CHAPTER 4

PROPOSALS AND RECOMMENDATIONS FOR FLOOD PRONE AREAS

A study carried out in the flood affected region of Krishna and Tungabhadra river course of Raichur has a detailed analysis in the previous chapter. The discussion in the analysis is ended up with the following questions.

1. Logical and hydro meteorological factors which evolve and control flash floods?

2. How to strategize the model in time and space scale of the disaster event?

3. Can regional model is accurate for time-space scales for flash floods?

4. Can climatic trends and its frequency of flash floods in the area being predictive for eventual flash flood?

5. Should the village built forms required to be modified for not to depend much on post flood relief assistances of government which are ineffective?

The first type of study has been carried out on built forms of the settlements and the second type of post flood studies deal with extreme events of flood that affects built forms and living pattern. All the past works are limited to describe the event through described data from observational survey and interviews at field. The descriptions provided by this type of studies are mainly concentrated on local information, which in no way add to the understanding of floods but causes and impact of flood. The randomness of rain fall and runoff will result in unpredictable situations mainly based on time related data from the CA on both rivers. The knowledge of extreme events and their peak discharge will not give any clue to the possible occurrence in near future. The study on patterns of river flow with extreme discharge are to reduce
uncertainties and flood frequency analysis. Much of the studies done in this nature are very specific to the actual topographic and local climatic data. Generalization of this event may not add to the understanding of the situation as a scientific manner. Much of the technical usefulness of post flash flood surveys are very tedious and difficult task. The importance of geology and soil types are counter intuitive behaviors of some areas with limited impact on the land use. The post flood procedure is suggested based on the study involving the general philosophy and necessary inaccurate or no method in perfection and is of very first concern to be verified. These skills of inter petition are based on practice and initiative taken at research site.

Spatial pattern of peak discharge may give the cause and starting point of flood circumstances. The peak discharge will happen due to stagnation and non movement of heavy clouds trapped by circular forces of depressions. If these depressions are on sea which cannot be noticed or will disturb the normal habitation, but when depressions happen around the land and sea, on mainly land the downpour will exceed 200 mm rainfall within 24 hours will be a definite flood warning if it happens in tens and hundreds sq. k.ms in CA. But scientific studies which were not done here on variability of rainfall and its runoff dynamics will help- in modeling flood generation.

Hence this study has been organized into two divisions namely,

i) **Built form planning strategies to mitigate impact of flood in flood prone areas, which are only replica of pattern followed in non-flood affected areas, and**

ii) **Integrated ways for scientific approach to flash flood prediction, and providing standards and possible solutions on executing future land development and flood impact mitigation strategies for the study area.**
i) **Built form planning strategies to mitigate impact of flood:**

The settlement planning pattern adapted in flood prone areas are similar to the one followed in other non-flood prone areas, hence there is no fundamental change in development of settlements near river course. During the flash floods the directions in which the water is flowing will get obstructed by grid-iron pattern of urban settlements which inevitably against the contour and valley terrain. The major roads are normally parallels to the river course, but the rural & urban settlement roads will work effectively only when they are perpendicular to the river course.

The practical means of built form strategies for housing is provided in Appendix III.

- The major roads gets aligned perpendicular to the river course, thus creating hindrance for normal flow, as buildings are designed along the road. This creates a wall for smooth flow which will accumulate and increases its velocity near the possible openings where water can escape.

It is recommended that the settlement built form pattern in these areas as to be modified to give smooth flow which might reduce the effect of water raising, thereby disastrous effect.

It is proposed to have a platform along the major road axis, which can be elevated above the determined maximum flood level with a natural slope to meet the existing road surfaces. These flat forms are to accommodate panic crowd during flash floods reaching maximum flood level. There is a need to train the urban/rural inhabitants to find ways effectively during flash floods through frequent exercises.
Structural methods and measures are highly expensive and require high skilled participants not all of these are fit for environmental conditions desirable for flash flood area. The advantages of these structures it to bring flexibility in soil settlements at its foundation. It is very important to build structures on soil with little load bearing capacity. They are highly permeable monolithic structures that allows flow of water. All these means smaller size structures can with stand great stress. Gabion structures are more economical than concrete structures. The construction of gabion structures are simple, fast and does not require skilled labour. These structures are unfavourable in climatic conditions and difficult to access the difficult areas. Gabions are eco-friendly and be used for a long time. Gabions only retains silt and small rocks as it allows water flow. Infiltration terrace are small canals or trenches built on the hill side to capture stone runoff and to reduce erosion by increasing water infiltration into soil. These soil recovery works can be built mechanically or manually. Trenches store runoff water as soil moisture and very useful in arid areas. Terraces are appropriate for restoration of forest and better the hydrological conditions on the hill side. These trenches can be used for water conveyance and distribution.

The planning guidelines calls for sound urban design in sloping areas which should be modified to the natural shape of the land to offer least resistance to water during flash floods. The landscaping and pathways local drainages can be shaped with respect to easy flow of runoff water during flash floods. It is well known that the obstruction for the smooth water flow at any level are the major cause for disaster. The slope management quantity and volume of water discharge should be equal to the maximum expected water flow per hour to maintain less than 1 meter height of water in the habitable area. Steeper sloped high density development are preferred in these environments than low lying, horizontally sprawling developments.
As far as possible no natural land movement should be allowed on slopes with gradient more than 25%. The maximum recommended land occupancy percentage on slopes of 10-15% is 30 while compared to slopes of 65% where occupancy shall be limited to 2%. In order to evaluate the quality of the views and best locations for development without disturbing natural landscape are desirable.

The uncontrollable expansion of the rural and urban habitation area with large scale impervious surface renders surplus storm water, which creates difficulty in managing the slopes. It is necessary to design solutions at planning stage, the components of streets, residential area, side walks, parks etc., to align with the conditions of smooth water movement. The runoff water should easily reach lower levels without drastic change in levels. Low impact urban developments will normally fall under the urban drainage concepts. The purpose of storm water runoff for traditional use gets affected by excessive storage. While green spaces contribute to landscapes and quality of life, they can also be used as hydrological infiltration and storm water retention. These landscape elements can also improve the quality of water filtration, sedimentation and biological pre treatment. They can be strategically located to process urban drainage system and lead the naturally processed water to the stream.

