Climate Change impact on Rainfall trend and Hydrological safety of Dams in TamilNadu

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ABSTRACT

The state of Tamil Nadu which is in the southern end of the Indian Peninsula greatly influenced by tropical climate. Anthropogenic activities and other factors contribute to climate change impacts which have resulted in variation in rainfall pattern in the state. Due to this, the hydrology of the dams which were constructed several years has been altered. Under Dam Rehabilitation and Improvement Project (DRIP), the hydrology of dams were analyzed and reassessed based on the latest rainfall data available in the respective dam catchment area. The structural adequacy has been assessed to cater the revised inflow to the dam and necessary structural and non-structural rehabilitation measures have been revamped under DRIP in order to ensure hydrologic safety and sustainability.

Key words: Anthropogenic activities, Climate change, reassessment of hydrology, DRIP, Structural and Non-structural measures, sustainability

Introduction :

The State of Tamil Nadu is situated at the south-eastern extremity of the Indian Peninsula having a geographical area of about 13 million hectares, bounded on the east by the Bay of Bengal, in the west by the Western Ghats and in the south by the Indian Ocean, and in the North East by Andhra Pradesh and North West by Karnataka states. The State can be divided into two natural divisions namely, the coastal plains and hilly western areas. The Palghat gap of Kerala about 25 km in width in the great western mountain wall is the only marked break to Tamil Nadu. The slopes of the Western Ghats are covered with heavy evergreen forests and the trend of drainage is from west to east into the Bay of Bengal. All the rivers are almost non- perennial except river Tamiraparani and few are interstate rivers. The proximity of sea influences the climate of the eastern and southern parts of the State whereas hilly orography and inland locations play important roles in modifying the climate over the rest of the State. The western portions of the State i.e the portions bordering with Kerala have a marine climate with mild winters and moist summers, and the remaining part of the State has a tropical savanna climate that is hot and seasonally dry. An attempt has been made to analyze the impact of climate change in the Hydrological safety of the Dams in Tamil Nadu.

Rainfall Pattern

The State mainly receives its rainfall in three seasons, viz. Southwest monsoon, northeast monsoon, and pre-monsoon seasons. The normal annual rainfall falling over the State was 958.9 mm about 35 years ago. About 50 percent of the total annual average rainfall is received during the northeast monsoon, while about 31 percent is received during the southwest monsoon and the balance in the other seasons. The coastal districts receive about 65-75 percent of annual rainfall and interior districts get about 40-50 percent in this season. The Annual rainfall pattern of Tamil Nadu is given in Table 1 and graph (Fig. a) and the trend line shows the rainfall pattern is in decreasing trend.

Table 1. TIME SERIES DATA – RAINFALL BY SEASONS IN TAMIL NADU

(in mm)

Year	Southwest Monsoon		Northeast		Winter		Hot weather		Total		%Deviation from Normal
	Normal	Actual	Normal	Actual	Normal	Actual	Normal	Actual	Normal	Actual	
2003-04	331.5	336.5	464.6	43.1	37.4	12	128.4	283.4	961.8	1034.6	7.6
2004 -05	331.5	360.7	464.6	472.1	37.4	14.3	128.4	231.7	961.9	1078.9	12.2
2005-06	332.9	308.5	459.2	828.8	36.8	15.9	129.6	150.9	958.5	1304.1	36.1
2006 -07	316.1	250.9	431.1	497.5	35.3	10.9	129.1	100.4	911.6	859.7	-5.7
2007- 08	316.1	341.6	431.1	515.4	35.3	46.6	129.1	261.2	911.6	1164.8	27.8
2008 -09	316.1	333.5	431.1	552.7	35.3	7.7	129.1	129.2	911.6	1023.1	12.2
2009 -10	316	317	431.1	482.6	35.3	11.5	129.1	126.7	911.6	937.8	2.9
2010 -11	319.2	383.6	430.3	605.2	31.3	36.3	127.8	140	908.6	1165.1	28.2
2011 -12	321.2	300.5	441.2	540.8	31.3	9.5	127.9	86.3	921.6	937.1	1.7
2012 -13	321.3	245.9	440.4	370.5	31.3	34.5	128	92.2	921	743.1	-19.3
2013 -14	321.2	325.4	440.4	294.3	31.3	13.8	128	157.1	920.9	790.6	-14.1
2014 -15	321.2	305.5	440.4	430.3	31.3	10.9	128	241.2	920.9	987.9	7.27
2015 -16	330.9	295.7	562.8	695.8	32.7	2.9	128.2	123.6	971.8	1138.8	17.2
2016 -17	330.8	265.8	468	174	32.9	41.7	127.1	116.6	958.9	598.1	-37.7

