REMEDIAL MEASURES ON FLOOD DISASTER

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Abstract: This study has been undertaken to investigate the intensity and magnitude of floods is supposed to be increasing world over in the recent decades because of climate change and global warming phenomenon. The Western Ghats are globally important, not only being rich in biodiversity, but primarily because of the role, they play in influencing climatic regime and annual precipitation in Indian subcontinent. The climate change has caused uncertainty and wide fluctuations in precipitation pattern from extreme droughts to heavy rains and periodic cloud bursts. Thus, floods, which were locally almost unknown, are becoming a potential disaster in the earlier relatively safe and climatically stable areas such as Western Ghats.

Kolhapur district being largely i.e., over 65-70% of the total area, being situated in the Western Ghats region, receives high annual rainfall in its western hilly part. It was therefore felt necessary to study the region for vulnerability and risk analysis of annual floods in Kolhapur district to know their main causes and their consequences. Therefore, this chapter deals with the relevant topics such as rainfall variability in Kolhapur district, correlation and multiple regression analysis of rainfalls and water levels in flood prone Panchganga basin. It also includes readings on drinking water quality from Panchganga river basin, during pre and post flood period and people's perception on the issue through social Impact assessment (SIA) studies. Panchganga flood line drawn by using Arc GIS Software 9.3 version. The secondary information collected on major rivers prone to floods in the area, flood prone areas, flood levels at different tahsils and the consequences and Impact of floods in Kolhapur city are also covered in the study.

***Index Terms* – Flood, Rainfall variability, Average rainfall, Rainfall percentage, flood disaster.**

1. INTRODUCTION

There are different views among the workers on Monsoon phenomenon and the rainfall pattern in India. It is assumed that better understanding of monsoon rainfall, based on the analysis of past record data, may give an indication of the future rainfall scenario, and that is possible through climatology by using latest technology. The making of a homogeneous rainfall data series (spatially as well as temporally) was the first step in this kind of a study (Guhathakurta and Rajeevan, 2006). There were interesting outcomes in All-India Summer Monsoon Rainfall during 1871-1978, suggesting the monsoon rainfall without any trend and mainly random in nature over a long time period, mainly on the all-India time scale (Mooley and Parthasarathy, 1984). However, on the spatial scale, existence of trends was noticed i.e., in inter-annual and long-term variability of Indian summer monsoon rainfall by (Parthasarathy, 1984) and spatial and sub-seasonal patterns of the long-term trends of Indian summer monsoon rainfall (Rupa Kumar et. al., 1992). Sinha Ray and Srivastava (2000) did trend analysis of heavy rainfall events over selected stations all over India and reported a decreasing trend over most parts of the India.

Using the daily gridded data of India Meteorological Department for the period 1951 to 2003, Goswami *et. al.,* (2006) examined the trend of extreme rainfall over India. They have reported an increase in the frequency and the magnitude of extreme rain events and a significant decreasing trend in the frequency of moderate events over central India. Whereas a study Guhathakurta, *et. al.* (2011) reveals the noticeable changes in the extreme rainfall events that occurred over India in the past century. This revealed that the likelihood of flooding and water shortages increases with economic development and population growth. According to Dulo *et. al.,* (2010) integrated flood and drought management for sustainable development in the Nzoia river basin and reported that we need to watchfully plan for both flood and drought, as do the majority other local and state governments are charged with managing water.

The annual average rainfall of Kolhapur district during the period 2001-2013 was assessed as 1943.6 mm, which is much more than the annual average rainfall mentioned in the Gazetteers of Kolhapur district i.e., 1138.5 mm which shows that apparently there is significant increase in the rainfall in the district in the recent years, particularly in last 13 years. In the present study in order to understand variation in yearly amount of rainfall, the annual rainfall was grouped into three sub- categories based on mean rainfall. The year wise categories were studied from 2001 to 2013.

The maximum average rainfall (more than 3000 mm) was observed in Gaganbawda and Radhanagari tahsils. The medium average rainfall (1000 mm-3000 mm) was observed in the five tahsils namely Shahuwadi, Panhala, Bhudargad, Ajara, and Chandgad. Also, low average rainfall (less than 1000 mm) was reported in the remaining five tahsils of Hatkanangale, Shirol, Karveer, Kagal and Gadhinglaj. According to Relief and Rehabilitation Department, Gov. of Maharshtra, (2012) flood of 2005 was the most disastrous in the recent history, in which 981 towns and villages were seriously affected. The houses damaged were reported to be 18458 and over 93000 people were evacuated.

