© August 2018 | IJIRT | Volume 5 Issue 3 | ISSN: 2349-6002

Assessment of Surface Water Potentiality in Supplying Water to Guruvayur Municipality (Kerala)

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Abstract- **Guruvayur Municipality which is having high floating population and commercialization is facing water scarcity issues despite of having plenty of water assets. This requires immediate attention and formulation of water management policies. In this study water availability modelling was carried out for Bharatapuzha River from where water was supplied for Guruvayur Muncipality. The water supply network in Guruvayur Municipality was traced in detail. The water availability study was carried out using the software MIKE HYDRO RIVER which is a 1D river modelling software. Hydrodynamic modelling was carried out using 28 years discharge data from CWC station. The modelling was carried out for a river stretch of 50 km. The past and present water availability of Bharatapuzha River (focussing on the spot Trithala) was simulated using the model and the future water availability (till 2030) was predicted based on climate change scenario. The study also covers the analysis of discharge data of Karuvannur River from where future water supply schemes are proposed for Guruvayur Municipality. The study results revealed that the water availability in both the rivers considered showed a declining trend over the years. The possible reasons for the declining trend were: decrease in rainfall trend over the years, increase in temperature over the years, groundwater exploitation, change in land use pattern and sand mining. Thus the dependency on surface water is not so reliable. So the recommendation for Guruvayur Municipality is to go for sustainable management of water resources within the Municipality rather than depending upon the unreliable sources.**

Index Terms- Mike Hydro River, Modeling of river, Quantification of fresh water (Bharatapuzha).

INTRODUCTION

Water scarcity has become a major hardship at present. It‘s a problem affecting almost all parts of the world. Even though two-third of the earth is covered with water, the water in consumable form is very scarce. To be more precise 97% of the total available water is saline and rest 3% is only in useable form. This 3% is available in various forms like glaciers, icecaps, groundwater, surface water etc. Glaciers and icecaps cannot be consumed directly; the groundwater has to be extracted for consumption. Surface water is the best fresh water source easily accessible for consumption. The surface water sources include: lakes, ponds, wetlands and rivers. Various activities are depended on surface water availability. The various activities include: aquatic life support, water supply, recreational activities, fisheries, transportation etc. All living organisms and various species depend on surface water for their existence.

LITERATURE REVIEW

Rivers are most important form of surface water and our dependency on surface water is immense. Human activity and ecology is sustained by rivers. The fresh water availability from rivers is about 0.006% of the total availability. (Kumar et al, 2013). Rivers are naturally flowing water bodies. They have natural downstream flow when compared to other forms of surface water like lakes and ponds. The flow in rivers is much faster than other surface water bodies. The quality and quantity of water in the rivers depend on the catchment characteristics. If the watershed condition deteriorates the river is also affected. The rivers are transporting medium; they transport nutrients, sediment, pollutants from upstream to downstream depending on the entry source to the river. The transfer of the pollutants can lead to the environmental pollution at the downstream points. The river morphology and the river characteristics are affected due to human activities, climatic changes and hydrological conditions. The human activities are becoming a prime factor in destroying water quality and quantity in rivers. Various wastes like agricultural effluents, industrial effluents, sewage waste are dumped to rivers without proper treatments are damaging the quality of the river water. The self purifying capacities of the rivers are affected due to huge deposition of waste and cause irreparable damage to rivers (Srivastava et al, 2007). Rivers have played a major role in emergence of societies. The population had always depended on the rivers for various activities. Initial settlements were always near to the rivers due to easy accessibility to water. As the population rate increases the dependency on the rivers also increase. The current water availability in rivers are becoming a major concern.

THE MAIN ISSUES FACES BY INDIAN RIVERS

Pollution : One of the major problems faced by the rivers is pollution. Pollution are of different types. This will include industrial pollution, domestic pollution, factories, agricultural etc. The level and intensity of pollutant drained to rivers are huge and is killing the rivers. Water pollution will affect entire biosphere(Ma et al, 2009). The source of pollutants can be classified as point source and non point source. The point source is contaminants that enter from a single, identifiable source. The non-point source is the diffused contaminant originated from multiple sources. The pollutants are being dumped to the water without any control. There is no proper legal control over the waste disposal or rather the existing rules and regulations are violated and no action for protection is taken (Agrawal et al., 1999)

Pollution in rivers

Impact of Construction Dams On Rivers

Climate Change: Most of the Indian rivers go dry during the summer season. The perennial rivers are turning out to be non perennial. The is rapid decrease in rainfall availability in various parts of the country. Rapid deforestation has led to this reduction in rainfall. Moreover the global temperature has increased at a rapid level, converting summers to much hotter summers, which increased the evaporation rates causing decrease in water level rivers (Pumo et al.,2017).