The maximum reduction of impervious areas can be attained through proper treatment of roofs and parking lots. Reduction of impervious areas can also be achieved in the following ways.

1. Retention / filtration ponds.
2. Grass buffers.
3. Grass swales.
4. Rain gardens
5. Urban streams
6. Wet vegetated swales.
7. Floodable parks.
8. Artificial wet lands.
10. Energy dissipation devises
11. Permeable cobble stone pavements.
12. Bio retention ponds

Space Bourne and ground based remote sensing techniques provides major information in time space resolution of hydro-meteorological data for prediction and advanced warning in flood affected areas. Cloud height, its thickness, water vapour, water content of the cloud, rainfall rate, elevated and surface temperature and topography can be modelled to predict rain in small areas, which will cascading affects to accumulation of flash flood conditions.

Small hydraulic structures namely gabion structures, infiltration terrace, water traps, slow terracing can reduce erosion at micro-level. Gabion structure are made of wire mesh filled with rocks and rubble are built downstream from the water trap structure. The modules of gabion structure are usually rectangular parallelepipeds of dimension 2 meter X 1 meter X 1 meter made of 12 mm reinforcement rods. Often lined with oven galvanized wire mesh of rhomboid shape and mad of 4.4 mm wire. These gabion structures are placed in front of water ditch, so as to prevent sedimentation in the water ditch.

Infiltration terrace are made in slope to the opposite direction of the water flow, in order to avoid silt movement. Water traps are 2-3 meter in diameter and 4-5 meter in
depth, which will store water during low runoff and also helps in reducing the speed of runoff water during flash floods. Large scale desilting will adversely effect the permeability of the river course. More water will enter sub-surface and become unpredictable in movement and levels. More extensive measures to be taken around water shed level, and at the maximum flood level. Mapping of flood level will help in devising the measure to mitigate disaster. Structural measures usually reduces the benefit to the cost it takes. Non structural interventions are more cost effective and involves technology to rapidly process real time streaming data for analysis.

Flood prone zoning will be limiting the availability of developable land, and thereby reducing the cost of rehabilitation. Implementation of non-structural measures will reduce the power of lobbying for the organization involved in developmental activities. The following measures can be taken to prevent soil erosion at slopes and rapid runoff axis in the CA.

1. Sloppy side terracing & elevated bund ways.
2. Wire mesh stoppage for stones and mud to fall into river course.
3. Intercepted ditches
4. Stone wall to retain soil.
5. Prevention of erosion through vegetation.
6. Stream bank protection
7. Stream direction structures.

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There were two main types of investigation carried out to satisfy the objectives and context. First is on commissioned authorities at National / Regional context after a major flood catastrophe. The main purpose was to find answers to questions raised by public and local stakeholders on cause of floods and its impact, on human habitat. Magnitude and frequency of flood are discussed and recorded, management of the crisis and the efficiency of flood mitigation methods and solutions to recover from flash floods. It is done to find the limits of risk involved in future.

The purpose of such studies is limited to the questions raised. It mainly draws the lesson of the event at regional scale and it will not increase the overall understanding scientific/ technical aspects.

ii) **Integrated ways for scientific approach to flash flood prediction, and providing standards and possible solutions on executing future land development and flood impact mitigation strategies for the study area:**
Average rainfall recorded in Krishna, Tungabhadra river valley is 780 mm. This annual rainfall varies from 3048 mm to 600 mm. 80% of this precipitation happens during south-west monsoon, followed by 5-8% from north-east direction, remaining are from south-east and north-west. This annual cycle gets extraordinary variations during about 12 years cycle of solar cold sun spots. (table --- chart---)

Apart from 12 years solar cycle, studies remind that there are variations in water precipitation in represented in 40, 100, 500, 1000 year cycles. (quote at least one reference study and include one review of literature) The study area of Raichur district concerning Krishna and Tungabhadra river flow comes under peak variations of 40 plus years. This cycle of peak rainfall creates flash flood situations in the river valley during this decade. National emergency flood disaster preparedness gets notified only when there are flash floods within 40 year cycle. This study area flash flood records exceeds 40 years cycle. Because of this much of the preparedness for flash flood disaster is not taken. Since the Krishna river basin has a population of 64 million of which 66% people live in rural area, 34% live in urban area, are vastly effected by flash floods of the nature which happened on October 5th 2009. This kind of flash flood happen in middle region of the river basin. Krishna river basin has been divided into three important areas namely upstream, midstream and downstream. Maharashtra has an area of 69,425 Sq Kms of river basin area in upstream, Karnataka with an area of 1,13,271 Sq Kms area in midstream of the basin and Andhrapradesh with an area of 76,252 Sq Kms of river basin as downstream.

Upstream river basin area collects large amount of rain for the river, it will flow through midstream and gets settled in dams of downstream area. Since Raichur district is in the midstream of the river valley which has vast large plain surface,
which results widespread of water during flash floods. This study area which consists of Krishna and Tungabhadhra river valley are most affected during 2009 flash floods. There are large scale human settlements in this midstream Krishna river valley. A total of 483 Kms of river course is in Karnataka. Since the tributary river Tungabhadhara joins Krishna river around the end of Raichur district, most of the flood affected area falls in this zone.

The total percentage of area is divided between Maharashtra, Karnataka and Andhra Pradesh, with 26.8%, 43.8% and 29.4% respectively. As Karnataka has 43.8% of the basin area, more than 50 % of the flash flood disaster will naturally happens in Karnataka. And 29.4% basin area in Andhra Pradesh is covered with hilly track has large water storage capability. Because of the large storage capacity created by Nagarjuna sagar dam of Andhra Pradesh the possibility of flood having reverse flow and main flow will result in flash floods in Raichur District. The probability of having a flash flood would have been reduced, had the Nagarjuna Sagar dam was at lower elevation.

The total length of the Krishna river valley is around 1400 Kms flows through Maharashtra, Karnataka and Andhra Pradesh with river length of 305 Kms, 483 Kms and 612 Kms respectively in these three states. 305 kms of flow in Maharashtra with rapid water flow capacity has end up with Nagarjuna Dam in Andhra Pradesh causing vast storage capacity and having a barrier for smooth water flow. This component of rivers resistance and high main river flow will come in opposite directions around Raichur distributing itself in Krishna and Tungabadhra river course.

