Urban Flooding:
[The Role of Urbanization & Climate Change]

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ABSTRACT

Urbanization means un-planned growth of the city. Slum culture is the principal character of unplanned growth in urban areas, more particularly in capital cities of states. However, the proportion of such character varies significantly with city to city. Extremes in rainfall also vary with space and time in association with the rhythmic variation in rainfall, which is the principal component of climate change. River floods follow this natural rhythmic pattern in rainfall. Both these scenarios are aggravated multi-fold by human interference through the destruction of nature/hydrology. These impacts change with location of urban areas, namely coastal, hilly & inland. The wastewater generated in urban areas also follows the population but major share of this water is imported from far away sources [ex-situ] and taken from groundwater. As a result even with not much rain, urban floods became a regular phenomenon. These issues are discussed in brief in the article with few examples.

Keywords: Urbanization, Hydrology, Flood, Population.

Introduction

Urban flooding is significantly different from rural flooding, as urbanization leads to developed catchments, which increases the flood peaks and flood volume and consequently flooding occurs very quickly due to faster flow. Our governments look at urban flood management, which is like post-mortem report. We rarely follow the precautionary principle, i.e., prevention is better than cure. In the case of GO111, the Supreme Court put forth this principle but governments rarely follow this. Urban floods can be classified as:

- Natural floods
- Human induced floods
- Natural + human induced floods

However, the impact varies with the place, namely coastal, hilly and interior.

Role of Urbanization on Urban Flooding

Urbanization means unplanned growth. Slum culture is part of unplanned growth in urban areas, more particularly capital cities of the states. Hut dwellers directly dump solid and liquid wastes in to nalas and water bodies wherein they encroached and built huts. Around 75% of the water used in urban areas, practically turns in to wastewater. This component has been steadily increasing with the population growth. This water includes groundwater and water brought from faraway places. In Hyderabad currently more than 2000 mld of wastewater is generated. It may go up further with the time unless urban growth is contained. Urban floods are caused by joining this wastewater with rainwater.

Urban drainage system is to take the responsibility of storm water runoff gathering, transport and discharge. Emergency discharge system is used to deal with the extra runoff that could not be discharged by urban drainage system under the extreme storm events. The emergency discharge system may include the natural water bodies (lakes or reservoirs), multiple function detention ponds, spillways, storm water tunnels, etc. These three systems are not independent of each other but they can be integrated to work together for comprehensive urban storm water management.

Historically, urban areas are located along the coasts. With the bifurcation of states and tourism created urban areas in hilly regions and inland areas. With the population growth, the farm sizes have been coming down drastically year by year per farmer. Input costs in agriculture are also going up with poor agriculture systems. Both states and central governments think this will be solved by incentives/subsidies. This has lead rural to urban migration. The rulers instead of improving the quality of life in rural India, developmental activities have been concentrating in urban areas. Thus, the meaning of urbanization changed as "unplanned growth". In this process the major casualty is natural resources. Water bodies turned in to concrete jungle and the remaining have been turned in to cesspool of poison with the polluted water. Rainwater channels/nalas turned in to shelters for hut dwellers. In this process rivers-rivulets and storm water drains disappeared or encroached.

Human induced floods, therefore, are associated with human actions in changing the hydrology of the place such as:

(i) Reduction in infiltration amount of rainfall due to roads & buildings, destruction of greenbelts, destruction of hillocks, etc.;
(ii) Reduction in surface water storage capacity due to destruction of water bodies [lakes/tanks, rivers/rivulets, etc.];
(iii) Destruction of storm water/rainwater drains;
(iv) Increased load of wastewater due to water from ex-situ sources use, groundwater, etc.

All these are associated with urban population and slum population.

Growth of Urban Population

Water and oxygen are the two nature's gifts to human survival on the Earth. With the non-linear growth in human population and associated infrastructure built to meet their needs under changing lifestyles lead imbalance on these two nature's gifts.

Rural population is static but urban population is dynamic. Urban population is growing steadily with abrupt jumps. At global level, Indian population constituted 18.0% of global population occupying 2.7% of the land area and uses only 4.6% of world's fresh water but uses 25% of global groundwater. At all-India level currently with urban population of 440 million, around 25% are living in slums. Such people are vulnerable for urban floods but at the same time the very same people are generating wastewater & water bodies; and thus increasing flood impact.

The population changed from 1950 to 2014 of China and India respectively is 543 million to 1.39 billion and 376 million to 1.27 billion. Though in terms of geographical area China is around "three times" to India but population is more or less the same. Also urban population in 2017 of China and India respectively are 57.9% and 33.5%. Though in China, area available per person is around three times to that of India, yet urban concentration of population in China is nearly double to that of India in 2017; and greenery is in opposite direction – recently NASA released data based on satellite images.

The urban population in India went up from 27.81% in 2001 to 31.16% in 2011. A total of 42.6 million people were living in slums according to 2001 census and they are 95 million in 2011, doubled. However, at state-wise these are quite different. Table 1 presents urban and slum population in % for few states in India in 2011: Andhra Pradesh they are 33.5% & 32.69%; Maharashtra 45.23% & 31.66%; Tamil Nadu 48.45% & 17.85%; and Karnataka 38.57% & 11.51%.

Table 1 Urban Population & Slum Population

Urban Area	Population Total (Million)	Urban	Slum
China [2017]		57.9%	
India [2017]		33.5%	
2011 census data			
Tamil Nadu	14.1	48.45%	17.85%
Kerala	02.5	47.72%	17.93%
Maharashtra	33.6	45.23%	31.66%
Gujarat	11.4	42.58%	11.78%
Karnataka	11.0	38.57%	11.51%
AP	15.7	33.50%	32.69%
WB	14.2	31.89%	26.82%
UP	18.8	22.28%	22.12%
MP	09.8	27.63%	24.32%
Bihar	04.8	11.30%	10.53%
Delhi	11.0		18.45%

River Encroachment

The Bangladesh High Court (HC) delivered on 30/31 January 2019 a historic judgment on river encroachments. In a petition, the organisation cited a report published in "The Daily Star" on November 6, 2016, headlined "Time to Declare Turag Dead". The court directed:

- The authorities to remove all structures from it in 30 days
- If any person, whose name is included in the list of river land grabbing, he or she will be disqualified from contesting elections and directed the Election Commission to take steps in this regard
- The Bangladesh Bank to make sure no river grabbers get bank loans
- The government to make a list of every grabber in the country and publish the list in the media to expose them to the public
- The education ministry to take steps for holding an hour-long class every two months at all public and private academic institutions, including school, madrasa, college and university, to build awareness among students about the importance of rivers
- The industries ministry to take measures for arranging an hour-long meeting every two months with factory workers across the country, also to create awareness