Construction Of Dams: Large dams, check dams that has been constructed along the rivers and other water bodies have created problems for the rivers. The flow pattern, extent and nature of sediment formation and sediment deposition, riverine biodiversity and water quality. Even though dams are considered to be source of water storage and restoration the negative aspects are many. It has become harm rather than becoming a boon (Bastawesy et al., 2015).

Sand Mining: The construction boom, fueled by the inflow of remittances from non-resident Indians and the inherent nature of people to construct ostentatious residential buildings, leads to indiscriminate mining of sand from rivers. This has pushed the water table down, reduced the water holding capacity and adversely affected the diversity of life forms thriving in the riverine eco system. Even though strict legal control is there against sand mining still this activity is carried out drastically.

RANK	PROBLEM
1	POLLUTION
2	CLIMATE CHANGE
3	CONSTRUCTION OF DAMS
4	SAND MINING
5	WETLAND FILLING
6	DEFORESTATION
7	CHANNELIZING
8	DEEPENING OF LAND ALONG RIVER BANKS
9	VEGETATION AFFECTING FLOW
10	OTHER HUMAN ACTIVITIES
11	NO PROPER LEGAL CONTROL

River Channelizing

2.3 Sand Mining In Rivers (www..downtoearth.org.in)

Wetland Filling: Due to increase in population people were in need of land for constructing house and other non agricultural purposes. And rather commercialization increased to large extent. This has led to large-scale conversion of paddy and other types of wetlands. This reduced the recharging of ground water and the subsurface flow to rivers, thus accelerating the drying up of rivers (Mondal et al., 2017).

Deforestation: The cutting down of trees has always been an issue. The trees which anchor the soil with roots can cause widespread erosion throughout the tropics. After heavy rainfall on cleared land due to runoff the soil will be carried into rivers. This will affect the natural regime of the river, flow pattern and sediment content (Lutrubesse et al., 2009).

Channelizing / River Modification: The channelizing of river or modification done on river for various activities like agricultural, storage or commercial use had led to change in flow pattern of the river.

Vegetation Affecting The Flow: Vegetation like tall grasses is a hindrance to the natural flow of the river. It cause damage to the river morphology and the ecosystem.

Other Human Activities: Human activities for entertainment have led to pollution of rivers. The activities like boating, fishing, carelessly throwing waste to water has led to river pollution and disturbance to river ecology.

No Proper Legal Control: Even though many legal controls are there against surface water exploitation, none has an effective impact in protecting the rivers. The rules and regulations are violated at an unimaginable rate in present society. The proper scrutiny of laws implemented has to be carried out else it will be of no use.

RIVER PROBLEMS RANKING

A ranking had been applied to the problems affecting rivers. The ranking is based on the impact of problems on rivers.

MODELLING AS A TOOL FOR WATER RESOURCE MANAGEMENT

Hydrological Modeling: Hydrological modeling is an essential component of water research and management in large river basins. Hydrological models help us to understand the past and current state of water resources in the basin, and provide a way to explore the implications of management decisions and imposed changes. In the current scenario hydrological modeling helps us mainly in 2 ways: to inform decisions relating to national development and poverty alleviation; and to prevent trans-boundary conflicts by promoting equitable allocation and access (Nkwonta et al.2017).

Need For Modeling: River models are interactive programs that utilize analytical methods, such as simulation and optimization of algorithms, to help decision-makers formulate water resources alternatives, analyze their impacts, and interpret and select appropriate options for implementation. Models are used to simulate water resource system behavior based on various hydrological parameters. Models are used to find the unknown parameters using the known parameters. Models are very helpful in reducing the decision- making time as well as providing consistent and quality decisions. In the context of trans boundary river basins, models are needed by planners, and managers of water resource systems, as well as other stakeholders who may be concerned about the economic or environmental uses of shared water resources. The objective of these decision-makers is, among other things, to provide a reliable supply of water with a quality appropriate for its use, production of hydropower, protection from floods and protection of ecosystem.

Data measurement and collection – receipt of various data (e.g., water level temperature, precipitation, air temperature, concentrations, etc) from station throughout a river basin.

Data processing – storage and processing of data related to the processes of interest in the basin, both spatial features as well as time series data.

Analytical tools – models designed to predict basin response to various climate and development scenarios.

Decision implementation – formulation of decisions regarding water use under various conditions.

