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Title- APPLICATION OF GEOSPATIAL TECHNIQUES TO ANALYZE SPATIO-TEMPORAL CHANGES IN RESERVOIRS IN PUNE CITY, INDIA

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Abstract:

The growing demand of water because of population growth, urbanization has put tremendous pressure on the water resources. The assessment of quantity and quality of water is therefore essentialfor optimum planning and the management of water resources considering the local, regionalor national needs. The present study focuses on spatial and temporal variation in water availability and various levels in Khadakwasla, Panshet, Temghar, Varasgaon and Mulshi reservoirs which supplies water to the Pune city. Using GIS and Remote Sensing, thematic layers of Slope, elevation, geomorphology, geology, stream density and land use land cover have been produced and statistical methods are used to get trend. The data use for the study is of 2005 to 2015, 10 years' monthly data for the period June to October have been obtained from the Irrigation Department. To analyze Spatio-temporal conditions of these reservoirs, Full Reservoir Level (FRL), Dead Storage Level (DSL), Live storage, Rainfall and Discharge, these parameters have been used. The result shows, these all parameters have decreasing trend. Discharge days and their intensity is also decreasing. After 2007, almost less discharge through spillways is seen for some reservoirs. This affects the flora & Fauna of the river system and adversely affect the ecosystem of the basin.

Keywords: GIS, Remote Sensing, FRL, DSL

Introduction

Around the globe population increase by more than 2 billion from 1950 to 2000, and it is expected that it will be increase by 2 billion more from the period 2000 to 2025. So, under these conditions urban water demand is also increasing. Urban economic activity and concentration of people in cities increase urban water demand (Meinzen-Dick and Appasamy, 2002). Domestic use requires high quality water in large quantity and large volume of water is requires for industrial production, this demand of water increase by growing cities. Although, the largest user of water is agriculture field which used almost 72% of water withdrawals around the globe (Rosegrant and Ringler, 1998). The studies indicate that regional factor, such as geology, climate, local land cover and land use combine determined the different parameters of water, such as stream hydrology, geomorphology, water chemistry and biota (Richards et. al., 1996, Seelbach et. al., 1997, Wehrlyet. al., 1998, Zorn et. al., 1998). At local level essential source of water is small reservoirs which help local population to overcome with drought (Liebe et. al., 2005). Agent-based modelling (ABM) has been used since many years in the field of natural resources management to facilitate the understanding of complex systems by allowing the simulation of their functioning on computers, likewise in water resources management, different types of A B Mhave been developed (Thoyer et. al., 2001). The present work is aimed in assessing the reservoir water availability with respect to different purposes. Water storage reservoirs are being created by constructing a dam across a river. Further, reservoirs are also meant to absorb a part of flood water and the excess is discharged through a spillway. It is also essential to study the relation between flood discharge, reservoirs capacity and spillway size. Reservoirs are the key infrastructure for the socio-economic development of a country. Information on reservoir water level, total storage etc. is necessary in the analysis and design of several water resources projects such as dam construction, irrigation needs and flood control.

Study Area

Five dams located in the western parts of the district, built across the Mutha and Mula River, supplies water to the Pune City. Pune uses the waters of the Mutha from the Khadakwasla reservoir. Dams at Panshet, Varasgaon and Temghar supplement the storage capacity of Khadakwasla. City of Pune also uses the waters of the Mula River from the Mulshi reservoir (Fig. 1).

Fig. 1. Location Map of Study Area

Khadakwasala is a moderate sized dam on the Mutha River, located about 20kilometers southwest of the city of Pune, and named after the nearby village of Khadakwasla. It is located at 18° 26'36" N Latitude and 73° 45' 57" E Longitude. Storage capacity 374 million cubic meters. The reservoir is the source of water for two canals that start at Khadakwasla. The right bank canal (112 km) irrigates about 45,000 hectares of land in Pune District, while the left bank canal supplies drinking water to Pune and Khadki.Total catchment area of the reservoir is 501.80 Km².

