Management of Flood and Drought through Development of Water Resources in Odisha State

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Abstract

In the state of Odisha calamities like drought and flood were repeated events. They usually have a direct connection with space and volume. High rainfall causes the flood and low rainfall drought. As per the state water commission reports the per-capita availability water in 2001 was 3359 m^3. Because of climate changes and uncertainty of monsoons by 2051 water is likely going to decrease 2218 m^3 (Source from Water Resources of Odisha Regional Centre for Development Cooperation). Growing of population, industries and other activates like mining, urbanisation the water requirements are raising, but recourses are shrinking day by day. All over the state rainfall is not equally spreading a few areas receiving abundant and remaining are low for the reason that floods and droughts are usually occurring. More and more reservoirs are essential to store flood water and supply to less precipitated drought areas. So in this paper mainly focusing on flood management through flood control structures like embankments, check dams and improvement of reservoir storage capacity by using effective rule curves and methods recommended as technical strategies to develop the water resources to minimise the drought.

Keywords: Space and volume, drought areas, population, strategies

1 Introduction

The Odisha state contains 11 river basins. Mahanadi, Subarnarekha, and Brahmani are central basins born in other state but their major portion laid in Odisha and remaining rivers like Kolab, Nagabali, Vansadhara, and Indravati are originated in Odisha, but after some length, they met their parent basins in other states. Water-associated large events floods and droughts have been a significant disturbance earlier starting from human civilisation. They continuously create problems of every generation of human beings, bringing deaths and property lost etc. By many observations, the rainfall pattern of Odisha state could understand the pace of climate conditions. The districts like Ganjam, Balasore, and puri are near to coastal belt are encountering more rainfall compare to normal and Nuapad, Bolangir and Baragarh districts are away from the coastal region getting less rainfall. Merely understand that where more rainfall is required, that is getting less and where requires enough rainfall be getting more and leading to the catastrophes. The average rainfall of the state is 1482 mm but in some years it is high and some year's less. Due to global warming, deforestation and greenhouse gases, the regular pattern of monsoons was changed and generating more dry sessions and thereby occurring droughts more regularly. State meteorological studies analysed that in every five years one rainy day losing the state. Due to rainfall variations in the state, the flow of rivers is rapidly declining and nearly eight months in the year rivers are in the dry stage. Experts who have studied Odisha's climate

they are astonished entirely by that catastrophes. They reported that between 1955 to2008 Odisha had encountered 28 flood years, 19 drought years and seven cyclone years along with one super cyclone in 1999 (Source from Water Resources of Odisha Regional Centre for Development Cooperation). Years with floods and droughts are enlarging not only in effect but also in spreading of new regions. Most of the districts which are beside the coastal belt are attacking the floods; the western part is suffering from acute droughts and some part of the state affecting by the earthquakes. Besides that, disasters the same heat wave and forest fires also occurring. The historical backdrop of catastrophes is indicating that around 80% of the state is inclining to at least one type of cataclysmic event. In 1992 two consecutive cyclones in October were severely affected the coastal districts, demolished the infrastructure in 14 districts, so many lakhs of trees are spoiled and disturbed the public life drastically. More population density, cracking of floodplains, low social and economic conditions, lack of reliable infrastructure magnified the vulnerability.

2 Identification of Flood and Drought

2.1 FLOOD ZONES

Based on flood data some of the districts marked as the flood-prone. Whenever there is heavy rainfall should alert that districts and take necessary actions regarding flood control. Particularly districts like Ganjam, Puri, Jagatsinghpur Kendrapara, Japur, Bhadrak, Cuttack were more flood venerable [In Fig. 1 the yellow colour marked portion]. For a better understanding of the flood and drought affected places could have to be separate from the standard regions. Between years (1993-2012) the flood districts were plotted based on past data in [Fig. 2]