The methodology carried out for the study consists of 3 parts:

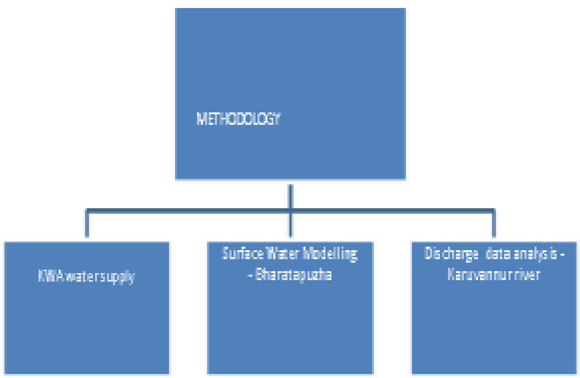


Fig. 3.1 Flowchart Depicting Methodologysupply

RESULTS AND DISCUSSION

Variation Of Discharge Over The Time Period

The Fig4.1 shows the simulation carried out for the period 1988 – 2016 (Trithala). The discharge considered is for the whole years including monsoon period & non-monsoon period. It can be clearly seen that the there is decreasing trend in the discharge from 1988 – 2016 period. The trend is not very drastic but it can be clearly observed that there is decrease in discharge trend.

The Fig4.2 shows the simulation of discharge carried out for the Non-monsoon period from 1988 – 2016 period. The Non-monsoon period includes the months: January, February, March, April, November, December. It can be observed that the decreasing trend has increased compared to the yearly cumulative discharge trend. Thus it is evident that the water availability is decreasing at a higher rate during Non.monsoon period.

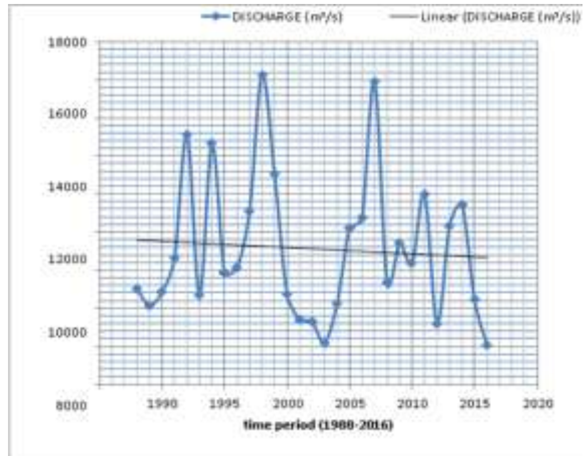


Fig. 4.1 Yearly Cumulative Discharge Vs Time - Bharatapuzha time period (1988-2016)

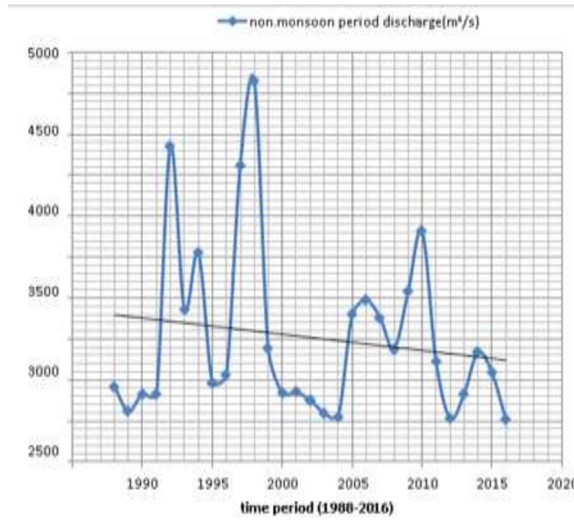
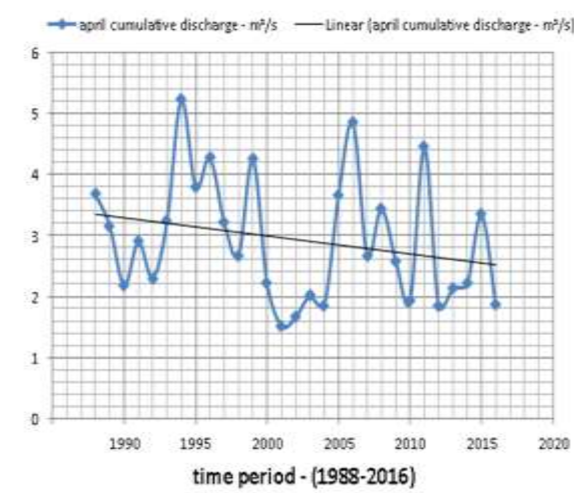


Figure. 4.2 Yearly Cumulative Discharge (Non.Monsoon Period) Vs Time – Bharatapuzha



In the Fig 4.5 the cumulative discharge variation for the month of April is shown for the time period (1988

– 2016). The month April was chosen because the month April had shown the least discharge values during the simulated period. The drastic change in discharge trend can be observed from the below figure.

