IDENTIFICATION OF CASCADE SYSTEMS AND ASSESSMENT OF THE PERFORMANCE OF VILLAGE TANKS AT MADUKANDA AGRARIAN SERVICE CENTRE

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ABSTRACT: *The objective of the study was to identify the cascades in the village tanks and to assess the performance of the tanks in the cascades. ArcGIS 10.2.2 and QGIS 2.8.2 software platforms were used to identify the cascades among the minor irrigation tanks in Madukanda Agrarian Service Centre in 2017. The study identified that there were 4 tank cascades consisting of 48 tanks with each of 15, 11, 6 and 16 village tanks in Madukanda area and twelve isolated tanks. The remaining 5 tanks were at the boundary of the study area. Among those 60 tanks in working condition, 44 tanks were randomly selected to assess the performance of village tanks. Cropping intensity and hydrological endowment were used to assess the performance of the tanks. Results revealed that 64% of the tanks were with good hydrological endowment whereas 36% of the tanks were with poor hydrological endowment. The average tank density was one tank per 2.68km^2 in the study area. The average yield under village tanks, good hydrological endowed tanks and under poor hydrological endowed tanks were 4456 kg/ha (0.44 kg/m^2) 4260 kg/ha (0.42 kg/m^2) and 2880 kg/ha (0.28 kg/m^2) respectively. The average cropping intensity and average yield of good and poor hydrological endowed tanks was statistically tested using t-test and found to be significant. Nearly 78% of the good hydrological endowed tanks had the cropping intensity of greater than one. Identification of the cascades would be useful to carry out rehabilitation activities which are essential to improve the tank performance in this district where tanks are the main source of water for irrigation.*

KEYWORDS: Cascades, Cropping intensity, Hydrological endowment, Rehabilitation, Tank performance

1.INTRODUCTION

In Sri Lanka, there are 24,199 minor tanks; under these 11257 village tanks and 12942 anicuts, while major tanks are nearly 542; under that 322 reservoir, 112 anicut, 96 drainage, flood protection and saltwater exclusion, and 12 are lift irrigation schemes. (Anon, 2008). Majority of these minor tanks are found in Kurunagala, Anuradhapura and Vavuniya.

Vavuniya is located in the Northern Province of Sri Lanka. It covers an area about 196,700.96 ha (1967.00 Sq km). Recent surveys indicated that 38% of the total land is engaged in Agriculture and 47% of the land is with forest cover. About 21,000 ha land is used for paddy cultivation of which 11,000 ha is irrigated by village tanks. In addition to this there are about 10,000 ha under perennial and other crops.

There are one Major, 21 Medium tanks and 674 Minor irrigation tanks including 26 anicuts in this district. The water resources mainly depend on rain fall as there are no perennial rivers. Out of the 674 Minor Irrigation Schemes (village tanks), 41 are abandoned. The water resources mainly depend on rainfall as there are no perennial rivers. Under the world bank funded project, improvement of 103 minor schemes were completed by end of April 2005 and also 22 minor

tanks were improved under the 10,000 minor tank rehabilitation program in year 2004. (Statistical Information 2011).
Even though there is enough rainfall during the rainy season there is no means of storing the water due to the limited capacity of available tanks. This is mainly due to the siltation and improper maintenance of tanks. Rehabilitation of tanks without the knowledge about cascades created the problem of inundation in the adjacent tanks in the recent past.

The cascades of interconnected village tanks influence the surface and subsurface hydrology in Vavuniya. Village tank cascades contribute for recharging of groundwater maintain sustainable and optimum stocks of groundwater for human consumption as well as for agriculture utilization. Hence, improving village tank cascades will provide opportunity for enhancing livelihood of households in villages while contributing to national food production.
The objective of this study was, to map spatial distribution of village tank cascades, to assess the performance and potential of cascades.

