HYDROLOGICAL STATUS OF A FEW TANKS IN MYSORE : A STUDY USING GIS & REMOTE SENSING

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ABSTRACT

Urbanisation is both a boon and a bane to the tanks. Hence, if managed well, urban tanks can be made to serve the purposes they are intended to better than they do under the normal conditions. Six tanks in Mysore have been studied in the present study, to understand ways to manage them better. The land use and the urbanization pattern in the catchment of these tanks have been determined through image processing. Availability of runoff and sewage in the area is determined. The present status of the quality of water in the tanks is analysed. The quantity of sewage needed to be diverted into the tanks is estimated and the treatment needed to be given is suggested.

INTRODUCTION

Southern Karnataka is characterized by an undulating topography and a subhumid climate, suitable for rain water being harvested through small tanks (RamaPrasad, 1979). People in the region have also shown unmatched interest in tank building (Vaidyanathan, 1982). Hence Mysore region is a treasure house of small tanks. In addition to irrigation, tanks provide water for daily requirements of people in villages and help recharge the ground water store. Hence, tanks form an integral part of the rural South Indian setup and have been considered the lifeline of the villages in this part of the country (Reddy,1985). However, tanks have been facing threats of destruction due to various reasons, including silting up, encroachment and sewage and waste dumping. It can be observed that urbanization is one of the most important factors leading to accelerated deterioration of many of the tanks. In addition to having converted tank beds in to dumping places for disposing off wastes, the urban development authorities have found tanks an easily and cheaply available space for construction of moffusil bus stands, commercial complexes and for donating free sites to social organizations. However, of late, there has been an awareness concerning the utility and importance of protecting tanks from pollution and extinction. Hence, studies concerning urban tanks and formulation of plans to develop them are on an increase. The present study was taken up in order to extend technical support to efforts underway to save and develop tanks in Mysore, a heritage city known for its palaces and thrust on water resources development.

The objective of the present study has been to determine the extent and the type of urbanization having taken place in the catchment of a few selected tanks in the city, to estimate the availability of runoff, to understand the influence of inflow of treated sewage in to the tanks, to determine the quantity of sewage needed to maintain a minimum level of water in the tanks throughout the year and to furnish the details on the pretreatment required to be given. Six tanks spread over the different parts of the city and under different phases of urbanization were studied under this student project, sponsored by the Karnataka State Council for Science and Technology.

THE STUDY AREA

Situated in the southern tip of Karnataka, Mysore is characterised by three seasons of rainfall – Pre-monsoon (April to May), South West Monsoon (June to September) and North East Monsoon (October and November). Rainfall is usually convective, with intense storms lasting just a few hours contributing a major part of the rain amount. Hence, unless stored, rainwater is lost early, providing little opportunities for being used. Tanks have been of great utility in storing surface runoff and in replenishing the ground water store. Mysore experiences a normal annual rainfall of about 775 mm, with about 60 rainy days.

Figure 1 shows the location of the city of Mysore and the tanks (tanks are called '*KERE*' in Kannada) around the city. Since the purpose of the study has been to demonstrate the method required to be adopted in planning, six of the numerous tanks found in and around the city were selected. The selection was so done that a representative sample, covering a range of different characteristics is available. Table 1 furnishes the details concerning the tanks. The reason for each of the tanks being selected for the study is also outlined in Table 1.

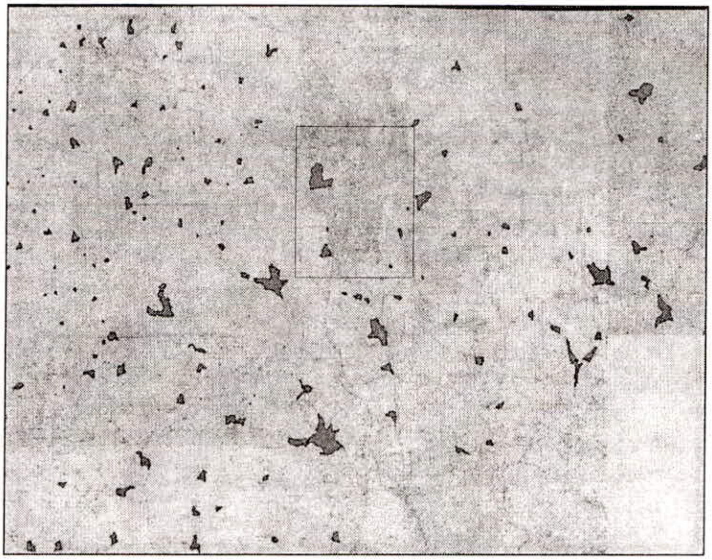

Figure 1: Water bodies in and around Mysore (the city limits are shown marked)

