction. Therefore tank and its water management were weak level.

It was studied the issues of every tanks which is used for the study. According to the data analyzing water scarcity in Yala cultivation cultivation season, water born plants in the tank, siltation of the tank, destroyed elements of the tank, decline the tank environment were the major issues of PahalaWewa tank. And the issues

ofPahalaAmanakkattuwa tank were water scarcity in Yala cultivation season, siltation of the tank, water born plants in the tank, land usage cultivations without permission in the catchment area, destroyed elements in the tank and decline the tank environment.

Water scarcity in Yala cultivation season, wasting the water of the tank, water born plants in the tank, siltation of the tank, destroyed elements of the tank and decline the tank environment were the major issues of Muriyakalla tank. The major issues of Perimiankulama tank were water scarcity in Yala cultivation season, wasting the water of the tank, water born plants in the tank, siltation of the tank, destroyed the elements of the tank and decline the tank environment.

As well as it has been studied the eco system changes in every tank which is used for the study. According to that water born plants in the tank, destroyed the catchment area, destroyed the elements of the tank, fallow the native fishes, reduced the birds, destroyed the gasgommana, cultivations without permission in the catchment area, destroyed the whole tank environment are the changes of the tank ecosystem of the PahalaWewa tank. And the changes of eco system in PahalaAmanakkattuwa tank are destroyed the catchment area, fallow the native fishes, destroyed the elements of the tank, cultivations without permission in the catchment area, destroyed the whole tank environment. Water born plants in the tank, fallow the native fishes, reduced the birds, destroyed the elements of the tank are the changes of tank's ecosystem of the Muriyakalla tank. Changes of tank's eco system of the Perimiyankulama tank are water born plants in the tank, destroyed the elements of the tank, fallow the native fishes, destroyed the whole tank ecosystem, destroyed the whole tank environment, cultivations without permission in the catchment area and reduced the birds.

Also it has collected the data of cropping intensity of paddy lands under every tank and those data analyzing as following.

Table 07: Cropping intensity in paddy lands cultivated under the studied tanks

Name of the tank	Cropping intensity									
	2010		2011		2012		2013		2014	
	Yala	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala	Maha
PahalaWewa	0	1	0.416	1	0	1	0.555	1	0.4236	1
PahalaAmanakkattuwa	0	1	0.424	1	0	0.984	0.454	1	0.075	0.90
Muriyakalla	0.352	1	0.470	1	0.470	1	0.411	1	0	1
Perimiyanklama	0	0.666	0	0.833	0.333	0.833	0.333	1.	0	1

(Source: Department of Agrarian Services, Thirappane)

According to the above table there is high cropping intensity in Maha cultivation season under every tank but there is low cropping intensity in Yala cultivation season within last five years.

The water management is doing by a same method in every tank. The activities connected with the cultivation lands under the tank controlled by the farmer organization and the officer named yayaniyojitha. The yayaniyojitha is elected by the ballot of the farmers. Yayaniyojitha have responsibilities of tank,

organize the maintenances of channels and enforce the decisions that were taken in the kanna meeting that is the most important decision making body of the water management of tank.

Also it has made two maps of lateral connectivity tanks of the studied areas by the researcher. Those maps are as following.

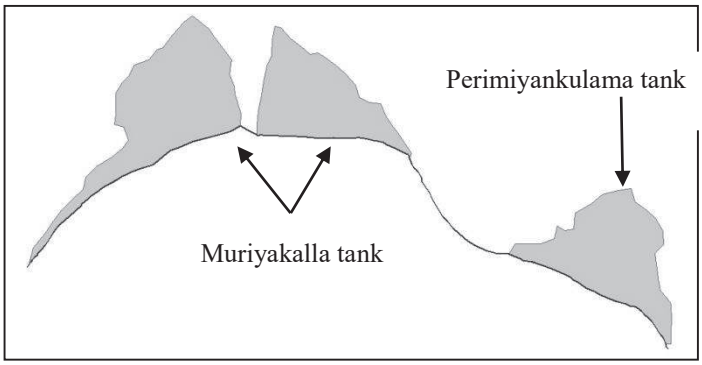

Figure 01: Map of the Muriyakalla and Perimiyankulama tanks

According to the above map Muriyakalla tank have divided two parts and the Perimiyankulama tank bund have connected with Muriyakalla tank bund by a soil bund.