2.METHODOLOGY

Madukanda Agrarian Service Centre (ASC) located in Vavuniya South Divisional Secretariat was selected as the study area. Madukanda ASC is consisted of 12 Grama Niladhari Divisions. Geo-morphologically, Vavuniya is a flat plain having undulated topography with broad valleys and small rock ridges forming cascades of irrigation tanks.
Identification of village tank cascades under the area belongs to Madukanda Agrarian service center was done with the combination of remote sensing and GIS approaches using available maps and field investigations. For statistical analysis Minitab 15 was used.

Mapping of tank distribution was done by using Quantum GIS 2.8.2 software. Tanks were digitized, and a tank shape file was developed by using an available map and the time series satellite data were used as base layer. 1:10000 map was used as the base map. The location of the tanks was also found out using the coordinates which were obtained using GPS device. One common coordinate system, Kandawala Sri Lanka Grid was used for every created map.

Digital Elevation Model (DEM) of Vavuniya district was clipped in order to create the flow direction map for the study area. The DEM was created using contour maps which were in the format of contour lines and points. Using elevation information a triangulated irregular network (TIN) was created which was then used to create the DEM. TIN file was prepared using Created TIN tool in Arc GIS 10.2.2 software. The DEM file for the study area was created as a square which could cover the total study area. Hence it would not collapse the stream flow.
Fill sink, flow accumulation, flow direction maps were prepared using hydrological tools in Arc GIS 10.2.2 software in order to understand the flow

pattern in the cascades. Then the flow pattern was validated at the field with local farmers' knowledge in the respective tanks.

Flow lines were extracted using threshold values 100, 200, 500 and 1000. The most suitable threshold value for the study area was selected based on the field investigations, past records and Google map. Finally, the created flow accumulation map was overlaid with the digitized tank shape file and tank cascade system map was developed. Mapping accuracy was assessed using field verifications and exact threshold value was selected as 100 for flow accumulation map.

Cropping intensity and the hydrological endowment were analysed in order to assess the performance of the tanks. The cropping intensity of any tank could be defined as the area irrigated or cultivated during the Maha season divided by the total command area under the tank, only during maha season, irrigated area was considered because there was a very little yala season cultivation available (Sakthivadivel, et al., 1996). In this study, area irrigated or cultivated during whole year was used to obtain the cropping intensity. The cropping intensity was used to assess the tank performance within the available land area.

If the ratio of cascade area / water spread area greater than 8.0 and the ratio of a tank capacity/ command area was around 2.0 then it was considered as a good hydrological endowment. Good hydrological endowment lead to better tank performance (Panabokke, et al., 2002). This concept was used to assess hydrological endowment of the tanks in this study.

3.RESULT AND DISCUSSION

In this study four cascades comprising 60 tanks identified in Madukanda Agrarian Service Centre which consists of 65 tanks. Identified cascades were shown in Figure 1. Among them 57 tanks were in operation while three tanks were abandoned at present. The remaining 5 tanks were at the boundary of the study area. Based on the GN divisions in study area the highest number of tanks belonged to Madukanda and the lowest number of tanks were recorded in Ausathapitiya.

Table 1 showed the the average yield under village tanks, good hydrological tanks and under poor hydrological endowed tanks were 4456 kg/ha (0.44 kg/m^2), 4260 kg/ha (0.42 kg/ m^2) and 2880 kg/ha (0.28 kg/m^2) respectively. The main reason for yield reduction was reported as inadequate water.

Table 1. Comparison of average yield with hydrological endowment.

Classification	Average yield (kg/ha)
Village tanks in Vavuniya	4456
Good hydrological endowed tanks	4260
Poor hydrological endowed tanks	2880
P value (95% CI)	0.026

Significant difference was observed for the average yield in 2015 between good hydrological endowed and poor hydrological endowed tanks at 95% confident interval

(Table 1). There was a marked reduction in the average paddy yield in poor hydrological endowed tanks when compared to that in good hydrological endowed tanks and in village tanks of Vavuniya district. This may be due to inadequacy of water in the village tanks for irrigation.

Table 2. Comparison of cropping intensity with hydrological endowment.