The surface water flow in Krishna river valley is 49.55 Cubic Kms. With an average annual flow of 78.12 Billion Cubic Meters (BCM), and there is a vast difference in
flow on Krishna basin of to a current annual flow of 21.5 BCM. This vast difference has made to classify the class of the river.

Classification of rivers in aspects of flow difference, has been categorized into,

a. The river which has at least a flow difference at 68.0 % is classified as Class A River.

b. The river which has at least a flow difference at 34.8 % is classified as Class B River.

c. The river which has at least a flow difference at 18.3 % is classified as Class C River.

d. The river which has at least a flow difference at 8.40 % is classified as Class D River.

Since there is wide variation from 78.1 BCM to 21.5 BCM, River has been classified as C type. According to the study, an assessment of environmental flow requirements of India river basins.

Since Krishna basin is classified as C type which are receding rivers. They have high potential of large probability of flash flood disaster. This is due to the region where river flows in Raichur district is in plain area with very little relative elevation. Any flash flood happening in this area of the river course has been spread to an area of 5-10 km wide. This kind of plain area has caused vast devastation of settlements which are normally away from the main river course. This kind of flash floods which happens with cycle of 40 plus years has greatly disturbed the social fabric of the rural settlements around both sides of the river course.
During the flash floods the river flow is resisted by urban/rural settlements, there by increasing the force to devastate building structures. Most of the buildings in the study area were experiencing an average water level of more than 1 meter from the ground surface. And all the houses which were effected by flood had a minimum of 3 days of water upto 1 meter level during floods.

The cultivable area under irrigation is 1,20,42,855 hectares and cultivable area not under irrigation is 27,88,141 hectares. (source: Integrated Hydrological data book 2005)

- The quality of soil in this river belt consists of black, red, laterite and mixed soil. This has low permeability, hence high flow of water without seepage. Thus further increasing the flow of water during floods. Krishna is now approaching the status of drowsing basin, hence a proposal has been made to accommodate environmental flow, which requires a well planned investment and largely affect the planned human settlements on the basin.

- A planning proposal under environmental flow, has many strategies such as strict enforcement and evacuation of encroachments of kharab land and territory (minor) water courses in the natural terrain which are generally in agricultural, horticultural, or other plantation areas, many time under assumed ownerships to avoid derouting or preservation of marchy land low lying areas which inturn preserves biodiversity.

- Encouraging deep root natural or trees of social forestry in the valley region to mitigate washing away velocity of flood discharge.

- Making provision of check bunds and barrages across major natural water courses to hold and arrest rapid flow.
The varied flow of river will change the future of the proposals to be planned and executed which in turn will not be fully utilized. There are 115 dams of various sizes are planned on the main river course and tributaries on the Krishna basin. The existing randomness of the river flow will continue to affect by more flash floods in future. Any water storage dams planed will have varied actual storage which will largely affect the irrigation of cultivable lands.

Very few studies have been done in correctly accessing the value and usage of water dams. All the dams are accessed on only the area of irrigated land it cultivates, but there is a variation in inputs to the extent of one is to six. Meaning 15-16% of the irrigable area gets 90% of the water and 84-85 % gets less than 15% water required for cultivation. However I have limited the study to the human settlements on both sides of the river valley in delineated study area in Raichur district.

The water flow in Krishna Basin (K.B) will help irrigating only one third of the area of basin with more than half of that in Andhra Pradesh. Highly disputed water storage within the state is irrigating 15-16% of the arable land which gets 90% water requirement. 85% of the arable land gets only 10 % water. Billion of cubic meters of water are used for hydropower generation which reduces the available water elevation to a greater extent, thereby not available for irrigating higher lands.

70%of the water pollution is from urban areas located in river basin. The K.B is over exploited for consumptive urban use for water and makes the basin as inactive river. River is polluted, but flow is constant with unusable water down the stream. The flash floods which occurred in October 2009 isolated 350
villages and leaving millions of people homeless which is believed as first occurrence in 1000 years.

- The soil conditions at the surface will vastly affect the water permeability in the catchment area in the river basin. The increase in Water permeability happens at the elevated ground levels, thereby allowing water in subsurface. This stored water which is below the ground will seek natural appropriate level at lower elevations by pushing fine soil to the surface, thus the probability of finding smooth textured soil is more than the one which would have eroded at higher elevated ground levels. This will have a cascading effect of un-permeable soil near the water course and permeable soil at the elevated levels. Thus there is a constant shifting of fine soil to the water course by water force. During rains at higher elevations will flow on the slopes and also flow under the soil surface. This eventually make the surface of the normal river course having non-permeable layer of fine textured clay. Which has a dimension of 2 microns, which is the lowest achievable by physical forces. This layer makes the river not to hold water at lower soil levels.

- Contrary to nature of river which have fine layer of clay only if left undisturbed. The urbanization and rural farming takes away the fine river surface of clay and consume the river sand, making river flow on permeable soil. Normally there will be a huge storage of river water below the surface of river course due to disturbed surfaces and urbanization and farming. This fine clay is the starting material for lowing plant lets which will spread it roots and absorbs minerals and nutrients at nano level. Since this is the starting point of growth the clay which is serving the purpose of constant river flow on the
river surface will be disturbed by removal of fine surface through exploitation of river soil.

- Water which is expected to flowing on the surface will have flow below the soil surface will change the measurability of the river flow. Thus giving way for random behaviour of water flow on above and below surface. Only the areas at lower elevation get more benefit than areas at higher elevations. Most of the dams which are constructed to storage and restriction to normal flow of the river will disturb the constant movement of river. The check dams which are meant for minor irrigation also become storage of fine soil material in the form of clay which gets settled at the bottom of the check dams, thus making more water to be stored and creating obstruction for surface water to flow. This kind of artificial intervention in the normal river flow will also make the river flow unpredictable.

- 19 districts of Karnataka falls in Krishna basin, Raichur being a district which comes under the middle Krishna basin and Thungabadhra river basin on the other side of the Raichur district. This district get maximum damage during floods both by main flow and reverse flow. The city of Karnool was submerged in water upto 3 meters for 3 days, making most of the affected area bordering Raichur district on north and south side of the district. Krishna and Tungabadhra river became an storage of water during the flash floods.