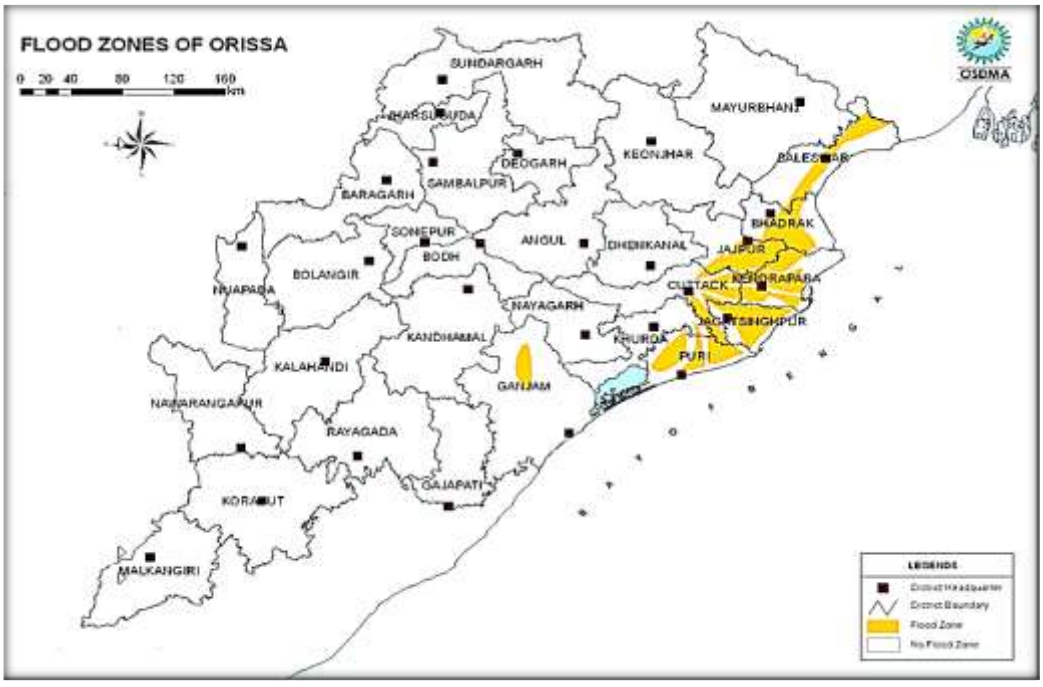

Fig. 1 Geographical view of flood zones in Odisha

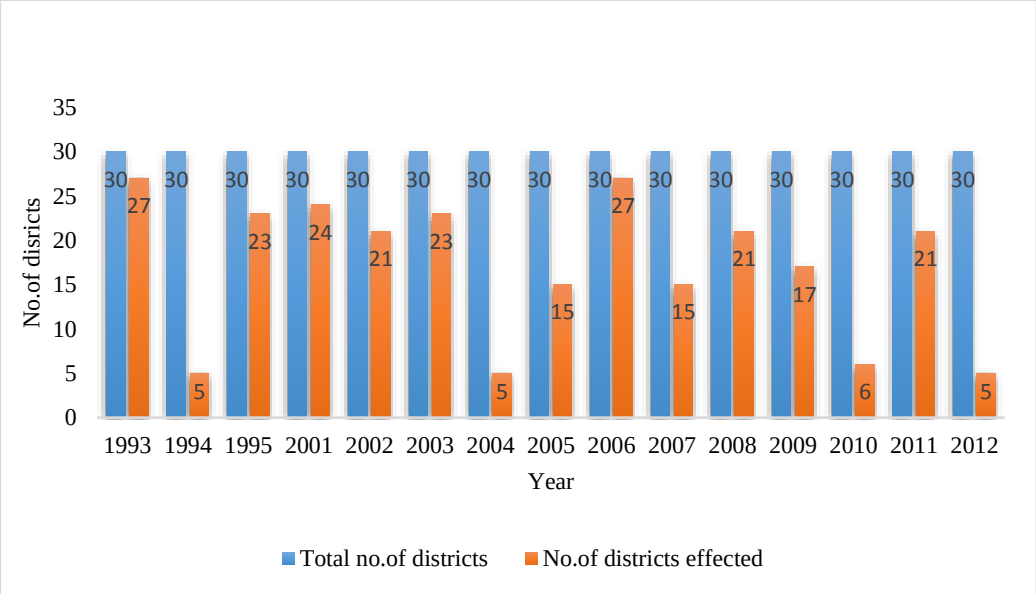

Fig. 2 Year wise analysis of flood-affected districts

2.2 DROUGHT ZONES

By studying drought series of the state, places like Titlagrh, Padampur, Titlagarh, Nuapada Patnagarh, Khariar, Phulbani, and Bhwanipatna encompass of 47 blocks have been recognised as drought prone. [In Fig. 3 it has shown in brown colour] and reaming places like Ganjam, Puri, Jagatsinghpur Kendrapara, Japur, Bhadrak, Cuttack were identified as moderate. [In Fig. 3 it has shown in light green clour] and Districts drought details declared by state has analysed in [Fig. 4]. (http://www.farmer.gov.in/Drought/Droughtreport.aspx)

