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Analysis of Streamflow at 3, 5 and 7-Day Intervals at Four Gauging Stations of the Krishna River

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ABSTRACT

Streamflow analysis plays a crucial role in understanding the availability and distribution of water within a river basin. Streamflow analysis helps us for predicting flood conditions and reducing the risks associated with heavy rainfall and extreme weather events. Additionally, streamflow analysis provides valuable insights into seasonal variations between monsoon and non-monsoon periods. Understanding daily variations in flow supports efficient utilization and conservation of water resources. The main objective of the current research works is to identify flood and drought conditions at four gauging stations of the Krishna River Basin and also an attempt is made to compute dependable flows at 3-day, 5-day, 7-day intervals. Based on the analysis we observed that very less streamflow discharge 0.0Mm3 at Sadalga gauging station, Samdoli gauging station, Terwad gauging station and Warunji gauging station during non-monsoon season and it is noticed that high discharge is occurred in the month of August as 1469.90 Mm^3,1584.45 Mm^3, 2394.20 Mm3 and 1030.85Mm^3 respectively for 3-Daily. This research work is useful for proper understanding of streamflow behavior for the specific locations. However, analysis of real time streamflow data is used for various purposes such as different time water withdrawal, river flow forecasts, flood warnings, drought warnings and to understand the patterns of natural flow in the river.

Keywords: Floods, Krishna River, Risk, Seasonal Variations, Streamflow.

INTRODUCTION

Streamflow is the volume of water that travels over a particular point in a stream or river over a fixed period of time interval [6]. It helps in the effective planning and management of water resources for agricultural, domestic and industrial needs. The study of streamflow patterns, better decisions can be made regarding irrigation scheduling and reservoir operations. It is also important for predicting flood conditions and reducing the risks associated with heavy rainfall and extreme weather events. Additionally, streamflow analysis provides valuable insights into seasonal variations between monsoon and non-monsoon periods. Understanding daily variations in flow supports efficient utilization and conservation of water resources. It also aids in the design and management of hydraulic structures such as dams, canals, and barrages. Overall, streamflow analysis is essential for sustainable water resource management and environmental protection. Streamflow of a river is critical to water resource estimation, proper planning because it is an integrated process of atmospheric and topographic phenomena [6]. Estimating streamflow is plays a vital role in determining the water resource availability and assessing the flood, drought management and mitigation studies [7]. Investigations of streamflow history, its flow behavior and continuous monitoring of streamflow data will help to determine the optimum usage of water for sustainable water management for better understanding of the climate change. From the view point of hydrologic component there is a need of the hour to explore for both short term and long-term forecasts of streamflow events in order to optimize the system and to plan for future expansion or reduction of the area [8], [9]. Identification of changes in the streamflow over the short term and long term for a series of hydrological variables is an important for sustainable management of water, which has given much interest in the research community. Estimation of the reliable flow in a river is essential for the development of water resources projects.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VII, July 2026

The streamflow flows during the non-monsoon periods are critical for water resources utilization of various purposes. [12].

