S&T APPLICATIONS IN FLOOD DISASTER MANAGEMENT

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ABSTRACT

Amongst various natural disasters, disasters due to floods can be managed due to a greater extent since their likely occurrence can be predicted. The man has devised structural and non-structural measures to mitigate the likely damages due to flood disasters and more advanced information systems are available for better preparedness. The large dams / storages help in flood moderation but large dams cannot be constructed everywhere due to various geographically and political constraints. Out of total of 5127 large dams constructed in India so far, there are 78 large dams of national importance but dedicated flood cushion is available only in 10 large dams. This speaks of urgent need for adopting other measures of flood moderation like creation of natural detention basins, construction of new embankments, regular maintenance&raising and strengthening of existing embankments, and of course, flood plain zoning and flood forecasting for minimising flood damages.

Flood Forecasting does not require huge capital investment and it has been recognized as an important non-structural measure as the advance flood warningsenhance capabilities and preparedness of concerned agencies to meet the risk posed by floods. CWC started flood forecasting in India in 1959 and due to its success in enabling the local authorities in planning the administrative measures including evacuation of people well in advance,the State Governments have been demanding extension of flood forecasting services to more areas. In order to meet the expectations of people at large,CWC has been making continuous endeavour for modernization and expansion of its flood forecasting network to cover other areas and meet the challenges in future.

The automation in data collection and its transmission, flood forecast formulation and its dissemination, has enhancedeffectiveness of flood forecast and time saved due to automation, has increased the net time of advance warning available with the project authoritiesfor planning suitable evacuation measures well in advance and plan for better reservoir regulation during floods. The automatic system of inflow forecastprovides benefits of flood moderation even in the reservoirs where dedicated flood cushion was not provided initially. As an example, the automatic system of data collection and inflow forecast installed at Hirakud Dam in Orissa has helped in flood peak attenuation considerably.

1.0 INTRODUCTION

A disaster is an event, natural or man-caused, which creates an intense negative impact on people, goods and services, and/or the environment, and exceeds the affected community's internal capability to respond, prompting the need to seek outside assistance.Recognising the need for effective disaster management, the Government of India enacted Disaster Management Act-2005 and accordingly, Disaster Management Authority(NDMA) under the Chairmanship of Hon'ble Prime Minister of India has been set up. The NDMA has classified the types of disasters as natural and man-made. The natural disasters which occur due to causes beyond human control are earthquakes, floods, droughts, tsunami, forest fire, cyclones, land erosion, land slides & avalanches. The disasters which are caused due to negligence of human beings or planned activities of miscreants are nuclear, chemical, biological, cyber terrorism and environment hazards. The NDMA has been coordinating the efforts being made both at State and Central levels in the areas of disaster mitigation, preparedness, response and recovery.

The prediction of natural disasters like earthquakes and tsunami is a difficult process but flood disasters are predictable to a great extent. The advance planning and suitable warning systems can play major roles in mitigation of impacts of flood disasters. In general, large storages areconsidered as the best solution for management of floods because of their inherent benefit in flood moderation by attenuation of flood peaks. Due to geographical and political constraints, dams can't be constructed everywhere and criticism by the local people backed by groups of various interests adds to the constraints. Therefore, the approach of combination of structural and non-structural measures backed by a smart blend of technological applications needs to be adopted for management of flood disasters. Frequent flood damages; which are more than Rs. 1800 crore annually on an average, loss of precious human lives, cattle and increased agony of losing beloved and belongings, houses and livelihood of flood affected ones, has really started irritating common man.Therefore, we need to make concerted efforts and increase our capabilities to fight against the menace of floods.