- River flow will largely depend on ridges and flow gets optimized to get the river course, this is what we presently see as a river. Drainage Area (D.A) is an very important component for estimation of water precipitation in the river valley. River Slopes (R.S) are the areas where precipitated water gets directed
to form tributaries and river lets. D.A and R.S are interconnected to establish speed of water flow depending on higher or lower slopes of water. This is further depends on Soil Permeability (S.P) and Relative Elevation (R.E) in the vast river basin area. Natural hilly contoured area will get more water flow because of wilder slopes but gets limited small area of exposure to rains and will become intensely resourceful for the river. A combination of D.A and R.A along with high R.E will always be a feeder for river water. But these are mainly dependent on monsoon rains, which will happen on only four months of monsoon season in a year, often preceded by two months before and after the season.

- Watershed Mean Elevation (WME) is an important measurement criteria which determines the location of the water flow w.r.t the elevation from the sea level. Rains with high precipitation will follow the river slopes and joins the main river course which can be measured at varying WME. WME records between and in the direction of water flow will give an exact estimation of the water flow from the higher area. Right now there is no integrated level reporting systems which can be used as an early warning for probability of flash floods.

The Command Area (CA) will have many WME’s which will totally signifies the source of water to the river. The CA management becomes critical because of predictability of monsoon rains in the KB region. CA’s are variously classified for each tributary or river lets. A combined information system on precipitation and water flow can give a good information about the flow of water at different CA’s in the KB region.
Agriculture Farm Area (AFA) and Urban and Semi-urban Area (USA) are the main components for determining the CA along with area coming under Forest Area (FA). The water flow coming from CA with Storm Duration (SD) will determine the Drainage Density (DD). Automated Level Evaluation in Real Time (ALERT) has been established in many river basins. Similarly it is required to be established in the study area region.

- Antecedent Moisture Condition (AMC) which can be networked in real time basis can predict the incidents of precipitation in various CA’s. This measure gives an advance predictability of incidence or rains and the expected quantity of rain water entering form the CA. The AMC based precipitation, prediction networking should be integrated with the local telecommunication, meteorological department and disaster management stake holder authorities.

Mean Basin Elevation (BE) and Basin Slope (BS) along with Basin Width (BW) will help to estimate the speed of water and width of the flow. These parameters should be well integrated with the hydrological management authorities by department of forest, revenue, agricultural and water shed management authorities.

All “flash floods” produced through “storm driven floods”. Flash floods accumulates the rain/ precipitation typically by constant pour of rain of 200 mm during less than six hours or to be controlled. The instant flash of down pour happens in watershed areas covering 25 to 25,000 sq kms and urban floods are typically 1-100 sq kms by even shorter storm of 50 mm less than one hour. The generation of flash floods are thorough moisture convergence, convection, and hydrological-soil saturation. Many times the flash flood occur through run off concentration of flow accumulating from heavy pour areas. Typically the flash flood factors are in relation to following factors.
1. Large scale accumulation of slow moving cloud

2. The high concentration of humidity in the environment.

3. The soil moisture condition and the topography.

4. Basin morphology and high gradients in upper basins.

5. Flat areas in middle regions favors fast run off, hence flooding.

The land use changing and land utilization are constantly changing due to large scale demand for development for both agricultural and non-agricultural activities. Topography, land use and large plain, and steep undulating surface accumulated over hundreds of kilometers can trigger flash floods when it exceeds normal flow level. The water raising rate measured in meter raised per hour and water velocity of several meter per second constitutes dangerous river floods and disturb human settlements. These factors gets further intensified through rapid soil erosion, solid transportation of fine clay surface of the river course, strongly influence the quality of water and ecosystems. New technologies offer real time data to allow for accurate and faster meteorological, hydrological model development. The flash flood prediction and its uncertainty will greatly be helped by forecasting models which can give advance warning. The Geographic Information System (GIS) and Remote sensing techniques should be well integrated with the topography, Basin morphology and meteorological dynamics along with the hydrological monitoring in the flash flood region. The existing working pattern of PWD, irrigation, forest and watershed management authorities have concentrated much on the general administration aspects than has
special focus cell on the flood issues of the region and administrative integration with the national flood mitigation mission is not established effectively.

This affects predictability of water flowing in CA through the quantity, speed, confined volume flow. There exist many strategies as studied to access the conditions in the post flash flood situations but there is a need for evolving the methods to understand the nature of flash floods in changing climate scenario. Hence a scientific approach and guidelines are required to be formulated for land reservation, land provision and land development.

Urban and rural human settlement areas provide opaque surface for water and causes run off at greater speed than natural ground. This kind of runoff will further create additional obstructions for smooth flow of flood water in areas of habitation. They is a need for directing the settlements growth to accommodate increase in population due to follow the migration of rural inhabitants to urban areas on KB including Tungabhadhra river course on south side of the Raichur District.

There is a need to demarcation of environmental area prevailing wild life population or other bio diversity elements and their habitats. Many times flash flood will spread into these habitats and permanently disturbs the natural ecosystem. There is a need for wild life habitat management where it gets affected by flash flood situations. Flash flood events will deteriorate the original low lying wild life habitats. They can also be useful in rejuvenating specific component of the original missing habitats at higher levels, it also helps to correct the situation. All these actions can improve the wild habitat through structural reinforcement.
The management standards which regulates human activities, aggregate extraction, wild or other bio life, and vegetation should be provided for the new land use planning directives. Many times the disturbance of natural resource will degrade the habitation. Therefore effective and guaranteed efforts are needed to critically manage the environment through education. Community awareness for significance of biological environment is necessary to implement number of actions in informal training. These forums will reflect the advantages of conducive ecosystem and its long time lifecycles.

Amongst all parts of India Eastern part is more prone to flood disaster. The main states which gets constant attention on flood disaster measures are Orissa, west Bengal, Bihar, Tamilnadu, north eastern part of Karnataka and Andhra Pradesh in recent past are striking examples of flood disaster situations. According to different government agencies published tangible and intangible losses due to flash floods in India are increasing.

This is also reported by central water commission under ministry of water resources, Government of India, the actual average area affected by flood is 7.56 M. Ha (Million hectares). This observation is based on data for the period of 1953-2011 published by Indian water resource commission (IWRC). There is a variability ranging from 1.26 M. Ha in 1965 to 1.75 M. Ha in 1998. On the average floods affected above 39 million persons during 1953-2016. There is an every possibility this figure may increase population growth increased encroachment of the flood plains for habitation, cultivation and other activities. The main causes of floods in India are inadequate capacity within river banks to contain high flow, river bank erosion and silting of river beds. The additional factors are landslides leading to obstruction of flow and change
of river course, reduction in flow to tidal back water effects are poor natural drainage in flood prone areas. Cyclone and associated heavy rain storms or cloud bursts, and dam overflows. After the disaster floods of 1954 a national programme of flood management was launched. Some of the important policies on flood management include.