Classification	Mean Cropping Intensity
Good hydrological endowed tanks	1.70
Poor hydrological endowed tanks	0.63
P value (95% CI)	0.001

Significant difference was observed for cropping intensity during yala and maha seasons between good hydrological endowed tanks and poor hydrological endowed tanks at 95% confident interval (Table 2).

There were three tanks namely Minimarichchanwewa, Puthiyasinnakulam and Mamaduwa tanks had shown cropping intensity less than one even though they were with good hydrological endowment (Table 3). Farmers reported that poor soil fertility, damage by animals and some unsuitable cultivation practices were the reasons for the reduction in paddy cultivation.

The study done by Sudusinghe et al., (2016) showed that the average tank density was one tank per 2.65 km^2 in Kovilkulam ASC region in Vavuniya. It was also reported by Panabokke et al, (2002) as one tank per 2.6 km^2 for the Northern Province, North Central Province and Sabragamuwa province and Akther et al., (2014) reported that the tank density was one tank per 2.68 km^2 in Vavuniya district. These findings indicate that the tanks are distributed everywhere in the respective regions.

The identified cascades with water flow pattern at Madukanda ASC using ArcGIS was shown in Figure.1.

Table 3. Average Cropping Intensity in Study Area.

Average Cropping Intensity (ACI)	Percentage of Tanks
>1	41%
1-0.85	32%
0.85 – 0.6	11%
< 0.6	16%

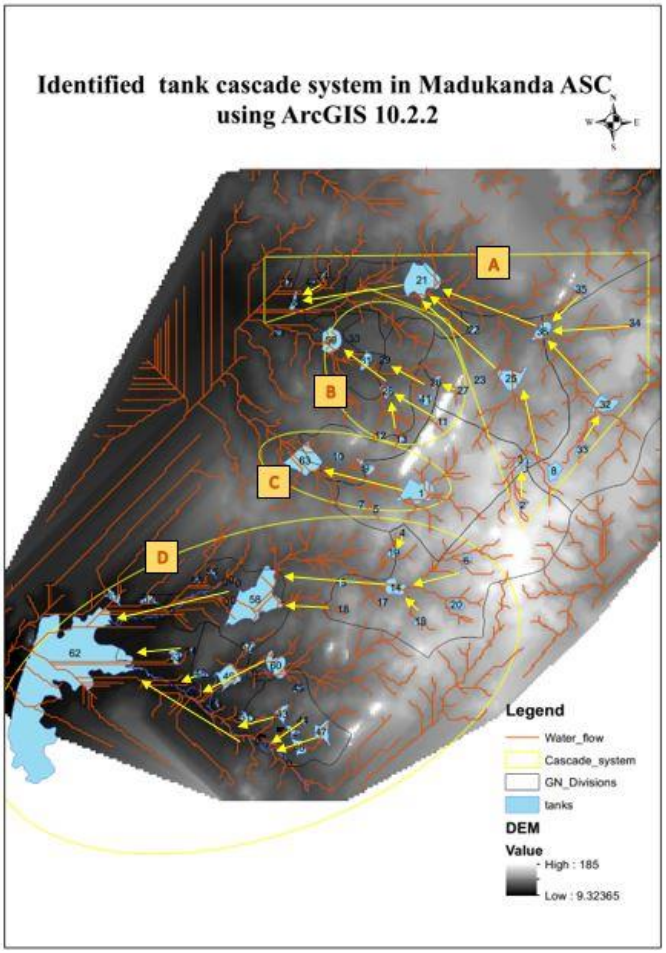

Figure 1. Identified tank cascades in Madukanda ASC

The water flow within the cascades was validated at the field during the study period in 2017 and shown in Figure 2. Among the four cascades identified, the Cascade “A” started with a stream flow which direct the water in to two tanks namely Mamaduwa and Mahairampaikkulam. The stream which directed to the Mamaduwa tank ended up in kollankulam and pirappanmaduwa tank and the stream which directed to the Mahairampaikkulam ended up in Atambagaskada, Malmaduwa, Kandenawakkulam, Malayaparaththikulam and Dikwewa. Cascade “B” started its flow from Pattiniyarmakilan kulam and ended up in Pandarikulam, Vairavapuliyankulam, Irampaikkulam, Velikulam, Minimarichchanwewa and Madukandatank. Cascade “C” started from Salamankulam and ended up in Kudakachchakodiya tank and Maniyarkulam. Cascade “D” started from Illupaikulam and ended up in Navatkulam and Padivettikulam.

