# Floods in Jammu & Kashmir –with special reference to 2014

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**Abstract: -**On September, 7, 2014, the river Jhelum, Jammu and Kashmir, was inundated by flood water everywhere smashing everything in its way. The flood waters, triggered by seven days of unusual heavy rains, caused havoc in the region. They washed away crops, orchards and devastated housing and business infrastructure. The main brunt of the ferocious floods, described as the "extreme of the extreme", was borne by Srinagar city - the city known as the summer capital of Kashmir - home to around two million people. Many remained trapped on roof tops, evading flood waters, for weeks. All major hospitals, shops and pharmacies were inundated and roads were washed away, plunging the Kashmir valley into chaos and causing unimaginable suffering. More than half a million people, most of them in Srinagar city, got trapped in their houses as the city was submerged under 18 feet water for more than three weeks. It was a nightmarish experience within few hours the whole localities got submerged and no way to flee.

**Keywords: 1.**Disaster; 2.Climate change; 3.Floods; 4.Deluge; 5.Paradise;6.Inundation; 7.Hazard.

## INTRODUCTION

A flood is a situation where water from the water bodies overflows on the adjacent dry land making the surroundings inundated. Flood risk can be defined as the combination of the probability of a flood event and its potential adverse consequences (Smith 1996; Sayers et al. 2002; UNISDR 2009). As both aspects of risk—hazard and vulnerability—are non-stationary, flood risk is a ''dynamic entity'' (Merz et al. 2010). This changeable characteristic of flood risk is emphasized in the EU Floods Directive (2007/60/EC), which specifies that ''…human activities (such as increasing human settlements and economic assets in floodplains…) and climate change contribute to an increase in the likelihood and adverse impacts of flood events'' (EU 2007). A key indicator for the spatiotemporal dynamics of flood risk is the observed increase in flood damages over the last decades (Barredo 2009; Kreft 2011; UNISDR 2011). This increase can be attributed to socio-economic factors, including settlement growth near rivers and the rise in the concentration of values in these areas (Evans et al. 2004; Barredo 2009; Munich Re 2013), which has been confirmed in numerous empirical analyses. The valley of Kashmir has an inherent relationship with the complex of mountain systems which emerges out of the Pamir Knot in different directions of the valley clearly defining the watersheds and basins. The general physiography of the valley is that of a basin, surrounded on every side by lofty mountains, and in the middle is a huge alluvial tract, intersected by the Jhelum and its numerous tributaries which flow down the mountains and are fed by the abundant snow and rainfall. The almost flat alluvial basin measures 150 kms from south-east to north-west and 42 kms from south-west to north-east. Thealtitude of this the flat plain varies from 1500 to1800 m above the sea level and the general slope of the valley is from south-east to north-west. A study on the development of flood exposure in the Kashmir valley found that socio-economic change and the increased intrusion of urban area in flood-prone zones have led to an exponential increase in potential flood damage during the last few decades. While there is a general unanimity that land development and land conversion in floodplains has and will continue to have an immediate effect on flood risk, practical findings concerning the climate change-related influences are less clear. According to the fifth IPCC assessment report (Hartmann et al. 2013), floods larger than recorded since the twentieth century occurred during the past five centuries in Asia , northern and central Europe, the western Mediterranean region and eastern Africa''. For Asia, although there is some evidence of a overall increase in extreme precipitation, no conclusive evidence is available for climate-related trends of extreme flow for the future (Barredo 2007, 2009; Kundzewicz 2012; Madsen et al. 2014). A comprehensive study of climate change impacts on flood frequency shows no clear climate signal (Nachtnebel et al. 2014). Blo¨schl et al. (2011), on the other hand, report on the basis of several if–then scenario simulations that future changes for flood peaks with a return period of 100 years are in the range of -4 to 10 %. Although no conclusive evidence and projections exist concerning changes in flood frequency and magnitude, it is clear that climate change is influencing and will further influence components of the Himalayan hydrological cycle, e.g. due to higher temperatures or rising snowlines.

**Study Area**

J&K is located in the northern part of the Indian subcontinent in the vicinity of the Karakoram and Western Himalayan mountain ranges. The state is a landlocked Himalayan region, surrounded by Pakistan, Afghanistan and China from west to east and by Punjab and Himachal Pardesh states to its south. There is a sharp rise in altitude from 1000 to 28,250 ft(amsl)within the state's four degree of latitude. The foothills ofthe Himalaya, rising from about 2000–7000 ft (600–2100 m), form the outer and inner zones. The PirPanjalRange constitutes the first (southernmost) mountain rampart associated with the Himalaya in the state and is the westernmost of the Lesser Himalayas. The Vale of Kashmir is a deep, asymmetric basin lying between the PirPanjal Range and the western end of the Great Himalaya at an average elevation of 5300 ft (1620 m).Fig. 1.