LITERATURE REVIEW

The variability of dependable streamflow is an important aspect in the analysis of river discharge and plays a key role in effective water resource planning and management. In the Krishna River basin, streamflow varies significantly due to seasonal changes, especially between monsoon and non-monsoon periods. However, a detailed understanding of these variations at shorter time intervals is necessary to accurately assess water availability. Most studies focus on monthly or annual data, which may not capture short-term fluctuations in streamflow. Therefore, analyzing streamflow at 3-day, 5-day, and 7- day intervals becomes essential to understand the dynamic behavior of the river. Such analysis helps in identifying variations in discharge more precisely and improves the reliability of water resource assessment. In addition, studying streamflow across multiple gauging stations provides insights into spatial variations along the Krishna River. Understanding the frequency and duration of high and low flows is also important for better planning of irrigation, flood control, and water utilization. Hence, the present study is necessary to analyze streamflow variability in detail using short-duration intervals and to compare flow characteristics at different gauging stations, which supports efficient and sustainable water resource management. [11] They carried out the research work on the polavaram site of Godavari River using dependable flows. In their research work they carried out reliability analysis at three different levels and results are compared, based on their research work they suggested that 90% of results are more useful for the construction of water resources purposes [13]. In their research work they presented dependable flows investigation in a river section by focusing on the concept of dependable flow, and also in their research work investigated streamflows within a river section which provide essential data for hydraulic engineering and water resource management, ensuring that infrastructure like dams or irrigation channels are designed based on realistic, reliable water availability rather than seasonal peaks. [16] Detection of changes over the long term for a series of hydrological variables is an important and critical issue, which is subject to increasing interest among the researchers in the last few decades. Researchers are shown much interest on emphasizing on trend detection within hydrological datasets. In their research work it is observed that identifying long-term shifts rather than just seasonal fluctuations is vital for understanding how our water systems are evolving. The research analysis of different variables such as rainfall, evaporation and runoff over many decades helps us to distinguish between natural climate variability and permanent changes, which is critical for sustainable urban planning and water security. The drinking water resources throughout the world are becoming depleted and water is contaminated by industrial sector. Currently, this water scarcity problem becomes worse due to climate change, rapid population growth, haphazard industry development, expanding agriculture and urban construction [15],[16]. They carried out the research by focusing on low flows, instream flow needs, and fish ecology within small streams. the intersection of hydrology and freshwater biology, specifically examining how the reduction of water levels affects aquatic life. By studying "instream flow needs," the authors identify the minimum amount of water required to maintain a healthy ecosystem. Their work is particularly significant for small streams, where even minor decreases in flow can drastically alter fish ecology, potentially leading to habitat loss, changes in water temperature, and reduced oxygen levels for local fish populations [2]. The research analysis is carried on the hydrological and meteorological data and compared for canada for two different decades and found the more recent decade to be generally warmer with the occurrence of both increases and decreases in precipitation and streamflow. The Dependable flow depends on the time-based data that varies with time period, known as temporal variation[15]. The trend analysis is determined by a series of observations of random variable by analyzing with increasing or decreasing trends and with the probability distribution will change with time by using statistical analysis. Streamflow statistics are very critical component of different hydrologic investigations on the river section. The maximum water which can be withdrawn from a stream section can be analyses by using low flow statics. However, during different time period of drought, stream flow can be influenced by springs or mining discharges, which prevents an accurate computation of flow from regional regression equations. Tasker (1987) suggested by using a 3-parameter, Log-Pearson Type III distribution to represent the annual series of 7-day low flows, in which the mean, variance, and skew of the distribution are computed from the annual series Although Q7, 10 is used in this report to characterize low flows in streams, the analytical methods could be applied to alternative low-flow characteristics. For example,

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alternative descriptors of low flow include the probability of zero f low [1], [5], The streamflow magnitude at critical times of the year or the duration of continuous low flow periods [4]. Cumulative distribution functions of daily streamflow (flow duration curves) are useful for characterizing the range of streamflows at a site and quantifying the percentage of flows that exceed specific low flows of interest [5].

MATERIALS AND METHODOLOGY

Description of the Study Area

The Krishna River is the fourth-biggest river in terms of water inflows and river basin area in India, after the Ganga, Godavari and Brahmaputra. The river is almost 1,400 kilometers long. The river also called Krishnaveni. It is one of the major sources of irrigation for Maharashtra, Karnataka, Telangana and Andhra Pradesh. The Krishna River rises in the Western Ghats, at an elevation of about 1,337 m just north of Mahabaleshwar, about 64 km from the Arabian Sea. It flows for about 1,400 km and outfalls into the Bay of Bengal. The principal tributaries joining Krishna are the Ghataprabha River, Malaprabha River, Bhima River, Tungabhadra River and Musi River.

The basin is roughly triangular in shape and is bounded by Balaghat range on the North, by the Eastern Ghats on East & the South and by the Western Ghats on the west. Clusters of hills running to the East of Sahyadris range of Western Ghats mark the South Western Boundary of the basin. Boundary between the Krishna & Cauvery Basins is marked by Devarayana Durga Forest- a small patch of 42.27 km situated along the hill chains running across Eastern part of Tumkur District of Karna- taka. An average annual surface water potential of 78.1 km3 has been assessed in this basin. Out of this, 58.0 km3 is utilizable water. Culturable area in the basin is about 203,000 km2 which is 10.4% of the total cultivable area of the country. As the water availability in the Krishna river was becoming inadequate to meet the water demand, Godavari River is linked to the Krishna river by commissioning the Polavaram right bank canal with the help of Pattiseema lift scheme in the year 2015 to augment water availability to the Prakasam Barrage in Andhra Pradesh. The irrigation canals of Prakasam Barrage form part of National Waterway 4. The Location map of the selected study area are presented in Figure.1. The Sadalga, Samdoli, Terwad and Warunji are selected to understand the behavior of stream at these locations in Krishna river basin.