However, in contrast to this in the year 2012 Shirol tahsil was considered as drought affected and water scarcity tahsil (one out of 122 drought affected tahsils in Maharashtra), as only less than 50% sowing of different agriculture crops could be done (Revenue and Forest Department, Gov. of Maharashtra, 2012). An attempt was made to study month wise total rainfall variation during rainy season in 2001 to 2013. It is revealed that there is no clear trend of increase or decrease in rainfall variation during 2001-2013. Allan, (2011) also reported that rainfall in the greater part of India is not certain, vagaries of monsoon is unevenly distributed and having no fixed course. Nevertheless, there was some uncertainty in the rainfall during the months of July and August, while June and September showed less variation than July and August. Only in the five rainy months, October showed less variation during

2001 to 2013. These five months rainfall is very crucial for the economic development of the country and it also influences management of disaster and hydrological planning, similar type of conclusion was drawn in case of Indian summer monsoon study of Solapur district of Maharashtra by Barakade and Sule, (2011).

Experts however, feel that there is no established correlation between the timing of the monsoon‟s arrival over Kerala and the performance of the monsoon and therefore 1 June date is more of "statistical interest "Thus in order to understand these unforeseen and uncertain events, an attempt therefore was made to study the magnitudes of extreme and less rainfall events over years in different parts of Kolhapur district. It was expected that the study of spatial variability of these events may help to identify the zones of high and low value of rainfall events. The annual average rainfall pattern in Kolhapur district is supposed to greatly differ year to year and from tahsils to tahsils. This has direct impact on human life in the major river basins in the district.

Fig.1 Kolhapur Flood

2. HISTORY

It is observed that flood intensity in Kolhapur district was not only dependent on the regional rainfall but it also depended on the water already stored before monsoon in the dams. The water levels in these tributary rivers in the district and their main river Krishna in which these rivers confluence, also matters considerably. When there is more water storage in these wetlands before monsoon, then the dams in the water shade overflow in the downstream rivers, even with modest rainfall in their catchments. The general belief among the irrigation engineers and hydrologists is that with downstream dams become full, their backwaters spread in the upstream areas causing floods. In Kolhapur district floods parallel conditions were observed, particularly in Panchganga River, due to the major dam downstream at Almatti of the Krishna River. Sathe *et. al.*, (2012) reported that the July-August 2005 flood disaster, on the banks of river Krishna and its tributaries, including river Panchganga was due to the excess water storage in Almatti reservoir in downstream Karnataka state.

3. RAINFALL VARIABILITY IN KOLHAPUR DISTRICT

The rainfall of the twelve tahsils of Kolhapur district, in the years 2001 to 2013, was collected from relevant agencies and analyzed for the mean, S.D., coefficient of rainfall variability, rainy month's rainfall percentage, and month wise total rainfall variation and finally the choropleth map were evaluated.

Sum	DF	SS	MSS=SS/DF	F Factor
YSS	11	22788154	2071650	18.21
PSS	11	30.19E+08	28110928027	247.14
ESS	121	13763287	113746.17	
TSS	143	3.46E+08	2417983.58	

Table No. 1 Two Way ANOVA table for Determining Significant Difference between Rainfalls

Where, DF= degree of freedom, SS= sum of squares, MSS= Mean sum of squares, YSS= Year sum of square, PSS= Place sum of square, ESS= Error sum of square, TSS=Total sum of square.

Two-way ANOVA (Analysis of Variance) table calculated for checking average equality between rainfall of 12 different tahsils for 13 years, shows that the two calculated F values are greater than cut of point value (1.8686) i.e., cut of point < F. Hence from the two ways ANOVA test; there is significant difference in the average rainfall of 12 tahsils of Kolhapur district in last 13 different years. It was noticed that there was large variation in the rainfall of these tahsils in the period from rainfall in Gaganbawda (average 5812.4 mm) to Shirol (average 535.4 mm). Kolhapur district annual average rainfall also varied from 16850.4 (2003) to 33102.9 (2005). Hence it was realized that the occurrence and intensity of flash floods, dependent upon the rainfall in a particular tahsils, is varied in different tahsils of Kolhapur tahsil.