1. Policy statement 1954

2. High level committee on flood on 1957

3. Policy statement 1958

4. Ministerial committee on flood control 1964

5. Ministerial committee on flood and flood relief 1972


8. Regional task force in 1996.


The committees and commissions constituted by government gave valuable suggestions and recommendations on issues of flood management. Various types of structural and non-structural measures have been taken up to reduce damages in flood plains. Construction of Embankments, levees and spurs (levees meaning small artificially constructed structures to regulate water levels and spurs are development activity to make the water flow in a water space) etc., are structural measures. They are implemented in some states. The total length of construction of embankments is 16,800 k.ms and drainage channels are of 32,500k.ms. A total of 1040 towns and
4760 villages are currently protected against flood. Excluding some occasional breaches in Embankments, a reasonable protection to an area of about 15.07 M, Ha has been achieved. Non-structural measures are flood forecasting and warning system 62 major rivers and more than 157 stations for issuing flood forecast covering all most all flood prone states. The flood management measures have been more focussed on targeted decided objectives within stipulated timeframe. The flood plain zoning have been evolved through consultation with local bodies have been initiated through legislation on flood plain zoning. The total life storage capacity of completed projects in India is about 174 km$^3$

A large flood storage space in reservoirs will be a successful flood management initiative. Flood management also calls for the following agencies for flood management decision making like

1. Community participation
2. Farmers
3. Professional bodies
4. Industry and voluntary organizations
5. People participation in preparedness
6. Flood fighting and Disaster response
7. Media like radio, T.V and news paper

The above agencies will provide an important role in flash flood management.

The Krishna river basin has a varied discharge due to vast area of watershed. This is nearly 8 % of geographical area of India. The patterns of rains during rainy seasons are at random with less scope of accurate predictability. The average annual rainfall is 600 mm, but it varies from 3 TMC to 21 TMC during cycle of 12.5 years.
The predictability is largely affected by randomness of raining pattern in the watershed area. Various models are studied to bring in fairly even level of prediction by rainfall of various intensities. A well simulated model for this kind of prediction is necessary.

New flood forecasting and post flood mitigation models should be taken into consideration’s in the flood prone area along the watershed zone. An attempt must be made to consider factors which we can predict and give early warning system by which major measures can be taken to alert disaster.

The above process needs, as components for further research, such as

1. Deep data requirements on topological conditions, quality of soil and quantity of areas with different soil characteristics.
2. Advanced rain predictability models which are already in use in many pre warning systems.

The flood prone areas need major aspect of Flood Disaster Response System (FDRS):

1. Flood advance warning system (FWS)
2. Flood mitigation advance preparation - maintenance.
3. Planning guidelines as modified and applicable to flood zones.

1. Flood warning System (FWS)

This is required as real time processing of advance information. By using advance weather prediction models.

The local information should be analysed and processed for decision making process. The following are the data needed to accurately work the vulnerable areas of flood.
1. Accurate prediction of rain intensity, frequency of precipitation in designated area.

2. Real time processing of information and early warning system.

3. Real time estimation of quantity of water and outputs at gauge measurement station.

4. Input from various branches or network of water flow in Krishna basin.

5. Real time model shall also take into account the cascading effects of probability to the critical extent. The warning shall be given in areas as and when the probability of flood increases more than 0.3 which is a co-efficient of accuracy of predictability.

6. All the network areas shall be at constant monitoring systems for accuracy of data acquisition for processing and predicting.

2. Flood advance mitigation, advance preparation- maintenance.

The above aspects are major actions needed for preparedness for different effects of disaster.

The planning strategies will vary for flood level of below 5mts and for flood level of 1mts and below. Adequate training is also needed to emergency migration measures.

Ground water is the major source of water for rural areas. More than half of the irrigation requirements of water come from ground water resource. As part of central ground water board (CGW) efforts the government has released the district level ground water levels. This will demarcate the districts which has water requirements status.
The administrative divisions of Gulbarga will have revenue jurisdiction of Bellary, Bidar, Gulbarga, Koppal, Raichur and Yadgir. Karnataka has constituted Karnataka state Disaster Management Authority (KSDMA). This is in accordance of directives from National Disaster Management Authority (NDMA). The Karnataka State Disaster Management Authority (KSDMA) is presided with statuary power to facilitate, co-ordinate, and Monitor the activities related to disaster management and utilization of resources. This KSDMA provides expertise of relevant government departments, District administration, local authorities, Non-Governmental organizations, public sector, International Development Agencies, Doctors and the community.

Figure 4.1: Administrative Structure for flash flood monitoring system in Karnataka State

Source: compiled by researcher.

The interaction of various agencies will direct the post flash floods action in the region with respect to timely deployment of resources, thereby reducing the casualties. All the departments act in tandem to effectively mitigate the effects of
disaster. The advisory institution has large expertise in handling these situations, more technically than the district Administration machinery.

The river settlement patterns are observed to have road alignments radially towards higher elevations, thus providing quick access to the river course, consequently provides obstructions for smooth water flow in the direction of river. Since the study area encounters large scale disaster due to plain lands. The flood water gets spread over large area and remains stagnant for more than a week, with an average elevation of 1 meter and above.

This scale of disaster is less frequent, but very hazardous for normal life around the river course area. Most of the developments are unplanned around the maximum flood level, which consumes water and also pollutes in the same levels. The pollution content of rivers is reaching maximum allowable levels, there by not fit for consumption. This further increases the vulnerability of human settlements and become a major spot of maximum damage during flash floods.

Since the roads are perpendicular to the river flow during the floods, the water takes more time to recede and also weakens and destroys the building structures by the water force.