The grabbers include powerful individuals, businesses and, ironically, government offices. The Gazipur City Corporation is among the grabbers, a judicial inquiry has found – unfortunately, same is the case in India and it is worse than that in Bangladesh. A classic example is river Musi in Hyderabad and several hundreds of chained lakes in and around Hyderabad. Also, the remaining parts are cesspools of poison. A 2009 landmark HC judgment had detailed measures on how to recover the ailing rivers from land grabbers and save them from pollution. After the verdict, the Bangladesh government now will have to amend the National River Protection Commission (NRPC) Act 2013 with provisions for punishment and fine for river grabbing. The current NRPC Act does not have provisions for punishment. The government must report to the court in six months on its action in this regard. The HC also declared the NRPC as the legal guardian of all rivers and act like their "parents". The landmark verdict comes when river grabbing by influential groups seems unstoppable. Often, grabbers return to steal river land soon after being evicted. India needs one such a judgment but there is no scope as the judges themselves are corrupt to the core. Just after retirement they expect plum posts and thus follow the rulers in delivering the judgments. See the case of KWDT-II, a highly "Technical Fraud" Award on Krishna River sharing among the three riparian states in favour of Karnataka state. As a reward, the government goes on extending the term of the tribunal and governments are spending huge sum on advocates for years for defending their side versions, though it is a technical issue and not a judicial issue. The reality in India is different.

Role of Climate Change on Urban Flooding

It has become a fashion to man on the street to people occupying the responsible positions in the society or governance or institutions to attribute every event to global warming – also they masque their ignorance by referring it as climate change, which they mean it as de-facto global warming. The fraudulent groups are also poisoning the young minds with such false alarming messages. The fact is that climate change is a vast subject.

To meet the greed, humans have been destroying the natural flow systems and now governments are putting the blame on global warming as it can't defend against such onslaught by politicians and bureaucrats to protect themselves for wrong doings. For all ills [heat waves, cold waves, floods, cyclonic fury, etc.] the easy prey is global warming. Natural variability in rainfall is the main component of climate change that plays the crucial role in urban flooding. However, the impact is controlled with through human interference.

The other important component of urban flooding relates to human interference on nature. Majority of such cases are attributed to weather, as it cannot defend against such attacks on it both by media and by the government agencies. Under natural weather conditions scenario, many a time human greed plays vital role in the loss of human lives and destruction of property and natural resources. A classic case is that of Uttarkhand floods of 2013. However, the urban flooding clears pollution by washing away and by diluting both surface water and groundwater.

December 2015 floods in England and October 2015 floods in Nile Delta in Egypt were attributed to climate change. Even in India the scenario is the same. In all such human greed the easy scapegoat is climate change. On 6th December 2015 received 9-10" rain in three days due to a huge storm "Goliath" in a belt across the central United States, centred just Southwest of St. Louis in the Mississippi River Basin. 1982 flood was similar to 2015 flood. Also, both were winter floods during an El Nino event. They should have been similar but it is not so. After 1982 there were large scale changes in the catchment area with construction activities and thus water level rise by several feet over 1982 flood level, resulting in the damage of 7000 buildings and several other damages and few people died. It is a manmade disaster. February 27, 2019 Mississippi River zone is facing flood fury.

A popular opinion is that the amount of available freshwater is decreasing because of climate change. Climate change has caused receding glaciers, reduced stream and river flow, and shrinking lakes and ponds. Many aquifers have been over-pumped and are not recharging quickly. Although the total fresh water supply is not used up, much has become polluted, salted, unsuitable or otherwise unavailable for drinking, industry and agriculture. To avoid a global water crisis, farmers will have to strive to increase productivity to meet growing demands for food, while industry and cities find ways to use water more efficiently.

A New York Times article, "Southeast Drought Study Ties Water Shortage to Population, Not Global Warming", summarizes the findings of Columbia University researcher on the subject of the droughts in the American Southeast between 2005 and 2007. The findings published in the *Journal of Climate* say that the water shortages resulted from population size more than rainfall. Census figures show that Georgia's population rose from 6.48 to 9.54 million between 1990 and 2007. After studying data from weather instruments, computer models, and tree ring measurements, they found that the droughts were "not unprecedented and result from normal climate patterns" and random weather events. "Similar droughts unfolded over the last thousand years", the researchers wrote, "Regardless of climate change, they added, similar weather patterns can be expected regularly in the future, with similar results." As the temperature increases, rainfall in the Southeast will increase but because of evaporation the area may get even drier. The researchers concluded with a statement saying that any rainfall comes from complicated internal processes in the atmosphere and are very hard to predict because of the large amount of variables.

Climate Change Vulnerability Index

Instead of presenting the impact of climate change in the right perspective, groups of researchers/groups used lump models such as Vulnerability Index, Environmental Vulnerability Index, Climate Change Vulnerability index, etc. by integrating several factors [up to 50 factors]. All these referred Climate Change, but in reality it is not realistically climate change.

The Environmental Vulnerability Index (EVI) is a measurement developed by the South Pacific Allied Geoscience Commission (SOPAC), the United Nations Environmental Program (UNDP) and others to characterize the relative severity of various types of Environmental Issues affected by 243 enumerated Individual nations. Environmental Vulnerability data for the 50 indicators are also divided up in the issue categories for use as required: climate change, biodiversity, water, agriculture and fishing, human health aspects, desertification, and exposure to natural disasters.

Climate Change Vulnerability Index (CCVI) in 2011 was rereleased by global risks advisory firm Maplecroft enables organizations to identify areas of risk within their operations, supply chains in investments. It evaluates 42 social, economic and environmental factors to assess natural vulnerability across three core areas: (i) exposure to climate related natural disasters and sea-level rise; (ii) human sensitivity in terms of population patterns, development, natural resources, agricultural dependency and complexities; and (iii) the index assesses future vulnerability by considering the adaptive capacity of country's government and infrastructure to combat climate change. 84% of the world's fastest growing cities are going to face extreme climate change risks.

In many countries, cities are located in coastal areas, beside rivers, on steep slopes or other risk-prone areas. Infrastructure such as roads, water networks, transmission lines, schools and hospitals providing basic services for urban populations, are vulnerable to extreme climatic events such as floods, storms or landslides. Cities located in tropical coastal areas are particularly vulnerable to cyclones or rising sea levels, the frequency and intensity of which have been on the increase over the past three decades. In addition, salt water intrusion restricts the availability of fresh water in coastal areas, jeopardizing food security as once fertile land becomes barren due to high salt content. Cities located in the hinterland or along rivers may be vulnerable to flooding. Conversely, areas where climate change is expected to reduce rainfall may be affected by drought, shrinking water tables and food scarcity. In urban areas, the poor are the most vulnerable to the effects of climate change, and particularly slum dwellers in developing countries.

Existing climate change models indicate that in warmer climates, overall average rainfall would increase by about one to two per cent per degree of warming (IPCC, 2007). This is caused by increased evaporation leading to increases in rainfall. A warmer atmosphere as a result of global warming can hold more moisture before becoming saturated.