Year	Average	Total
2001	1482.5	17790
2002	1587	19044
2003	1404.2	16850
2004	1807	21684
2005	2758.6	33103
2006	2557.5	30690
2007	2266.3	27195
2008	1967.3	23607
2009	1889.1	22669
2010	1897.6	22771
2011	2129.4	25553
2012	1688.1	20257
2013	1832.7	21992
Mean	1943.6	23323

Table No.2 Annual Rainfall (in mm) of Kolhapur District (12 tahsils) during Period 2001 to 2013

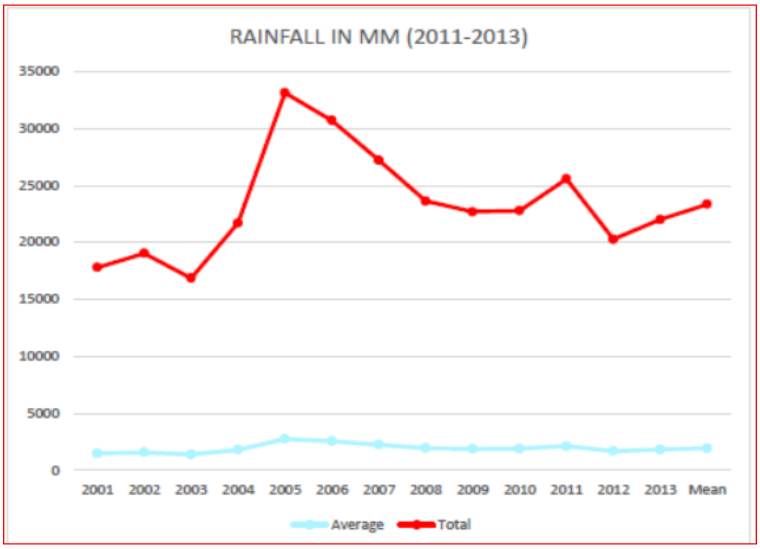


Fig.No. 2 The annual rainfall during the period between years 2001 to 2013

The figure no.2 shows the annual rainfall during the period between years 2001 to 2013 where the total average rainfall of the district for this period is 23323.4 mm. From the figure it is apparent that in the years 2001, 2002, 2003 and 2012 rainfall received as compare to other years in the period, was less than or near to 20000 mm and below average, as the years 2005, 2006, 2007 and 2011 received little higher, i.e., more than 25000 mm rainfall more than average. In other years of the period i.e., 2004, 2008, 2009 and 2010 comparatively moderate rainfall (nearly equal to the average) was received. During years 2001 to 2003 rainfalls showed below average i.e., 23323.4 mm that is total rainfall of Kolhapur district was in between minimum (16850.4 mm) to maximum (33102.9 mm). However, after year 2003, which received lowest rainfall (16850.4 mm), water scarcity was observed as compare to the other years. After this year there was sudden increasing trend in the rainfall pattern in 2004 and in the year 2005 received abnormal and highest rainfall in the previous thirteen years resulting in to one of the disastrous floods experienced by Kolhapur district in years. Then rainfall showed gradual decreasing trend in the following years 2006, 2007 and 2008.

The years 2009 and 2010 received nearly same amount of rainfall. There was slight increase in the rainfall in the year 2011 to drop again in the year 2012, when again water scarcity was experienced in the district. There was slight improvement in rainfall in the year 2013 during the study period.

It was observed that whenever there was more amount of rainfall it was directly proportional to the intensity of floods observed in the study area. For example, in high rainfall years i.e., 2005 (33102.9 mm), 2006 (30689.7 mm) and 2007 (27195.3 mm) respectively, there were high flood levels observed in Panchganga river at Rajaram Bandhara (K.T. weir) at Kasba Bawda in Kolhapur city. They were 545.11 meters, 544.16 meters and 543.11 meters, above MSL respectively where normal flood line is 541.77 meters. During the period (2001-2013) mean annual rainfall for Kolhapur district was 23323.45 mm. In the thirteen years Gaganbawda tahsil received highest annual rainfall with more SD. It is revealed that high precipitation takes place in the western and NW direction tahsils of the Kolhapur district, located along the Western Ghats namely Gaganbawda (5812.4 mm), Radhanagari (3719.6 mm) Chandgad (2610.4 mm) and Shahuwadi (2057.7 mm) tahsils with more standard deviation. Also, high rainfall is received in the other tahsils namely Ajara (1866.5 mm), Panhala (1720.9 mm) and Bhudargad (1593.3 mm) as most of the area of the tahsils located partially in the Western Ghats.