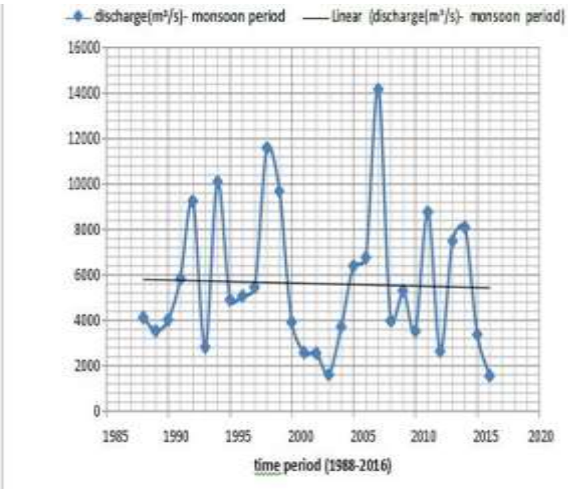


Fig4.3 shows the simulation of discharge carried out for the monsoon period from 1988 – 2016 period. The monsoon period includes the months: May, June, July, August, September, and October. It can be observed that the decreasing trend has decreased compared to the yearly cumulative discharge trend. Thus it is evident that the water availability has not varied too much in monsoon period over the simulated period. Even though there water availability has decreased; it is not showing a huge variation during monsoon period.

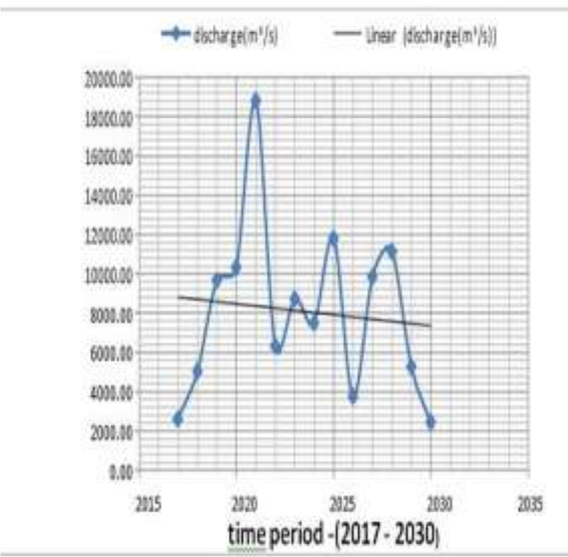


Fig. 4.6 Yearly Cumulative Discharge Predicted On GCM Basis (2017 – 2030)

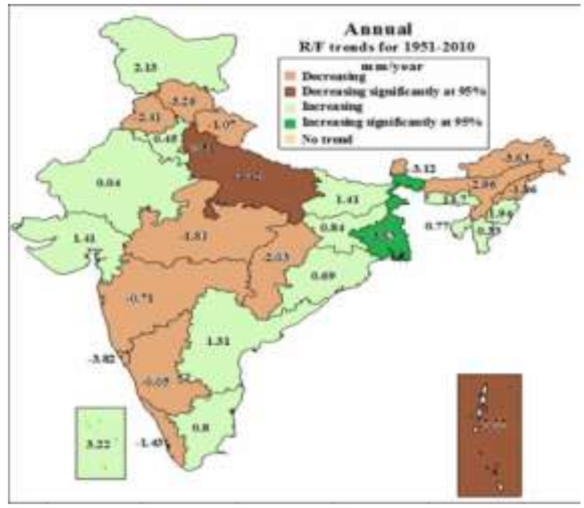


Fig. 4.7 state wise annual Rainfall Trend – IMD Report (1951 – 2010)It can be observed from Fig 4.7 that in Kerala the rainfall is showing a decreasing trend. About 1.43% of reduction in rainfall is observed per year from the period (1951 - 2010).

