"Identification of cascade systems and assessment of the performance of village tanks in *Kovilkulam* Agrarian Centre Area" ICSBE 2016

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Abstract: Vavuniya district of Sri Lanka consists of nearly 674 minor irrigation tanks which are in a cascade system supplying water for 10900 ha (10900×10^4 m^2) of paddy land. But there is no documentation available for the cascade systems. In the recent past effort was taken to rehabilitate some of those tanks with the available source of funding. Since there is hardly any knowledge on the pattern of those cascades, the tanks for rehabilitation were selected randomly. As a result, the neighborhood tanks were inundated and the livelihoods of the poor farmers in those tanks were severely affected. The objective of the study was to identify the cascade system and to assess the tank performance. Kovilkulam Agrarian Centre in Vavuniya was selected for this pilot study. GIS platform was used to identify cascade systems among the tanks in Kovilkulam Agrarian Centre in which 83 tanks were located including abandoned tanks. This study identified 17 tank cascade systems consisting 66 tanks and 17 isolated tanks. Among those 66 tanks, 30 tanks were randomly selected to assess the tank performance. Cropping intensity (CI) and hydrological endowment were used to assess the performance of the tanks. Results revealed that 64% of tanks were with good hydrological endowment whereas 36% were with poor hydrological endowment. Average tank density was one tank per 2.65 km^2 in the study area. The average yield under minor tank irrigation systems, good hydrologically endowed tanks and poor hydrologically endowed tanks were 4456 kg/ha (0.44 kg/m^2), 5092 kg/ha (0.51 kg/m^2) and 3876 kg/ha (0.39 kg/m^2) respectively. The average cropping intensity of good and poor hydrologically endowed tanks was statistically tested using t-test and found to be significant. Nearly 90% of the good hydrologically endowed tanks had the CI of greater than one. This study could be extended to the whole district and to the adjacent districts. Documentation of the cascade system 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.

Key words: cascade systems; cropping intensity; hydrological endowment; rehabilitation, tank performance.

1. Introduction

Sri Lanka has a long history of irrigation development and the tanks were constructed in the past centuries by ancient kings. In Sri Lanka, there are 24,199 minor tanks; among them 11257 village tanks and 12942 anicuts, while major tanks are nearly 542,among them 322 reservoir, 112 anicut, 96 drainage, flood protection and salt water exclusion, and 12 are lift irrigation schemes .Total command area under these tanks is 685,625 ha ($685,625 \times 10^4$ m^2) and represents nearly 42% of total land area of Sri Lanka [1].Irrigation tanks in Sri Lanka are located in 'cascade' systems. Majority of these minor tanks are found in Kurunegala, Anuradhapura and Vavuniya.

Vavuniya district is predominantly an agricultural districtwith unique cascade systems having asweddumized land extent of 21,010 ha (21,010 × 104 m2) for paddy cultivation. There are one major tank, 22 medium tanks and 674 minor irrigation tanks including 22 anicuts in this district. The water resources mainly depend on annual rainfall as there are no perennial rivers. Out of the 674 Minor Irrigation tanks, 83 are abandoned [2]. Recent surveys indicated that 38% of the total land is engaged in Agriculture and 47% of the land is under forest cover. About 21,000 ha (21,000 × 104 m2)of land is used for paddy cultivation of which 10,900 ha (10,900 × 104 m2)is irrigated by minor irrigation tanks. In addition to this, there are about 10,000 ha (10,000 × 104 m2)under perennial and high land crops. Inadequate water for crop cultivation is one of the major issues faced by the farmers in Vavuniya

district. The tanks were unable to store adequate water during rainy season due to tank siltation and improper maintenance. Rehabilitation of tanks may be a solution to increase the water storage in the tanks. It has been notified that tank rehabilitation without the knowledge of cascade system in Vavuniya district created inundation in the neighborhood of those tanks.

The objectives of this study were, to map spatial distribution of village tank cascade systems, to assess the present status, performance and potentials of cascade systems and to formulate strategies for improvement of the tank performance.

2. Materials and Methods

Vavuniya district was in the Northern part of Sri Lanka. *KovilKulam* Agrarian Service Center (ASC) in Vavunuya district was selected as the study area. *KovilKulam* ASC consisted of sixteen Grama Niladhari divisions (GND). Geo-morphologically, Vavuniya is a flat plain having undulated topography with broad valleys and small rock ridges forming cascade systems of irrigation tanks [3].

Comprehensive evaluation of spatial distribution of village tank cascade systems within *Kovilkulam* ASC area in Vavuniya district was performed with the combination of remote sensing and Geospatial approaches with available maps and field investigations. For statistical analysis Minitab 15 was used.