Source: Statistical Handbook of Tamil Nadu-2018, Department of Economics and Statistics

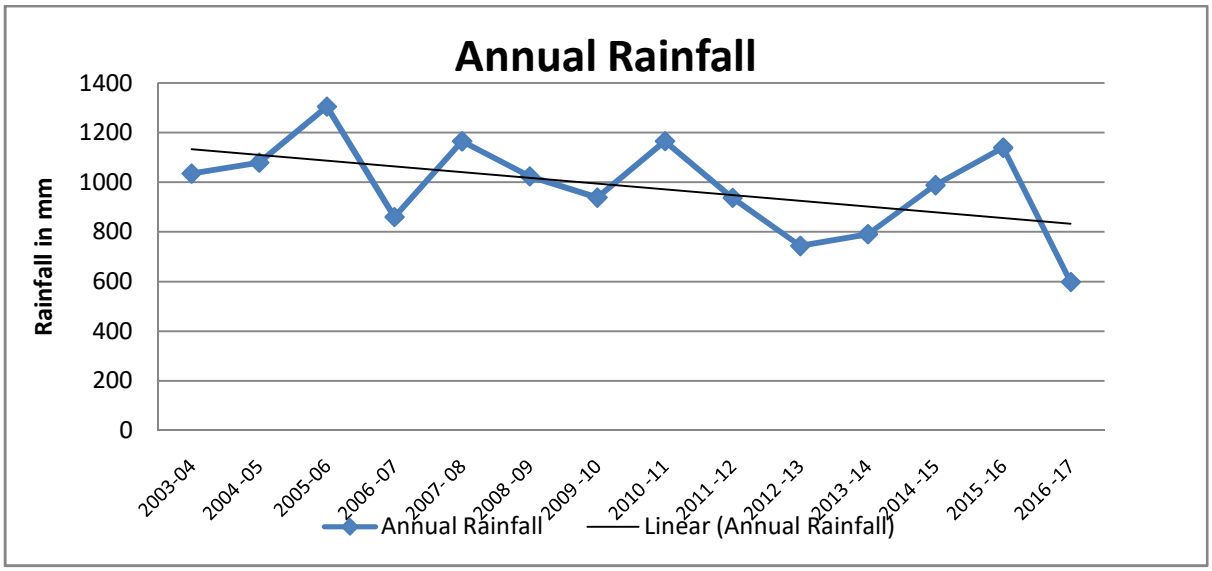


Fig. a. Variations in Normal Rainfall

A study conducted by Indian Meteorological Department (IMD), Pune on the Observed Rainfall Variability and Changes Over Tamil Nadu State considering 30 years data (i.e. from 1989 to 2018) confirmed with the same trend in rainfall pattern and concluded that heavy to extremely heavy rainfall (daily rainfall >=6.5mm) days lies in the range of 1.8 to 3 days in most parts of Kanyakumari and Tirunelveli, some parts of Nilgiris, Coimbatore and western parts of Erode, Theni and Thoothukudi districts during the SW monsoon season. While minimum number of Heavy rainfall days lies in the range of 0.4 to 0.8 days mainly in central part of the state comprising of Nagapattinam, Tiruvarur, Tanjavur, Pudukottai, Tiruchirapalli, Karur, Dindigul, Tirupur, Erode, Namakkal, Ariyalur, and Cuddalore districts.

Extreme Rainfall

Long-term studies carried out by Guhathakurta et al (2011), from IMD, Pune for the period 1901-2005, indicates, that Tamil Nadu is experiencing more dry days than wet days every year. However, there has been a significant increase in heavy precipitation events as indicated in the recordings of the IMD (India Meteorological Department) observing stations in the State. An Increase in one-day extreme rainfall events of the order of 5 to 10 cm has been observed along the northern coast of the State.In the rest of the State, the extreme rainfall event has increased by less than 5 cm or less. The analysis of 25 year return period of rainfall shows a large variation from 10cm in the western parts of Tamil Nadu to 25 cm and more in the northern and central coastal regions of the State.