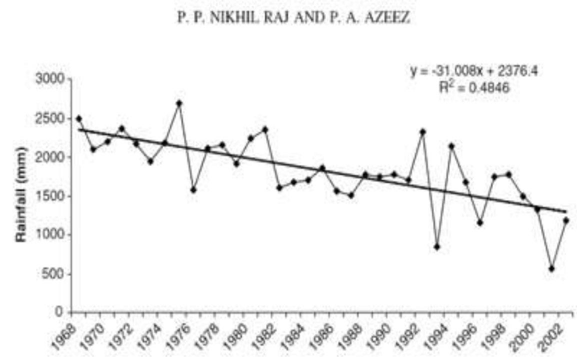


Fig. 4.8 Rainfall Trend In Bharatapuzha River Basin (1968 – 2002) (Raj et al 2010) Based on the rainfall trend analysis study conducted in Bharatapuzha river basin from 1968 – 2002, it can be observed from Fig 4.8 that the annual rainfall in the basin had shown decreasing t

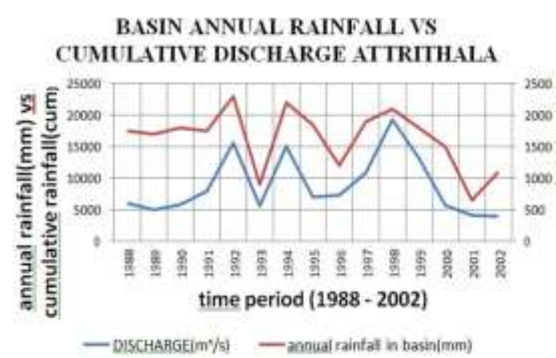


Fig. 4.9 Basin Annual Rainfall Vs Discharge at Trithala

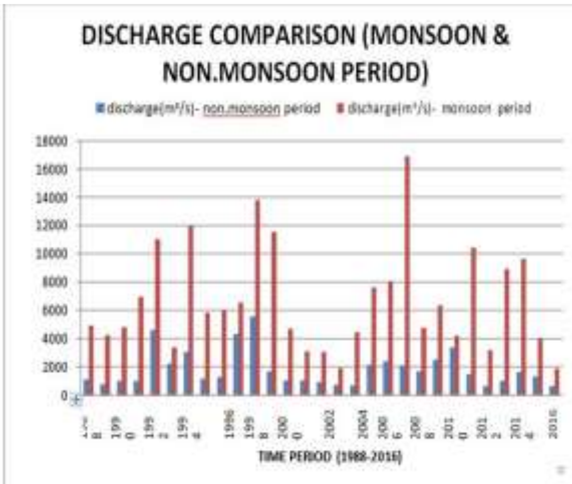


Fig. 4.4 Comparison Of Discharge (Monsoon & Non.Monsoon) – 1988 To 2016 (Bharatapuzha)