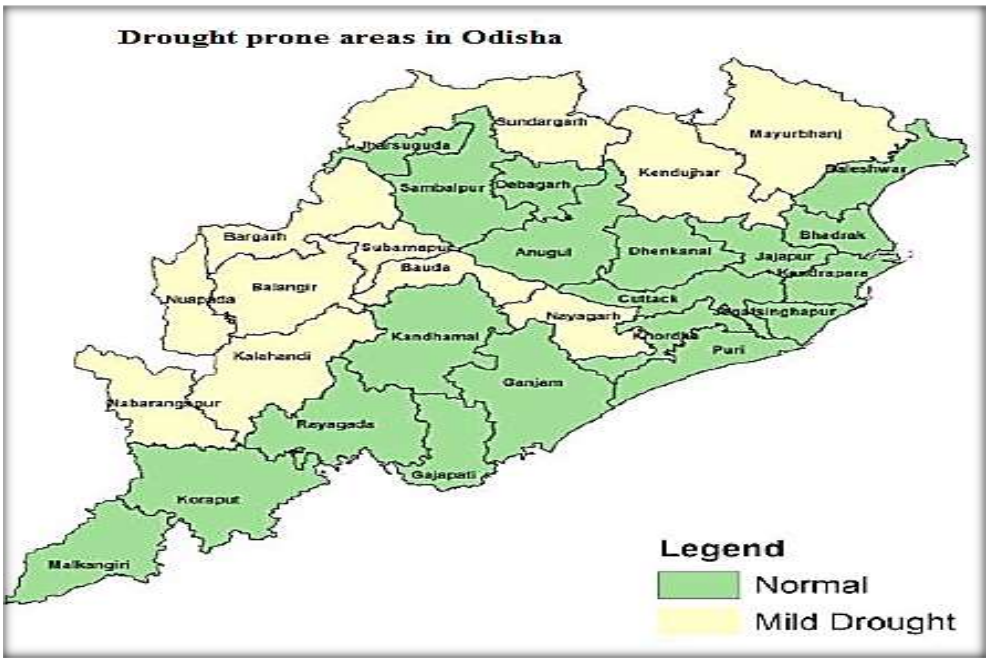

Fig. 3 Geographical view of drought zones in Orissa

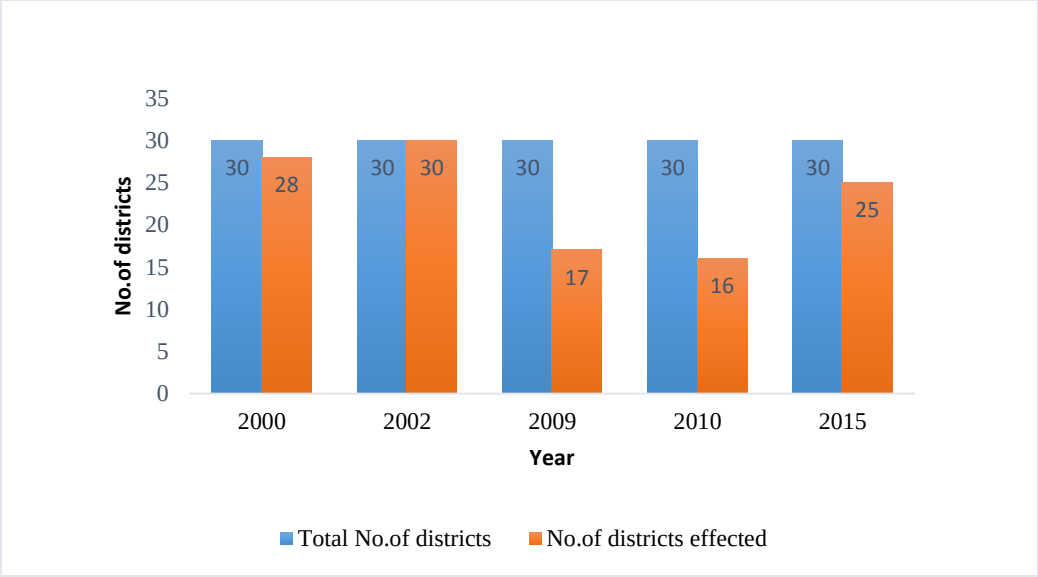

Fig. 4 Year wise analysis of drought-affected districts

3 Causes of Flood and Drought

In upper catchment of the river basins high force of precipitation, diminishing of vegetation close to the river banks causing extreme soil disintegration. The eroded soil is flowing through streams of the river causing sediment deposition. The catchment regions of Mahanadi, Brahmani, and Baitarani are considerably more significant than their Deltas. These streams convey a large measure of residue from mountain ranges during monsoon, and in reaching the floodplains, the speed of stream abruptly lessened, and sediment gets depositing in the river beds and blocking the river mouths. Because of these things storage reservoirs becoming flattered and that leads to decreasing of storage capacity and inefficient flood control. Construction of power generation and irrigation projects on drainage lines of rivers creating the offensive floods. As a result of lesser percolation, the sub-surface storages are becoming ineffective, ultimately causing light flows in the rivers and streams causing the further capacity decline in groundwater recharge. The Central Ground Water Board (CGWB) has clearly stressed that the groundwater of 24 out of 30 districts in Odisha is depleting. The aquifers in several parts of the state have gone dry. Global mean temperature ascended by 0.5 degree Celsius over the most recent 50 years that of Odisha ascended by 1 degree Celsius. Climate is getting to be plainly outrageous more than ever. In ten years normal of most significant recorded temperatures has expanded by 4.4 to 6.6 degree Celsius and the normal of least recorded temperatures has additionally diminished by 3 to 