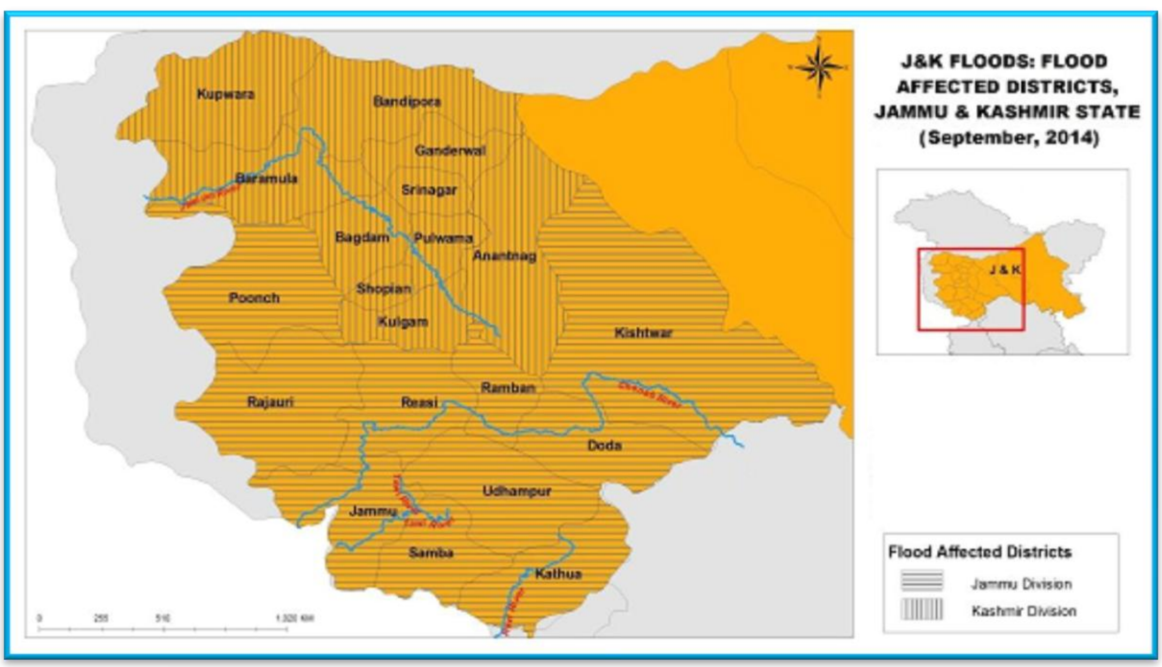

Fig. 1. Study Area

**Data and methodology**

For the monsoon season, Indian Meteorological Department (IMD), New Delhi publishes, in its weekly weather reports, daily rainfall for each day of the season as recorded at about 2600 rain-gauge stations comprising IMD's own network, automatic weather stations (AWS) network ofIMD, state rain-gauge networks, etc. The normal daily and monthly rainfall over various stations/districts has been calculated using average data for the period 1970–2000 for which long-term records are available. DailyIndian precipitation analysis from a merges of rain-gaugedata with the TRMM TMPA satellite-derived rainfall estimates during 3–7 September 2014 have been used to show rainfall over the J&K region. The rainfall rates have been calculated for some of the stations using hourly rainfall recorded in AWS installed in J&K.

**The Jehlum and its Tributaries**

The Kashmir valley, which forms a composite Jhelum basin, has a fairly well established drainage system headed by the Jhelum, the main channel of drainage. The river is initially formed by the confluence of 3 streams, the Arapal, the Bringi and the Sandran which rise at the south-east end of the valley. The river has shaped up the ecology, economy and the life style of the inhabitants of the valley. The whole length of the Jhelum from its source from Verinagto Baramulla is 150 miles. The drop of the river is 18 m in 113 kms. The Jhelum itself rises from the Pirpanjal range near Verinag, a spring at the bottom of high scarp of a mountain spur at the upper end of the Kashmirvalley. Below Srinagar it receives the Sindh and beyond, the Wular Lake, thePohru stream joins it from the Lolab valley. AfarBaramulla the Jhelum leaves the fertile banks of the valley and rushes head long a deep gorge between lofty mountains. AtMuzaffarabad, the Kishanganga joins the Jhelum from its heights. Lower down, the river borders the outlying spurs of the salt range and finally emerges upon the plains near the city of Jhelum in the West Pakistan about 402 kms from its source. From its source, the Jhelum flows in a north westerly direction, but at its exit from the Wular lake the river takes the south westerly direction. All along its course, the river is characterized by two main features (a) the sluggish flow(b) the highly torturous course. The later one is the outcome of both topographic and hydraulic factors.The river is navigable without a single lock from Khanabal to Baramulla.Upto the present by a good amount of transport activity is carried along it in the flat bottomed boats. The river Jhelum during the floods carry heavy loads of silt and a great volume of water and its channels get choked by the siltation, which in turn makes floods a recurrent phenomenon affecting agriculture and other land use/cover.Jhelum drains the whole valley of Kashmir and from north-west of Anantnag where its head waters the Arapal from the north-east unit. Two to three miles north of Anantnag the Jhelum receives the Lidder which rises in the snow fields from north of the Sheshnag and do contribute a volume of water scarcely inferior to that of the Jhelum. A few miles north of Bijbehara it receives waters of the Vaishav and Rambiarastreams, both of which flow down from the PirPanjal Mountains. The former stream rising in the holly spring of Kounsar Nag and later in the NandanSar and BhagSar lakes. At Srinagar, it receives the Dodhganga stream which also rises in PirPanjal range. Besides these, it is fed by numerous smaller streams and mountain torrents and its water communicate with those of the Dal, Anchar and Manasbal lakes. The river makes source of the finest meanders over this stretch and lays down a good deal of its suspended load along its bank.The Jhelum basin has 24 tributaries and some of them drain from the slopes of the PirPanjal range and join the river on the left bank and some others flowing from Himalayan range and join the river on the right bank. In all, the Jhelum basin has 24 catchments (Fig. 2).