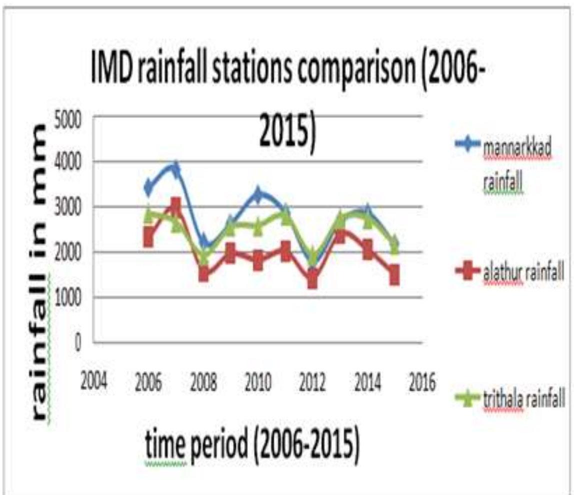


Fig. 4.10 Annual Rainfall comparison Of IMD Stations in Bharatapuzha River Basin

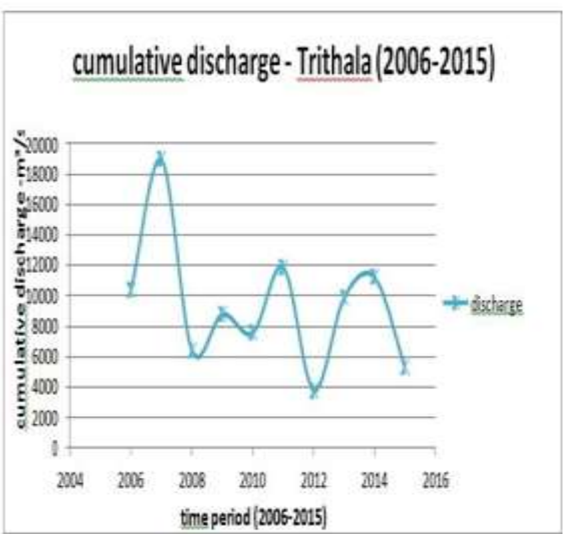


Fig. 4.11 Yearly Cumulative Discharge Vs Time - Trithala

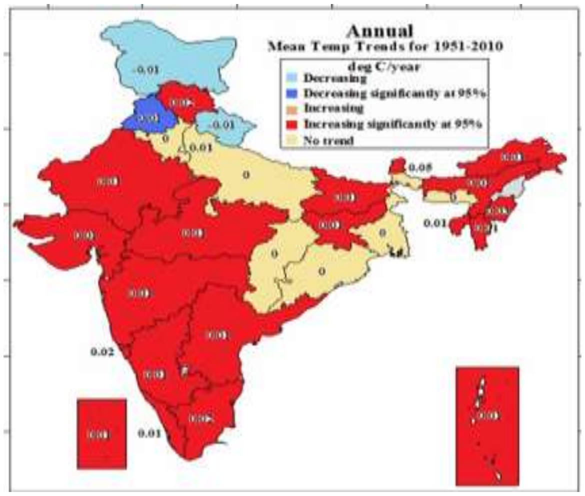


Fig. 4.12 State wise Mean Temperature Trend in India – IMD Report (1951 – 2010)

From the Fig 4.12 it can be observed that Kerala comes in the zone where the temperature is increasing at a very rapid rate. As per the rate of increase is 0.01 degree C per year. Also a temperature trend study conducted in Bharatapuzha river basin for the period 1968 – 2005 showed that there was increase in temperature all around the basin. The mean, maximum and minimum temperatures showed an increasing trend in the river basin.fig. 4.13 Temperature Trend In Bhartapuzha River Basin(1968-2005) (Raj et al 2009)

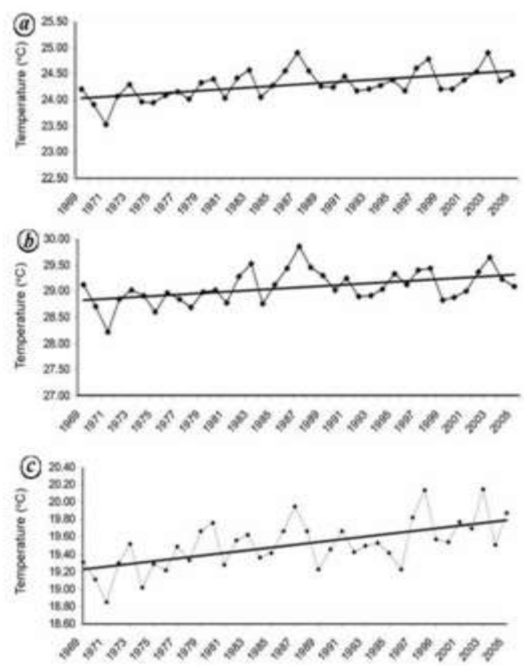


Figure 1. Annual mean (*a*), maximum (*b*) and minimum (*c*) temperature in the Bharathapuzha river basin.

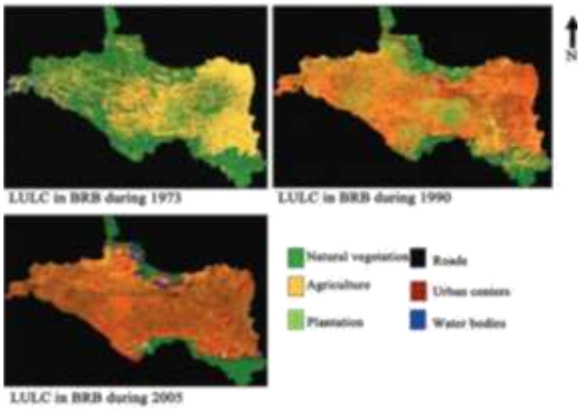


Fig. 4.14 Variation In Lulc In Bharatapuzha River Basin (Generated From
Landsat Tm 1973, 1990, 2005) (Raj et al 2010)

	1973	1990	2005	Change (%) during 1973-1990	Change (%) during 1990-2005	Change (%) during 1973-2005
Agriculture	27.84	27.54	19.15	−0.30	−8.39	−8.69
Natural vegetation	43.43	12.07	12.28	−31.36	0.21	−31.15
Plantation	7.46	14.20	8.64	6.74	−5.56	1.18
Roads	7.61	8.40	16.24	0.79	7.83	8.62
Urban centers	9.83	32.63	41.76	22.80	9.13	31.93
Water resources	3.82	5.16	1.93	1.34	−3.23	−1.89