5.1 degree Celsius in different parts of Odisha (Source from www.rcdcindia.org). Rising temperature has an intimate association with water and forest assets of the region. Declining water assets in the late summer months and decreasing forest cover, which helps in directing temperature and giving adjustment. Activities like mining, the taking of sand from rivers and industries are reducing the water table levels and polluting the groundwater. A “Global Environmental Negotiation” reports warned that if current sea level increase in one meter then almost all 1.70 lakh hectares are going to submerge. (Source from www.rcdcindia.org).

4 Analysis of Flood and Drought

4.1 FLOOD

The flood can classify as Early Season Flood, Mid-Season Flood and Late-Season Flood depending upon its time of occurrence. In coastal regions, sometimes flood remains 5-14 days continuously and root to damaging of life, properties, and food security. In the total geographical area of 15.751 lakh hectares,1.40 lakh hectares are flood-prone, and 516 are vulnerable points. In last 25 years, 12 times of flood with different severity and in 2006 out of 30 districts 27 districts were damaged by the flood. By using rainfall data analysed the year wise flood and drought conditions in the [Fig. 5] (1998) Severe drought, (1999) Severe Cyclone, (2000) Drought and Flood, (2001) Flood, (2002) Severe drought, (2003) Flood, (2006) Moisture stress/Flood, (2007) Flood, (2008) Moisture stress/Flood, (2009) Flood/ Moisture stress, (2010) Drought/ Un-seasonal rain, (2011) Flood/ Drought, (2012) Drought in Balasore, Nuapada and Bhadrak, Mayurbhanj districts. (Source: Status of Agriculture in Odisha, Directorate of Agriculture, Odisha). In [Fig. 5] bars below the trend line indicates the low rainfall year and above trend line indicates excess rainfall year.