Panshet Dam (also called Tanajisagar dam) is a dam on Ambi river tributary of Mutha, which is located at 18° 23' 15" N Latitude and 73° 36' 46" E Longitude. The height of the dam above its lowest foundation is 63.56m, while the length is 1,039m. The volume content is 4,190km3 and gross storage capacity is 303,000.00m3.

Varasgaon Dam is a dam on the Mose River which supplies water to city of Pune. It is also called Veer Baaji Pasalkar Dam. It is one of the three major dams which provide water to Pune city. The Panshet dam is adjacent to Varasgaon dam.

Temghar Dam is built up across the river Mutha. The full reservoir level has been fixed at RL 706.5 m. An area of 499 ha is coming under submergence including 4.50 ha. Of forest land. (About 0.9% of submergence land).

Mulshi Dam is the name of a major dam on the Mula River. It is in the Mulshi Taluka. Water from this reservoir is diverted to the Bhira power house for generating Hydro-electricity operated by Tata Power. The station operates six 25MW Pelton Turbines established in 1927 and one 150MW Pumped Storage Unit. Water from the dam is also used for irrigation.

Methodology

For assessment of the current reservoir operation and planned capacity expansion can use multi-objective deterministic and stochastic optimization and by the adoption of a more sophisticated information system we can use potential improvement for evaluation (Castelletti et. al., 2012). For this assessment ancillary data has been used viz., Digital Elevation Model (DEM), slope map, land use land cover, stream density (Fig.2).

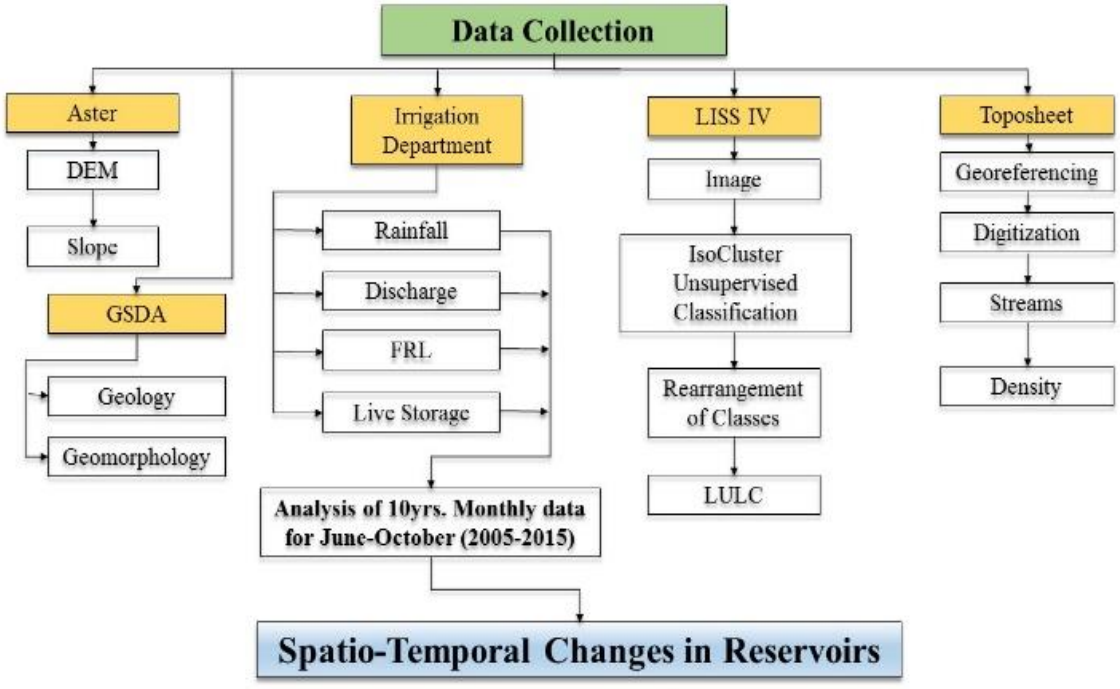


Fig. 3. Methodology Chart

With this view, an attempt has been made here to analyses the reservoir parameters such as FRL, Live Storages etc. For the 5 reservoirs namely Khadakwasla, Temghar, Panshet, Varasgaon and Mulshi located in Pune district and supply water to Pune City. Temporal variations in these characteristics for last 10 years have also been examined.