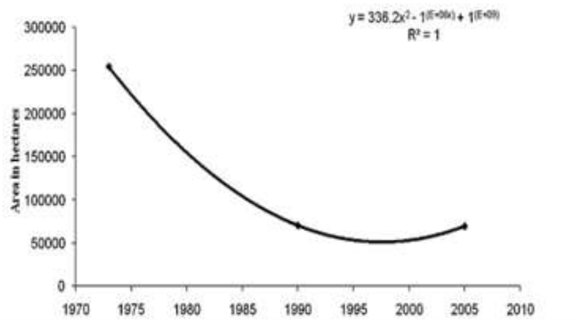


Fig. 4.15 Natural Vegetation In Bhartapuzha River Basin (1973 – 2005) (Raj et al 2010)

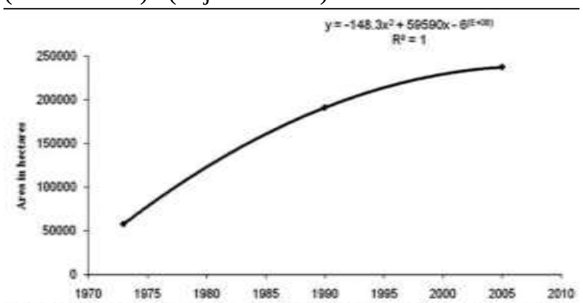


Fig. 4.16 Change in Urbanization in Bharatapuzha River Basin (1973 – 2005) (Raj et al 2010)

It can be clearly observed from the images that the urbanization had increased at a very high rate from 1973 to 2005. Due to the rapid urbanization there was decline in natural vegetation.

From the above graphs it can be observed that natural vegetation, area under water bodies and area under agriculture had decreased but the urban centers had increased.

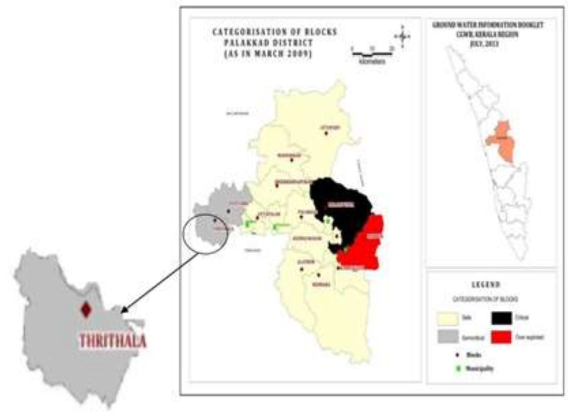


Fig. 4.17 Block Categorizing Based On Groundwater Exploitation – CGWB REPORT Source: GROUNDWATER INFORMATION BOOKLET OF PALAKKAD DISTRICT, KERALA STATE – CGWB

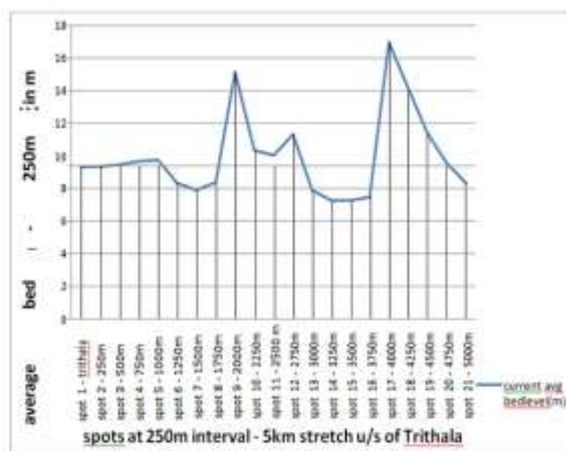


Fig. 4.18 Average Bed Level In The River Over A Span Of 5km At 250m Interval - Trithala

In the Central Ground Water Board report for the Palakkad region (2009), Trithala was declared as semi critical zone considering groundwater exploitation. In the year 2002, Chittur & Trithala were declared as drought hit by Central Ground Water Board, there was too much of groundwater exploitation during this period. The over exploitation of ground water had affected the discharge in the river as water table goes down due to ground water exploitation.

As per the study conducted by CWRDM in the Trithala region (Prasad et al.,2011) the average bed level was 15m. In this study the latest river bed level was extracted from SRTM DEM (2017), it was clearly observed that there were changes in the bed level. In this study the bed level was taken for every 250m upstream to Trithala for a span of 5000m (as the stretch considered in CWRDM study was for 5000m upstream of Trithala. The following graphs were prepared on the basis of SRTM DEM data.