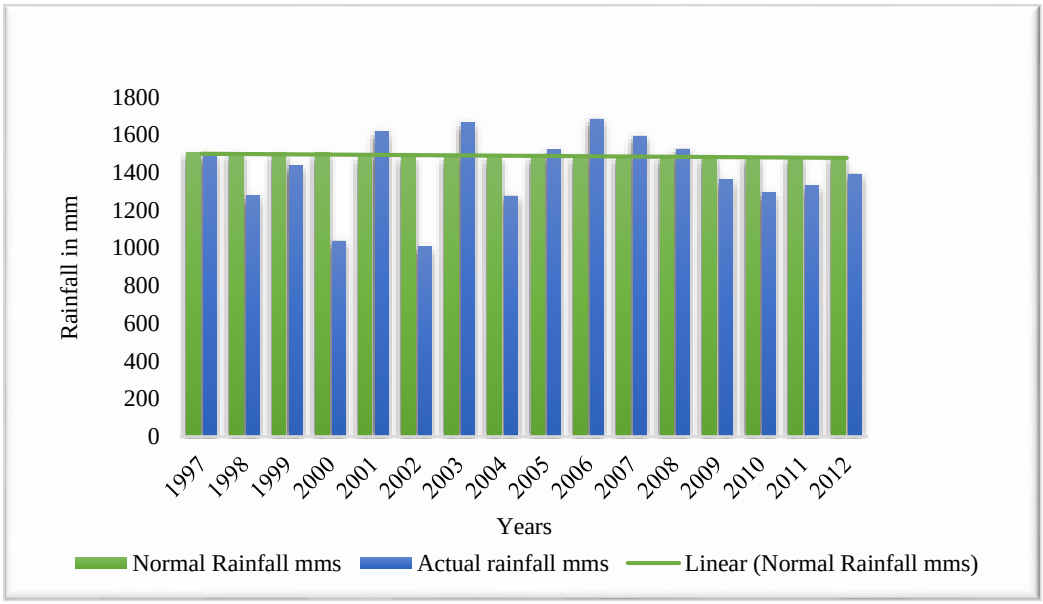

Fig. 5 History of natural calamities based on rainfall data

4.2 DROUGHT:

India drought describes as a crisis when rainfall significantly less than or more up to 5 mm for the week. Moreover, agricultural drought is an amount of 4 such immediate weeks from mid-May to mid-October or 6 such weeks during the remaining portion of the year. Nearly every alternate year state is encountering some drought or moisture stress condition because of uneven and uncertain spreading of rainfall in monsoon. The first, mid and late season droughts are influencing the crop yield and production based on intensity, duration, type, and stage of the crop. Based on the intensity of the drought it has been divided as the severe and moderate. In **[**Fig. 6] it has been shown the frequency

of drought with intensity. (Source: Kar et al., 2004, Agro-climate and Extreme Weather Analysis for Successful Crop Production in Odisha Bulletin No. 22 WTCER)

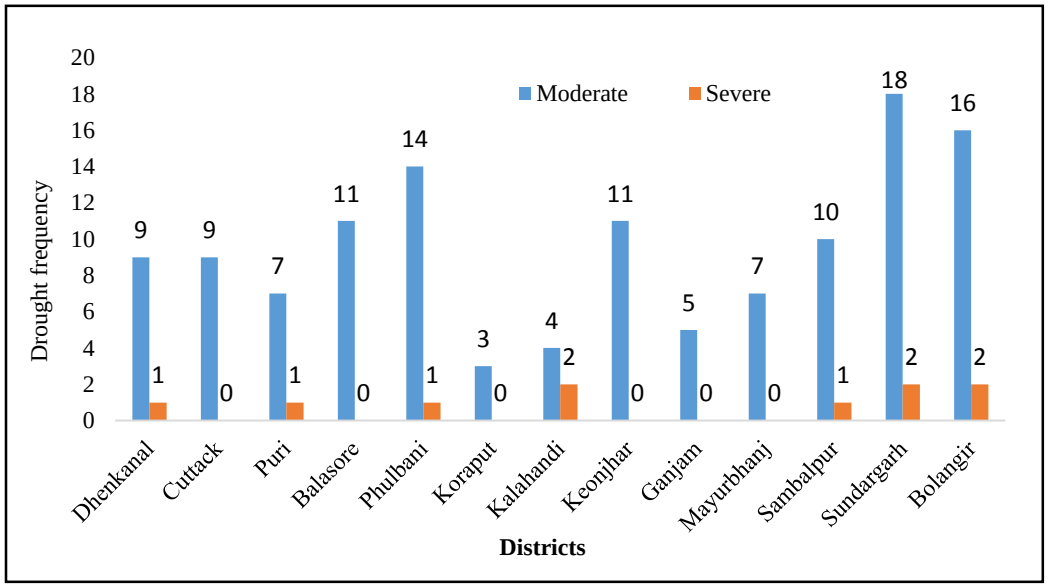

Fig. 6 Based on annual rainfall departure data drought frequency analysis between the years (1960-2003)

4.3 IMPACT OF DROUGHT A CASE STUDY OF THE 2000 YEAR:

A case study of the 2000 year is the right example to explain the drought impact. By comparing the 2000-year yield with an average yield of the state [Table 1] simply understand the effect. Based on land type also the impact will vary by observing the [Table 1] medium type of lands was been lost the more yield, and low land type has lost less. High lands have moderately lost their crop yield. The early season, mid-season and late season droughts affect crop growing and production to various extents based on their intensity, duration and type and stage of the crop.