Full Reservoir Level (FRL) It is the level corresponding to the storage which includes both inactive and active storage and the flood storage, if provided for. In fact, this is the highest reservoir level that can be maintained without spillway discharge or without passing water downstream through sluice ways.

Dead Storage Level (DSL) Below the level, there are no outlets to drain the water in the reservoir by gravity.

Live storage: This is the storage available for the intended purpose between Full Supply Level and the Invert Level of the lowest discharge outlet. The Full Supply Level is normally that level above which over spill to waste would take place. The minimum operating level must be sufficiently above the lowest discharge outlet to avoid vortex formation and air entrainment. This may also be termed as the volume of water available at any time between the Dead Storage Level and the lower of the actual water level and Full Reservoir Level.

Dead storage: It is the total storage below the invert level of the lowest discharge outlet from the reservoir. It may be available to contain sedimentation, provided the sediment does not adversely affect the lowest discharge.

Thematic Layers:

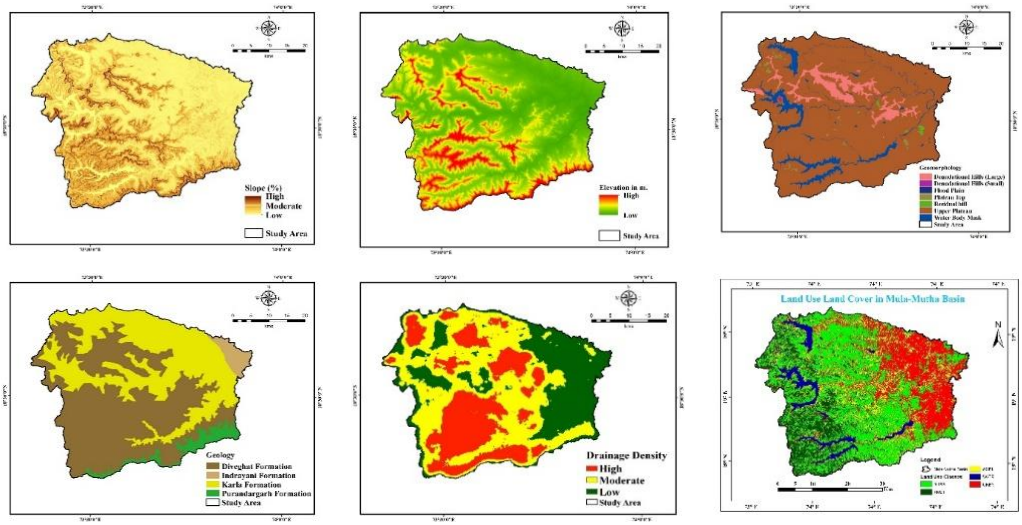


Fig. 3. Thematic layers of Slope, elevation, geomorphology, geology, stream density and LULC

Slope map is generated from cartosat DEM to understand the relative slope of reservoirs, likewise geological formations and the landforms and the drainage density also important to study reservoirs (Fig. 3). Land-use change models, for their part, are based on specific procedures for land allocation either in agricultural areas or urban areas (Torrens, 2001; Balmann, 1997).

Result and Discussion:

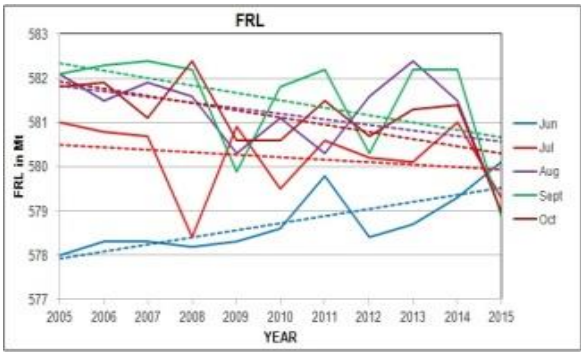
Small descriptions of these reservoirs are given here, and their characteristic features are given in Table 1. Storage capacity of Panshet and Varasgaon are maximum (more than10TMC), while for Khadakwasla it is minimum (1.96TMC).