2.0 STRUCTURAL MEASURES AND THEIR EFFICACY

When we plan structural measures we generally think of various perspectives, the national, regional or the local**.** When the structural measures are planned with wider perspectives or with a view to extend benefits on national arena, the history has been evidence, there has been lot of criticism by the people who wanted only a local or regional perspective to be satisfied from any such structural measures. India has constructed 5127 large dams and 397 dams are under construction. Of these, 78 large dams are of national importance but dedicated flood cushion is available only in 10 dams. It has been emphasized in the policies of Government that the storage dams provide promising and long-term solutions for flood mitigation but non-availability of adequate flood cushion even in existing dams, is matter of worry. Here comes the issue of perspective whether national or regional or even local. But, it needs a dedication of all concerned since ensuring safety in a larger perspective at national level should reign supreme. The XII Plan discussion looks forward for concrete actions from all custodians of existing dams and even from those proposing new dams that a dedicated flood cushion of even 10 to 20% could be considered in storage dams.

There are other structural measures like creation of natural detention basins but their availability is not very common. The identification of suitable sites for their location should become primary aim of the planners involved in flood mitigation efforts particularly in those areas where construction of dams appears to be difficult either from geographical constraints or others**.**

Construction of embankments is essential even if we have large storage dams because a river channel needs strong banks to contain the flood water and to avoid spilling from banks. Embankments are although conceived as short-term measure of flood control but their significance lies in the situation under which they have been planned. The recent fears generated by floods caused due to breach / failure of important embankments like Kosi embankment have also compelled to think of adverse impacts of embankments**.** The important factor on which emphasis should be laid is the regular watch and maintenance of such embankments and the failures can be minimized by adopting good practices of regular inspection and maintenance.

3.0 NON-STRUCTURAL MEASURES AND FUTURE NEEDS

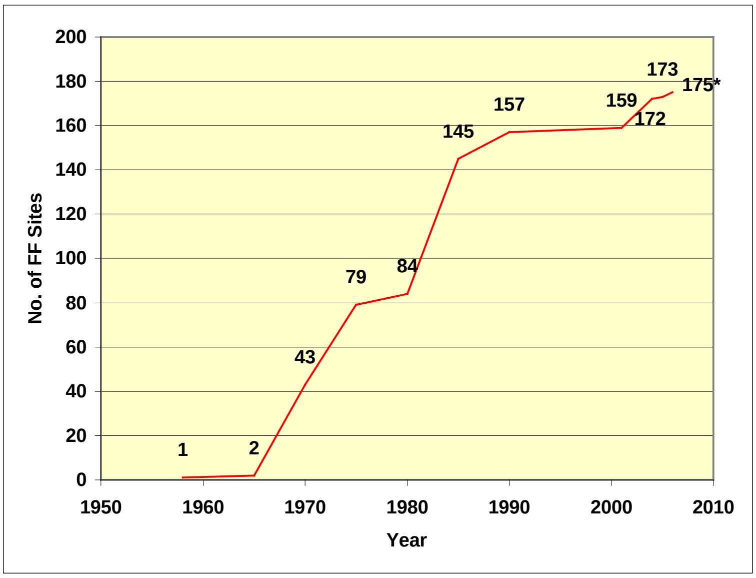
The non-structural measures like flood forecasting and flood plain zoning play important roles in preparedness against impacts of floods and mitigation of floods.While flood plain zoning has become a difficult task in India because timely actions for enactment of legislation and its enforcement have not been taken by any State / UT. Although the Government is planning various schemes of incentives and disincentives for flood plain zoning but application of flood zoning concepts on ground is really posing numerous problems before the State/ UT Governments. However, modified flood zoning concept being suggested to the Government by various experts still need actual shapes. The other option is of flood forecasting which includes both level forecasting and inflow forecasting but the adequacy of network and state of the art technologies are need of the hour. In view of immense benefits of flood forecasting in enabling the administration in taking suitable measures including evacuation of flood affected people to safer locations as well as use of inflow forecasting in better operation of reservoirs bringing moderation of flood peaks in the downstream releases from dams, Central Water Commission (CWC) has been making continuous endeavour of modernization and extension of its flood forecasting network to cover other areas.Presently, CWC issues flood forecasts at 175 stations comprising of 147 level forecast and 28 inflow forecast stations and the CWC’s future plans include setting up a network that would be capable of providing level forecasts and even inundation forecasts to A, B1, B-2 and C-class cities and inflow forecasts for additional 160 reservoirs in the country. This would also enhance capabilities of State Disaster Management Authorities in ensuring timely preparedness against likely impacts of floods.