Irrigation in Tamil Nadu:

Out of 13 million hectares of geographical area, about 7 million hectares of land are under cultivation. Of this, 55 percent is irrigated and the rest is rain-fed/ dry land. The major occupation is agriculture and hence the dependency on irrigation is more in Tamil Nadu. For better water management, Tamil Nadu has been divided into 17 major river basins and 86 reservoirs are the major sources of irrigation along with about 39,000 tanks which are being maintained by the Water Resources Department. These valuable assets of Irrigation are being maintained through various projects for improving its efficiency and structural adequacy thereby ensuring sustainability.

Dam Rehabilitation And Improvement Project (DRIP)

The main objective of the Dam Rehabilitation and Improvement Project is to improve the safety and operational performance of the dams considered under the project. To ensure the safety of the dam the following, two criteria are to be satisfied. A). the dam should be hydrologically safe and B) it should be structurally safe. The hydrological safety of the dam is ensured by reviewing the hydrology of each dam for the present rainfall scenario and confirmed whether the existing surplus arrangements are sufficient to handle the derived inflow peak.

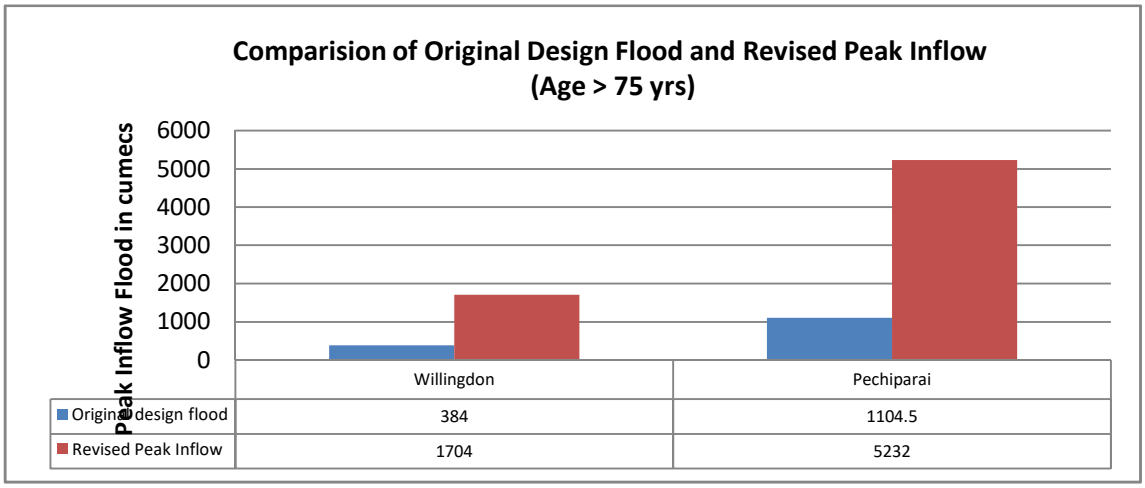
Hydrological Review Study of DRIP Dams in Tamil Nadu

The hydrology of the selected dams under DRIP were reviewed based on the current rainfall details available in and around the catchment area . The Indian Standard IS : 11223 – 1985 "Guidelines for fixing spillway capacity" gives the criteria for calculating the inflow design flood. The dams are classified based on the capacity and the hydraulic head (from normal or annual average flood level on the downstream to the maximum water level) as given below.