Here, we must remember one important fact: severity, intensity, frequency of occurrence of extreme weather events occurred in the past, occurring now and will occur in future. For this one need to understand the natural variability in climate, more particularly in rainfall. Without such study, harping on rhetoric will not serve the real problem related to climate. Let us the case of Maputo in Mozambique:

Maplecroft observed that the over the past 25 years, Mozambique has suffered from an uninterrupted succession of droughts and floods, with damaging consequences for social and economic development. The most severe drought periods were recorded in 1981-1984, 1991-1992 and 1994-1995; while floods were observed in 1977-1978, 1985, 1988, 1999-2000 and more recently in 2007- 2008. Floods are often exacerbated by cyclones. Since 1970, Mozambique has been hit by 34 significant cyclones or tropical depressions and four major flood events (2000, 2001, 2007 and 2008). In particular, the number of recorded cyclones during the 1999-2000 wet seasons was extraordinarily high and flooding had terrible consequences. In February and March 2000, a combination of torrential rains and tropical cyclones caused the most devastating floods in the history of Mozambique, killing 700 and causing US$600 million worth in damages. These postulations are inaccurate.

Reddy (1987) presented estimation of global solar radiation and evaporation through rainfall over northeast Brazil. Historical carbon dioxide followed ocean surface temperature but carbon dioxide is lagging by temperature. That is when the ocean surface temperature is warmer carbon dioxide from the ocean is released in to the atmosphere and when the ocean temperature is low carbon dioxide from the atmosphere is absorbed by the ocean. Vice-versa is not true. That is ocean temperature is not rising due to carbon dioxide [Reddy, 2019a – page 279, Fig. 15a].

Figure 1 presents the annual temperature variation with annual rainfall over India. 2002 and 2009 are drought years with 0.81 and 0.79 % of average raised the temperature by 0.7 and 0.9 ^{o}c. Formation of cyclonic activity is not related to temperature as they occur in pre-monsoon, monsoon post-monsoon seasons. However, irrespective of temperature, temperature gradient plays important role in the formation of cyclonic storms.

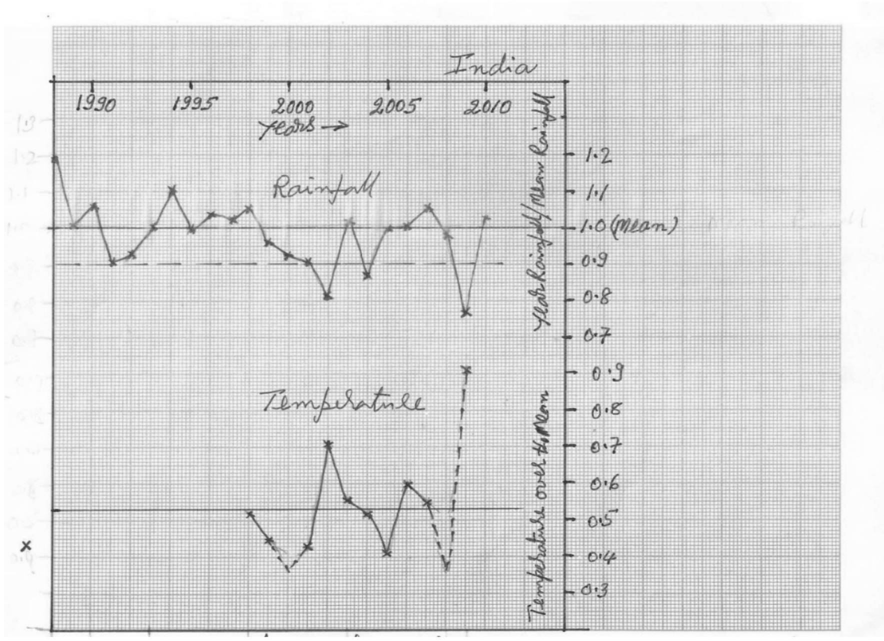


Figure 1 Annual march of rainfall and temperature over India

Figure 2 presents the annual march of southwest monsoon (SWM) and northeast monsoon (NEM) coastal Andhra met sub-division rainfall for 1871 to 1994. They both follow 56-year cycle but in opposite direction [[see dotted lines pattern]. The cyclonic activity follows the NEM rainfall pattern.

I studied the agro-climate scenario of Mozambique and the reports are available in the National Institute of Agriculture Research [INIA] under the Ministry of Agriculture, Maputo. The study of Reddy (1986) presented natural variability in Mozambique rainfall – Reddy & Mersha (1990) presented the same for Ethiopia. However, there is phase shift with coast to inland and with latitude. These are clearly evident from Catuane, Maputo & Beira rainfall with 54 year cycle superposed on it the sub-multiple of 18 years. Table 2 presents information of these three Mozambique met stations rainfall

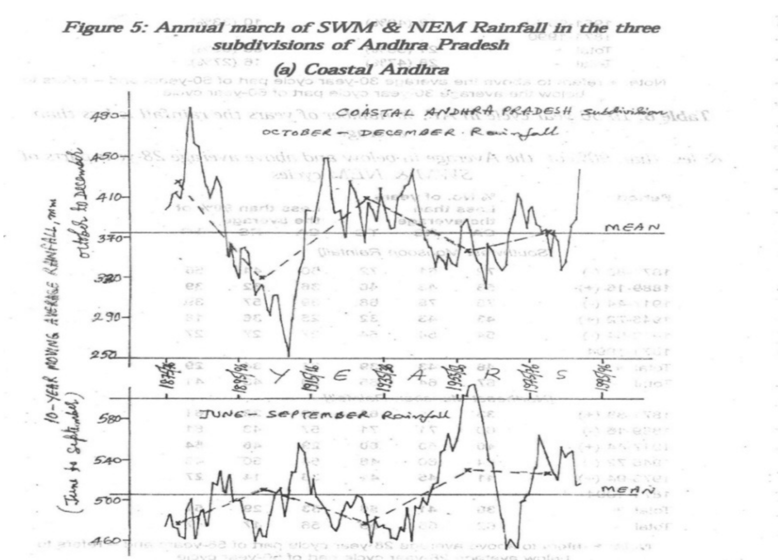
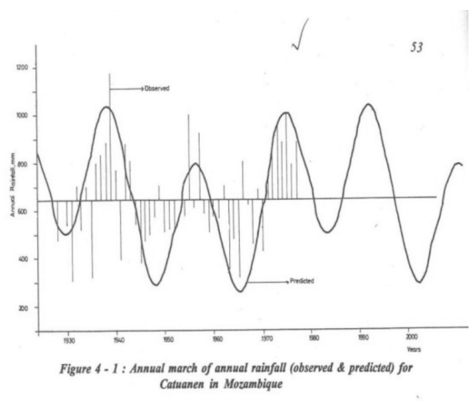