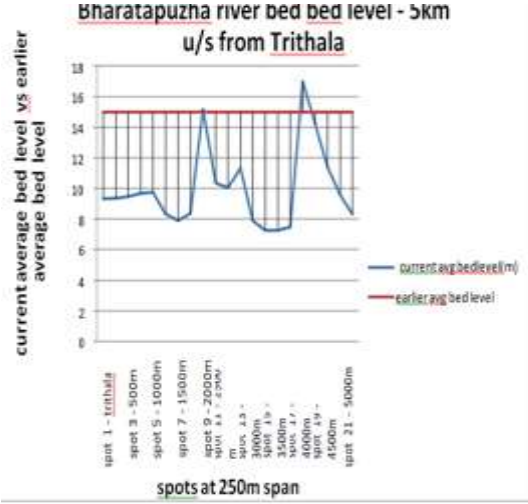


Fig. 4.19 Current River Bed Level Vs Earlier Average Bed Level - Trithala

The water holding capacity decreases as the river bed level decreases. Thus the river water availability decreases during peak summer period. The water drains faster to the sea, causing decrease in water level.

CONCLUSION

Water scarcity has been affecting the world at a very rapid rate. The proper water management has become the need of the hour. Surface water availability trend is a sign of upcoming water scarcity. In the current study surface water availability trend was analysed and future water availability was predicted based on climate change scenario for Bharatapuzha River considering a stretch of 50km from Mankara to Trithala. Bharatapuzha river is the surface water source on which Guruvayur Municipality is currently depending upon. The trithala pump house is having withdrawal capacity of 6.5MLD (0.075 m^3/s) from the river. In the study the model simulation was carried out for a period of 28 years (1988 – 2016) using the CWC discharge data of the same mentioned period to find the water availability at Trithala. The least discharge was observed during the month of April throughout the period. The monthly average discharge value in April 1988 was 3.67m^3/s and that of April 2016 was 1.86m^3/s. Thus indicating a very steep decrement in discharge during the driest period in the year. But the least discharge value was observed in the range 0.5m^3/s – 1m^3/s was observed in the year 2001. As per Central Ground Water Board report Trithala was declared drought hit in the year 2001. When compared to the least discharge values the intake values comes to 7.5 – 15% of the total water availability. This means that water is available in the river for supply as very little amount is taken from the river for supplying to Guruvayur Municipality. But the major point to be noted is that the trend in discharge is decreasing over the years which mean the water availability is also decreasing. Currently there is enough water available in Bharatapuzha for supply but there is decline in water availability considering the past availability. So by the near future the surface water supply will not be a reliable source. It‘s a known fact that the rivers all over the world are dying. There is no exemption incase of Bharatapuzha & Karuvannur river.

Guruvayur Municipality is planning to withdraw water from Karuvannur river in the near future. So an analysis of discharge trend was carried out in the study based on the available discharge data. The discharge data of Karuvannur river for 5 months(June, July, August, September & October) in the monsoon period showed decreasing trend. Only 5 months data were available from the hydrology department of Irrigation Department. This trend will be followed as the rainfall trend is also decreasing and urbanization is increasing. Currently 34MLD (0.39m^3/s) water is withdrawn from Karuvannur river by various schemes. The proposed scheme for Guruvayur Municipality is 22MLD (0.25m^3/s). So the total water withdrawal will 56MLD (0.64m^3/s). The least discharge value in the monsoon period was observed to be 11.11m^3/s indicating the current withdrawal did not face any problem during the observed period. The present discharge analysis of Karuvannur River was not conducted due to data unavailability. But from the observed discharge the trend is decreasing. So the study concludes that surface water sources on which Guruvayur Municipality depends is showing a decreasing trend in water availability. At present the water demands are being met but in the near future the surface water may not be a reliable source of supply.

RECOMMENDATIONS

Guruvayur Municipality has dependency on imported water which also includes surface water. This will not be a permanent solution for the water scarcity issues in the Municipality. The sources are showing a declining trend in water availability. So alternate solutions have to be considered. Sustainable water resource management is a main factor that is needed to be considered for the Municipality, rather than importing water it will be better if the available resources are utilized properly. As per the water audit conducted in Guruvayur Municipality it was observed that out of 33 public ponds 31 are in unusable condition similarly out of 144 public wells 23 are in unusable condition. The rejuvenation of the public ponds, public wells and canals can reduce the water scarcity problems in the Municipality. Another alternative that can be considered is implementation of a decentralized system like desalination plant. As coastal area is nearby, the idea of desalination plant can be considered as possible alternative. FUTURE SCOPE are The karuvannur river water availability study can be carried out collecting the present discharge data, in the present study the time period considered is 2007. 2013 only as further data was not available. Only discharge data of 5 months (June – October) were available. The future water availability prediction can be carried out based on various scenarios for both Bharatapuzha and Karuvannur river.

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