Fig.1: Location map of the selected study area

Methodology

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VII, July 2026

In the current study the methodology adapted as the hydrologic year is divided into twelve months of a calendar between first June of one year and thirty first May of the next year. The availability of water shows considerable variation within this hydrologic year. It is necessary to divide a calendar year into a convenient number of smaller intervals. In the present study 3-daily, 5- daily, 7-daily, 10-daily intervals are carried out. Each of the 12 months in a year is divided in to number of intervals. The streamflow data is collected by the central water commission (CWC), Godavari and Krishna basin Organization Hyderabad, Andhra Pradesh. The streamflow data are available from 1980-81 to 2005-06. In the current study the changes are analyzed, for this analysis the three different scenarios were considered. The available data is considered from 1980-81 to 2005-06. The details of Location of selected gauging stations in Krishna River basin are given in Table.1.

Table.1**:** Details of Location of different gauging stations in Krishna River basin.

S.No.	**Name of the Gauging Site**	**Name of Local River**	**Independent River**	**Latitude**	**Longitude**
1	Sadalga	Krishna	Krishna	16°33’44”	74°31’00”
2	Samdoli	Krishna	Krishna	16°51’18”	74°29’50”
3	Terwad	Krishna	Krishna	16°40’31”	74°34’30”
4	Warunji	Krishna	Krishna	17°16’20”	74°09’54

Data Analysis

The raw data related to the discharge of water for the period from 1980 to 2006 was obtained from the Central Water Commission (CWC), Godavari and Krishna Basin organization, Hyderabad, Andhra Pradesh. The dataset specifically covers the water years from 1980–81 to 2005–06. For systematic analysis, the collected data was organized based on water year, which is defined as the period from 1st June to 31st May of next year. This classification helped in understanding short-term as well as long-term variations in discharge patterns. Based on these intervals, probability analysis was carried out at 50%, 75%, and 90% exceedance levels to evaluate the reliability and variability of water discharge. In addition, the variations in discharge were carefully analyzed for both monsoon and non-monsoon seasons helps us to identify seasonal trends and fluctuations. Finally, comparative graphs were plotted for the selected stations and compare the discharge characteristics across different locations and time periods.

RESULTS AND DISCUSSIONS

The major focus of the present study is to investigate the dependable flow available in different gauging stations of Krishna basin. The data are analyzed at different intervals 3-daily, 5-daily and 7-daily intervals at the three levels reliability (50%, 75%, & 90%). The minimum, maximum and average of 3-daily, 5-daily and 7-daily intervals of streamflows at Sadalga, Samdoli, Terwad and Warunji are presented in Table.2.

Based on the analysis we observed that very less streamflow discharge 0.0Mm^3 at Sadalga gauging station, so there is severe chance of droughts will occurs and also very high discharge is observed in the month of August 1469.90 Mm3. Some drastic changes in the flow pattern in the river during monsoon and non-monsoon period have been noticed. From the analysis we observed that very less streamflow discharge 0.0Mm3 at Samdoli gauging station, so there is severe chance of droughts will occur and also very high discharge is observed in the month of August 1584.45 Mm^3. The less streamflow discharge 0.0Mm^3 was observed at Terwad gauging station, so there is severe chance of droughts will occur and also very high discharge is observed in the month of August 2394.20 Mm^3. We observed that very less streamflow discharge 0.0Mm^3 at Warunji gauging station, so there is severe chance of droughts will occur and also very high discharge is observed in the month of August 1030.85 Mm^3.