However, constraints in inundation forecasting are mainly non-availability of Digital Elevation Models (DEM) for the entire India and particularly the flood plains. Without DEMs, inundation models can’t be developed. Therefore, preparation of DEMs need to be undertaken in a project mode with definite time frame mobilizing the resources of the concerned agencies like Survey of India (SOI), National Remote Sensing Centre (NRSC), States in close association of CWC.

4.0 DEVELOPMENT OF FLOOD FORECASTING SYSTEM IN INDIA

"The Reddy Committee" on whose recommendation, a beginning of scientific flood forecasting system was made and a Flood Forecasting Unit was set up in the erstwhile Central Water & Power Commission (CWPC) for providing timely flood warning to Delhi Administration about floods in the Yamuna at Delhi Railway Bridge. The first scientific forecast was issued on 2^{5th} July, 1959 marking the beginning of the new phase in flood control activity in the country. Subsequently, another Flood Forecasting Station was set up in Delhi on the Sahibi river in 1965. These two stations continued for the first Decade. The Disastrous floods of 1968 in many parts of the country necessitated setting up of Flood Forecasting & Warning centres on major inter-state flood prone rivers all over the country. Accordingly, a Flood Forecasting and Warning Organisation was set up in Central Water Commission and 41 additional stations were opened in 1969 all over the country in flood prone areas oninter-state rivers.

Presently, there are 878 Hydrological and Hydro-meteorological sites being operated by CWC across the country covering 20 river basins for gauge, discharge, sediment & water quality observations. The formulation of a forecast requires effective means of real time data communication network from the forecasting stations and the base stations (380 nos approx at present). Wireless Communication system installed at all these stations is the backbone of the communication system required for flood forecasting activities. The forecasts are issued once the water in a river is likely to reach pre-defined warning level (one meter below to danger level). The level forecasts help the local administration and other agencies in deciding mitigating measures like evacuation of people and their movable property to safer locations. The Inflow Forecasting is used by various reservoir/dam authorities in optimum operation of reservoirs for safe passage of flood downstream as well as to ensure adequate storage in the reservoirs for meeting demand during non-monsoon period.



The staff remain alert round the clock during flood period and observes the river water levels on hourly basis for passing on to the forecast formulation centers in real time basis.

Presently, Flood forecasts are issued by CWC at 175 stations (28 Inflow Forecast Stations + 147 Level Forecast Stations). Annually, about 6000 flood forecasts are issued by CWC during floods with more than 95% accuracy which is a milestone in the area of scientific flood forecasting. The basin-wise and State-wise distribution of existing flood forecasting stations is given in **Table-1 & 2** below:

Table-1: Basin-wise Existing Flood Forecasting Stations

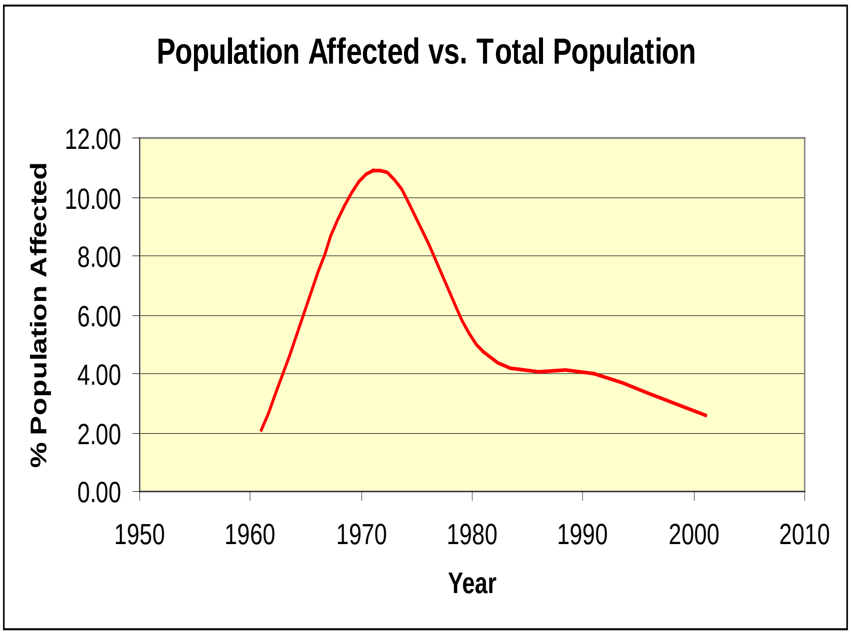
SN	Name of River-systems	Number of flood forecasting Stations		
		Level	Inflow	Total
1	Ganga & Tributaries	77	10	87
2	Brahmaputra & Tributaries	27	-	27
3	Barak-System	05	-	05
4	Eastern-Rivers	08	01	9
5	Mahanadi	03	01	04
6	Godavari	14	04	18
7	Krishna	03	06	09
8	West flowing Rivers	09	06	15
9	Pennar	01	-	01
Total		147	28	175

Table-2: State-wise Existing Flood Forecasting Stations

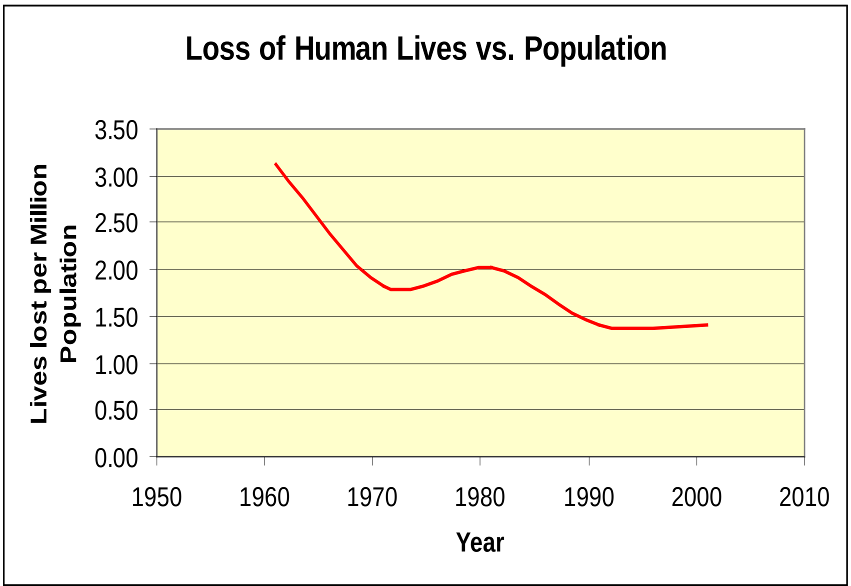
SN	Name of State/UT	Number of flood forecasting Stations		
		Level	Inflow	Total
1	Andhra Pradesh	9	7	16
2	Assam	24	0	24
3	Bihar	32	0	32
4	Chhatisgarh	1	0	1
5	Gujarat	6	5	11
6	Haryana	0	1	1
7	Jharkhand	1	4	5
8	Karnakata	1	3	4
9	Madhya Pradesh	2	1	3
10	Maharashtra	7	2	9
11	Orissa	11	1	12
12	Tripura	2	0	2
13	Uttar Pradesh	34	1	35
14	Uttarakhand	3	0	3
15	West Bengal	11	3	14
16	Dadra & Nagar Haveli	1	0	1
17	NCT of Delhi	2	0	2
	Total	147	28	175

5.0 IMPACTS OF FLOOD FORECASTING & WARNING

Flood Forecasting has proved to be a reliable tool in mitigation of impacts of floods. The success of this important non-structural measure, not requiring larger capital investment, is quite evident from the steep falling trend of percentage population affected to total population in fig.-1 and human lives lost per million population over the years especially from the year 1960 onwards when the flood forecasting system based on scientific approach was put in place in India.