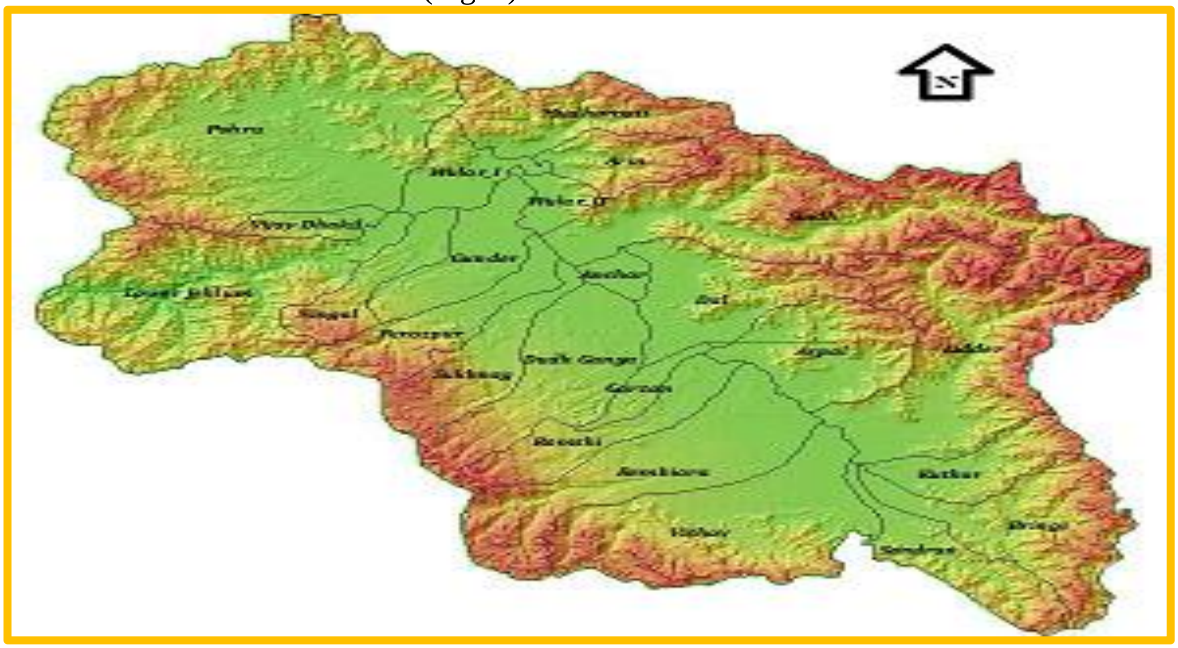

Fig 2.Jehlum Basin with its Catchment source: - JKENVIS

**HISTORY OF FLOODS IN J&K**

Jammu and Kashmir has a long history of flooding. Floods in the stateare linked to the Jhelum River and it has history of crossing the danger mark and thereby inundating the 'Valley'. And history was once again ferociously repeated in 2014, the statehad seen an unprecedented amount of rainfall, resulting in its worst floodssince 1959. While the scale of devastation caused by these floods wasnothing short of massive. The Valley, along with the Jammu region has, over the time witnessedfloods occurring at regular intervals."Many disastrous floods are noticed in vernacularhistories, but the greatest was the terrible inundation which followed theslipping of the KhadanyarMountains below Baramulla in AD 879. Thechannel of the Jhelum river was blocked and a large part of the valley wassubmerged" (Lawrence, 1895). The other major flood to affect Kashmir happened in 1841,which Lawrence notes, "caused much damage to life and property."However, the first flood of devastating proportions to hit the state camehalf a century later in 1893, when 52 hours of continuous rainfall,beginning 18 July, caused what Lawrence describes as "a great calamity". The Valley also recorded major floods at the turn of the century, with the most devastating one coming 10 years after the 1893 disaster. The floods, of that day were classified as the "greatest flood ever known", which came down the Valley and inundating Srinagar on 23 July 1903, converting the city into "a whole lake". For the next quarter of a century, the Valley did not record major floods, largely thanks to lessons learnt and mitigativemeasures, which were put in place. Kashmir was hit by a flood in 1948 also. Then in September 1950, another major flood hit the state, with nearly 100 people losing their lives. The flood was, rather unsurprisingly, caused by the Jhelum's overflow. In August-September of

1957, another major flood was recorded in Jammu and Kashmir, with the Valley bearing its devastating impact. The floods almost submerged the entire valley. The then Prime Minister of Jammu and Kashmir, BakshiGhulam Mohammad was quoted as saying that, "the floods recorded in Jammu and Kashmir were the highest ever recorded in the state, and that the damage caused by them was colossal." Two years later, in July 1959, the state witnessed yet another massive "glacial" flood, perhaps worst ever at the time, when four days of incessant rains lashed the valley and Srinagar, triggering floods in the Jhelum. While the state did witness floods thereafter in the following three decades, the one in 1992 was unprecedented in terms of its fury. Recording its heaviest rainfall since 1959, the 1992 floods were most devastating, purely in terms of casualties. According to print media reports from 1992, over 200 people lost their lives and the floods left over 60,000 people marooned in several north-western border districts. Floods were witnessed in 1996 and more recently in 2006 as well. Massive floods were caused by a cloudburst in the Leh-Ladakh region of Jammu and Kashmir, which occurred on 6 August 2010, produced flashfloods in the area after a night of heavy downpour. While it only lasted for half an hour, the devastation caused by the cloudburst was enormous. It destroyed many buildings in the city of Leh.