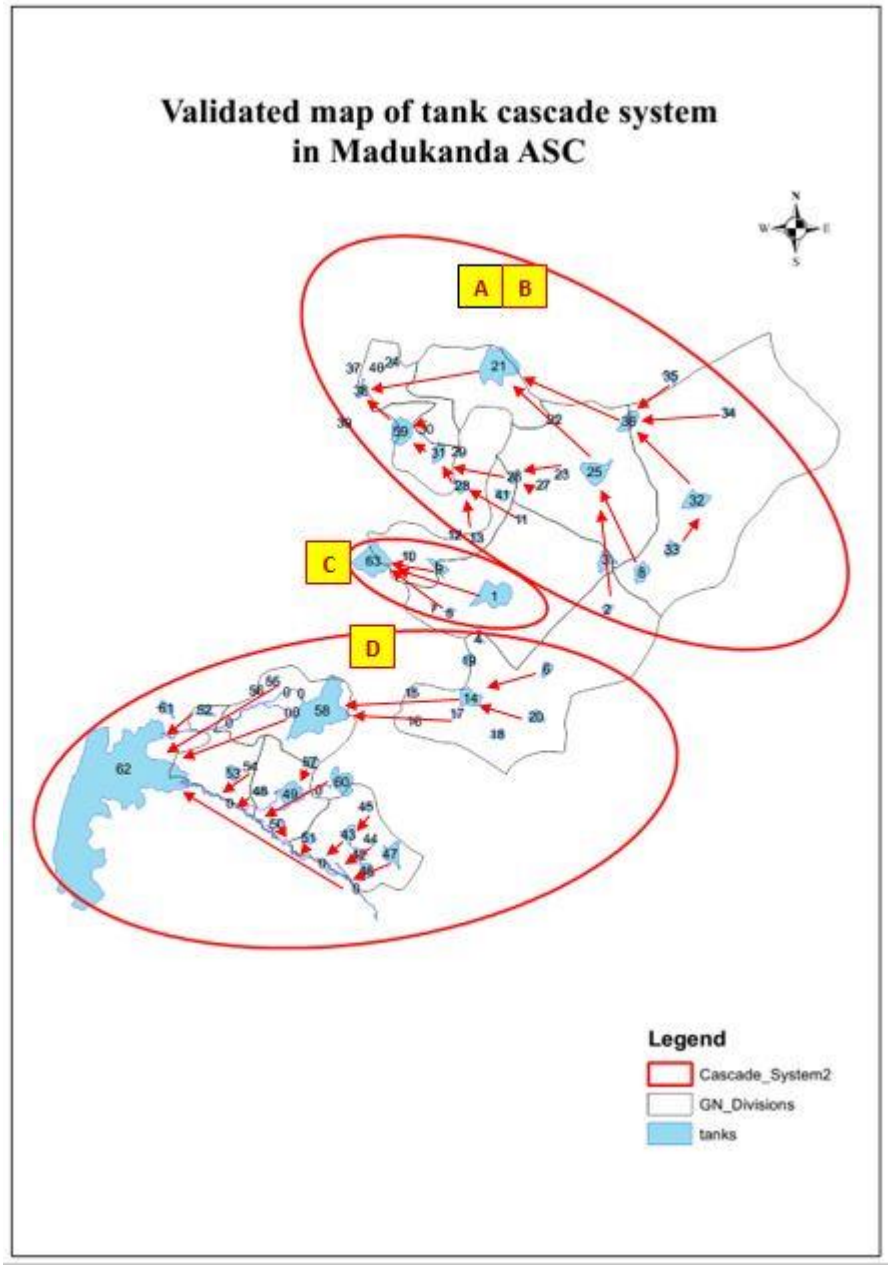

Figure 2. Validated map of tank cascade system in Madukanda ASC

During field validation it has been observed that the cascades A and B were together. This combination was created due to the connection in between Mahairampaikulam and Kokweliya amunubamma.