The other factors contributing to these falling trends include more flood management measures undertaken by the States / UTs and more dedicated efforts made by the Protection Forces under the guidance of NDMA /MHA /SDMAs. However, flood forecasts has certainly provided vital inputs for planning suitable administrative measures including timely evacuation of people from flood affected areas to safer locations.



6.0 IMPACT OF SATELLITE BASED TELEMETRY SYSTEM OF AUTOMATIC DATA COLLECTION, TRANSMISSION, FLOOD FORECAST FORMULATION AND DISSEMINATION

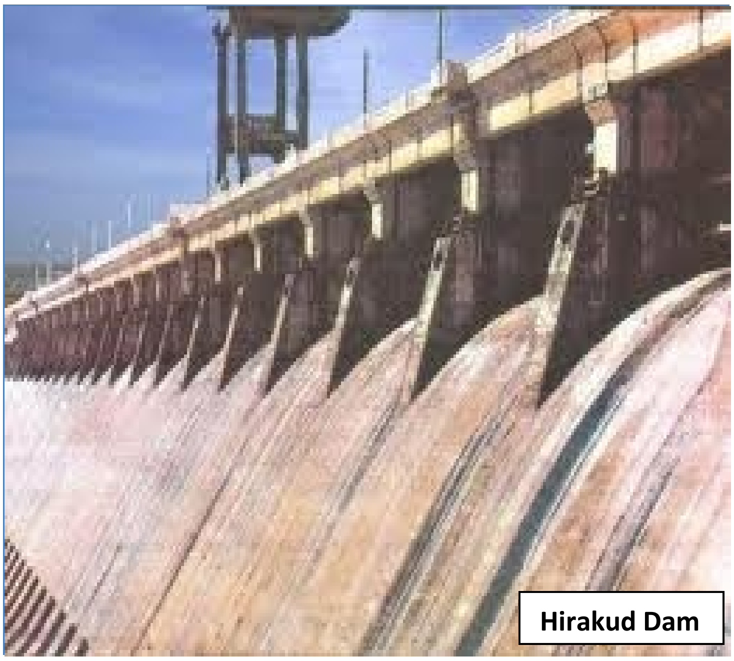
In the conventional system of flood forecasting the steps involved are data collection manually, data transmission from site to Sub-division office is a mixed mode of manual and through Walkie-Talkies on VHF (Very High Frequency) and then Sub-division to Division Office is through HF wireless sets or telephone. The data analysis at the Divisional offices is done manually or with the help of computers using small flood forecast formulation programmes. The flood forecasts are communicated manually or by telephone/FAX and e-mail. All this processes consume a lot of time and do not meet the requirements of the agencies who need the information about floods in a most expedient manner. There are also chances of human errors in recording and management of data.

Under the modern system installed by CWC, data collection has been initiated with sensor based equipment and transmission of data is done through satellite, data analysis, its validation, trend analysis and flood forecast formulation is done with the help of state of the art mathematical models and dissemination of the flood forecasts is done through a VSAT system. The new technique reduces considerably the time taken in all the process of data collection, transmission, flood forecast formulation and its dissemination to local administration. The time saved which ranges 2 to 5 hours is now available as enhanced warning time and the local administration can ensure better preparedness in taking suitable administrative measures including evacuation of people from flood affected areas to safer locations.