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Table.2. Maximum, minimum and average of streamflow discharge

S. No	Gauging Station	Statistical Parameters	3-Daily (Mm^3)	5-Daily (Mm^3)	7-Daily (Mm^3)
1	Sadalga	Max	1469.90	2295.80	2643.30
		Min	0.00	0.00	0.00
		Avg	160.52	288.77	343.59
2	Samdoli	Max	1584.45	2445.16	2704.00
		Min	0.00	0.00	0.00
		Avg	180.70	321.66	385.95
3	Terwad	Max	2394.20	3058.20	4204.65
		Min	0.00	0.00	0.00
		Avg	293.84	382.60	516.35
4	Warunji	Max	1030.85	1930.65	1768.04
		Min	8.11	30.28	60.55
		Avg	174.40	307.11	407.00

The average streamflow is observed as 160.52 Mm^3, 288.77 Mm^3 and 343.59 Mm^3 for 3 -Daily, 5-Daily and 7 daily respectively for Sadalga gauging station. The comparison of 3 Daily for 50%, 3 Daily for 75% and 3 Daily for 90%, Dependable flows at Sadalga, Samdoli, Terwad, Warunji gauging station are shown in Fig.2. Fig.3. and Fig.4. respectively. Stream flow statistics are a critical component of many hydrologic investigations. Low-flow statistics are used to determine the quantity of water that can be withdrawn from a stream and used to analyze the available water for different purposes based on the top priority. [12].

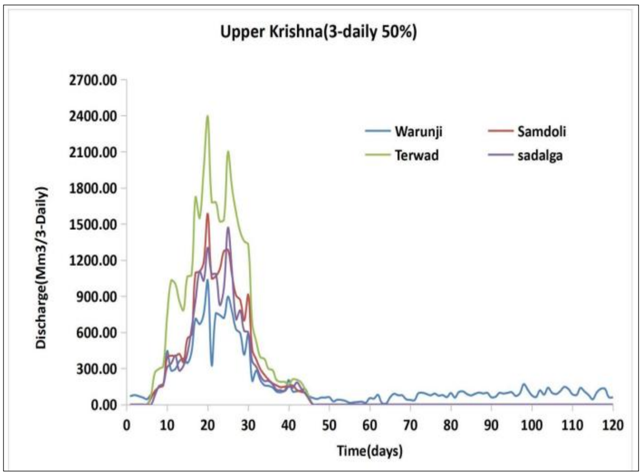

Fig.2. Comparison of 3 Daily for 50% Dependable flows.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VII, July 2026

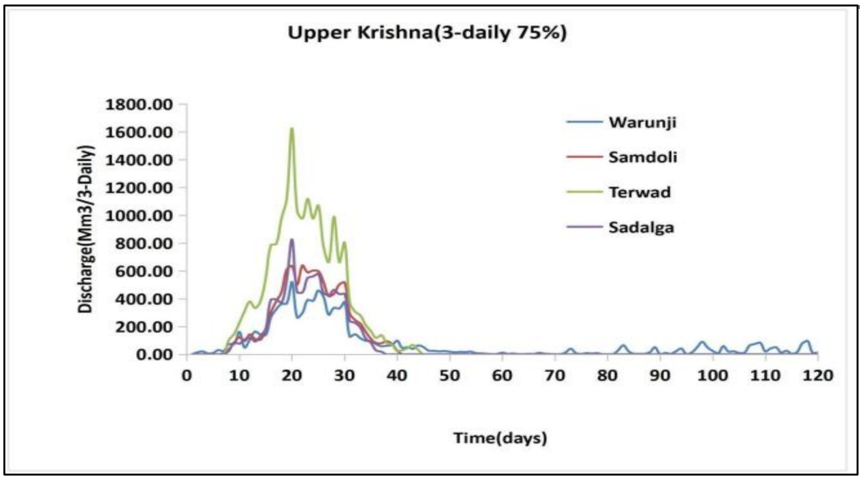

Fig.3. Comparison of 3 Daily for 75% Dependable flows.