Table 1 Comparison of Yield in the 2000 year with Normal Yield Year

Land type	Affected area (in lakh hectares)	Land yield per hector (in Quintals)		Total yield (in lakh tons)		Estimated loss of the yield (in lakh tons)	Money lost (in cores)
		On average	In 2000	On average	In 2000		
High	3.48	15.16	4.72	5.28	1.64	3.64	192.92
Medium	5.16	2.80	10.84	12.28	5.59	6.69	354.57
Low	2.05	14.78	16.02	5.08	3.28	1.80	95.40

(Source: Revenue Department, Govt. of Odisha)

5 Floods and Drought Management through Water Resources Development:

5.1 FLOOD:

Total rainfall control is not feasible for trade considerations, and therefore management of rainfall is essential. So thoroughly, the structural and non-structural measures have to take for decreasing the flood. In case of structural measures Hirakud dam on Mahanadi river, Rengali dam on Brahmani river, Upper Kolab on Kolab river and Upper Indravati on Indravati river have developed. In Jharkhand Chandil and Ichha dams are in under construction these two will help in reducing the flood in Subernarekha delta and Kanpur dam also under construction at Keonjhar it will control the flood in Bitarani delta. In delta areas, floods have managed by the construction of embankments on both sides of the river. Till now total 1952 spurs, 7138 km of embankments and stone packing of 253 km have been constructed in different basins. As a non-structural things zoning of flood areas and control the intensity levels, proofing materials supply, forecasting and warning regarding floods have to develop for threatening places.

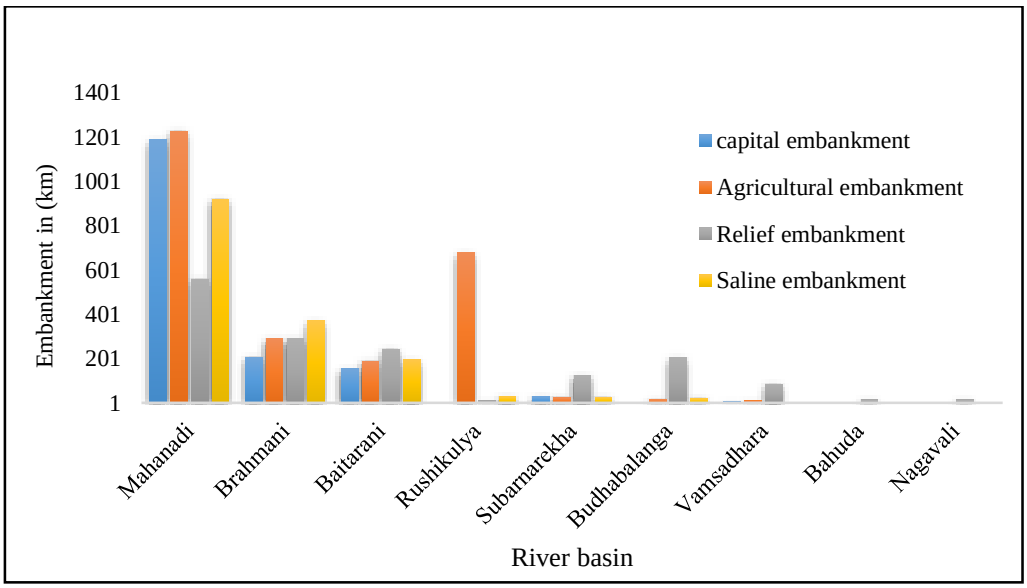

Fig. 7 Development of embankments graphically on different basins

Non-structural measures like flood forecasting and caution of incoming floods have additionally performed a massive role in reducing the loss of life and belongings other than alerting the civil and engineering government in-charge of various works to take suitable increase action to combat the onslaught of floods. There are eleven flood forecasting stations controlled by using CWC positioned in the Odisha at naraj, alipingal, nimapada in Mahanadi basin, jenapur in Brahmani basin, anandapur and akuapada in baitarani basin, NH5(gobindapur) in budhabalanga basin, rajghat in subernarekha basin, purusottampur in rushikulya basin and gunupur, kashinagar in vansadhara basin. Aside from that one inflow forecasting station is functioning at burla in Mahanadi basin. In higher Mahanadi basin, a present-day approach consisting of telemetry machine was installed for flood forecasting. CWC collects day by day readings of river gauges, discharge, and rainfall of diverse water bodies in all basins. In addition, they acquire daily hydro meteorological statistics from state departments, IMD, and other sources. CWC keeps wireless

communication network among their gauge stations in the State. Journey times of flood in various rivers have been worked out so that develop caution of the flood in the delta zone can be given. Basing on the field records and IMD forecast, they prepare the forecast message and warnings and talk them to various departments which includes water resources department. This message is without delay communicated to the field functionaries, collectors along with Revenue Branch to take precautionary measures. A long time and everlasting solution of the flood disaster is yet to be performed. The action plan for the flood reduction has to formulate based on time scale foundation, the short-term control, and the longtime management.