Table 1: Some details pertaining to the tanks studied

Sl. No.	Tank	Catchment (km^2)	WSA (km^2)	Max Depth(m)	Water Use	Other information
1	Dalavoyi	26.1	0.49	4.5	Irrigation, Domestic, aqua culture	Catchment comp. urbanised treated sewage input round the year
2	Devamba	14.2	0.55	4.6	---do----	Little urbanisation, fed by canal
3	Hebbal	8.2	0.08	3.7	Irrigation	Partially urbanised, no sewage .
4	Lingabudhi	41.6	0.7	5.5	Irrigation, aqua culture	Partially urbanised, raw sewage small amounts, fast development.
5	Yennehole	156.1	1.09	6.7	Irrigation, Domestic, aqua culture	Large catchment, partly urbanised, raw and partly treated sewage
6	Udburukere	3.1	0.13	3.7	Not much	Totally rural, totally neglected

A few studies concerning the tanks in Mysore have been reported. However these studies have all concentrated on the status of pollution of the tanks only. Karnataka State Pollution Control Board, KSPCB (2002) has carried out a study on 15 tanks in Mysore District including four of those being selected for the present study. In this study, water samples, collected from the tank twice during the year June 2001 to May 2002, were analysed to determine the important chemical parameters. The results show that the tanks in the city limits have been polluted to some extent due to inflow of sewage. This study provides useful data, some of which has been used in the present study. Other notable studies include those by Mahendra et.al. (1991) and Prasad et.al. (1995), who have respectively studied the status of Dalvoyikere and Karanjikere and have provided detailed guidelines to restore them. However, none of the studies seem to have laid emphasis on the runoff available from the tank catchment and considered the effect of urbanization on runoff inflow. The present study is an effort to make available information on runoff available and utilise this runoff in maintaining the urban tanks in a healthy state.

GIS AND REMOTE SENSING FOR ANALYSIS

Two important aspects of catchment studies include estimation of the volume of runoff available and of the sewage generated and to be handled in the area. Both require knowledge of land use pattern in the catchment. Hence, determination of the catchment area and the land use in the area forms the most important technical component of the present study. With six tanks to be studied and a wide variety of land use patterns to be determined, use of facilities of GIS and image processing would be of great benefit – it would help accomplish the task faster and more accurately. Images obtained from remote sensing satellites can provide information pertaining to any particular duration of interest. Hence such images are the best sources of the most recent data on land use pattern. In the present study, LISS-III and PAN images covered in Path 99 and Row 64 of the IRS–1D satellite, pertaining to 5th August 2000 and 18th March

2000 respectively were used. Data obtained from these images, as well as those from Topo-sheets for the area, were analysed using the GIS software ARCVIEW 3.2a, and the following thematic layers were created:

- Tank map – consisting of polygon features, presenting water spread area of the tanks studied;
- Stream channel layer – showing all the streams feeding the respective tanks;
- Ponds' layer – created from the topo sheet and showing smaller ponds, many of which characterize the catchment of larger tanks. Many of these small tanks have been, over the years, destroyed – converted into fields, playgrounds or encroached upon. But many of them still form potential areas for providing preliminary treatment to sewage which may be used as an additional source of water for major tanks;
- Catchment area layer – polygon features showing the catchment boundary of the tanks;
- Land use layer – showing various land uses in the area demarked by processing digital images supplied by NRSA.

The process of combining various themes in GIS is called overlaying. The ponds and streams within each catchment and distribution of different land use types over each catchment are determined using the overlaying option. Figure 2 shows the important details pertaining to the catchments of the six tanks studied.