Figure 2 Annual march of SWM & NEM rainfall of Coastal Andhra met sub-division

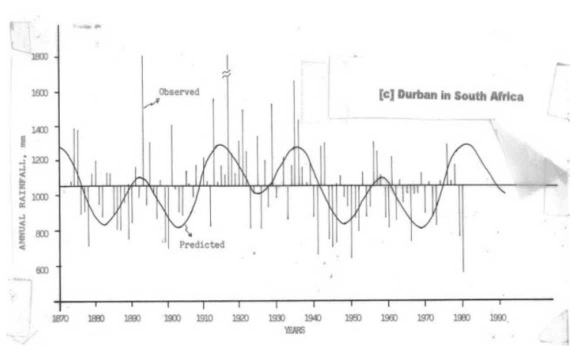
Figures 3 (a&b) presents the annual march of rainfall over Catuane in Mozambique and Durban in South Africa [Reddy 2019a – pages73 & 74, Figs. 4.1 & 4.2]. Table 2 presents the starting and ending years of 54 year cycle superposed on it the sub-multiple of 18-years for Catuane, Maputo & Beira in Mozambique and Durban of 66-year cycle superposed on it the sub-multiple of 22 years in South Africa. Cyclone Idai caused severe blow to Sofala-Beira reaching Zimbabwe and Malawi on 14th March 2019 killing around 300 people. The flood and drought years mentioned above follow the 54 year cycle of Beira [Table 2]. These publications are available in INIA, Maputo/Mozambique. However, the droughts and floods are not uniform over different parts of the country as the natural variability changes with coast to inland and with latitude. The recent droughts in southern South Africa are clearly seen in Durban cyclic pattern, wherein 2010 to 2076 of 66 years, the 1st part is W and the second part is M. That is, in 2010 to 2032 of W, 14-5-14 years present dry-wet-dry years in 33 year period.

Table 2 Catuane, Maputo & Beira information

Station	Average Rainfall (mm)	Cycle 1	Cycle 2	Cycle 3
Catuane	low rainfall (620)	1943-1996	1997-2050	2051-2104
Maputo	medium rainfall (900)	1925-1978	1979-2032	2033-2086
Beira	high rainfall (1480)	1931-1984	1985-2038	2039-2092
W =	1985-1995(-)	1996-2000(+)		2001-2011(-)
M =	2012-2022(+)	2023-2027(-)		2028-2038(+)
Durban	medium (1050)	1876-1942	1943-2009	2010-2075
W =	2010-2023(-)	2024-2028(+)	2029-2042(-)	
W =	2043-2056(+)	2057-2061(-)	2062-2075(+)	



(a) Catuane/Mozambique



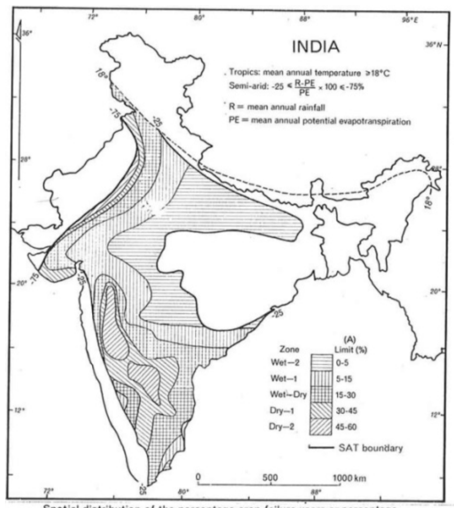
(b) Durban/South Africa

Figure 3 (a&b) Annual march of Rainfall [observed and predicted] (a) Catuane and (b) Durban

Vulnerability of Indian Agriculture to Climate Change

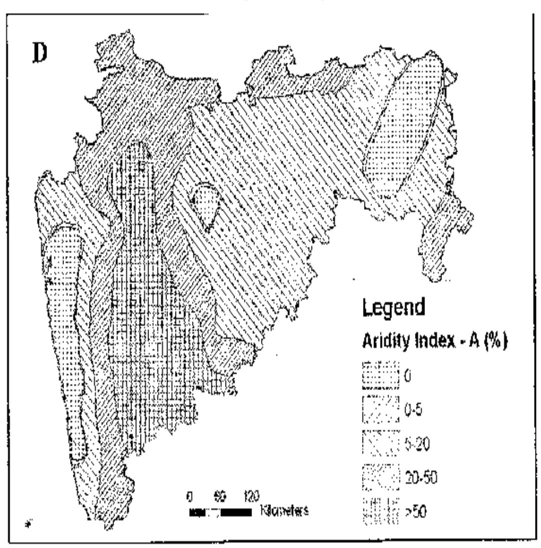
When the global warming studies are in the birth stage, I carried out agro-climatic and agrometeorological studies for India, northern Australia, Mozambique, Ethiopia, Upper Volta [now Burkina Faso] and Senegal countries. All these I compiled in a book form [earlier they were published in Journals of international repute] (Reddy, 1993). Now the second edition is out from the publisher (Reddy, 2019) with the same title. Scientists from Pune University from India carried out the analysis for Maharashtra State in India in 2009 [Akumunchi Anand, et al., 2009]; a student did Ph.D. from Pune University on Bhīma Basin in Maharashtra state earlier to this under my guidance. Such analysis provides the level of sustainability – drought risk. These are linked to local/regional rhythmic pattern in rainfall.

Droughts and floods are part of natural variability in precipitation and are modified by local conditions and method used to define them. Rao, et al. (2013) presented elaborate study and prepared an Atlas on “Vulnerability of Indian Agriculture to Climate Change”. The study has not really studied the climate change but used it as an adjective. Same is the case with Raja, et al. (2014) study though they made some efforts in the rainfall variability [referred my agro-climatic model]. Rao, et al. (2009) report presented a map of drought proneness. It showed except coastal Gujarat, all parts of India present less than 25%. In my work cited above [Reddy, 1993, 2019] they reach as high as 60% in the Eastern side of Western Ghats – Anantapur-Bellary-Sangly belt. Figure 4 [a, b, c] presents the drought proneness maps from the three publications.

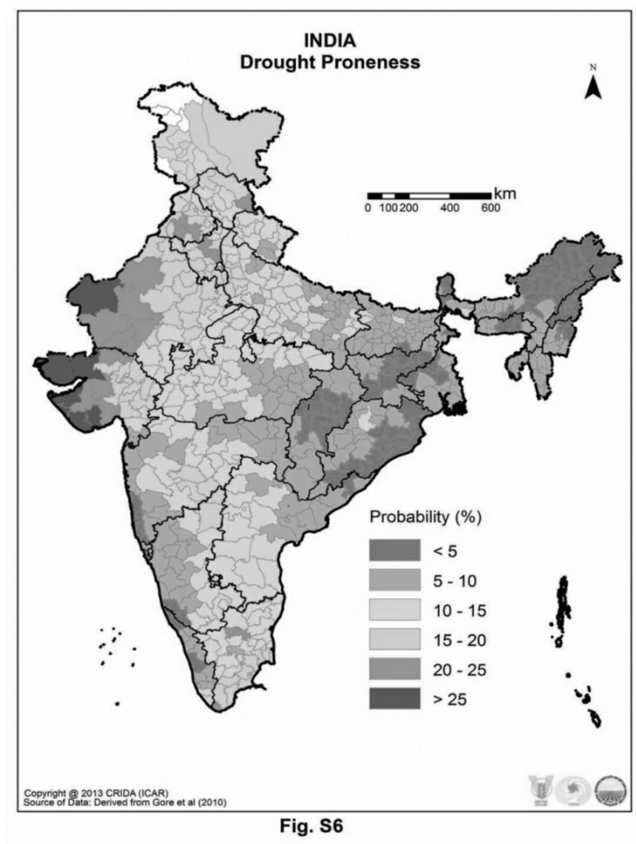


Spatial distribution of the percentage crop failure years or percentage years with G≤ 5 weeks [A]

(a) India by Reddy [1993]



(b) Maharashtra by Akumunchi Anand, et al. [2009].