All extension plans are planned away from the fringes, but they will inundate during floods. As observed the houses which experience floods has raised the plinth level over the maximum flood water level post disastrous flood in 2009. These corrections made by local in habitants are a better solution than shifting the houses to the elevated areas which are 2-3 k.ms away from the present settlements. The NGO’s have contributed many housing clusters located away from the present settlements, thus not being used for the purpose it was given. They are presently used for raring livestock.
and storage. This may not be useful as shelters during future flash floods. This pattern has been observed in most of the areas where development works have been taken within few months after flash floods. Even the quick discharge to the river after the flood will create damages due to reverse high pressure of water before joining the river. Further even the slow discharge will make water to be stagnant for weeks before it recedes. Thus causing further damage to many structures which are submerged in water. Quick discharge will render animals to go helter-skelter by the force of water. All these considerations are to be taken care while rehabilitating the affected human settlements. It was observed that the traditional settlements in the flood affected areas were safer which has buildings at more than 3-5 meters above the experienced maximum flood level. This would have been good information for any settlements which are developed in low lying areas, without safety standards being followed. This shows that early settlers had previous knowledge to keep the buildings higher to protect from disaster eventualities.

The present rural development and planning guidelines have not taken flash floods as a factor while designing/developing settlement patterns the constant intervention of sprawling urban/rural settlements in the vulnerable areas increases the risk during flash floods.

It was observed that some of the religious structures are located high above the flood level, there by offering shelter during floods. There is a need for having national planning initiatives to be followed while planning and furthering the settlements in the rural areas which has river fringes. It is proposed to have amendments in the town and country planning act to take care the changes suggested by the experts to be followed in developing areas around dangerous rivers during floods.
The following proposals are recommended for post flood development initiatives:

1. Accurate assessment of water inundation expected at various levels of flash flood in the entire region.

2. Making design efforts to increase the flow, so as to avoid stagnation of water after floods.

3. Designing emergency structure to contain water before becoming a flash flood.

4. Containing spread of water during flash floods through structural platforms and emergency elevated areas.

5. The suitable settlement patterns appropriate to various situations have to be devised to take care of innovation in designing such structural systems.

6. Elevating the existing settlements in order to retain the same location which can be useful during non–flood times.

7. Emergency help during disaster should not go to the choice of NGO’s who fund the initiatives as they are allowed to take decisions on their own and the local authorities advise is not taken in scientific/ eco-sociological manner.

8. All measures are localized and guided by political pulls and pushes, without consultation of experts, designers and urban planners.

9. Marking on the existing structures to remind the possible water disaster on all structures will provide a constant reminder to build above that level, whenever the structures are reworked.

10. Long term planned execution to be effected to take measures to mitigate disaster in future. Taking the present observation during flash floods.
11. Timed relocation of dangerous low lying settlements with recreation of same habitat pattern.

12. Corrections to the existing structures by elevating plinth levels, and raising the road levels.

13. Road network should be user friendly and to the directions of the water flow, and at elevated levels.

14. Reconfiguring of the layouts by elevating ground levels on which buildings are erected in future.

15. Long lead time can be got for mitigation, if only the early warning can be devised. Even if the warning is given early, the residents should be able to quickly cope to face the eventuality. This needs regular training.

16. Search and rescuing of affected people is largely dependent on local skills and preparedness. Effective training will help to mitigate, last minute efforts.

17. There is a necessity of mechanism to reestablish and recover the lost movable and non-movable assets.

18. Decisions of ongoing nature will help more than delay in decisions. This calls for empowerment of local inhabitants to decide about the infrastructure needed for mitigation. The accurate collection of data in the flood affected area during the floods, may give more information and hence better strategies could be evolved.

19. Prior experience in handling emergency situations is needed for disaster preparedness.

   a). voluntary organizations experience
b) Training on vulnerability and methods of mitigation.

c) Updating guidelines

d) Logistic strategies.

20. Agriculture:

a) Preservation of seeds

b) Flood resistant crop planning.

c) Insurance systems.

d) Constant upkeep of health practice in life stock maintainace.

e) Fishing methods will increase family food resource.

21. Regular maintenance of roads, desilting, improved systems to offer credits, is in innovative ways to be explored. Asset registration, recording to be modified for fringe areas. Asset protection insurance plans to be re-established.

22. Prolonged efforts will lead to inability to earn in a devastated environment.

23. Choice based earning; training and education are needed to recover from disaster.

24. Cash loans from reliable agencies will help to avoid money lenders and exploitation.

25. Active health practice in pre-flood and regular preventive methods designed for flood prone areas will help in mitigating the effects of disaster.

26. Provisioning of resources to build shelters on self-help basis is better than giving ready made houses.
27. Availability of drinking water in advance to rescue process at elevated levels will be used during post flood rescue process.

28. Initial operations will mainly depend on relaying on skills of residents, to face the disaster. There should be rapid shifting needed as the flood will move at the speeds exceeding 40 km/h and recedes at lower speeds.

29. Direction of change in direction happens naturally when flood water reaches settled water in the lower elevations. Access to information and re working on lost documents, to establish ownerships of assets for compensation or re-allotting plots at changed elevations.

30. There should be no delay in decision for rescue and evacuation action.

31. Community shall be informed the allocation per person/asset and its distribution in an equitable manner.

32. Conditions on ground shall be the major factor while considering funding of rehabilitation.

33. Logistics play an important part to reach the needy in post flood situations.

34. affected people should be given more choice to choose, and concern on priorities to take decisions.

35. Often accurate collection of data will help in accurate analysis to define approaches to mitigation.

36. It is expected that rescue operators, has prior experience before attempting the operation.

37. It was found that decision taken on ground by experienced operators are for more superior to the ones taken without experience.
38. More the quick response to flood victims, emphasis shall be laid on rehabilitation and creation of eco-system for living, working, and recreating environment.

39. Practices in Agriculture shall encourage seed storage in stocks, and help in resilience to post disaster effects.

40. Provisions for prevention and spread of epidemic shall be a part of design strategy.

41. Fisheries shall be encouraged in shallow waters collected in zones, which has filled during floods. This will give employment and food safety for the habitants.

42. Planning guidelines shall be laid separately for these zones, popular layout techniques are the cause of major failures.

43. We have found that all the roads will get breached during floods, which is a major obstacle for rescue operation. Infrastructure works shall be carried at higher level which provide shelter/platform during inundation period.