## FLOODS-2014

Jammu & Kashmir experienced the worst floods in the past 60 years was that of September 2014 due to unprecedented and extremerains. The Jhelum River and its tributaries were in freshet and infusedhavoc and huge damage in various districts of Kashmir Valley. The Jammu and Kashmir state experienced catastrophic rainfall from 1st to 7th of September. On September 4th, 2014 J&Kexperienced 30hour long rainfall that has broken the record of manydecades; the major parts of the state recorded an average of more thansome aspects of catastrophic rain fall in J&K. Some parts of the stateexperienced more than 650mm of rainfall in 3 days. Even moderaterainfall was also recorded in Ladakh region. September was notconsidered rainy season in the Kashmir and Ladakh region, butin 2014 both these region had recorded moderate to heavy rainfall.

The areas affected by floods were mostly districts, including Anantnag, Pulwama, Baramullaand Srinagar. These are in rain-shadow region of the PirPanjal Range of the lesser Himalaya and receive less than 300 mm rainfall during the monsoon season. The total cumulative rainfall during the week from 4–10 September 2014 over these districts was 309 (Anantnag), 256 (Baramulla), 243 (Pulwama) and 148 mm (Srinagar), which is higher than the average rainfall for the entire monsoon season in these districts. The continuous heavy rains were due to interaction between the westward-moving monsoon low and the eastward-moving deep trough in the mid-latitude westerlies.

## Unprecedented rainfall

Around September 2, a confluence of three rain-bearing systems over Punjab drew copious amounts of moisture into north India in a five-day spell that wreaked havoc in J&K. The change was most dramatic in Kashmir Valley. The state had a deficit of 32% on September 3 which in a span of five days was transformed to 18% excess rains — a change of 50 percentage points. The Tropical Rainfall Measuring Mission (TRMM) downloaded from http://trmm.gsfc.nasa.gov was utilized. The data from 1st September, 2014 to 7th September 2014 was analyzed and the accumulated rainfall for the day was calculated watershed wise for Jehlum basin. Also, IMD data from 28th August to 10th of September 2014 was analytically studied.Analysis of pre and post flood satellite images also revealed that snowmelt had an impact though small.The post flood images showed more snow than pre-flood image indicating about fresh snow fall. Which might have actuallygotwashed away by incessant rains resulting in cold flood water. While analyzing the cumulative rainfall from 1st September to 7th September 2014 catchment-wise, it was observed that Lidder Catchment received maximum amount of rainfall i.e. 277mm with adjoining catchments in South Kashmir viz-a-via Arpal, Bringi, Kuthar, Sandran, Vishaw, alsoreceiving rainfall above 200mm.The rainfall data collected from Metrological department srinagarfrom 28th August to 10th September 2014 for Jammu and Kashmir also revealed that actual rainfall received (1645mm) in South Kashmir area was way above normal (124.9mm) rainfall. (Anantnag = 402.3mm, Kulgam= 540.5mm, Shopain = 406mm, Pulwama = 292.7mm) was way above normal (Anantnag = 32.9mm, Kulgam = 42.9mm, Shopain = 29.2mm, Pulwama = 19.9) rainfall (Table -1).It is evident from the results that South Kashmir region received the maximum amount of rainfall during this period causing massive floods in Srinagar and its adjoining areas.

Table-1: Rainfall data during two weeks in Jammu and Kashmir (Source IMD)

| | **28 aug-03sep, 2014** | | | **04aug-10sep, 2014** | | |
|---|---|---|---|---|---|---|
| Region/ District | Actual (mm) | Normal (mm) | Cat. | Actual (mm) | Normal (mm) | Cat. |
| J&K | 43.2 | 27.9 | E | 267.7 | 30.0 | E |
| Anantnag | 93.2 | 15.6 | E | 309.1 | 17.3 | E |
| Budgam | 35.8 | 8.4 | E | 76.7 | 19.5 | E |
| Bandipora | * | 9.5 | * | * | 10.3 | * |
| Baramula | 25.6 | 13.3 | E | 255.9 | 16.1 | E |
| Ganderbal | 91.2 | 9.2 | E | 32.6 | 9.8 | E |
| Kulgam | 80.3 | 19.3 | E | 460.2 | 23.6 | E |
| Kupwara | 7.6 | 11.7 | D | 129.2 | 6.2 | E |
| Pulwama | 50.0 | 6.5 | E | 242.7 | 13.4 | E |
| Shopian | 58.0 | 17.8 | E | 348.0 | 11.4 | E |
| Srinagar | 43.5 | 9.2 | E | 148.0 | 9.8 | E |
| Cat:-Category E:-Excess, D:- Deficit | | | | | | |

During the previous recorded floods on the Jhelum were almost 100,000 cusecs of discharge recorded at Sangam and about 80,000 cusecs recorded during the 1928 floods. There are no reliable discharge statistics available for the 1959 floods though some reports suggest that the discharge was almost 100, 000 cusecs at Sangam. While as, during the 2014 floods discharge at Sangam was highest ever recorded on 6th September 1,35,000 cusecs. This figure doesn't include the breachesof river Jehlum(I&FC). The flood inflow was more than the combined carrying capacity of Jehlum and flood channel despite the natural breaches of huge size at Kandizal, Chursu, Lelhar, Marwal, etc. The data clearly reveals the magnitude of September 2014 floods. The carrying capacity of Jehlum in Srinagar city is about 35,000 cusecs and another 15,000 in the supplementary channel. Unless the flood basins which stand encroachedupon are restored to cater to the surplus flow besides taking some other measures, the city of Srinagar will continue to be under the threat during the flood fury in future.