(c) India by Rao, et al. [2013]

Figure 4(a,b&c) Drought proneness maps

Figure 5 presents the drought proneness variation with 56 year cycle for Kurnool in AP [S = week of sowing rains, G = available effective rainy period in weeks]. The drought proneness is on an average is 45% with 35% and 70% respectively during the above and below the average cycle parts.

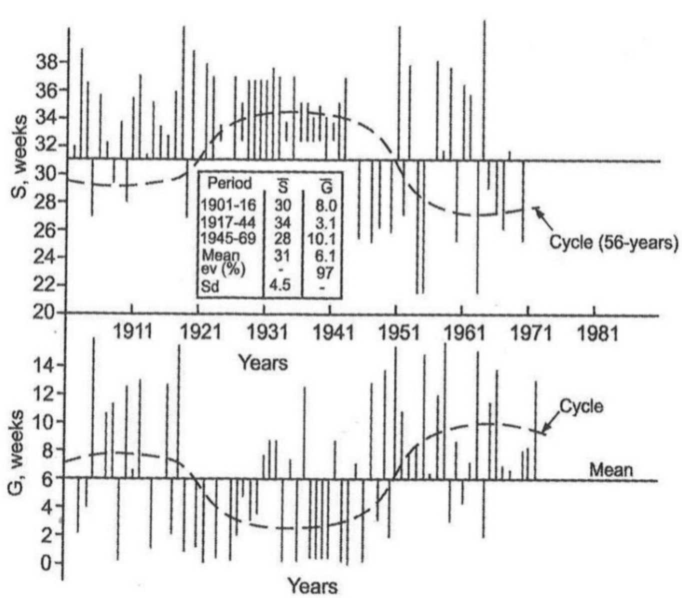


Figure 5 Annual march of agroclimatic variables: G & S

In agriculture sense, climate change relates to water availability from rainfall and snowfall; and destruction of production through floods and cyclonic activity – they are region specific. However, they are the major sources for water availability at local and regional level. Normal rains rarely work for sustainability of dams/reservoirs, tanks, etc. In the case of human interference, the major issues are the sharing of water and pollution – domestic, industrial and agricultural.

Natural Variability part of Climate Change

Climate Change is a vast subject. It includes both natural variability and human induced variations. Natural variability in rainfall form part of it. This is the principal component of climate change. However, agencies like World Bank harping on the global warming carbon credit even after IPCC in its AR5 report categorically said no. Also World Bank and other agencies [national & international] giving hype to such reports and sensationalizing. Here modellers playing spoil sport as such studies are far from realities.

We have seen now a day media bombarding with all sorts of stories on temperature. In fact if we look at the highest temperature recorded in February to June in Hyderabad they are given as: 37.2, 42.2, 43.3, 44.4 & 43.9 °C. Then highest average for the February month is 35.3 °C. The current weather scenario in Hyderabad has not deviated from these past occurrences. Also, there is a theory on high temperature built up in north western parts of India, "monsoon will be early".

In fact Earth's climate is dynamic and it is always changing through the natural cycles. What we are experiencing now is part of this system only. They are highly region specific systems. Floods and droughts are part of this natural variability component of climate change in rainfall. Extreme rain spells are also part of this. Figure 6 presents the annual rainfall (June to May) at all-India from 1871-72 to 2014-15. This data series presents the 60-year cycle with zero trend which shows no human induced component. Floods in rivers follow the natural rhythm in rainfall. Table 3 presents the frequency of occurrence of high magnitude floods in north western Rivers following the 60-year cycle presented in Figure 6. To a question raised in Indian Parliament, IITM & IMD scientists prepared a reply saying that Indian rainfall is decreasing. They arrived at this answer based on the data of one 60-year cycle [sine curve – one up and then one down]. If they would have shifted 30 years forward, then the conclusion would have been that "Indian rainfall is increasing".

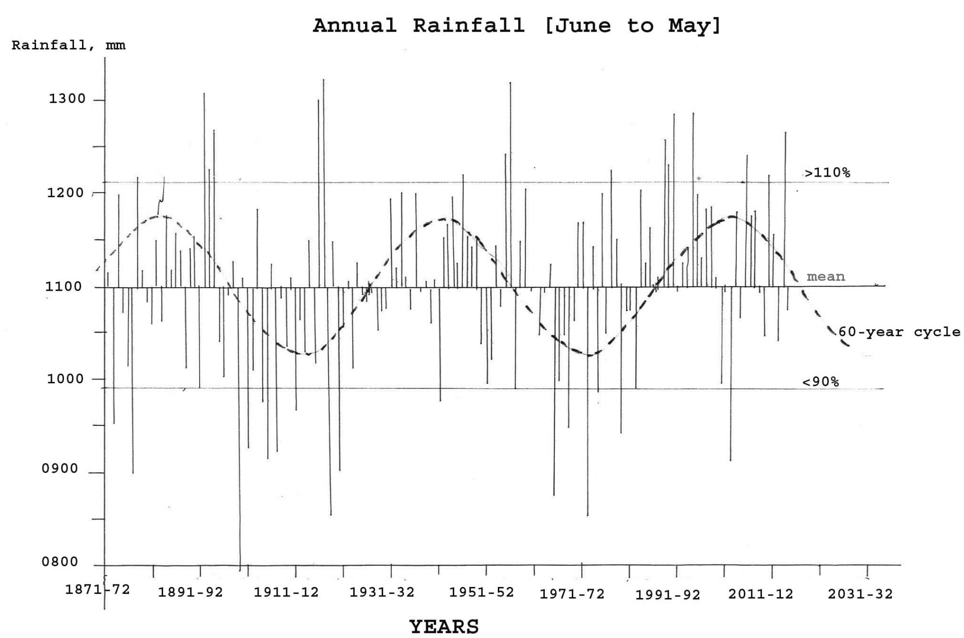


Figure 6 All India Annual Rainfall [Observed, vertical lines & Predicted, dotted curve]

Table 3 Frequency of occurrence of high magnitude floods in few northwest Indian Rivers

	Frequency of high magnitude floods*		
River	**Period**	**Frequency**	**Climatic cycle**
Chenab1962-1990	1 in 9 years	(a) below the average	
1990-1998	1 in 3 years	(b) above the average	
Ravi	1963-1990	1 in 14 years	(a)
1990-1998	1 in 3 years	(b)	
Beas	1941-1990	1 in 8 years	(a)
1990-1995	1 in 2 years	(b)	

*State of Environment Report, India – 2009, MoEF/GoI : The frequency of floods in India is largely due to deforestation in the catchment area, destruction of surface vegetation, changes in land use, increased urbanization and other developmental activities – this is a false statement but it is more in association of cyclic variation in rainfall.