44. Infrastructure shall be carried at higher level roads, which provides shelter during inundation period.

45. Roads shall be aligned in curvature of flood flows, technically sound for expected speedy mitigation.

46. Suggestion at neighborhood level shall be drafted, differently for affected zones.

47. Normal settlement pattern found to be not suitable for navigation and travel during floods.

48. Recommendations to re work the village plans, by experienced urban / rural designers, accounting flood mitigation demands.
49. Recreating eco – sustainable habitat after floods is a great challenge for all the departments of government. All aspects from agriculture to infrastructure are needed to be coordinating in short Time space constraints.

50 Tools, seeds, capital, are given to the victims of disaster in an equitable manner

51. Many efforts are needed to rework on water and drainage paths, including storm water drainages immediately after the flood. Drainages are modified to cater for flood water drainage.

The following actions are suggested to be taken in event of flood.

a) Tube well casing to be raised to avoid water seepages.

b) Accurate level marking on existing structures

c) On the list of rescue resources, water containers, mugs, and drinking water during operation for evacuation.

d) Innovative designs shall be evolved for affected areas. All site and services at community level shall be elevated while re-building.

e) Many issues of health and prevention of communicable infections shall be attended in post flood period.

52. Displacement of community has many components. Govt. and NGO’s only Housing and aids.

53. Shelters are the main element of post flood Infrastructure, this consumes maximum resources.

54. Self-Help community shall be given empowerment to take responsibility.
55. Reconstruction of raised plinth, additional supports, will lead to time effective rehabilitation. Planting to stop erosion.

56. Physical planning guidelines shall be redrafted to take flood as a major parameter.

57. More involved guideline has to be formulated.

58. It was observed that small settlements have highest number of persons per household, when compared to national average.

59. All villages in river fringes were affected, which records illegal occupation. Their population varied from 300 to 2000. This is a serious concern for documenting flood estimation. Mainly extensions of existing settlements.

60. Flood early warning and forecasting in most parts of the world can produce information with longer lead times. They are useful for both contingency planning and defining immediate actions in responding to a flood. Early warning has little relevance if people do not have the ability to respond to warnings in terms of taking decisions on preventive actions and evacuation.

61. Initial search and rescue measures depend largely on the local community and authorities, so strengthening local capacities is an effective disaster mitigation measure. Search and rescue should be more rapid and effective.

62. Information is a right that enables people to claim other rights. Access to information allows a community’s own recovery plan to drive the recovery process. It is essential, therefore, that an affected population can receive useful information. Awareness about both flood risks and rights to humanitarian assistance have to be informed about recovery plans and activities. Communities
have to be informed about the amount of money or other support they could expect to receive.

63. Conditions on the ground should be analysed to programme in phases. In the midst of an ongoing flood response operation the team should highlights the importance of ongoing process in relation to changing conditions.

In a flood response situation, it is often difficult to ensure that vulnerable people can access assistance and take part in the decision-making process, because communications infrastructure and road networks are inundated and other effective means of transport are lacking. Agencies may also face logistical problems in reaching affected people.

It is important to allow vulnerable people’s own choices, concerns and priorities to influence agencies’ response strategy. Holistic assessment and participatory planning can facilitate this process. Good research during a flood often provides good analysis to help redefine programme approaches and phases

64. The targeting strategy would be effective if selected the Agencies that had previously worked on disaster preparedness and other related works. Because;

- Agencies that had previously worked on disaster preparedness were best able to define the criteria and method to select the most vulnerable people and implement and monitor the selection.
- Agencies that had taken up lessons identified from the 1998 flood developed flood vulnerability concepts and maps, based on major river basins and flood plains.
Agencies with pre-selected partner NGOs for disaster-based relief and rehabilitation usually provided them with up-to-date training and guidelines in beneficiary selection.

65. Quick and effective livelihood recovery from the impact of floods depends significantly on how quickly livelihoods are restored. There is no single way to protect livelihoods in the post-flood context. Often it is feasible and desirable to combine relief and recovery in a flood context because recovery can start as soon as floodwaters recede. However, adopting a livelihoods approach (in the operation) is harder to implement where agencies have a limited presence in the affected areas.

66. Livelihood recovery assistance in floods are required to adopt approaches which might serve as models to strengthen livelihood resilience:
Agriculture:

- Methods for drying and preserving seed stocks can facilitate the continuation of farming.
- Promotion of flood-resistant crop varieties and cultivation practices and provision of seed stock can strengthen resilience.
- Crop insurance systems can enable farmers to spread their risk.
- Provision of fodder, vaccinations and de-worming can ensure livestock survival.

Fish culture:

- Pens and trap ponds can help to retain fish during floods. Food provision, small business and alternative livelihoods:
- Repair of roads and other infrastructure, improved access to credit and support for re-skilling can provide a base for developing accessibility and marketing opportunities or alternative income sources less prone to flooding.

67. Suggestions for Asset protection: Helping people to protect their assets during and after a flood not only makes it easier for them to recover quickly but also reduces future vulnerability and poverty. However, according to the study, people are often forced to sell their productive and household assets to cope, as post-flood support is frequently overlooked.

Floods also destroy productive or livelihood assets. ‘during the recovery period these assets were, in general, not replaced, leaving the households more vulnerable to subsequent disaster episodes’. Nevertheless, good practices do exist. There should be agencies to practice ‘asset protection’ as a key part of
their flood response. This includes supplying livestock fodder, restocking livestock, reconstructing community and household assets and distributing agricultural/business tools.

68. The Household food security depends on how floods affect food security is a complex matter to which there is no straightforward response. Floods destroy standing crops. Prolonged flooding often limits people’s ability to earn money and replant quickly after floodwaters recede because either the cropping season is over or agricultural support is not available.

69. Vulnerable people should be given various financial and material options, so that they can choose what works best for them. The decision to provide food, cash, a combination of both or something else should be based on an objective problem analysis and clear aims and not on what resources are available, what the agency has the capacity to distribute or the donor’s preferences. The greater use of cash, distributed directly as either grants or part of kits, or in payment for work, would have allowed beneficiaries to respond better to their own needs.