**Spatial Magnitude of Flood Inundation**

The continuous downpour for almost more than a week had accumulated much water to inundate the major low lying areas of the valley. Almost for otherwise 6 sunshine's sun had gone literally missing. The flood inundationthough of varying nature as for as spatial extent is concernedwas recorded as per the data given in table 3, during this flood event. It wascalculated that about 557 $km^2$, which constitutes about 3.5% of the Kashmir Valleys geographical area, was inundated due to flooding.(table 2).

Table-2: Table showing extent of inundation from 07-25 September, 2014

| S.No. | Date | Area($km^2$) |
|---|---|---|
| **1.** | 7TH September 2014 | 346.7* |
| **2.** | 8TH September 2014 | 370.6 |
| **3.** | 9TH September 2014 | 361.2 |
| **4.** | 10TH September 2014 | 358.6 |
| **5.** | 12TH September 2014 | 338.6 |
| **6.** | 15TH September 2014 | 312.3 |
| **7.** | 17TH September 2014 | 291.7 |
| **8.** | 19TH September 2014 | 282.9 |
| **9.** | 21ST September 2014 | 271.3 |
| **10.** | 25TH September 2014 | 251.9 |
| • **As per the Govt. Records** | | |

**District wise inundation of Kashmir Valley**

Unprecedented rainfall led to widespread flooding in the Kashmir valley. Flood waters breached embankments in many low-lying areas in Kashmir, including the capital Srinagar. Jhelum and all its tributaries were flowing above danger mark. The worst affected districts were Srinagar, Anantnag,Bandipora,Baramulla, Pulwama, Ganderbal, Kulgam, Budgam (Table 3).

Table-3: District-wise inundation of Kashmir Valley

| S.NO. | DISTRICT | AREA ($km^2$) |
|---|---|---|
| 1 | **Anantnag** | **43** |
| 2 | **Bandipora** | **143** |
| 3 | **Baramulla** | **89** |
| 4 | **Budgam** | **54** |
| 5 | **Ganderbal** | **6** |
| 6 | **Kulgam** | **15** |
| 7 | **Pulwama** | **102** |
| 8 | **Srinagar** | **100** |
| | **Total** | **552** |

**Land use/Land cover**

As above mentioned the major districts which were inundated during the flood,revealed the following landuse, landcover categories deluged with their areal extent (table 4).

Table-4: Land use/land cover classes under flood inundation.

| S.No. | LAND USE/LAND COVER | AREA ($km^2$) |
|---|---|---|
| 1 | Agriculture | 436 |
| 2 | Horticulture | 23 |
| 3 | Built-up | 69 |
| 4 | Forests | 3 |
| 5 | Wastelands | 19 |
| 6 | Others | 2 |
| | Total | 552 |

**Flood Duration**

The flood waters isolated several areas in the valley and many villages were drowned by flood water for several days. About 287 villages were affected by floods as on 25 September 2014. The Flood duration/persistence map was prepared to analyze the stay period of flood water in various areas. Accordingly, areas under 1-5 days, 6- 10days and 11 to 18 days were delineated.