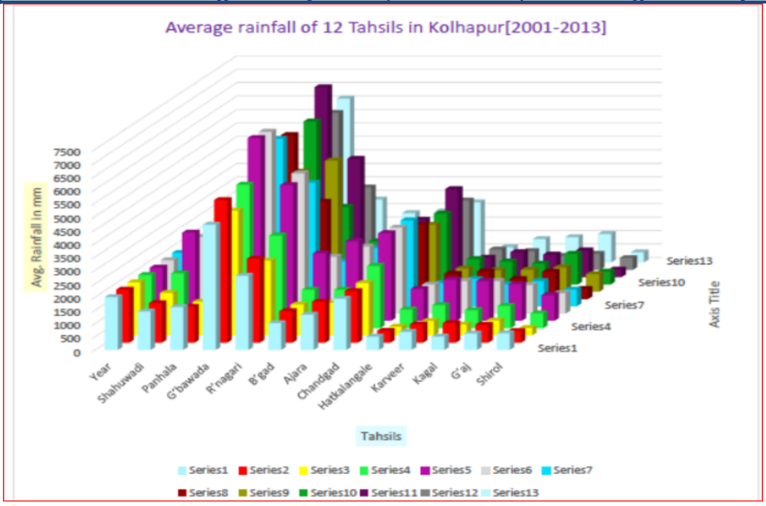


Figure No.3 Average Rainfalls of 12 Tahsils in Kolhapur District during the Period 2001 to 2013

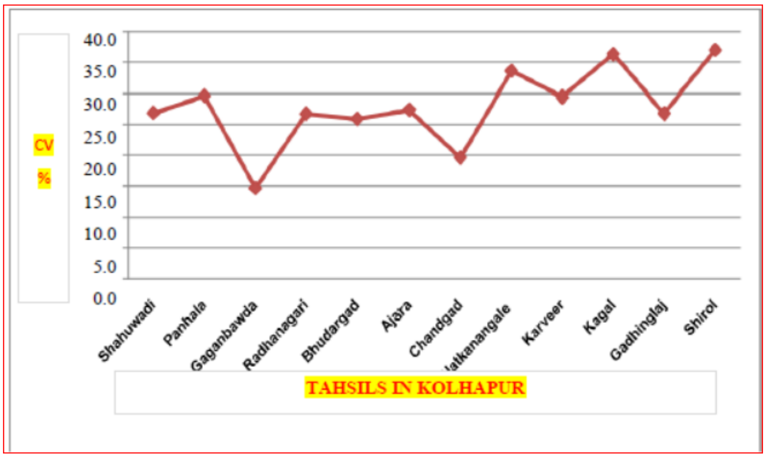


Figure No. 4 Coefficient of Variation in Percentage of Rainfall of Tahsils in Kolhapur District during Period 2001 to 2013

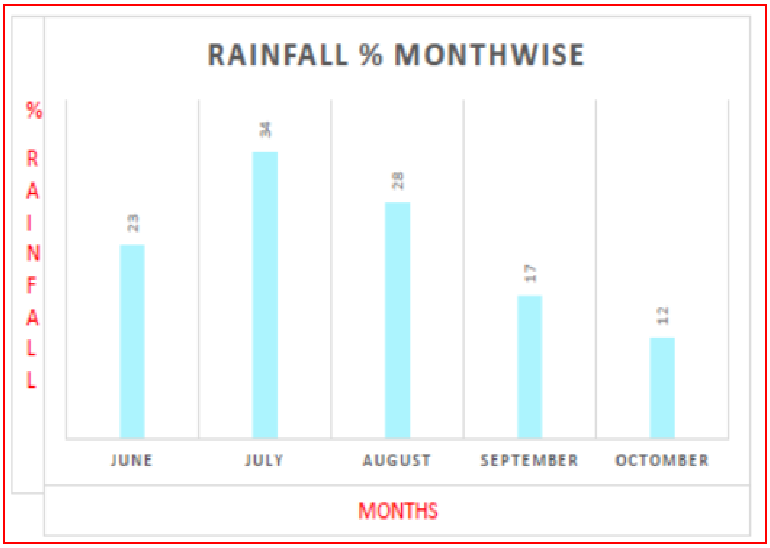


Figure No. 5. Rainfall Percentage during Rainy Months between 2001 to 2013 in Kolhapur District

4. IDENTIFICATION OF PROBLEM:

4.1 Floods in Kolhapur District

River Panchganga is formed by five tributaries in the mid-section of the district and is the major flood prone river along with others in the south of the district namely Dhudhganga, Hiranyakeshi, Vedganga, and Tamraparni. These flood plains are restricted only to lower reach in the east of the district till they meet river Krishna flood plain.