1:50000 digital maps of Survey Department and ASTER Global Digital Elevation Model (GDEM) acquired from USGS web sites were used for geo-spatial and terrain analysis.

On-screen investigations to check accuracy of tank cascade map (1:50000) was conducted by overlaying on Google Earth in QGIS (ver 1.8) software and found low accuracy levels. Tank-cascade systems map of *Kovilkulam* area was developed by on-screen digitizing with Google-map and 83 tanks were identified.

GDEM of Vavuniya district was used for extraction of watershed boundaries and drainage network to get an idea on the pattern of natural drainage/cascading system. For this ArcGIS 10.2.2 software was used.

Flow lines were extracted using threshold values 100, 500 and 1000. The most suitable value and the names of those tanks were identified based on field investigations, past records and Google earth. Finally, the created flow accumulation maps were overlaid with digitized tank shape file and the map of tank cascade systems for *Kovilkulam* area was developed. Mapping accuracy was assessed using field verifications and exact threshold value was selected as 100 for Flow accumulation map.

Secondary data on tank command area, capacity, catchment, water spread area, cropping extend and yield were collected for sample tanks using random sampling techniques through field Questionnaire survey and interviews with the head and the members of Farmer's Organization (FO) and Irrigation department in Vavuniya.

Cropping intensity could be defined as the area irrigated or cultivated during the *Maha* season / total command area under the tank [4]. In this study, area irrigated or cultivated during the whole year 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, indicated as good hydrological endowment. This concept was used to assess hydrological endowment of tanks. Good hydrological endowment lead to better tank performance [5].

3. Results and Discussion

All together 83 tanks including abandoned tanks were mapped through this study. The study revealed that the average tank density was one tank per 2.65 km^2 in the region of *Kovilkulam* ASC [6] reported the same as one tank per 2.6 km^2 for the Northern Province, North Central Province and Sabragamuwa province and [7] reported that the tank density was one tank per 2.68 km^2. Based on the GN divisions in study area the highest number of tanks belonged to *Asikulam* and the lowest number of tanks were recorded in *Pandarikulam* and *Thonikal*.

All together 17 tank cascades comprising 66 tanks identified in *Kovilkulam* agrarian area of Vavuniya district. Identified cascade systems were as shown in Figure 1.

Command areas of all the tanks were less than 80 ha and all were non-system tanks. 30% tanks were isolated and 70%of the tanks were located as cascades, which means those tanks were having feeding tank, output tank or both.Nearly64% of tanks were with good hydrological endowment and

about 36% were with poor hydrological endowment.

Table 1: Average Cropping Intensity in Study Area.

Average Cropping Intensity (ACI)	Percentage of Tanks
>1	60%
1-0.85	3%
0.85-0.6	3%
<0.6	34%

Nearly 90% of good hydrological endowed tanks had cropping intensity greater than one. It was noted that Karungkallikulam tank had cropping intensity lesser than one even though it was with good hydrological endowment. The reason was, farmers did not cultivate full extent during *maha*2015 due to wild animals attack in 2014.