Figure 7 presents [a - upper] the 132 year cycle in annual rainfall of AP. Bangalore was under severe drought during 1876-78 [Figure 8] which is clearly seen in annual rainfall [Figure 8a] wherein the rainfall was less than 50% of the average with four successive years with below the average. Figure 7 also presents [b - lower] the water flows in Krishna River. It follows the rainfall pattern. The current below the average part started in 2001. This can be seen from the water reached Srisailam dam during 2009-10 to 2018-19 in tmc ft. They are: 1222, 1028, 736, 197, 848, 614, 59, 345, 489, & 562. This presents the character of low rainfall after 2001 [Figure 7a].

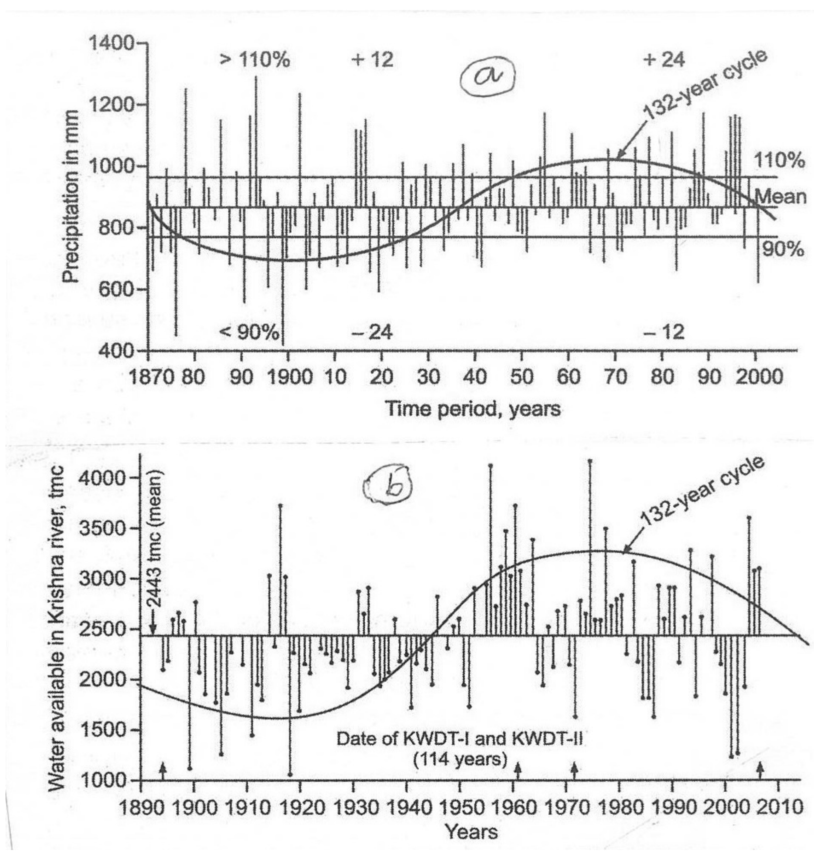


Figure 7 (a) Andhra Pradesh Annual Rainfall & (b) Annual Water Availability in Krishna River

Figure 8 1876-78 severe drought impacts on Bangalore

Natural Floods

Areas with high rainfall, cyclonic activity, sloppy terrain, etc. are affected by floods. A classic example of natural floods is the floods prior to 1930 in Musi River in Hyderabad. On September 26, 1908, due to cyclone in the Bay of Bengal Musi River catchment area received over 48 hours 98.57 cm of rainfall. Of the 788 tanks and lakes in the river basin, 221 breached due to cloudburst. At 11 a.m. on September 28, an estimated 4.25 lakh cusecs of water raced through the city swirling away over 19,000 homes, and killing about 15,000 people. However, some other reports put the death toll at 55,000. Figure 9 presents a scene of floods in Hyderabad. The arched gateway of the then British Residency, now OU Women's College, was partially in water, which never again saw a flood of such proportion. A 200 year old Tamarind Tree in Osmania Hospital premises saved 150 people who climbed on it.

Figure 9 A Picture of 1908 September Floods in Hyderabad

Human Induced Floods

Natural floods associated with heavy rainfall are contained with building of reservoirs in many river basins. For example, after 1908 September devastating floods to Musi River, the then ruler built two reservoirs, namely

Osmansagar on Musi River and Himayatsagar on Musi's tributary Esi to contain Musi floods. With these two reservoirs Hyderabad has not experienced natural floods after 1930. Now inflows also have comedown drastically from upstream catchment area due to human actions. In the case of Hyderabad after 1930 the floods are associated with human actions on nature. They are caused by:

- Hussainsagar Lake was built in1562 [Hyderabad was built in 1591]. The extent of the lake covered 5.7 sq. km. "Save Lakes for a Better Future" released on 4-5-2000 showed the present area was 1356 acres; "Restoration and Management of Hussainsagar waters" showed it as 1066 acres; and now it is around 700 acres. The depth of the lake was 32' and now it is less than 25 ft due to silting and immersion of different kinds of idols over years;
- In 2001 "Water Conservation Committee" got a report prepared by NRSA, Hyderabad on lakes in Huda area. According to this report in Huda area there were 932 tanks spread over 51,480 acres. Now, more than half of them were encroached and this process of encroachment is continuing. The remaining are partially encroached and are now filthy lakes;
- More than 80% of the rainwater drains/nalas were encroached;
- More than 50% of Musi River was encroached and still continued the encroachments;
- With the growing population, water has been brought from faraway places. Around 75% of them along with the groundwater used is turning in to wastewater. Thus we add daily around 2000 mld of water in to drains/waterbodies and finally in to Musi River. This will steadily rise with the time. This amount adds to rainfall.

The huts are built on drains and in water bodies; and solid and liquid wastes generated by those hut dwellers have been dumping in to the nalas and lakes. Domestic solid waste that includes plastics has been dumping in to nalas and water bodies. After desilting, the waste is not moved away and thus finally joins the same water bodies/nalas. Sewage treatment plants generate huge solid waste. During rainy season the large part joins the water bodies, nalas/drains and Musi. Industrial solid waste is another part of it. In India produced around 15,000 t/day of plastic in 2015. 70% is going as waste. Figure 10 presents plastic waste in drains in Hyderabad & Delhi and similar scenarios can be seen in all urban areas in India.

(a) Hyderabad [Lingampalli to BHEL]

(b) Delhi

Figure 10 Nalas choking with the plastic waste in (a) Hyderabad & (b) Delhi

With drastic reduction in the water holding capacity of Hussainsagar & drains that carry water from Hussainsagar Lake to Musi, in 2000 the flood water reached 2nd floor in Ashok Nagar. Flood water carried cars with it.