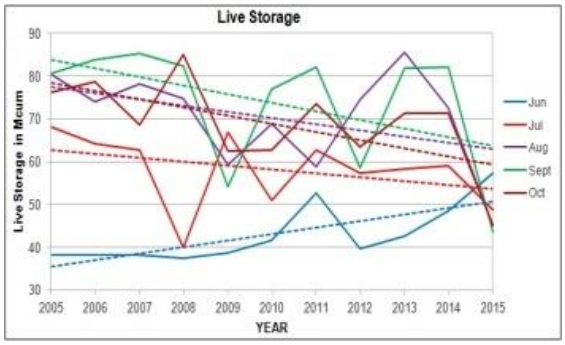
Table 1. Average Parameters of these reservoirs

Name of Reservoir	FRL(m)	Live storage (mcum)	Dead storage (mcum)	Total discharge(cusecs)
Khadakwasla Dam	582.47	55.91	30	97116
Panshet Dam	636.37	301.61	9	41036
Varasgaon Dam	639.50	363.13	12.23	51948
Temghar Dam	706.50	105.01	2.95	12120
Mulshi Dam	606.10	523.00	13	67240

Mulshi has a large storage of 523 mcum and it receives rainfall around 300 cm during a year. Its annual discharge is 67240cusecs, 2nd largest than after Khadakwasla. Khadakwasla has dead storage of 30mcum.The spatial and temporal analysis for each of the reservoir are as follows,

Khadakwasla:





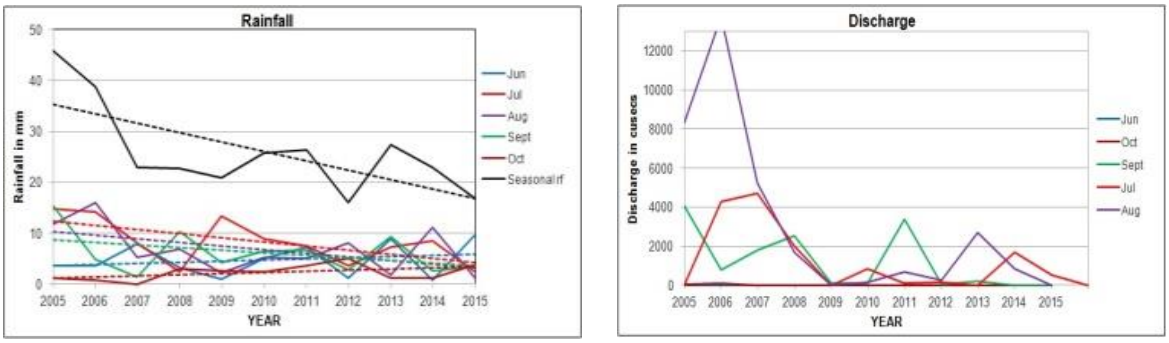


Fig. 4. Monthly time series of 4 parameters (FRL, Live storage, Rainfall andDischarge) at Khadakwasla

It is clearly seen from the Fig. 4 that FRL is continuously decreasing for all the months except June. Maximum being observed in the month of September, as Jul-Aug are the months of maximum rainfall as seen from the Figure. In similar way live storage is also seen to be maximum in the month of September. Low values are seen in the start of the rainyseason. Monthly rainfall shows declining tendency for last 11 years except for the month of October. Seasonal rainfall has also been shown in the figure which is declining in the reservoir area. 2005 and 2006 are the 2 years when substantial water was released in Jul-Aug. Months. Otherwise discharges through spillways are declining to a greater extent in recent years.