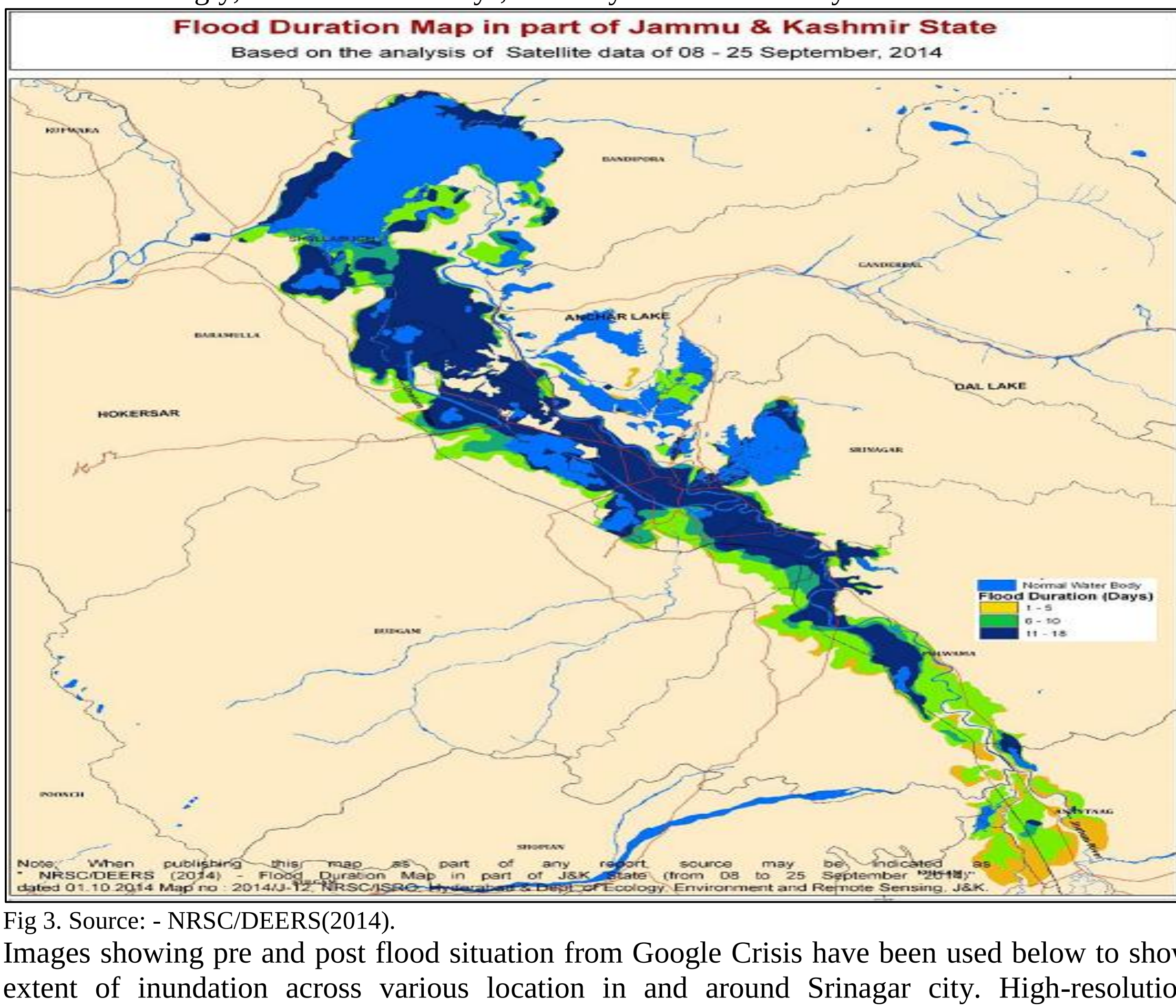


Fig 3. Source: - NRSC/DEERS(2014).

Images showing pre and post flood situation from Google Crisis have been used below to show extent of inundation across various location in and around Srinagar city. High-resolution datafrom world view 2 satellites from Digital Globe has efficiently captured flood.

**<u>Plate 1</u>**

***Pre and post flood- Central parts of Srinagar Municipality.***

**Plate 2**

*Pre and post flood- Srinagar Railway Station Nowgam..*

*Pre and post flood- Indoor and Bakshi Stadium, Srinagar.*

**Plate 3**

***Pre and post flood- NumaishGah (central market) High Court complex and JihangirChowk.***

**POSSIBLE CAUSES OF FLOOD**

Unexpected and unprecedented precipitation can be defined in terms of number of rainy days if it exceeds the currently observed average number of rainy days in a year as well as the volume of rainfall in a day if it exceeds a particular threshold. Currently, the frequency of rainy days is more in East and North-East India and less over western India. Studies revealingprojections for the 2030s, however, indicate that the frequency of rainy days is likely to decrease in most parts of the country. The number of rainy days in the Himalayan region may increase by 5–10 days on an average in the 2030s. They will increase by more than 15 days in the eastern part of the Jammu and Kashmir. The intensity of rainfall is likely to increase by 1– 2mm/day (INCCA, 2010). Climate change is responsible for the increasing trend in the number and intensity of extreme weather events (IPCC, 2013). Studies show extreme rain events are becoming more frequent as compared to moderate rain events. Rainfall is also becoming variable and unseasonal. Extreme rainfall events related to monsoon are also expected to increase. As per IPCC 5th Assessment Report there will be 30% increase in the incidence of extreme rainfall in Asia. Highly anomalous rainfall storms and shifting of their distribution is now an internationally admitted manifestation of climate change induced by indiscriminate industrialization, urbanization, consumerism and other factors. Occurrences of floods outside the traditional States of Bihar, Assam, Eastern UP and Orissa have increased due to higher frequency of extremely high intensity rainfall storms. Many a times clouds entering into the valleys are not able to escape because of orography, go on accumulating and ultimately burst into a high intensity precipitation. Valleys enclosed by high hills are prone to heavy rains and cloud bursts with rainfall intensity of more than 100 mm/hr. Unlike other areas, more than 90% of rain falling on hard and solid glaciers as well as rocks flows down as run-off and may cause flooding by high rainfall. Incessant rains may also induce melting of glaciers and add to ferocity of floods and deluge. Encroachment of wetlands, construction of communication network and other developmental activities associated with land use change also add to vulnerability and fragility.

Kashmir is a closed valley and Jhelum River with narrow section flowing through PirPanjal hills is the only outlet for releasing waters. In the year 2014, J&K received 55% excess rainfall, Western Rajasthan33%, Eastern Rajasthan 34% and was deficient in Punjab (-63%) and Himachal Pradesh (-48%) over the normal. Shopian district of J&K received 2953%, Kulgam 1850%, Anantnag 1687% and Pulwama 2380% excess rainfall over normal in the week ending 9th September 2014. All districts except Poonch received high rainfall. The rainfall data collected from Indian Metrological department (IMD) from 28th August to 10thSeptember 2014 for Jammu and Kashmir revealed that actual rainfall received (1645mm) in South Kashmir area was way above normal (124.9mm) rainfall. TRMM data also showed that south catchments of Jehlum River received heavy downpour of around 650mm of rainfall on 4th of September. The glaciers and hard rocks produced lot of run-off, the soil of the region was already saturated and incessant high rainfall for four days generated unprecedented floods, which raised the flood level of Jehlum at Sangam to about 34.70 ft (danger level 21) breaking all the previous records. This resulted in the abrupt increase in the flood level at Ram MunshiBagh which touched around 29.50ft (danger level 18). This was boosted by the heavy rains in Sindh basin (105mm) resulting in heavy discharge in Sindh Nallah which joins the Jehlum at Shadipora causing an upward rush and limiting the free flow of Jehlumwater into the Wullar Lake which had the necessary detention capacity at that point of time. The flood inflow was more than the combined carrying capacity of Jehlum and flood channel despite the natural breaches of huge size at Kandizal, Chursu, Lelhar, Marwal, etc. The data clearly reveals the magnitude of September 2014 floods which caused deaths of human lives, damaged communication, other infrastructure, livestock and wildlife. Hundreds of villages were inundated, damaged or destroyed and lakhs of people stranded in Kashmir valley.