Figure 11 presents the floods in 2016 in Hyderabad. In Durgam Cheruvu area, where drainage system non-existing & tanks/lakes were enriched in upstream areas and thus sceptic tank waste was carried by flood water to the 1st floor of the houses that were built illegally in Durgam Cheruvu FTL and Buffer zone. Military personal helped stranded people in flood water were rescued through boats. During 2000 floods ICRISAT Colony-Phase-I was under flood water as the three lakes were encroached. Boats were used to rescue residents.

Figure 11 Hyderabad floods in September 2016

Figure 12 presents a case of Chennai floods in November 2015. There is no unusual scenario with the November 2015 rains. The main problem here is that governments over the years allowed the people as well government agencies to destroy the rainwater carrying channels and water bodies/rivers. This resulted the aggravating the impact for the same flood capacity. Added to the rains is huge quantity of the domestic sewage, which is increasing year by year. We have seen above the population increase in urban Tamil Nadu. Similar scenario was the case with Nellore floods.

Figure 12 Chennai Floods in 2015

Tamil Nadu government appointed a committee to evaluate Chennai 2015 floods. The report highlighted the encroachments of three rivers, namely Gooum, Adiyar and Kasasthalayar and flood channels/river beds, release of water from overflowing reservoirs, etc. It received 1200 mm in November 2015. More than 500 people dead and more than 1.8 million displaced due to flooding of Chennai.

Nellore to Chennai receives rains during the Northeast Monsoon Season [October to December] that coincides with severe cyclonic activity. The highest rainfall in 24 hours (mm)/year and the highest per month (mm)/year for Nellore and Chennai from 1931-60 Normal (Red Book of IMD) are given below:

Nellore – 444/1950, 357/1936 & 189/1902; 647/1920, 982/1915, 494/1946

Chennai – 234/1888, 236/1922 & 262/1901; 892/1943, 1088/1918, 699/1946

Natural + Human Induced Floods

The severity of destruction changes with the time of the year, the terrain, with the population growth, and growth in infrastructure. However, with the violation of existing local, state and national laws the rainfall based destruction is aggravated. Here human factor plays crucial role on the death toll and destruction. Let us see few examples.

Kurnool Floods: Natural floods are associated with heavy rainfalls in the catchment areas of the rivers flowing through urban areas. 2009 floods in Krishna-Tungabhadra-Hundri Rivers that inundated Kurnool town and Mantralayam in Kurnool district causing heavy toll on humans and property. These are associated with human negligence. Even with the early warning, water from Srisailam dam [reached 896.5 ft, with capacity 885 ft] was not released to Nagarjunasagar Dam in the downstream. This is basically because of poor water use practices in Nagarjunasagar dam. This dam was full, which includes carryover water for the next deficit year [if any] but they reduced 590 to 536 ft by the flood time. This led animosity between the people of these two dams that caused severe damage to humans and property in the upstream of Srisailam dam. Also, government sanctioned money to build karakattas at Kurnool along the Tungabhadra River bank. The officials did not do their job and on the contrary they showed the compound wall at Saibaba Temple as karakatta [I was on TV channels discussions from morning to night]. Figure 13 presents Kurnool Floods around Kondareddy Burju.

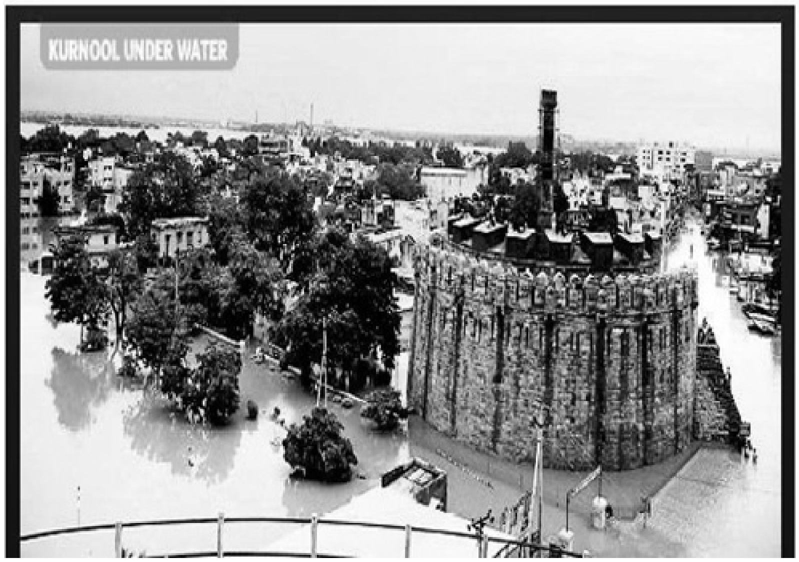


Figure 13 Kurnool Floods in 2009

Uttarkhand Floods: Figure 14 presents the classic example of human greed wherein in violation of laws built commercial complexes in the river bed by cutting the bank. June 2013 a multi-day cloudburst centered on the north Indian state of Uttarkhand caused devastating floods and landslides. The main day of the flood was June 16, 2013. The rainfall recorded was 375%.

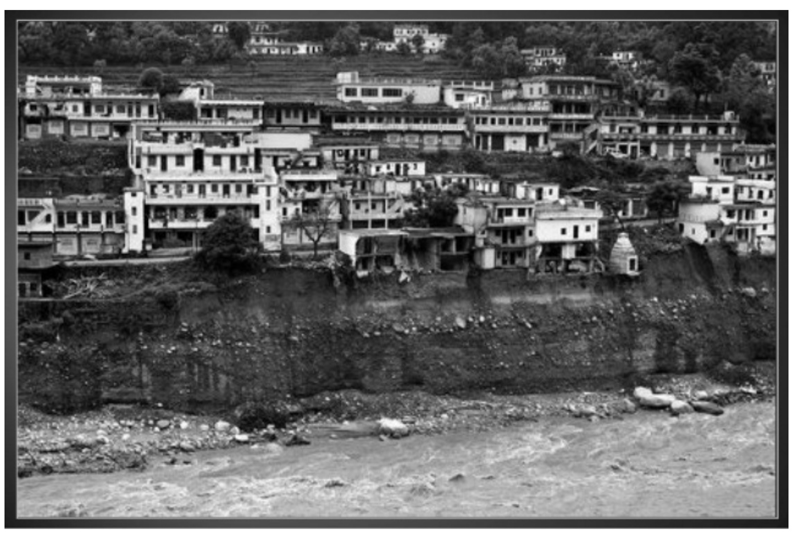


Figure 14 Uttarkhand Floods in 2013

However as seen in Figure 14, it is a manmade disaster with the government's apathy. Even the disaster management was taking rest until everything was over. People illegally filled with rubbles the sloping river bed on bankside and built commercial buildings on this. With the heavy upstream rains, the guessing river water washed away these commercial complexes along with 10,000 people. Though in the upper regions pilgrims were also affected by the heavy rains, but the casualty was not that severe and thus deaths are not that high.