5.2 DROUGHT:

Heavy rainfall areas also sometimes face the failure of rains and that time drought effect is more critical. Nevertheless, make those areas precisely because of hydrological abnormalities. In semi-arid regions, there are many variations of rainfall both in time and space. Generally, in summer season it will become too dangerous. So make sure that develop this area entirely different from other regions. A few methods suggested technical strategies to improve the water resources to decrease the drought:

1. *Transferring of water between inter-basins.* In Mahanadi basin, at kilasama village from Hirakud reservoir a flowing canal suggested with the discharge of 230 m^3/s to deliver spill water of Hirakud reservoir to the Rengali project in Brahmani basin. However, another one Hirakud to Samal Barrage from this link could cover the areas which Rengali has not covered. From the Nagavli - Bansadhara - Rushikulya connection Odisha can use maximum 556 Mm^3 of Nagavali basin but only utilising 368.34Mm^3 for utilisation of remaining 197.66 Mm^3 of water, this link will help.
2. *Recharging of depleting Groundwater.* Recharging of groundwater will improve the water resources, including a lot of artificial methods harvesting of rainwater on the top roof should be encouraged. Developing of water is responsible for stockholders. Periodical assessment has to be conduct based on scientific methods in every district of the state. This information has passed to all people of the state on a continuous basis. Strong legislation should prevent overexploitation of groundwater.
3. *Watershed Management.* The retention capacity of the catchment will decrease due to degradation of the watershed and it will higher the intensity and frequency of floods. Collaborative efforts have to put for standard management of catchment as a non-structural of drought and flood mitigation
4. *Creation of large storages.* Most of the places in this state depending upon only on rainfall so whenever rainfall is heavy store water by construction of massive storage projects for future purposes. Because mostly 80% precipitation occurs in 4 months of the monsoon season only. Now in Odisha Hirakud and Rengali dam reservoirs are nearly giving 60% water to the state.
5. *Women's Participation.* Women's are essential stockholders in the household water sub-sector. If we bring awareness among them about water conservation, they will know how to manage the water for daily activities, and they will teach to their kids also. Therefore, they should be involved in decision making about water use and management.

5.3 A CASE STUDY OF FLOOD AND DROUGHT MANAGEMENT THROUGH WATER RESOURCES DEVELOPMENT:

Rengali Dam:

Rengali Multipurpose Project of Odisha State has constructed for utilising water of Brahmani for power generation benefit and providing flood control in the low lying areas of the river valley. The main Dam across river Brahmani with the Power Station has situated near village Rengali of Talcher Sub-Division of Angul District at a distance of 65 Kms. Upstream of Talcher Town. The height of the dam is 70.5 m and width is 1040 m. It is the second largest reservoir of Odisha. It severs 28,000 hectares at a mean level and 37, 840 hectares at full reservoir level. It has 25,250 km^2 catchment area with forest and wasteland. Moreover, it is also producing electricity of 250 MW with 5 unit's capacity of 50MW.As per the flood protection master plan it has been considered that after routing of flood at Rengali, the outflow of 2.5 lakh cusec (7075 cumecs) with intermediate discharge of 1.5 lakh cusec (4245 cumecs) will combindly result in a discharge of 4.00 lakh cusec (11320 cumecs) at Jenapur for which embankments are to be designed. Under this dam, Cuttack, Kendujhar, Jajapur, Dhenkanal, Angul districts are benefiting. Nearly 2,600 sq.km of the area is protecting from the flood**,** 10.8 Lakh people are benefiting with drinking water, average annual direct income 6.65 Crores and cultivating the 2.70 lakh hectares. The discharge values of the Jenapur delta (Brahmani basin) was more before the construction of the dam and after the construction of the dam the peak flow values decreased due to the construction of Rengali dam [Fig. 8]. Due to this dam flood-prone area is descended a lot compared to previous times. The dam is controlling the heavy floods and storing the water for future purposes of the state. Because of this dam cultivating area also increased under the Brahmani basin. Highest flood level of river Brahmani recorded at Jenapur. (Source: http://www.ohpcltd.com/Rengali).