Table 4.Names of the tanks in the cascades and the cropping intensity

No of cascade	No of Tanks	Cascade name	Tank code	Tanks belongs to particular cascade	Cropping Intensity
1	**1**	**A**	**2**	Aluthgama wewa	1.80**
	2		**3**	Vedithibba wewa	3.33**
	3		**8**	Kollankulam	1.09**
	4		**21**	Mamaduwa	0.86**
	5		**22**	Thapasaweliya	2.32**
	6		**23**	Vairavasanthikulam	1.13**
	7		**24**	Thavaran kulam	0.78*
	8		**25**	Mahakachchakodiya	0.99**
	9		**32**	Pirappanmaduwa	2.56**
	10		**33**	Kanakkayagama	2.24**
	11		**34**	Bodankulam	0.46*
	12		**35**	Kimbulagala wewa	4.23**
	13		**36**	Eropothana	1.13**
	14		**38**	Kokweliya amunu bamma	1.00**
	15		**40**	Karambakulam	0.86*
2	**1**	**B**	**11**	Kandenavakkulam	2.75**
	2		**12**	Kurundankulam	0.78*
	3		**13**	Malayaparaththikulam	0.90*
	4		**26**	Malmaduwa wewa	1.30**
	5		**27**	Mailagaswewa	0.98*
	6		**28**	Atambagaskada wewa	1.22**
	7		**29**	Nugagahawewa	0.25*
	8		**30**	Aanabulundana	2.33**
	9		**31**	Pudubulankulama	1.00**
	10		**41**	Dikwewa	2.23**
	11		**59**	Mahairampaikulam	
3	**1**	**C**	**1**	Madukanda	1.08**
	2		**5**	Piramankulam	4.88**
	3		**7**	Pinwewa	0.27*
	4		**9**	Nedunkulam	1.29**
	5		**10**	Minirarichchanwewa	0.83**
	6		**63**	Vavuniya tank	
4	**1**	**D**	**4**	Kudagamawewa	0.13*
	2		**6**	Maniyarkulam	0.68*
	3		**14**	Mahamailankulam	0.98**
	4		**15**	Lunuwewa	0.85*
	5		**16**	Sinnakulam (Ab)	
	6		**17**	Sinnamailankulam	1.25**

7	**18**	Padivettikulam	1.00**
8	**19**	Pudurukulam	0.50*
9	**20**	Kudakachchakodiya	1.00**
10	**42**	Puliyankulam	
11	**43**	Sinnakulam	0.70*
12	**44**	Viranthakollawa	
13	**45**	Aluthgamawewa	
14	**46**	Alagalla	
15	**47**	Theeruwegama	
16	**48**	Weherabandiwewa	
17	**49**	Kalukunnamaduwa wewa	
18	**50**	Nochchikulam	
19	**51**	Ilamaradankulam	
20	**52**	Arugampuleliya	
21	**53**	Pahalaputhukulam	
22	**54**	Ihalaputhukulam	
23	**55**	Kurunthankulam	
24	**56**	Ukkulankulam	
25	**57**	Puranathudarikulam	
26	**58**	Eratperiyakulam	
27	**60**	Kalnaddinakulam	
28	**61**	Karuveppankulam	
29	**62**	Pavakkulam	

** Good hydrologically endowed tank
*Poor hydrologically endowed tank

4.CONCLUSION

This study was carried out to identify the tank cascade system with the flow direction and to assess the performance of village tanks administered under Madukanda Agrarian service centre. Average tank density was one tank per 2.68km^2 in the study area. The four cascades identified consisted of 15, 11, 06 and 16 tanks respectively. Out of 47 tanks in the study area 28 tanks with good hydrological endowment, 15 tanks with poor hydrological endowment while 3 were abandoned. Significant difference was observed between good hydrological endowed tanks and poor hydrological endowed tanks at 95% CI for cropping intensity during yala and maha seasons.

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