There are several irrigation and multipurpose projects in the district which include 3 major dam projects, 12 medium project and 10 minor projects. It is seen that majority of these dams are situated in the maximum rainfall area i.e., western parts of the district. This will be helpful to reduce the impact of flood during maximum rainfall period and also it maintains river flows in the summer season and reduces the severity of water.

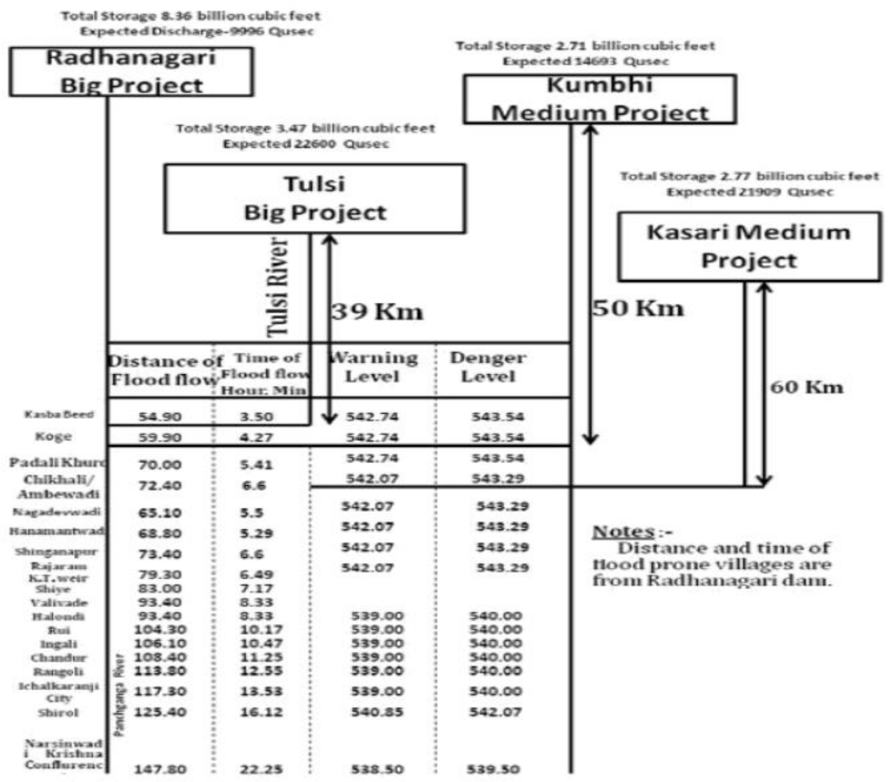
However, in the event of unforeseen situation, as a result of climate change, the excess water from these tanks also needs to be considered as potential threat for flooding. It can be seen that the large percentage of flood affected villages in Kolhapur district are from Chandgad Tahsil followed by Karveer and Shirol tahsils.

Whereas excessive rainfall in the river basins is the main cause to flood prone villages in Kolhapur district except in Shirol and Hatkanangale Tahsil, where main cause of floods is due to the back water pressure of Panchganga River caused by excesses swelling of Krishna River flood during the same time. In all 70 villages in the district come under flood threat, potentially caused by major dams in the district, out of which majority 42 villages come under red belt (Restricted zone / Abnormal flood line) area and only two villages come under category of the blue zone (Prohibition Zone /Normal Flood Line). Also 26 villages from the study area come under yellow belt (Caution Zone/Danger area) (Multi Hazard Management Plan of Kolhapur district, 2005). See list of the villages in different zones in Annexure –V.