Panshet:

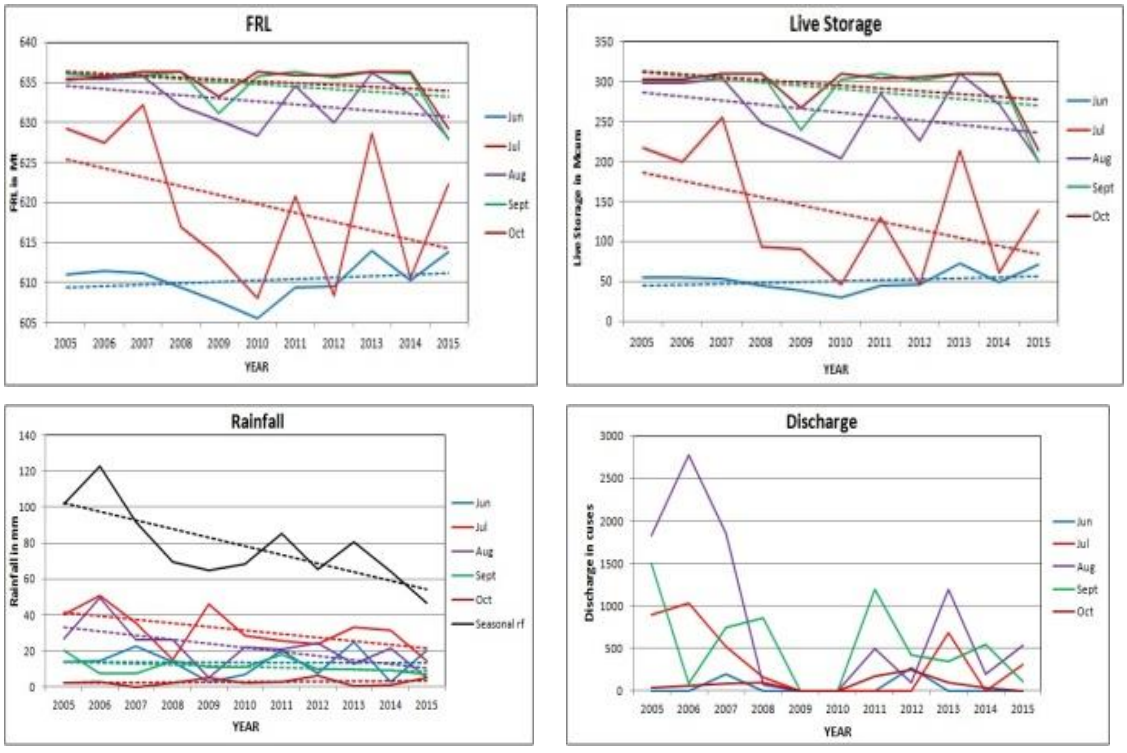


Fig. 5. Monthly time series of 4 parameters (FRL, Live storage, Rainfall andDischarge) at Panshet

No change in the FRL and Live storage is observed for all the months (Jun-Oct) except for July month,

where it is decreasing substantially (Fig. 5). Seasonal rainfall shows significant decrease while for other months' rainfall shows no change. Except for years 2005-2007, discharges through spillways are decreasing. This has adverse impact on the water quality of the river as waste water is released in the river at some places. This has also adverse impact on the flora and fauna of the river side.

Varasgaon:

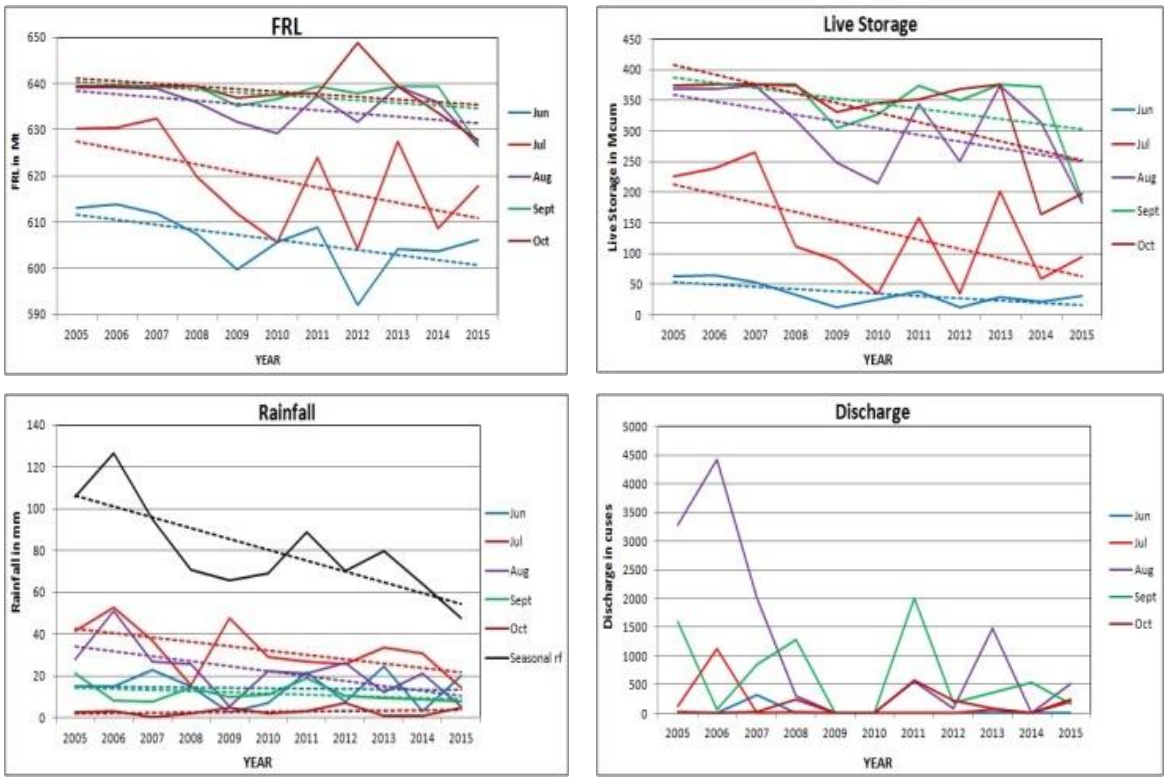
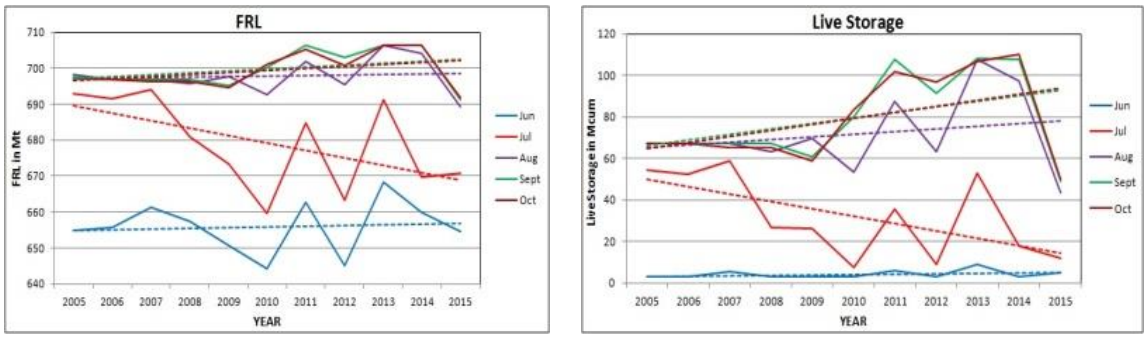


Fig. 6. Monthly time series of 4 parameters (FRL, Live storage, Rainfall and Discharge) at Varasgaon

Substantial variations in live storage are seen between different months. Like other places seasonal rainfall is decreasing on seasonal scale. Discharge through spillways has been declined after 2007 (Fig. 6).