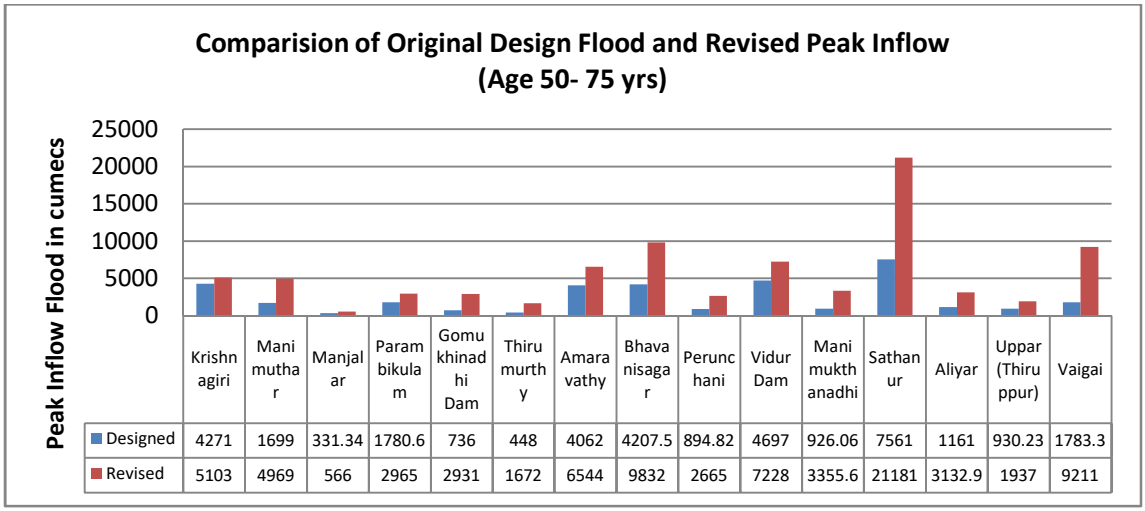
Classification	Gross Storage	Hydraulic Head	Inflow design flood for safety of dam
Small	Between 0.5 & 10 million m3	Between 12 m & 30 m	100 Year flood
Intermediate	Between 10 & 60 million m3	Between 7.5 m & 12 m	Standard Project Flood (SPF)
Large	Greater than 60 million m3	Greater than 30 m	Probable Maximum Precipitation (PMP)

The hydrology of totally 74 Dams was reviewed under DRIP. Nearly 17 Dams are large dam category and 19 dams are small dam category and the remaining dams are intermediate. The hydrological review study was carried out by considering the recent rainfall data available in and around the catchment area and adopting the recommended inflow design flood applicable to the dam as per the IS Code stated above. The revised inflow peak has been derived based on the empirical methods or synthetic unit hydrograph method which is decided based on the catchment size and classification of the dam. The results of the study and the variation with respect to the original design flood are analysed with respect to age of dam.

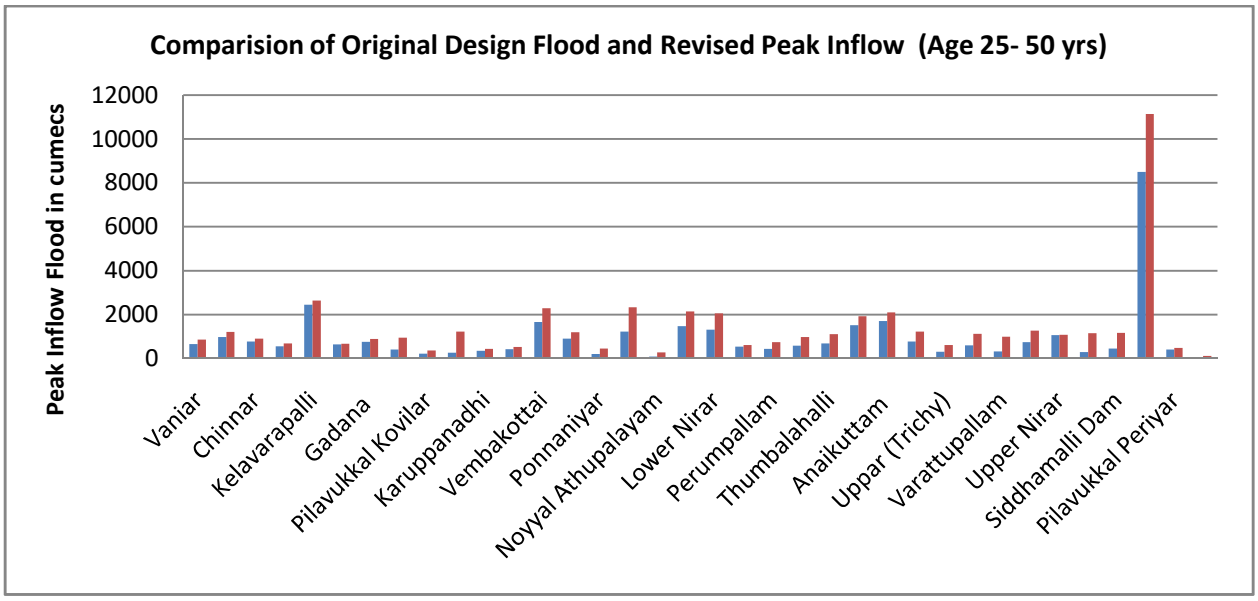
The variation in revised peak inflow with respect to age of Dams is presented graphically:

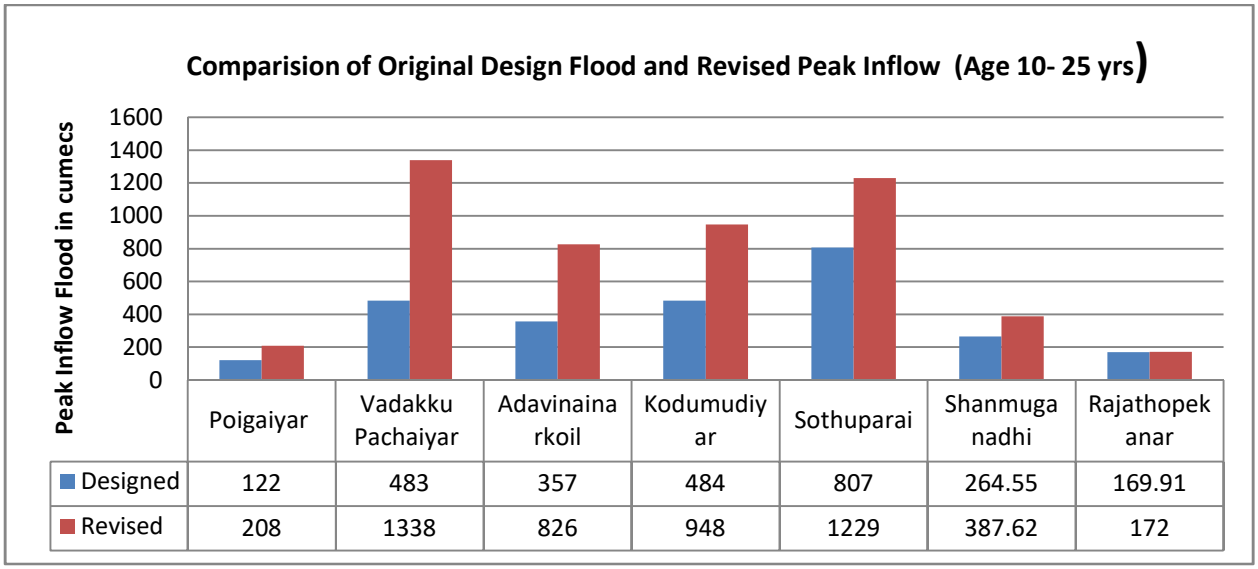


3.5 times increase in estimated peak inflow as per revised hydrological study.



1.5 times increase in estimated peak inflow as per revised hydrological





	Poigaiyar	Vadakku Pachaiyar	Adavinainarkoil	Kodumudiyar	Sothuparai	Shanmuganadhi	Rajathopekanar
Designed	122	483	357	484	807	264.55	169.91
Revised	208	1338	826	948	1229	387.62	172

The above graphs show that the reservoirs having age more than 50 years have a substantial increase in peak inflow as per the present estimation. For the reservoirs with less than 50 years age, the increase in peak inflow is about 80-90 %.

From the rainfall trend and peak inflow arrived at various dams in Tamil Nadu, it is observed that the normal annual rainfall trend shows a decreasing trend, but the peak inflow realizing at various dam sites found to be increasing. This is because the trend of extreme rain events is in increasing trend in north and western slopes of Tamil Nadu and the probability of realizing flash flood is more which is the greatest impact of Climate Change and is of great concern in the future.

Recommendations of Hydrological Review:

After deriving the inflow peak, the revised flood was routed through the existing surplus arrangements to check the adequacy of the existing surplus arrangements using different reservoir routing techniques such as Modified Puls method and/or channel routing techniques such as Muskingum routing method etc. If the existing arrangements are not sufficient to handle the revised inflow peak, the one or combination of the following structural rehabilitation measures were taken based on the specific requirement of each dam and feasibility at the site.

- Construction of additional spillway arrangement
- Construction of fuse plug arrangement
- Construction/ Modification of U/S Parapet wall
- Strengthening the existing spillway conveyance system

Also, wherever structural risk reduction measures are not possible non- structural measures such as revision in reservoir operation pattern, establishment of flood forecasting arrangements and Emergency preparedness plan have been explored.

Conclusion:

The design flood review and associated rehabilitation measures taken under DRIP not only improved the hydrologic safety of the dam but also have brought awareness of the necessity of a continued and updated hydrologic risk assessment and management for ensuring safer dams. As an alternate, ecologically sensitive flood mitigation measures could also be explored.