Food aid can save lives and support livelihoods, particularly when used early and long enough to protect the livelihood assets that people rely on. Cash schemes allowed households to avoid taking exploitative loans from moneylenders and to clear their debts, to buy essential items and to invest in small-scale income generating activities. This provided economic benefits for individual households and local businesses in addition to benefits for the whole community.
70. The agricultural rehabilitation can be done in many flood-prone areas are also rich agricultural lands. Assistance in the form of tools, seeds, fertilizer, capital and training, for example, can help people to restore their agriculture. Flood trends are changing and more frequent flooding impacts on cropping seasons, making people food and livelihood insecure. The provision of seeds, agricultural inputs and, in some cases, cash, helped farming families remain in their communities, despite massive harvest, soil, housing and livelihood losses. (The probability of threat is normally accessed by insurance authorities, who give cover for flood damage. They normally access the threat of 1% , with a high probability of occurrence in 100 years. Insurance being the economic factor the threat perceived for coverage will be greatly less than the expected outcomes of the disaster. Insurance companies will take the risk of not more than 1% occurrence. Coverage will largely increase if the threat is perceived within 40 years. Most of the insurance companies will not publish the profit made during non disaster period. Classification depending on insurance data will not help the living standards to be achievable by the inhabitants of human settlements. The boundaries of coverage are also fixed by perceived level of threat and risk taking capacity of the insurance. Since the water flow happens on the average course in plain areas, the centre line of the river flow varies. Thus making insurance authorities to constantly change the risk factor is to their advantage. All these happen because of varied flow and randomness in frequency of occurrence of flash floods in river basin.)

71. The potential for disease outbreaks is always present after a flood disaster. Good understanding and provision for water and sanitation conditions, disease surveillance, speedy response to warning and above all, preparedness of health
agencies are the preconditions to reduce the spread of diseases and preserve the quality of the environment during and after flooding. Also it is required to have Initiatives to improve water supply or water systems should incorporate long-term sustainability.

Water and sanitation interventions need to be locally appropriate and take into consideration possible problems regarding the availability of water, local perceptions regarding water quality and purity, testing water purity regularly and prevalent sanitation practices and needs. Water-borne diseases are preventable through provision of clean water and sanitation.

a. Raising tube-wells and boreholes above flood water level to prevent contamination.

b. .Including buckets and water containers in relief packages to reduce secondary contamination.

c. Planning sanitation and shelter together to ensure completion.

d. Attention to placement and arrangement of sanitary facilities to limit impact on groundwater and ensure safety for community members.

e. Innovative approaches to sanitation in flooded areas, such as raised latrines, pit liners or rings, sealed pits or tanks, or contained leach fields .

f. Extending hygiene education to schools and to community groups.

72. The provision of shelter and housing is an ultimate necessary component during and after flood. Shelter is necessary to provide security and personal safety, protect from the climate and enhance resistance to ill health and disease. It is also important for human dignity and to sustain family and
community life as far as possible in difficult circumstances. Thus shelter and housing are more than just a roof over a person's head. The livelihood activities of many flood-prone communities are home- or homestead-based and may be destroyed by flooding. This may cause displacement, the nature and duration of which depend on the duration of inundation.

Strategies for post-flood housing programmes need to be based on the impact of flooding on houses and their long-term consequences rather than on the standard housing cycle concept (transitional to permanent housing). The response needs to cover affected people’s immediate survival needs up to the point at which durable solutions are reached.

Quick provision of temporary shelter reduces exposure, can help to limit the outbreak of disease and allows people to move quickly out of community shelters, which may be needed for schooling or other community facilities. Reconstructing permanent housing in large-scale disasters may take a long time.

In such cases, temporary or transitional shelter should have adequate facilities (for water and sanitation and cooking) and a system should be in place to monitor conditions of shelter. Agencies should have equipped for providing assistance to get land tenure, linking with service provision, and government policy help through good coordination with local authorities, participation of the affected communities and advocacy.

Effective shelter and settlement planning can reduce damage and build resilience. Some suggestions include:
Reconstruction:

- Raised plinths and foundations.
- Combining a strong frame with lighter wall material that can be replaced after floods,
- Raised shelves to protect valuables.
- Using more durable building materials which resist water damage.
- Planting water-resistant plants and trees to protect shelters from erosion (ITDG).
- Establishing community committees to monitor construction quality and settlement planning
- Community outreach to promote hazard resistant design approaches in future building.

Settlement Planning:

- Prohibiting resettlement in the most hazardous areas, if possible.
- Improving access to safe land. Many people must choose to live in flood-prone areas to ensure access to shelter or livelihoods.
- Limiting obstruction of natural channels, using absorbent paving materials and roof catchments to reduce runoff, and designing drainage to minimize intensity of water flows.
- Community emergency shelters and evacuation routes.
- Early warning systems, including rain or river gauges and community monitoring, to alert communities to flood threats.
73. Proposals for the ecosystem approach in the rehabilitation processes. The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. Thus, the application of the ecosystem approach will help to reach a balance of the three objectives of the Convention: conservation; sustainable use; and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources.

An ecosystem approach is based on the application of appropriate scientific methodologies focused on levels of biological organization, which encompass the essential structure, processes, functions and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of many ecosystems.

This focus on structure, processes, functions and interactions is consistent with the definition of "ecosystem". "'Ecosystem' means a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit." This definition does not specify any particular spatial unit or scale, in contrast to the Convention definition of "habitat". Thus, the term "ecosystem" does not, necessarily, correspond to the terms "biome" or "ecological zone", but can refer to any functioning unit at any scale. Indeed, the scale of analysis and action should be determined by the problem being addressed. It could, be a grain of soil, a pond, a forest, a biome or the entire biosphere.
The major predictive models are in large scale meaning meso scale. These models will not be helpful for flood prediction as it is a regional occurrence. The following scientific methods which helps for understanding the occurrence of flash floods are.

1. The generation of storm which produce flash floods.
2. Hydrology of floods
3. Observation strategy.
4. Factors affecting predictability issues
5. Interaction of various observed data for prediction.

There are only two possibilities of predicting the flash floods in real time basis through model prediction of precipitation in CA and the intensity of precipitation in condensed concentrated areas. *Any precipitation which is more than 100 mm in 24 hours will be called heavy rainfall. This followed by number of days and reaching 200 mm will further enhance the possibility of flood in middle basin.* If the same pour get distributed in time, there is a possibility of controllable flood. Since KB comes under C category of rivers with large variation or river flow. The rural and urban are closely developed near the water course. The national flood warning system gets activated only on frequency of floods and not the flash flood which occurs in random nature, but creates major devastation. Advanced preventive measures in the existing rural settlements can help to mitigate the effect of disaster in the normal life cycle of the settlement.