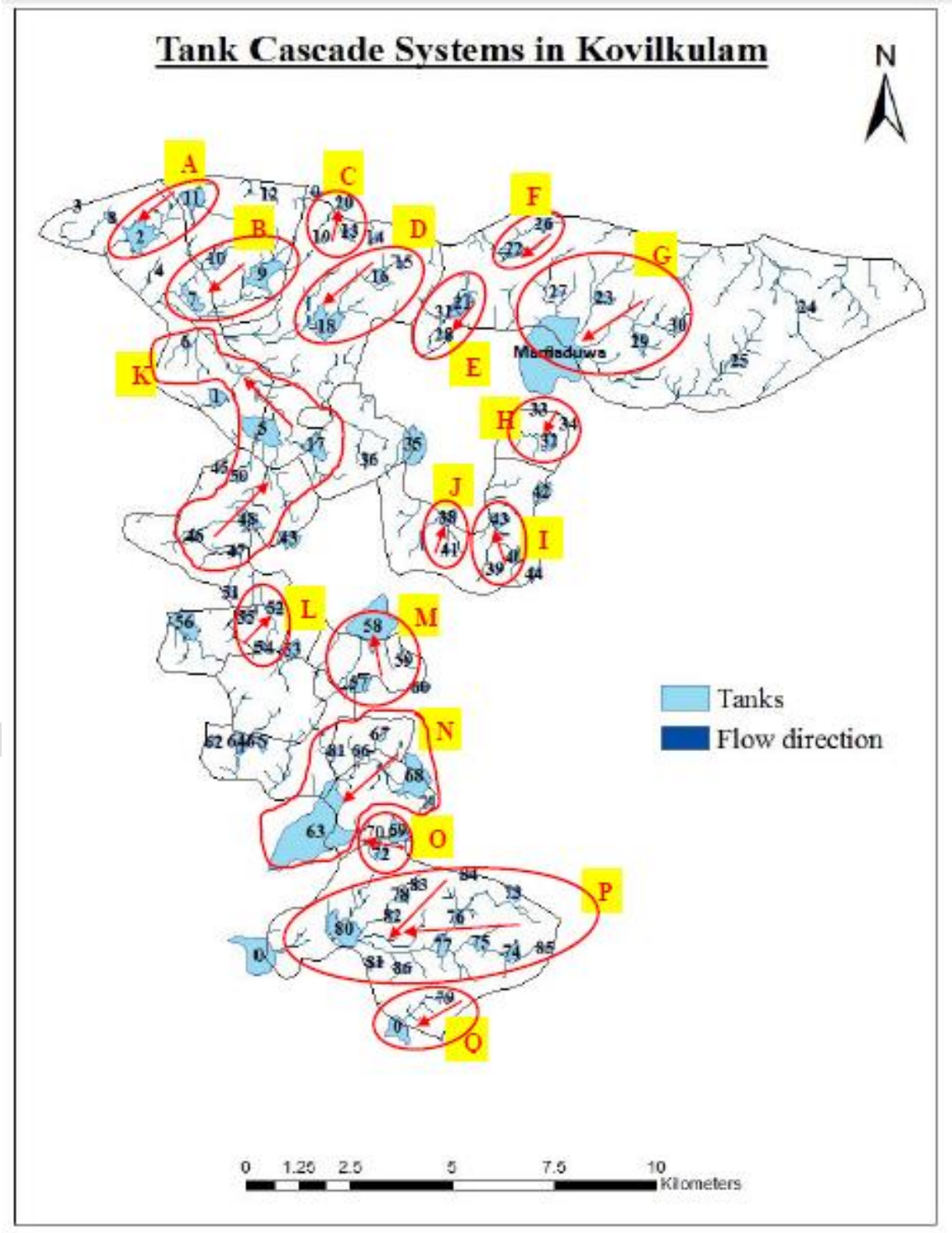

Figure 1: Map of Tank cascade systems

Table 2: Cascade systems in Kovilkulam agrarian area.

Cascade name	Tank Code	Tanks belongs to particular cascade
A	2	Velikulam
	11	Met kulam
B	7	Karunkallisinnakulam
	9	Paranaddakalkulam
	10	Kakkaiyankulam
C	13	Navatkulam
	19	Thachchankulam
	20	Kat kulam
D	15	Punniyathikulam
	16	Pechaththipoddukulam
	18	Nochchimoodaikulam
E	21	Kunchukulam
	28	Nalumurippukulam
	31	Thuvarankulam
F	22	Pirappankulam
	26	Kathirankulam
G		Mamaduwawewa
	23	Krunkalikulam
	27	Parasankulam
	29	Mavilankulam
	30	Mel kulam
H	32	Veemankallukulam
	33	Vedankulam
	34	Sinnalankulam
I	39	Katharsinnakulam
	40	Karuvalpuliyankulam
	43	Alaputhukulam
J	38	PihchuvilaththikKulam
	41	Karupanichchankulam
K	5	Puthukulam
	6	Maniyarkulam
	17	PeyadikulanKulam
	46	Paddakaddukulam
	47	Thirukkovilnavatkulam
	48	Pathiniyarmahilankulam

	50	Oyarsinnakulam
L	52	Pattanichchuepuliyankulam
	54	Pandarikulam
	55	Thachchanaangkulam
M	57	Irampaikkulam
	58	Vavuniyakulam
	59	Sinpputukkulam
N	61	Mathavuvaithakulam
	63	Iratperiyakulam
	66	Kovilkulam
	67	Kovilputhukulam
	68	Samalankulam
	71	Lithikulam
O	69	EllapparmaruthanKulam
	70	Vedarkulam
	72	Littikulam
P	73	IllupaiKulam
	74	Asikulam
	75	Pootharkulam
	76	Sinnakomarasakulam
	77	Periyakomarasakulam
	78	Vannakalveerankulam
	80	KalnaddinaKulam
	81	Sinnakulam
	82	Vannanpuliyankulam
	83	Sinnakalveerankulam
	84	Tharanikulam
	85	Gal kulam
	86	Thuvaramkulam
Q	79	Kalkulam
	0	Unknown

Table 3: Details of Sample Tanks.