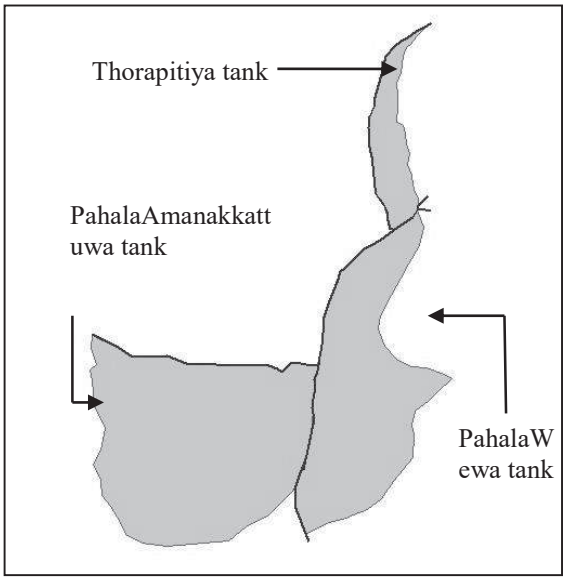

Figure 02: Map of the PahalaWewa – PahalaAmanakkattuwa and Thorapitiya tanks

According to the above map the tank bund of PahalaWewa, PahalaAmanakkattuwa and Thorapitiya tanks have connected with each others. As well as Thorapitiya and PahalaWewa tanks are locted in same elevation and those tanks have divided by the tank bund of the PahalaWewa tank.

7. Conclusion and Recommendation

It can be identified a lateral connectivity in the tanks of the study areas. Water is circulating among those parallel tanks. Also the lateral tanks can be defined as “A tank system which water circulates as parallel among tanks which are located parallel elevation in a cascade system”.

The flooding probability in rainy seasons is reduced in the lateral tank system because the exceed water circulate to the parallel tanks. As well as if a tank is dry because of reducing rainfall or destroying water supplies in the upper catchment area or destroying the catchment area in a lateral tank system, water is circulating to the tank from the parallel tank. So lateral tanks are the best solution for the drought and flood

as a water management method.The breaching probability of lateral tanks is less than other tanks because when the tank is filling exceed water circulates with parallel tanks. Therefore lateral tanks are suitable for the safety of the tanks.

Water is circulated between parallel tanks in the lateral tank system. So if water reduced a tank by destroying the catchment area the paddy cultivation under the tank can be done continuously because water circulate from another parallel tank. So it can be getting the water to the paddy fields in best level.

Water scarcity in Yala cultivation season, the silt of the tank and increase the water burn plants in the tank are the major issues which are effect to reduce the water management of the studied lateral connectivity tanks. Those issues have close relation to reduce the water management in a tank. So the water management has reduced because of those issues in every studied tank. Therefore the importance and water management of the lateral connectivity tanks have reduced by those issues.

Decline the major elements of the tank and destroying the catchment is the major changes of the studied tanks.The field survey showed those are the major changes of the tank ecosystem in every tank. The water management and life of the tank is reduced because of those changes.

And there is a relationship between the tank maintenance and flooding in the studied areas because when the slit filling to the tank capacity of the tank is reduced and it causes to the flooding.The cropping intensities of all tanks in Yalacultivation season are less than the Mahacultivation season because there is low rainfall in Yalacultivation season. As well as the water capacity of all tanks have reduced by situation and the over population of weed and water born plants in all tanks. The water for paddy fields is reduced and the cropping intensity is reduced. According that it can be identified a relationship between the cropping intensity and tank maintenance.

Water management of the every tank is activated under the farmer organization. In this method the decisions are getting by commonly. So it can be satisfied about the decision making, decision making body and the decisions about the water management.

And following recommendations can be indicate for improving the role of studying lateral tanks.

- It must be activated the tank maintenances.
- Continue the tanks in current shape.
- It should reestablish the major tank elements.
- Safeguard the tank catchment area.
- Regular the water management method because some problems have arisen between the farmers in water management.

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