History bears powerful testimony to the fact that in Srinagar city many flood spill channels were dug during the reign of various kings, administrators in the past. The Nalaameer channel was dug during the reign of the great Kashmiri king, Zain-ul-Abidin while as the TchountKhulNallah was dug by Mehan Singh in 1835 AD with the sole purpose to save Srinagar city from floods. Nature has already bestowed a vast network of wetlands locally called "Dembs" to the Srinagar city which acted as sponges during the floods and shared the Jhelum waters, but during the last few decades due to rapid urbanization, these wetlands and water ways were converted in to urban jungle. No attention was given towards de-silting of the existing flood spill channels. Wetlands in Kashmir valley have lost their water absorption capacity due to excessive siltation and encroachments, thus decreasing the chances to minimize ferocity during floods. Wetlands includingNarkara, RakhiArath and Nowgam(Budgam),Hokersar, Anchar, Gilsar, KhoushalSar(srinagar), Haigam, Shalabugh, Mirgund(sopore),Asham( Bandipora)Poshkur(pulwama) considered as natural sponges in times of floods – have been converted into "agriculture and built-up" over the past two decades which worsens the flood susceptibility. An important study by Humayan Rashid and GowharNaseem of Jammu and Kashmir Remote Sensing Centre reveal the loss of nearly 50% of the wetlands over the period of 100 years (Fig-4). In 1911 the total extent of water bodies with marshy areas was 356.85 km2 however it has reduced to 158.54 $km^2$in 2011 (table: 05).

**Table-05: Extent of Lakes and wetlands in Kashmir valley (1911-2011)**

| S.NO. | Year | Category | | Total ($KM^2$) |
|---|---|---|---|---|
| | | Marshes | Water bodies | |
| **1.** | 1911 | 271.70 | 85.15 | 356.85 |
| **2.** | 2011 | 117.43 | 41.11 | 158.54 |
| **Loss in Arial extent** | | 154.27 | 44.04 | 198.31 |

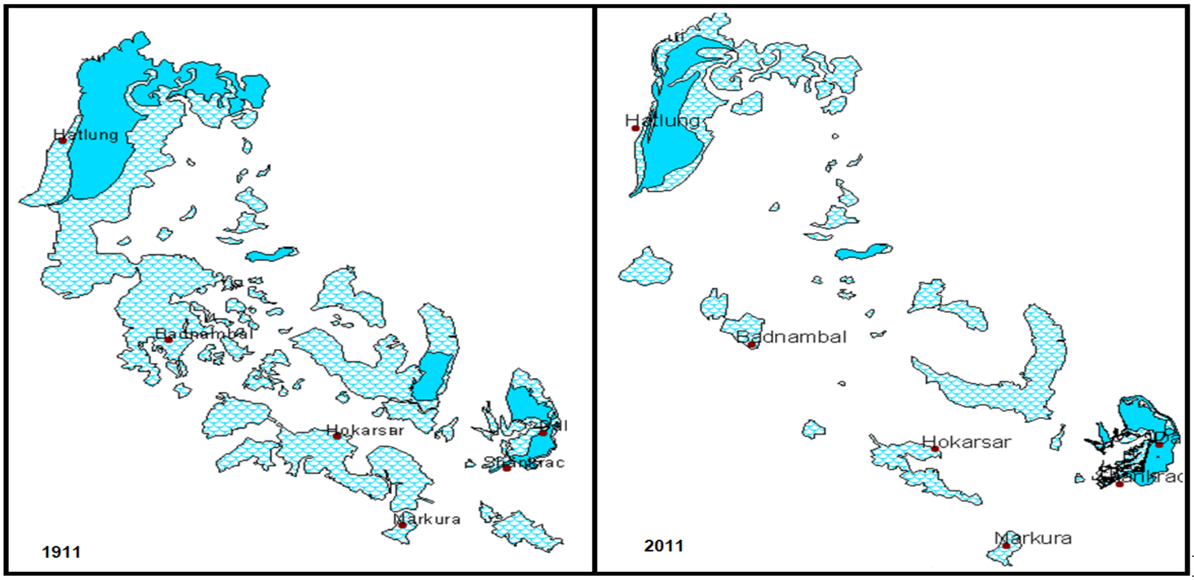


Fig-4: Extent of Lakes and wetlands in Kashmir valley (1911-2011)

Most of the housing colonies built in the floodplains of Jhelum and along the Jhelum river course stand regularized by the successive governments and thus, encouraging the conversion of the remaining wetlands and marshes in the vicinity of the Srinagar and elsewhere to built-up enclosures. And to the surprise is the construction of Government offices government residential colonies in these low lying areas of Srinagar and the adjacent areas.One of the important studies by the DEERS within the 10km buffer of Srinagar reveals the land use / land cover has changed by about 30%. Study identified around 43 priority wetlands and water bodies, which showed significant reduction in their extent.