4.2 Case Study of River Panchganga Floods.

In Panchganga river system (PRS) basin has 5 major dams in its upper catchment, namely Radhanagari (8.36 TMC) with 10400 cusec total discharge capacity, Tulsi (3.47 TMC) with 640 cusec total discharge capacity, Kasari (2.77 TMC) with 22266 cusec total discharge capacity, and Kumbhi (2.71 TMC with 15046 cusec total discharge capacity (Sangli Irrigation Board, 2010). however, It has been seen that the flood intensity in Panchganga river is largely depended upon the discharge from Radhanagari dam due to its large capacity and position in PRS system, where more rainfall in the district is reported every year.

Kolhapur Irrigation Department, (2009) has estimated the flood flow time (hours: minutes) required to reach the particular site after release of water from Radhanagari dam the time required to reach at particular place is varies from Kasba Beed (3:50) to Nrusinhwadi (22:25) hence there is less time for upper steam of the Panchganga river system as compare lower stream flood reaches in 6:49 hours at Rajaram K.T. weir in Kolhapur city. Warning levels and danger levels of the flood varies from place to place depending upon surface gradient. Warning level varies from 542.74 MSL (Kasba Beed) to 538.50 MSL (Nrusinhwadi) and danger level varies from 543.54 MSL (Kasba Beed) to 539.50 MSL (Nrusinhwadi).



Kolhapur Irrigation Department, 2009

Figure No.6 Panchganga sub basin organogram

4.3 Flood Zones of Panchganga River in Karveer, Hatkanangale and Shirol Tahsil

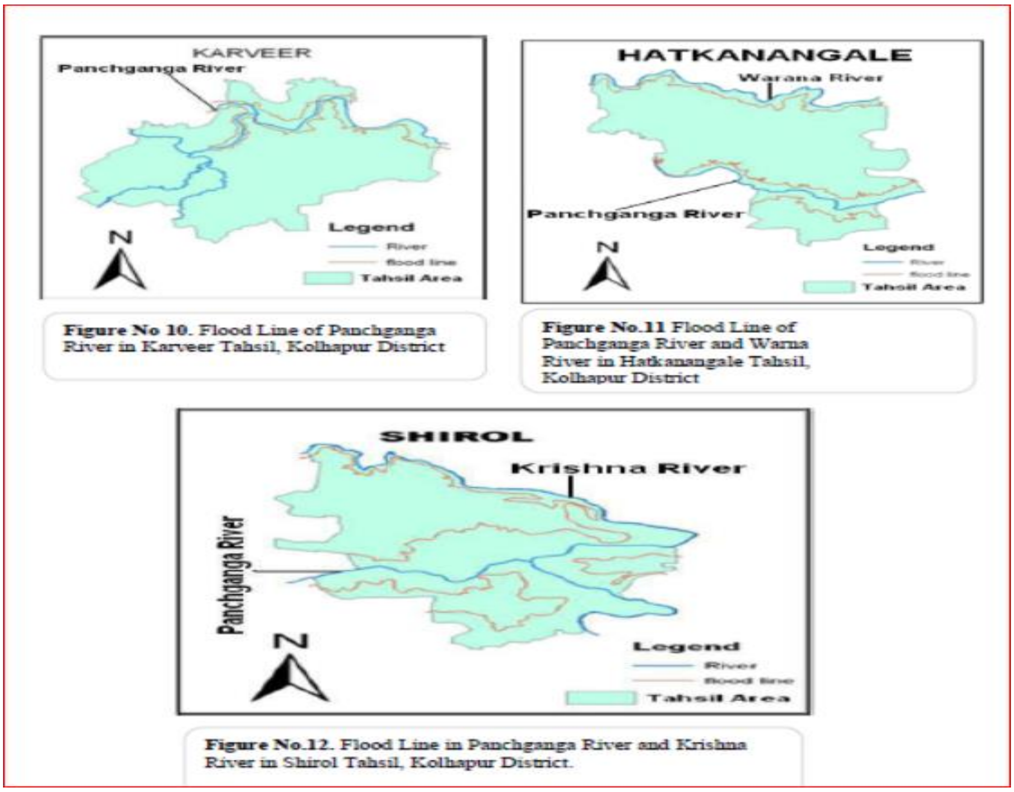


Figure No.7 Flood Line in Panchganga River and Krishna River in Shirol Tahsil, Kolhapur District

4.4 Floods in Kolhapur City

Kolhapur Municipal Corporation (KMC) has demarked flood lines covering an area of 6682 hector in Kolhapur city. Out of which a significant area (1391.50 ha) is covered by the flood line i.e., red line (Flood Danger Line of year 2005) which is 20.82% of the total city area. According to the 2nd Developmental Plan of Kolhapur city, area covered by the blue line (No development zone line) is 1518.26 hector which is 22.72% of total city area indicates where all developmental activities are prohibited. The area between Blue Line and Red line is known as "Red zone" where prior permission of KMC is required for any construction. Where the residential area covered by the blue line is 8.64 hector and the area covered between blue line and red line is 9.31 hector. The Plate IV (a-f) shows floods in the Kolhapur city. For prevention and mitigation of impact of floods, KMC in (2011), arranged 17 evacuation places for different flood prone areas in the city (Annexure- VI).