Temghar:



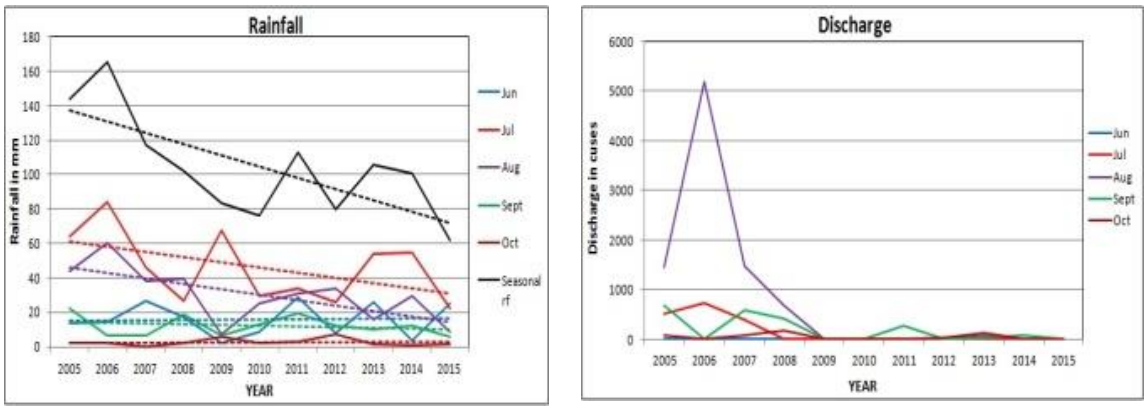


Fig. 7. Monthly time series of 4 parameters (FRL, Live storage, Rainfall and Discharge) at Temghar

Substantial decrease in FRL and live storage during July is noticed while rise in these parameters in the month of Set-Oct are also noticed. Like for other reservoir locations, seasonal rainfall shows significant decrease. Discharge values are very low except for the years 2005 and 2006 (Fig. 7).

Mulashi

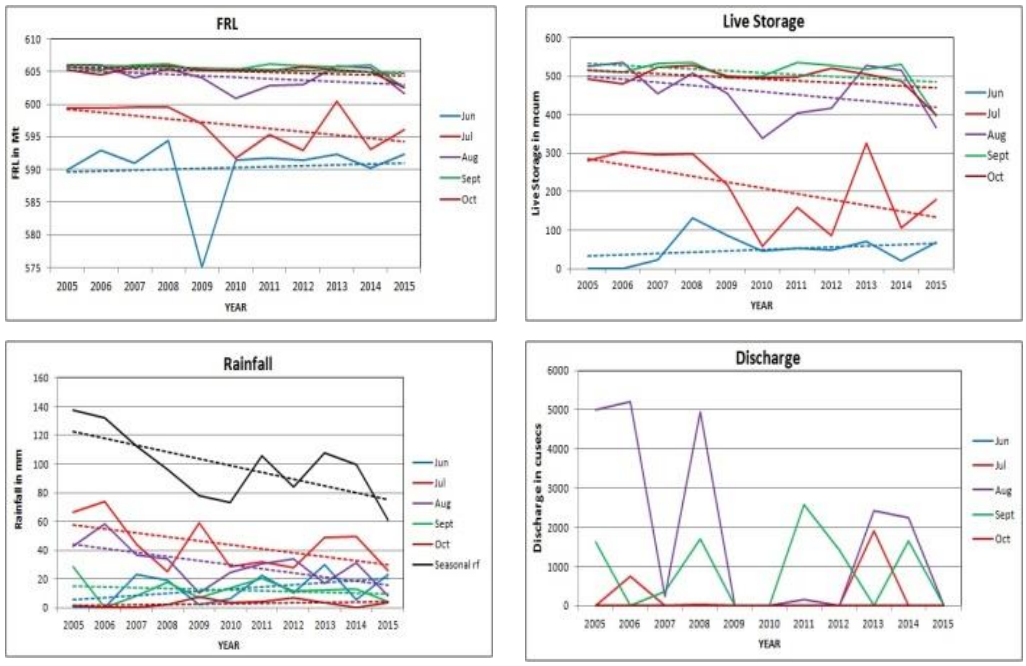


Fig. 8. Monthly time series of 4 parameters (FRL, Live storage, Rainfall andDischarge) at Mulshi

Variability between months in live storage is large. No temporal changes are seen in FRL and Live storage (Fig. 8). Seasonal rainfall shows sharp decline in last 11 years which is like other reservoir locations. Except August, Discharge through spillways is very small.