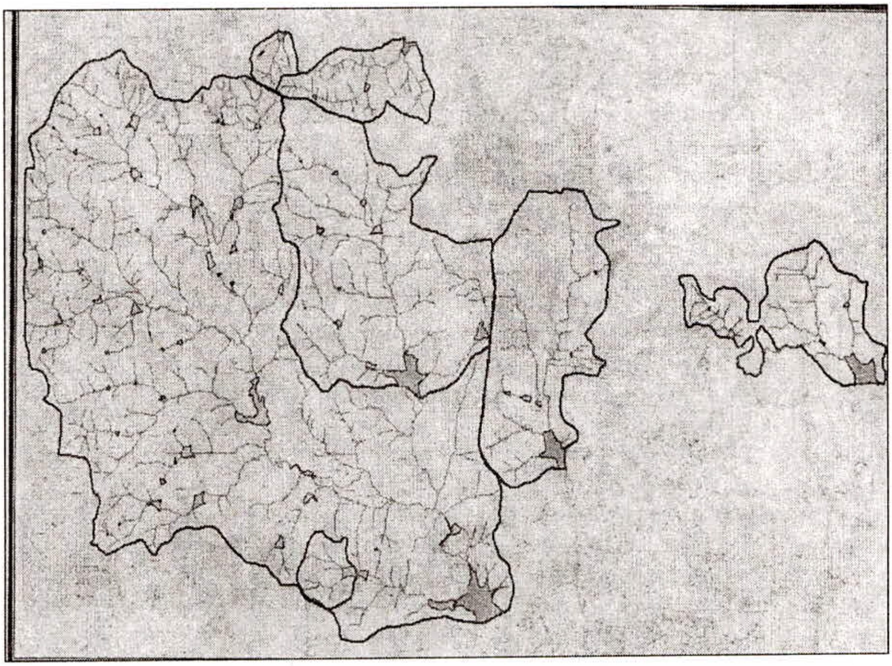

Figure 2. Catchment and other details concerning the tanks selected for the study

Land Use Classification and Image Processing

In order to estimate the runoff yield available from the catchments and to determine the population in the area, the following land use types are demarcated:

- Business Area – These are partly commercial and partly residential areas, which are densely built and almost completely paved;
- Old Residential Areas – Areas with single family houses and quite densely populated. A part of the storm water is diverted into sewers here;
- New Residential Areas – These are sparsely built up areas with many open spaces and much less runoff;
- Unimproved Areas – The areas which are being urbanised or are likely to be urbanized in near future come under this class;
- Openspaces and Playgrounds – These occupy small areas within the land used types (i) to (iii) above. Although they are open, runoff is substantial; and,
- Parks and Lawns – Areas within the city with good vegetation or lawn cover, contributing very low runoff.

The runoff from the various classes of areas is determined using monthly normal rainfall and runoff coefficients suitably assumed. The runoff coefficients for the various months for the above land use types and the monthly normal rainfall for Mysore are presented in Table 2.

Table 2 : Run off coefficients used monthly normal rainfall for Mysore

Sl.	Land use	May	June	July	Aug	Sept	Oct
1	Business area	0.8	0.8	0.8	0.8	0.8	0.8
2	Residential Area (old)	0.4	0.4	0.4	0.4	0.4	0.4
3	Residential Area (new)	0.35	0.35	0.35	0.35	0.35	0.35
4	Unimproved Area	0.2	0.1	0.2	0.2	0.25	0.30
5	Open spaces / grounds	0.3	0.2	0.25	0.15	0.30	0.35
6	Parks, Lawns, Vegetated	0.2	0.1	0.2	0.1	0.2	0.25
	Normal rainfall (mm)	121.3	104.7	92.1	87.1	97.7	199.8

As mentioned earlier, digital imageries, made available by NRSA was used for extracting information on land use in the catchments. Initially both the PAN and LISS images were classified by the Supervised Classification procedure, using the software ERDAS 8.4. However, since reliability of the classification was not satisfactory, manual classification was resorted to. The so determined distribution of land use over the various catchments is shown in Table 3 and illustrated for the case of Dalavoyikere in Figure 3.