Srinagar Floods: It is also a manmade disaster in the presence of heavy rains. On the 5th September, the Jhelum River in Srinagar was reported to be flowing at 22.4 ft which was 4.40 ft above the danger mark. Ironically the entire flood basin that saved Srinagar in 1893 from greater devastation was vandalized through mindless planning for urbanization. Most of the southern waters of the Dal Lake were drained through "Nallar Mar" (Serpentine Canal) that went round the city and drained all its surplus water in to the Jhelum. The impact of rainfall is aggravated with human interference in both urban areas and catchment area. In fact when we fill the river banks, the width of the river reduces and thus with heavy upstream rains, water overflows on either side. This is clearly seen in Figure 15 wherein flood water entering the city on either side.

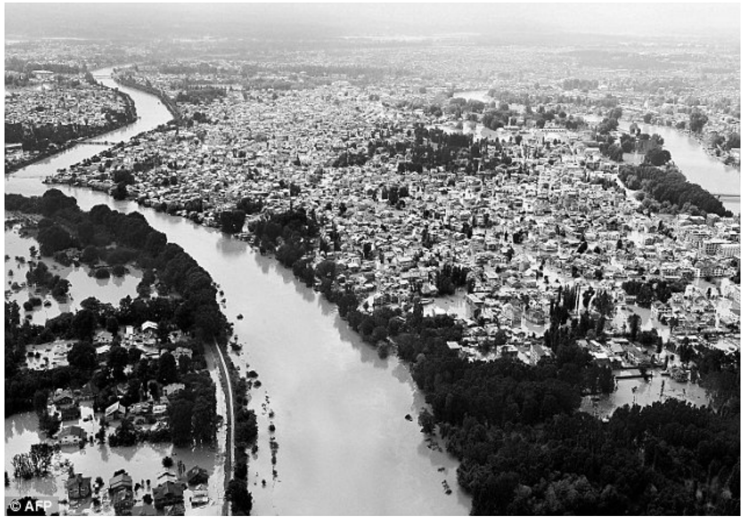


Figure 15 Srinagar Floods in 2014 – Jhelum River

Mumbai Floods: Mithi River is the main river system that used to carry rainwater in to the Sea. This has been filled with rubbles and waste around 62% and converted in to concrete jungle. The protective Mangroves were destroyed and thus water that enters the river moves in to urban sprawl in Mumbai. Also several lakes were converted in to real estate ventures. Added to this is the infiltration has been gradually come down with urbanization roads & buildings. With high percent of urban population & slum dwellers, sewage component gradually increased. Figure 16 presents an aerial scenario of flooding disaster in Mumbai during July 2018 rains.

Kerala Floods: It is not unusual to Kerala. In 2013, June 1 to August 15 received 2087 mm with normal of 1606 mm – 30% excess. In 1924, received the highest is the recorded history. A total of 3368 mm rainfall has been received and most parts of Kerala submerged. Kerala received heavy monsoon rainfall on the mid evening of August 8, resulting in dams filling to capacity were opened. In the first 24 hours received 310 mm. 80 reservoirs were full. According to district-wise IMD data for rainfall the 2018 monsoon, 45% of the districts of the country are facing deficit rain. But Kerala 12 out of 14 districts received heavy rainfalls and floods. Figures 17 presents the aerial Photo of flood impact. Table 3 presents the rainfall figures.

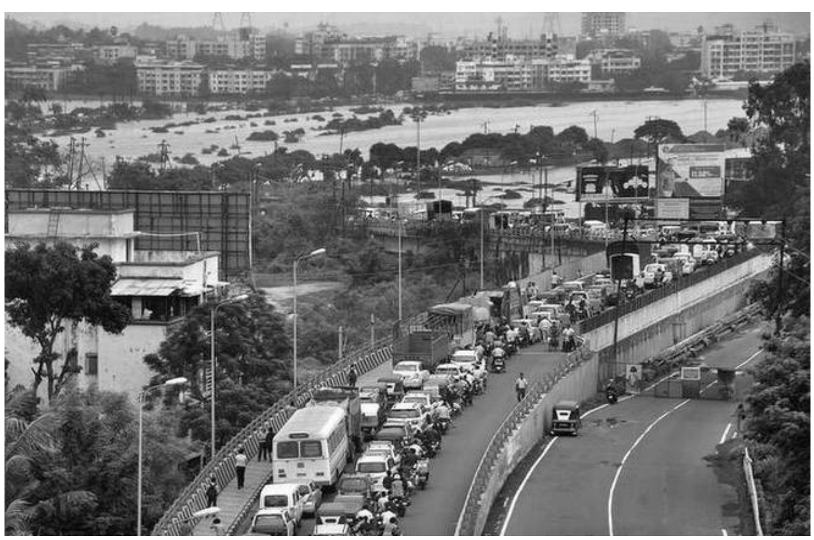


Figure 16 Aerial scenario of flood devastation in Mumbai during July 2018

Figure 17 Kerala Floods Aerial Photo [Periyar River floods in Aluva]

Table 3 Actual and observed rainfall

Period (mm)	Actual Rainfall (mm)	Normal Rainfall (% normal)	Actual Rainfall
June 2018	750	650	15
July 2018	857	726	18
1-19 August	759	288	164
Total	2347	1649	42

Excessive mining, quarrying, use of land for non-forest purposes and construction of high rises in the catchment area of rivers & river beds created landslides and heavy flows and as a result reservoirs were filled with debris and water. This is on one side. Around 10% of the area of Kerala is below the sea level and thus on the other side sea water entered the rivers mouths and pushed back the flood waters from the reservoirs overflows. 80 reservoirs gates raised and water released.

Summary & Conclusions

The rainfall extremes are not new under natural variability [climate change] in rainfall. The cyclic nature of rainfall presents periods of droughts and floods. However they present high variation with space and time in association with local/region specific general circulation patterns in different seasons. The severity of floods impact changes with location [coastal, hilly and inland]. The severity of urban floods is aggravated with human interference on nature to meet their greed at the cost of environment. The wastewater [polluted water] generated in urban areas that relates to population and slum population create flood condition even with little rains. That is, even if we contain the flood fury related to natural variability, this will help in creating local floods.

Humans are the major source of urban flooding in Indian cities. To minimize this, as a major first step, governments must put a break on rural to urban migration of population and thus slum population. This can be achieved by bring out new agricultural policy & developing appropriate food processing units, completing smaller irrigation projects that give immediate results, developing education & health care systems. Etc. Around 50% of total subsidies/incentives in India has been going in to the pockets of unscrupulous people. By saving such money, storage facilities could be built at village/mandal level.

To reduce the urban flooding treat and re-use wastewater locally & protect water resources, start treating wastewater from upstream side and not from downstream side, see more rainfall infiltrates in to the ground, bring out a law to punish the encroachers of natural water resources, etc. Unplanned urbanization raises temperature and thus increases power consumption and water demand.

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