Name of Tank	Command area(acr)	Capacity (ac.ft)	Catchment area/water spread area	Catchment area (ac)	Capacity/ Command area	Water spread area(ac)	Average CI
Parasankulam*	38.07	75	21.85	512.00	1.97	23.44	1.19
Met kulam	72.00	84	2.40	435.20	1.17	30.00	0.59
Vadan	15.00	16	24.00	192.00	1.07	8.00	0.52
Sinnakalveerankulam	21.00	30	17.07	256.00	1.43	15.00	0.60
Lithikulam	18.00	24	16.00	192.00	1.33	12.00	0.61
Kathirankulam*	45.00	128	8.40	384.00	2.84	45.71	1.16
Kalanaddinakulam*	147.00	252	19.20	1728.00	1.71	90.00	1.19
Kunchukulam	65.00	87	2.06	64.00	1.34	31.07	0.73
Mavilankulam	120.00	80	22.40	640.00	0.67	28.57	0.29
Kovilkulam	16.50	52	9.45	204.80	3.15	21.67	0.78
Karupanichchankulam	46.00	65	11.03	256.00	1.41	23.21	0.78
Karunkalikulam*	43.00	80	22.40	640.00	1.86	28.57	0.91
Pirappankulam*	40.91	63	54.04	1216.00	1.54	22.50	1.05
Karunkalisinnakkulam	35.00	95	7.55	256.00	2.71	33.93	0.76
Paranaddakalkulam*	120.00	250	12.90	896.00	2.08	69.44	1.48
Velikulam*	32.50	90	9.96	320.00	2.77	32.14	1.08
Sinnakoomarasan*kulam	22.03	65	11.85	275.20	2.95	23.21	1.79
Tharanikulam*	32.00	60	11.95	256.00	1.88	21.43	1.10
Iluppaikulam*	62.00	110	8.96	352.00	1.77	39.29	1.53
Navatkulam*	40.00	100	17.92	640.00	2.50	35.71	1.66
Katharsinnakulam*	40.00	72	9.96	256.00	1.80	25.71	1.70
Asikulam*	52.00	144	11.20	576.00	2.77	51.43	1.26
Pattakaddukulam	87.00	112	10.97	384.00	1.29	35.00	1.18
Pattanichoor*	76.00	144	17.42	896.00	1.89	51.43	1.12
Vadarkulam*	8.00	16	33.60	192.00	2.00	5.71	1.01
Thachanathankulam*	15.50	30	17.92	192.00	1.94	10.71	1.50
Mathavuvaithakulam*	58.00	110	8.16	256.00	1.90	31.38	1.31
Kovilputhukulam*	11.00	30	8.53	128.00	2.73	15.00	1.06
Kat kulam*	15.00	30	19.20	288.00	2.00	15.00	1.55
Thachchankulam	30.00	130	4.92	320.00	4.33	65.00	0.63

*Good hydrologically endowed tanks

Significant difference in CI was observed between good hydrological endowed tanks and poor hydrological endowed tanks at 95% confidence interval.

95 % of respondents stated that they were not able to cultivate command area successfully. The reasons for this were recorded and found that nearly 68 % of the respondents reported as water scarcity whereas 20 % as poor soil fertility and 10 % as soil salinity.

The average yield under minor tank irrigation systems were 4456 kg/ha (0.44 kg/m^2) [8].And the average yield under good

Hydrologically endowed tanks and poor hydrologically endowed tanks were 5092 kg/ha (0.51 kg/m^2) and 3876 kg/ha (0.39kg/m^2) respectively. The main reason for the yield reduction was reported as inadequate water.

4. Conclusion

Seventeen cascade systems were identified which comprises 66 tanks in *Kovilkulam* Agrarian Center area. Cascade "P" was containing the highest number of tanks. Out of 30 sampled tanks 19 tanks were with good hydrological endowment and 11 tanks with poor hydrological endowment. Average tank density was one tank per 2.65 km^2 in the study area. High density of irrigation tanks was very much important for paddy cultivations. There was significant difference of cropping intensity (CI) between good hydrologically endowed and poor hydrologically endowed tanks.

5. Recommendation

The identified cascade system could be used as a guide to carry out rehabilitation activities in those tanks in order to increase the tank performance without affecting the neighborhood tanks. Agrarian Development Centre should ensure the frequent update of data for effective management. Similar study in the rest of the same district and other districts with minor irrigation tanks would be essential to increase agriculture production in the country.

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