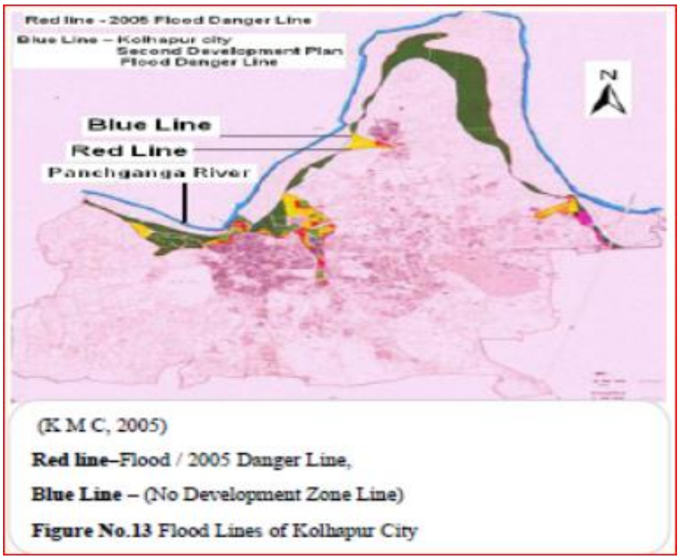


Fig.No.8 Floods in Kolhapur City

5. FACRORS AFFECTING FLOOD

A. **Climate**

In terms of future uncertainty Climate change present perhaps the greatest challenge. The impacts include expected rises in peak surge tide level, mean sea level, wave heights and fluvial flows.

B. **Socio economic**

The Foresight flood risk project [OST2004] identified the critical uncertainty that socio-economic development presents to the future of flood risk. On the national scale it was more influential in changing the scale of future flood damages than the effects of climate change.

C. **Asset deterioration**
The deterioration of existing assets means that much of the existing flood management infrastructure will require replacement over the next 100 years, at a cost of several billion pounds. The rate of deterioration is therefore a vital factor in future planning.

D. **The physical environment**
The estuary has been essentially fairly stable history over the last century or so in terms of its physical development. The outer sandbanks in the estuary protect it from the worse effect of wave attack. However, sea level rise could disturb this picture and it will be essential to monitor the state of the estuary into the future.

E. **Public behavior**
At present the Awareness of flooding on the estuary is low and the present high standard of protection means that there is little need for the public to be aware of the risk. However, with an uncertain future it may be desirable for this situation to change so that the public can be better prepared for the risk of future flooding. The types of adaptation envisaged within the plan to cope with future change include:

F. **Changes to the timing of new interventions**
The plan will have a preferred option for managing the flood risk throughout the century given the envelope of change that is considered to be most likely based on current information. However, the actual rate of change is likely to differ from the rates assumed in the plan and this could lead to the changes in the timing of interventions.

G. **Ability to the change between options**
If the rate of change of a critical factor is predicted or is observed to change significantly above the expected rate of change when the preferred option is selected, it may be necessary to switch to an alternative option that is able to cope with larger changes.

H. **Adaptation of Engineering response**s
Engineering responses should be designed so that they can be adapted to changing circumstances, for example by providing foundations for new defences that can take higher future loadings, or designing barriers and other control structures that can be modified in the future.

6. CONCEPTUAL PLAN TO AVOID FLOOD

A. **Land use planning that provides flexibility in the selection of options**
Each flood risk management option will require land for new Defence enlarged defences, new areas of Habitat creation and in some cases flood storage. It is essential that the planning system is aware of the land required for the preferred option and the alternative option so that the land can be safeguarded.

B. **Adaptation to new infrastructure**
New infrastructure on the Thames estuary could have a major impact on the flood risk management. New transport links could provide the opportunity to combine a new crossing of the estuary with a new barrage. The plan should be flexible enough to accommodate major changes such as these.