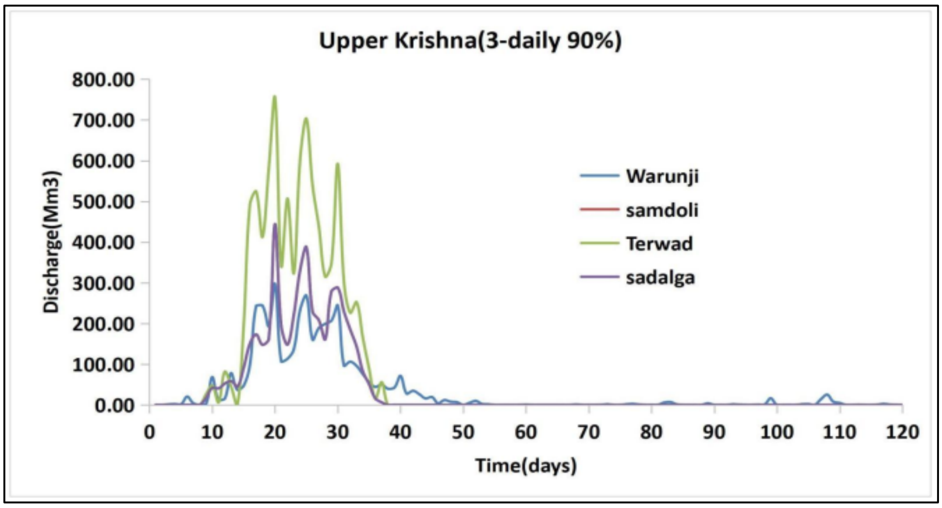

Fig.4. Comparison of 3 Daily for 90% Dependable flows at Sadalga, Samdoli, Terwad, Warunji gauging station

The average streamflow is observed as 180.70 Mm^3, 321.66Mm^3 and 385.95 Mm^3 for 3 -Daily, 5-Daily and 7 daily respectively for Samdoli gauging station. The comparison of 5 Daily for 50%, 5 Daily for 75% and 5 Daily for 90%, Dependable flows at Sadalga, Samdoli, Terwad, Warunji gauging station are shown in Fig.5. Fig.6. and Fig.7. respectively.

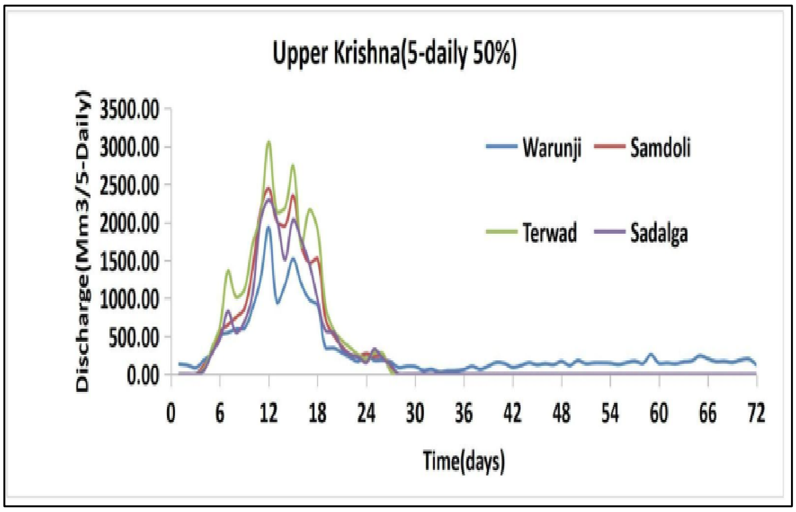

Fig.5 Comparison of 5 Daily for 50% Dependable flows.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VII, July 2026

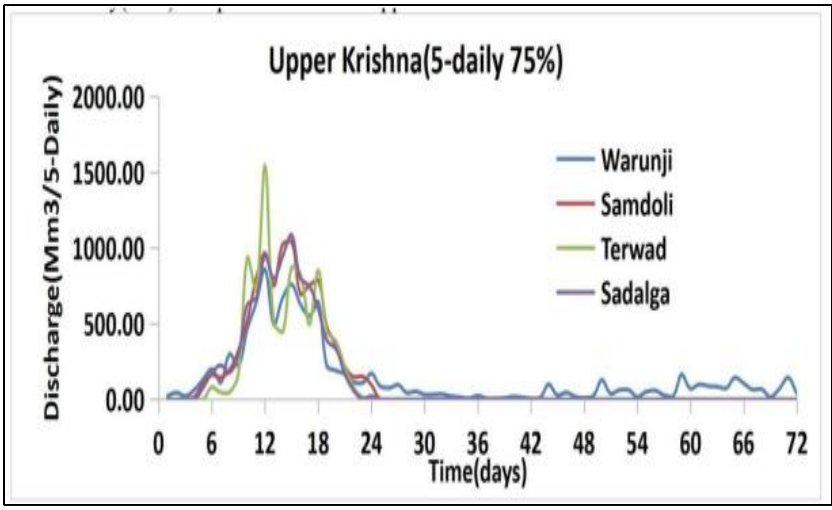

Fig.6 Comparison of 5 Daily for 75% Dependable flows.