Monthly average Pattern of 3 parameters (FRL, Live storage and Rainfall) and their variability in different reservoirs

Monthly average values of Discharge data are not considered as most of the days' discharge values are equal to zeros only during heavy rain spell days these values are positive. So monthly average values of discharge data may lead to misinterpretation so not considered here.

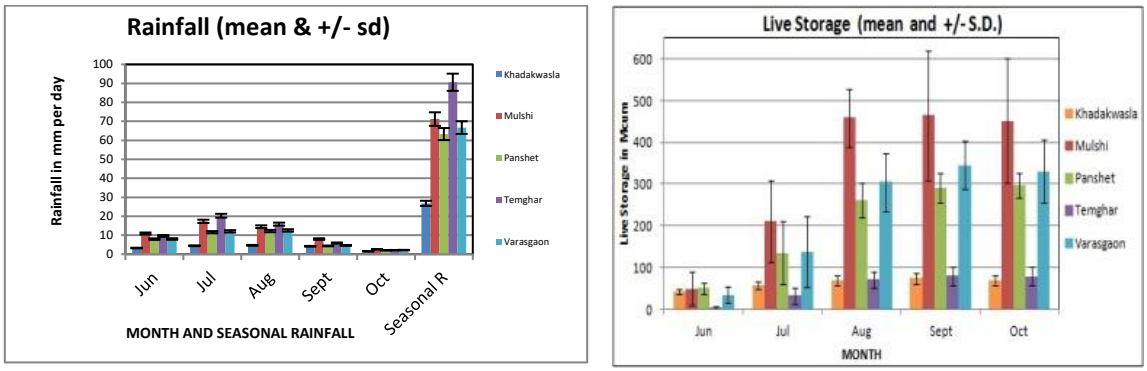


Fig. 9. Monthly averages of FRL, Live storage and Rainfall for 5 reservoirs

It is seen from the figure that Maximum value of FRL is observed for Temghar dam. Variability of Mulshi FRL is maximum in June, while that of Varasgaon is in October. Live storages are maximum for all the months for Mulshi reservoir. Rainfall activity is maximum in July (Fig. 9).

Table 2. Reservoir Seasonal rainfall (mean and SD in mm.)

Name of reservoir	Seasonal Rainfall mm (mean)	Seasonal Rainfall mm (SD)
Khadakwasla	780.81	494.42
Panshet	2345.72	1082.12
Varasgaon	2407.09	1115.07
Temghar	3135	1546.53
Mulshi	2970.81	1519.58

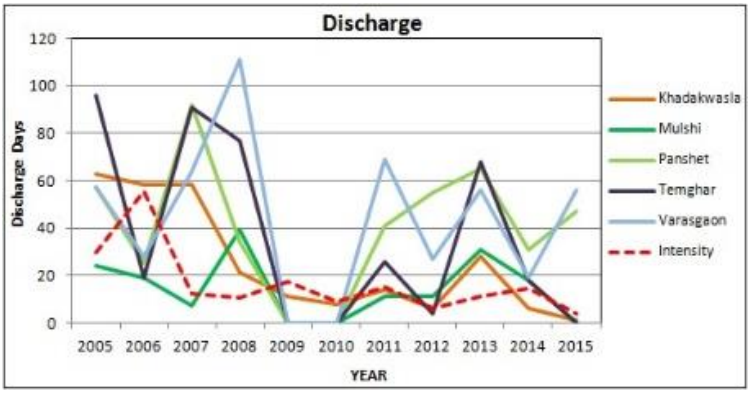


Fig. 10. Temporal variations in discharge intensity and days

Discharge days are maximum for Temghar as its rainfall is comparatively high. A Large variation in number of Discharge days is seen for Varasgaon location. Discharge intensity is decreasing for last 11 years from the reservoirs of Pune city (Fig. 10).

Conclusion

From the analysis of different parameters of the reservoir, it is seen that FRL, Live storage and seasonal rainfall are decreasing in the reservoir area. Discharge days and their intensity is also decreasing. After 2007, almost less discharge through spillways are seen for some reservoirs. This affects the flora & Fauna of the river system and adversely affect the ecosystem of the basin.

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