Figure 3. Land use pattern mapped from the NRSA images for the Lingabudhi tank

Table 3 : Land use distribution over the catchments (all areas in km^2)

Sl. No.	Land use	Dalvoyi	Devamba	Hebbal	L. Budhi	Y. Hole	Udburu
1	Business area	0.56	0	0	0	0	0
2	Residential Area (old)	5.81	0.98	1.84	7.55	6.39	0.18
3	Residential Area (new)	1.82	0.93	1.17	4.62	3.80	0
4	Unimproved Area	5.60	0.37	0.86	2.32	2.89	0
5	Open spaces/ grounds	6.03	2.46	2.74	17.03	90.04	1.77
6	Parks, Lawns, Vegetated	6.18	9.43	1.63	10.11	52.98	1.17
Total Catchment		26.0	14.2	8.2	41.6	156.1	3.1

RUNOFF QUANTITIES AND THE WATER USE

The details concerning the capacity of the tank and the runoff inflow pertaining to the six tanks are shown in Table 4. It can be observed from this table, that except in the case of Udburukere and Devamba tank, tank capacities are less than a quarter of the runoff input. It can be further noted that the volume of runoff increases with increased urbanization (Chow et.al., 1988) and hence it can be safely inferred that runoff volume is sufficient to meet even the irrigation needs, in the case of four of the tanks. Further, at present, Devamba tank is being supplied water from a canal drawing water from a major irrigation project and hence is being used to irrigate two crops in the command area. However, Udburukere is being used only for domestic purposes during the rainy season and is getting dried up early after the end of the season.

Table 4 : Run off yield compared with tank capacity

No.	Characteristics	Dalvoyi	Devamba	Hebbal	L. Budhi	Y. Hole	.Udburu
1	Capacity (1000 m^3)	1129	1248	142	1927	3658	237
2	Runoff Inflow (1000 m^3)	5181	2272	1586	8198	27808	550
3	Capacity / Inflow (%)	21.8	54.9	9.0	23.5	13.2	43.1

It should be noted that a large portion of the runoff available in the region is during the months of September and October. Hence, water stored in the tank can be used to irrigate the second crop grown during the *Hingaaru* season, which extends between October and January. Rainfall during this season is low and non-reliable. Hence, tank storage becomes very critical and is utilised completely during the season. As a result, the tanks go dry by the end of the season and unless the storage is augmented by other means, it is possible neither to have a guaranteed supply for irrigation nor to maintain a minimum level of water in the tank during the summer. Urban tanks have the advantage of availability of sewage, and if properly managed and quality ensured, urban sewage could be a perennial source of water for the tanks. A discussion on the aspects of quality of water in the tanks with the inflow of urban sewage and the quantity of sewage that can be safely diverted into the tanks is discussed below.

WATER QUALITY AND SEWAGE INPUT

At present while Dalavoyikere is being supplied with outflow from the sewage treatment plant at Vidyaranyapuam, the Yennehole kere is getting an inflow of raw sewage from a few areas and partly treated sewage from the rest. On the other hand, while Lingabudhi tank gets a small inflow of raw sewage, the other tanks have no sewage inflow at present. Hence, in order to understand the impact of sewage inflow on the quality of tank water, water samples from the four of the tanks were analysed. The results are presented in Table 5, where parameter values averaged over all the samples including those presented by KSPCB (2002), are shown. Further, specifications for drinking water quality as per IS:10500-1991 are also presented in the table. A careful observation of the results indicates that Dalvoyi tank is considerably polluted due to sewage inflow, dispute the treatment given. This indicates that the tanks cannot sustain excessive quantities of sewage even when preliminary treatment is available. Low dissolved oxygen level indicates the tank is at the verge of turning into a septic tank. The tank needs immediate attention of the concerned authorities to prevent further deterioration. On the other hand, Devamba tank is little polluted. The water quality of this tank indicates minimum inflow of sewage and tank is replenished by storm and canal water only. Also the other two tanks, namely, Lingabudhi and Yennehole are only moderately polluted, despite sewage inflow. Further deterioration in the quality of water can be expected, if appropriate actions are not initiated. Further, it can be noted that all the four tanks can be restored to their original glory if lake authorities and public work together in right direction.