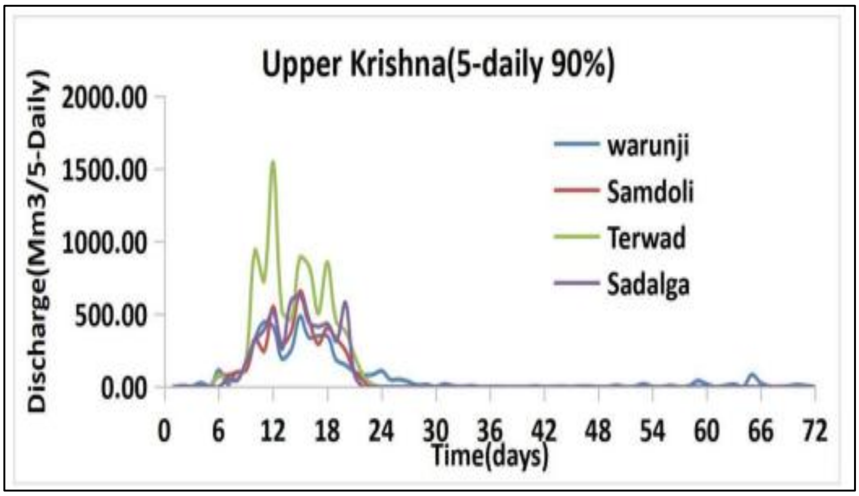

Fig.7 Comparison of 5 Daily for 90% Dependable flows at Sadalga, Samdoli, Terwad, Warunji gauging station.

The average streamflow is observed as 293.84Mm^3, 382.60 Mm^3 and 516.35 Mm^3 for 3 -Daily, 5-Daily and 7 daily respectively for Terwad gauging station. The average streamflow is observed as 174.40Mm^3, 307.11Mm^3 and 407.00 Mm^3 for 3 -Daily, 5-Daily and 7 daily respectively for Warunji gauging station. The comparison of 7 Daily for 50%, 7 Daily for 75% and 7 Daily for 90%, Dependable flows at Sadalga, Samdoli, Terwad, Warunji gauging station are shown in Fig.8. Fig.9. and Fig.10. respectively.

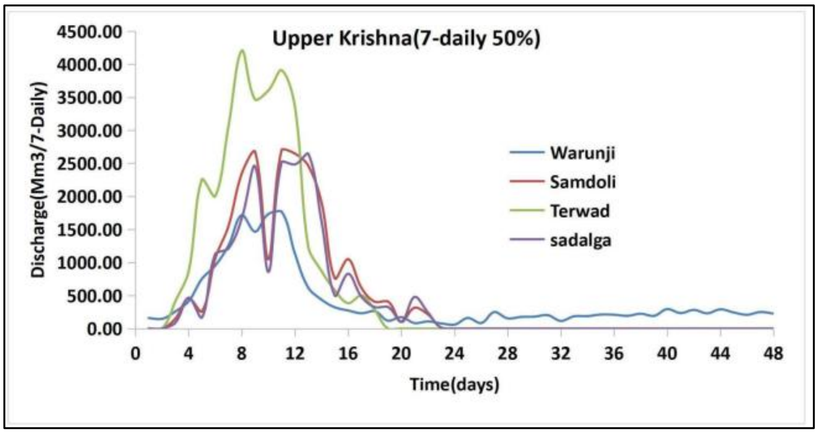

Fig.8 Comparison of 7 Daily for 50% Dependable flows.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VII, July 2026

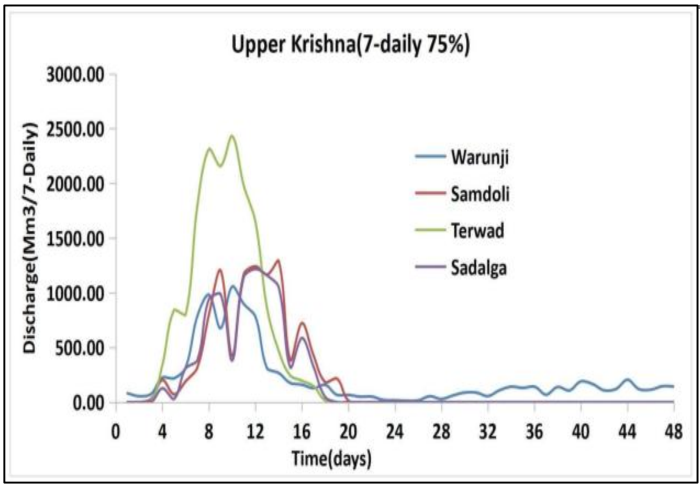

Fig.9 Comparison of 7 Daily for 75% Dependable flows.