C. **Procedure for developing the plan**
A set of option including a preferred option is a key output of the plan. The preferred option is needed to set the direction for flood risk management. The alternative option is needed in case the preferred option is no longer able to manage flood risk because the actual rate of future change is greater than expected. The method for developing the options at estuary wide level is described in the following steps.

a. The main drivers of flood risk management are identified.
b. For each driver, indicators are identified which describe the impact of the drivers and can be monitored.
c. For each indicator the thresholds where interventions are needed to maintain the required level of flood risk are identified. For example, in the case of climate change, a particular sea level at South end.
d. A range of possible interventions for each threshold is identified.
e. The lead time for implementing each intervention is estimated. This is the time needed to plan and construct the intervention, in order to determine when decision should be taken.
f. Options are developed for the following cases:
g. Best available estimate of future change.
h. Different 'what if' assumptions regarded the rate of change of key indicators. For each option, interventions needed for each threshold are identified. The overall option consists of all the interventions needed to manage all the threshold.
i. A preferred option is identified for the best estimate of future change available at the time that the options are developed. This is achieved by appraisal of options developed under 6 a above.
j. Options are developed at estuary wide and policy management unit (PMU) level. The process of linking them is as follows:

➢ Estuary-wide option are developed and a preferred option is selected.

➢ PMU options are then developed which include the relevant component of estuary wide options.

➢ There may be some feedback from the PMU options into the estuary-wide options which would lead to refinement of the estuary-wide options. This should not affect the overall study wide approach of This information will be provided by plan.

k. At this stage there is a preferred option for the best available estimate of the future change. Alternative options for the different assumption of future change. This information will be provided by plan.

7. REMEDIAL MEASURES ON FLOOD DISASTER

A. Drivers and indicators of change

Drivers are defined in this content contest as the factors that create the need for flood risk management and therefore the plan. The main drivers of the plan include the following:

B. The existing flood risks

Much of the tidal food plain is protected from flooding by flood defences. As the flood plain is intensely developed, it is essential that the plan includes management of the existing flood risk.

C. Flood risk management policy

This determines the direction in which flood risk in the flood Plains will change, for example increases, reduce or stay at the same.

i. Climate change.
ii. Deterioration of the existing defence system.
iii. Probability of failure of the Thames barrier and other barriers.
iv. Socio-economic development on the flood plains.
v. New infrastructure that directly affects flood management.
vi. Physical change to the estuary.
vii. Loss of Habitat
viii. Creating a better place.

The environment Agency's corporate strategy entitled 'creating a better place' seeks to achieve an improved environment, taking account of a wide range of issues including improving river environment and landscapes, enhancing biodiversity and working with natural processes.

i. Public behavior this includes public awareness of flood risk under conditions of an uncertain future.
ii. Measurable indicators for the above drivers include the following:
iii. Mean sea level.
iv. Peak surge-tired level.
v. Developed area or asset value of development.
vi. Intertidal Habitat area.
vii. Condition grade of a flood defences.
viii. Extent of erosion and deposition.
ix. Public awareness of flood risk and how to respond.

The options are based on assumptions about each of these indicators. For example, guidance on climate change is assumed.

8. CONCLUSION

The approach to flood risk management presented in the plan include a method of developing option together with a regular updating process in which options and decisions are reviewed taking account of changing circumstances. Interventions will be introduced as the need arises taking account of lead time needed for planning design and construction. These include both flood defences and floodplain Management. In some cases, it may be recommended that pre-design work is commenced early to reduce lead times and vulnerability of the plan to rapid change. The flood defences involve engineering construction works to provide continuous flood defence system for the estuary and tributaries. They require land for the works, including land for the future improvement and adaptation. Floodplain management includes non-structural responses and some structural works, such as a safe haven. A preferred option will be identified by the appraisal process.

This will set the direction for flood risk management on the estuary but will be reviewed as a change occurs. If future changes are within the envelope that can be accommodated by the preferred option, it is likely that the choice of option will be unchanged. There may however be changes in the timing of future interventions, which depend on the rate of change of drivers of flood risk management. If future changes lie outside the envelope of change that can be accommodated by the preferred option and alternative option will be selected. This could lead to significant changes in the interventions. The evolutionary approach of responding to change is intended to minimise the risk of implementing responses that become redundant long before they reach the end of their design lives.

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