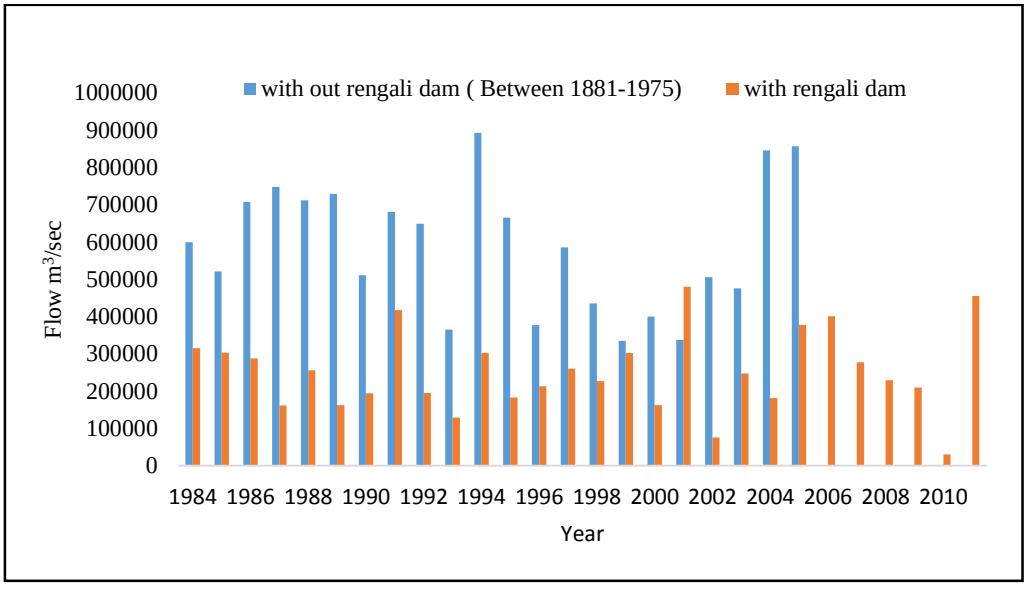

Fig. 8 Moderation of flood at Jenapur delta (Brahmani basin) after construction of Rengali Dam

6 Conclusions

Pre-construction of Rengali Dam (between 1881-1975 years) the maximum peak flood value is 892000 m^3/sec but after construction of the Dam the maximum peak flood value is reduced to 454871 m^3/sec [Fig. 8]. Rengali Dam not only mitigated the flood but also useful in storing water and power production. For the long-term solution to flood management, it needs to construct the reservoirs with substantial storage. Now in the present set of condition, construction of big flood reservoirs is complicated because of large submergence area and environmental effects. By using effective rule curves for existing reservoirs flood can moderate easily. Moreover, developing of embankments, cleaning of rivers, transfer of water within the state, zoning of flood areas and forecasting and warning systems will help for better flood control. The methods like River linking, Recharge of groundwater, large storages and women participation will give good results to conserve and generating of new water resources. A reliable database has to create and regularly update on weather conditions, agricultural yields, input supply and market information, fertilisers supply etc. to assist regulation drought. Awareness has to bring among the farmers on drought regulations and enforcement that aid to the reduction of farmer's suicides.

References

Behera, S. (2008), "Water Resource Planning for Mineral Based Industries in Orissa. Requirement of Water for Mining and Mineral Based Industries in Orissa", SGAT: 23-32.

Beura, D. (2009), "Cyclone Disaster Management with Special reference to Orissa Coast, India", Chapter in book 'Geological Hazards' by New India Publishing House, New Delhi: 133-153.

Chittibabu, P., Dube, S. K., Macnabb, J. B., Murty, T. S., Rao, A. D., Mohanty, U. C., Sinha, P(2004), "Mitigation of Flooding and Cyclone Hazard in Orissa, India**",** Natural Hazards Vol 31: pp.455–485.

Das, G. (1998), "Flood Management in Mahanadi Basin", Water Resources Department, Orissa.

Khatua, K.K and Patra, K.C. (2004), "Management of high flood in Mahanadi and its tributaries below Naraj", 49 annual sessions, IEI, Orissa State Centre.

Khatua, K. K. and Mahakul, B. (1999), "Flood in Mahanadi delta stage II area - A case study", Proc. Nat. Sem on Disaster Management, UCE, Burla, Orissa.

Khatua, K.K., Panigrahi, S. (2001), "Flood and Cyclone in Coastal Orissa.", conference on Disaster Management held at BITS, Pilani (Rajasthan).

Kumar, D. N., Baliarsingh, F. And Raju, K. S. (2011), "Extended Muskingum method for flood routing", Journal of Hydro-environment Research, Vol.5: 127-135.

Mishra and Behera. (2009), "Development and Management of Water and Energy Resources", 7th International R& D Conference, Bhubaneswar, Orissa.

Patri, S. (1993), "Data on Flood Control Operation of Hirakud Dam. Department of Irrigation", Government of Orissa, India.

Rakesh.K, Singh R. D. and Sharma K. D. (2005), "Water resources of India", Current Science, Vol. 89, no. 5, 10.