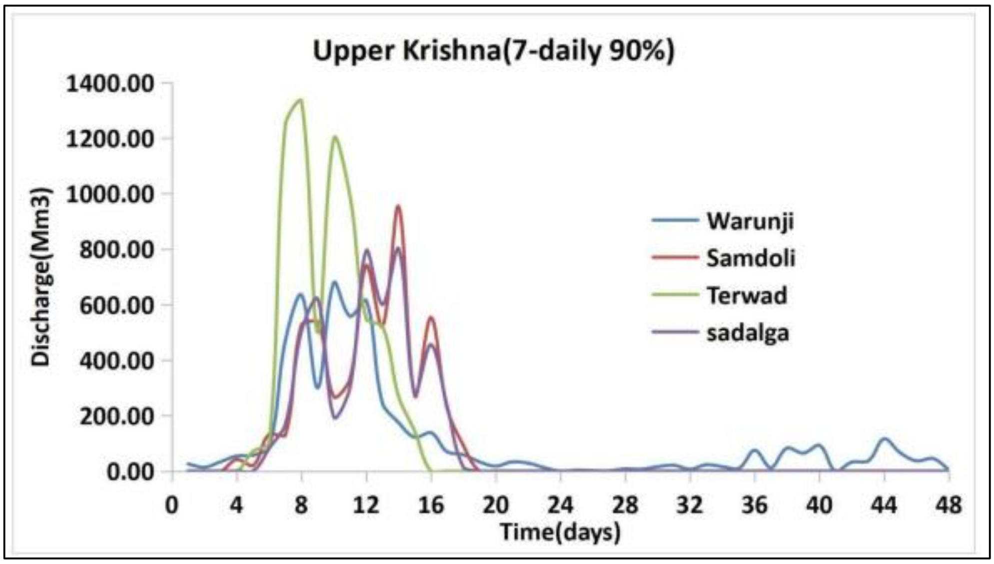

Fig.10 Comparison of 7 Daily for 90% Dependable flows at Sadalga, Samdoli, Terwad, Warunji gauging station

SUMMARY AND CONCLUSIONS

Based on the analysis we observed that very less streamflow discharge 0.0Mm3 at Sadalga gauging station, so there is severe chance of droughts will occur and also very high discharge is observed in the month of August 1469.90 Mm^3. The analysis reveals that less streamflow discharge 0.0Mm3 at Samdoli gauging station, so there is severe chance of droughts will occur and also high discharge is observed in the month of August 1584.45 Mm^3. we observed that less streamflow discharge 0.0Mm3 at Terwad gauging station, so there is severe chance of droughts will occur and also high discharge is observed in the month of August 2394.20 Mm^3. we observed that very less streamflow discharge 0.0Mm3 at Warunji gauging station, so there is severe chance of droughts will occur and also high discharge is observed in the month of August 1030.85 Mm^3.

The peak discharge will lead cause of floods and damages nearby areas and low-lying areas. In order to minimize these problems, we can take initiatives like diversion of water, to minimize drought we can divert sufficient of water to nearby water bodies in excess of water during floods, interlinking of gauging stations, construction of check dams, bunds, weirs after geological survey which will increase the ground water recharge, increase in groundwater water levels, wet lands management etc. Due to water availability in these areas the chances of increase in the industrial development, reduction in people migration and more agricultural practices and increase in the crop productivity. Out of selected four stations it is noticed that the max discharge is observed as 2394.20 Mm^3 for Terwad gauging station for 3 daily and 3058.20 Mm^3 as max discharge for Terwad gauging

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station for 5 daily and also max discharge observed as 4204.65 Mm^3 for Terwad gauging station for 7 daily respectively. Smaller data intervals have more accurate results than the higher intervals and more accurate will be the result.

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