Table 5: Quality Parameters (Averaged) compared with IS:10500-1991 Standards

Sl. No.	Parameter	Dalvoyi	Devamba	L.Budhi	Y.Hole	IS Values	
						Desired	Permis.
1	D.Oxygen(mg/l)	1.04	6.1	6.0	7.3		
2	PH	7.97	6.8	9.2	8.9	6.5	8.5
3	Alkalinity	375	90	313	407	200	600
4	Total Solids (mg/l)	691	161	704	735		
5	Turbidity (NTU)	450	31	29	20	05	10
6	Conduct. (μmho/cm)	1.18	0.23	1.20	1.11		
7	Chlorides (mg/litre)	143	14	138	117	250	1000
8	Sulphates (mg/litre)	16	0.5	1.2	23	200	400
9	Phosphates (mg/l)	6.7	2.3	6.7	3.6		
10	Nitrates (mg/litre)	2.9	1.5	1.2	2.0	45	100

Treated Sewage as a Source of Tank Storage

Since maintaining a minimum level of water in the tanks is beneficial in many ways, and since inflow of limited quantities of partly treated sewage is found to be not at all harmful, it can be suggested that the sewage available in the catchment may be beneficially used to feed the tanks. However, such sewage needs to be given a preliminary treatment before being let into the tanks. The mode and the level of treatment needed depend on the quantity of inflow needed. This quantity is estimated assuming that the sewage is needed to make up for the loss of water from the tank as evaporation and seepage from an area equal to half the maximum water spread. Evaporation loss is estimated considering the maximum evaporation rate for Mysore (Mohan and Prasad, 1987) of 166 mm for March. The seepage loss is estimated using the commonly adopted thumb rule (Wajid et.al., 1974) - 0.9 mm per day per unit water spread area.

The volume of sewage required making up for these losses and the population required to make available this quantity of sewage are shown in Table 6. It is here assumed that the sewage generated is 80% of the water used in the urban areas, which can be considered as 100

LPCD. The actual population (according to the 2001 data) present in the various catchments is found to be more than sufficient, except in the cases of Devamba tank and Udburukere. Since Devamba tank gets canal water, it is only Udburukere for which sufficient water cannot be obtained in the near future. Hence, if proper arrangements are made to divert treated sewage, the other tanks can be made to serve the purposes they are intended to, to the full extent. However, as mentioned earlier preliminary treatment must be necessarily given to sewage before being let into the tanks. This is best done by passing the required amount through a series of oxidation ponds and reed beds (Arceivala, et.al., 1970). The area of oxidation ponds required for the treatment can be calculated assuming a detention period of 7 days and a storage depth of 1 m. The tank size required in the various cases is shown in Table 6. It has been observed that these extents of area are available in each of the tanks and hence after detailed designs, the plant can be successfully implemented.

Table 6 : Sewage input required, population needed, dimensions of the oxidation pond

Sl. No.	Tank	Monthly losses in 1000 m^3		Tank Capacity (1000 m^3)	Monthly Sewage required (1000 m^3)	Population in 1000's		Oxidation Pond	
		Seepage	Evaporation			Reqd.	Availble	Area ($1000m^2$)	Dimens. (m x m)
1	Dalavoyi	13.3	61.5	1129	74.8	31.2	126.8	16.2	130
2	Devamba	14.7	67.9	1248	82.7	34.5	6.2	17.9	133
3	Hebbal	2.1	9.7	142	11.8	4.9	42.8	2.6	52
4	Lingabudhi	18.9	87.4	1927	106.3	44.3	114.2	23.0	152
5	Yennehole	29.5	136.0	3658	165.4	69.0	122.3	35.8	190
6	Udburukere	3.5	16.2	237	19.7	8.2	NA	4.3	65

SUMMARY AND CONCLUSION

The present study was taken up in order to determine the quantity of runoff yield forming inflow into six selected tanks in Mysore and to suggest ways to maintain a minimum storage in the tanks in the year round. The inferences drawn from the study are as follows:

- The runoff yield available is sufficient to irrigate at leas one crop in the command in four of the tanks. In another case, canal water fed into the tank caters to the irrigation needs.
- In all the cases there is ample scope for further urbanization and runoff can be expected to increase.
- The quality of water seems to be moderately good in all the cases except in the case of Dalavoyi tank. The inference is that excessive inflow of sewage, even when partially treated, is not desirable.
- In order to maintain a specified minimum storage in the tanks, it is necessary to divert sewage into the tanks. The quantity needed for the purpose is found to be available in all the cases, except one. Preliminary treatment to sewage to be diverted may be provided by passing it through an oxidation pond and reed beds.

To conclude, the study has established that there is ample scope for maintaining the tanks in good condition and for further development.

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