7.0 CASE STUDY – IMPACT OF MODERNISED FLOOD FORECASTING SYSTEM IN FLOOD MODERATION AT HIRAKUD DAM (ORISSA)

7.1 Hirakud Dam

Hirakud Dam, located across river Mahanadi about 15 km from Sambalpur in Orissa, is one of the world's longest earthen dam. The Dam having length of 4.8 km was constructed in 1957 and is also the first major multipurpose river valley project started after India's independence. The dam with a total reservoir area of about 743 sq. km. and gross storage of 8136 MCM, is 60.96 m high, has a designed spillway capacity of 42450 cumec. With successful irrigation provided by the dam, Sambalpur is called the rice bowl of Orissa.



Hirakud Dam

The Hirakud Dam is a multipurpose project meant for catering to various aspects such as flood control, irrigation, power generation etc. Moderation of floods in the delta region is one of its main objectives. Pressing demands for production of power and for irrigation necessitates release of water from the reservoir. Thus the regulation of reservoir sometimes becomes difficult and it becomes necessary to issue inflow forecast with sufficient warning time for ensuring the safety of the dam and public property and for regulation of outflows.

7.2 Inflow Forecasting At Hirakud Dam And Impact Of Automation

The Central Water Commission (CWC) provides inflow forecast for the Hirakud Dam. Using conventional approach, 24-hours Inflow flow forecasts were provided for the Dam. The modernized system of automatic data collection,. transmission and flood forecast formulation, was installed at the dam in 1999 due to which more and near real-time data is now available; which has enabled CWC to provide advisory forecast even 48 hours in advance. With this, more time is available with the project authorities for operation of reservoir more appropriately and more uniformly.

To study, the impact of automation in flood moderation at Hirakud dam, the ratio of Daily outflow to Monthly volume released from the reservoir has been plotted in **Figure-1**for the year 1999 i.e, prior to installation of satellite based telemetry system and the for year 2011 after installation of satellite based telemetry systemof automatic data collection, transmission and flood forecast formulation. The total volume of water released from Hirakud Dam during monsoon period i.e. 1st June to 31st October in 1999 was about 45058 MCM whereas in monsoon period of 2011 it was about 57073 MCM, therefore, a direct comparison between the flood peaks of outflows for these two different years does not give a correct picture about the impact of automatic system as the total volumes released were different. Ideally, the inflow conditions should be same for a fair comparison. In order to overcome this difficulty, the trends of ratio between daily outflows to total monthly volumes releasedfrom the dam was considered for the present study.

The Ratio was computed as under :

$$\text{Ratio} = \frac{\text{Daily Outflow Volume}}{\text{Monthly Volume Released}}$$

Where Monthly Volume Released = $\sum_{N=1}^{N}$ (Daily Outflow Volume)

Where N is total number of days in the month.

The trend of the ratio during 1999 shows larger peaks as compared to 2011 this means with the installation of automatic system, the releases from the reservoir were regulated in a more uniform manner and thus, the higher peaks of releases from the dam were moderated which helped in flood control in the downstream areas.

8.0 CONCLUSION

The automation in the system of data collection , transmission , flood forecast formulation and dissemination flood forecast, is quiet useful in elimination of human errors in observations , recording , data analysis and related computations etc. and reduction in time taken in various process right from data observation to flood forecast formulation and dissemination thereof. As result there is more reliability of flood forecast formulated besides huge saving in the time usually taken in performing the related process. Therefore, the automatic system of data collection, its transmission and flood forecasting has proved to be immense benefits as the time saved is available to the local administration for taking suitable evacuation measures well in advance and the project authorities can plan better and timely regulation of reservoirs including those reservoirs where dedicated flood cushion was not provided.

BRIEF PROFILE OF THE AUTHORS

S. P. Kakran-*He graduated in Civil Engineering from University of Roorkee in 1974 , joined CWC in 1975 and worked on mathematical modelling for flood forecasting in Brahmaputra Basin. He has vast experience of design of Water Resources development of projects, hydrological observations and flood forecasting. He is presently working as Member (RM) in Central Water Commission (CWC.).*

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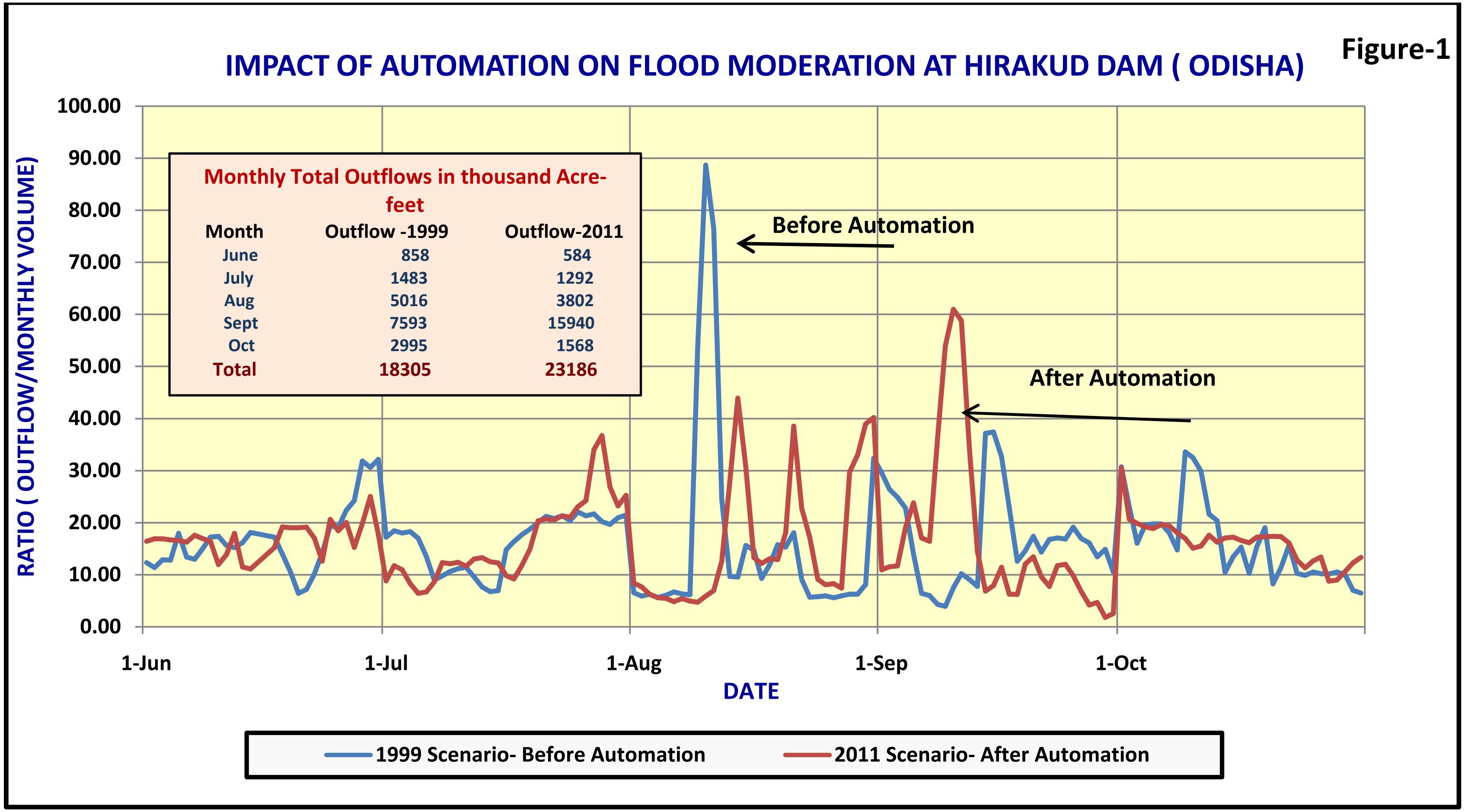

Month	Outflow -1999	Outflow-2011
June	858	584
July	1483	1292
Aug	5016	3802
Sept	7593	15940
Oct	2995	1568
Total	18305	23186