**RECOMENDATIONS AND PREVENTIVE MEASURES**

Normally surface runoff disappears very quickly after the rains in the undulatingtopography of hills but it was other way round in J&K, and we have repeatedly seen the same way in last few years, especially in 2016 and 2017. The settlementsalong the embankments of Jhelum and on wetlands and other water-bodies have strangulated the natural drainage network and water gets stagnated in local low level zones even if water level in Jhelum goes down and would require pumping out. It is a very critical issue because there is only one flood water outlet of Jhelum river, large number of settlements etc. is already inplace along it and extreme rainfall events are going to multiply in future due to global warming. Yet another factor of concern is that whole state ofJ&K falls in seismically active zone and normally experiences about 20 earthquakes in the range of 3.3 to 5.4 on Richter scale which furtheraccentuate its instability and vulnerability to landslides and mass erosion of soil. Accordingly, all means of communications and transport systems of the fragile hills and mountains are highly vulnerable; it requires very unique strategy of rescue and relief as well as re-construction and rehabilitation operations. Frequent landslides, erosion of river banks, washing away of roads, bridges, houses and other infrastructure is a very challenging job of reconstruction, rehabilitation, restoration and mitigation of floods in Jammu & Kashmir.Primarily, the topography and structure of the floodplain determine the extent of the increase in flooding intensities (i.e. inundation area and inundation depth), as, for example, wider

and deeper river channels combinedwith steeper gradients can absorb higher peak discharges.Secondly, the impact of future increases in flood threat depends on the effectiveness of flood protection infrastructure to withstand the climate change. In some cases, the increase in peak discharges could lead to the overflow (and possibly breaching) of retention basins, while in other cases the flood protection schemes persist due to a considered safety margin.
Following measures can be taken up to minimize the risks associated with flood:

- The need of the hour is to dig up an alternate flood spill channel for Jehlum.
- Feasibility for an additional alternate flood channel from Kandizal to Wular should be carried out.
- The spill channel running acrossRawalpora via Peerbagh and Narkaraneeds to be desilted on priority basis to receive the overflowing waters of DoodhgangaNallah. And the construction works in this area must be stopped immediately to hamper the worsening of the situation in future.
- Strengthening of the bunds and embankments and removal of the encroachments along them.
- De-siltation and revival of flood basins of Khushalsar, Gilsar, Anchar, Hokharsar, Shalabugh, Haigam.
- Bunds along the Nallahs be raised and strengthened as these low lying bunds are always prone to breach.
- There is a serious need to develop a flood risk/hazard zonation map for Jammu and Kashmir in terms of assessment of physical and socio-economical vulnerability.
- Monitoring of sediment loads from catchments and timely extraction on scientific ways under proper supervision..
- Monitoring of Land use/Land cover changes of river basin.
- There is a need to have water-bodies monitoring and flood warning system, that can be achieved by equipping the state with proper instrumentation, by using satellite based observations, supported by a dense network of automatic weather stations/towers/profilers.
- The state should come out with an advanceddisaster mitigation and preparedness plan especially regarding evacuation strategy, optimum locations for rehabilitation/relief camp sites,and capacity building programs.
- Inventorization, renovation and reconstruction of old heritage buildings, flood zoning, relocation of buildings very close to the river banks, strictregulations to check future interferences with drainage system, emergencyrestoration of will minimize infrastructural damages and human agonies.

**Conclusion**

Heavy rainfall and associated flash floods cause tremendous damage to life and property across most of the mountainous regions of the world, including the Himalaya. The Himalayan ranges are prone to heavy and prolonged rainfall events and associated flooding, particularly during the summer rainy months of June to September. Variability in precipitation over the Himalaya during monsoon season is controlled by the atmospheric systems (lows or depressions).
A continuous spell of 5-7 days of very heavy rainfall in first week of September 2014, caused disastrous floods in many parts of the J&Kstate. According to media reports, the state government claimed that ‘the calamity, worst in the century, caused colossal losses to life and

massive damage to housing and business sectors, public institutions particularly hospitals, road infrastructure, agriculture and transport sectors. Over 300 people lost their lives across J&K, including 85 persons from Kashmir. A preliminary survey by the government revealed that the flood damaged over 3.50 lakh structures, including 2.50 lakh residential houses and affected 12 lakh families in 5500 flood-hit villages across the state. In worst-hit Kashmir, 2.60 lakh structures got damagedwith 95,000 houses in Srinagar alone. It was a “disasterof international magnitude” and the losses to propertiesand business were in excess of rupees one trillion.Heavy rainfall led to landslides and widespread floodingin the Kashmir valley. Flood waters breachedembankments in many low-lying areas in Kashmir, includingthe capital Srinagar. Jhelum, Chenab and many otherstreams were flowing above danger mark. The worstaffected districts were Srinagar, Anantnag, Baramulla,Pulwama, Ganderbal, Kulgam, Budgam, Rajouri, Poonchand Reasi. It as such concluded that we need to be more vigilant in future. We as responsible citizens are supposed to work for the betterment of state in our individual capacities.

**Plate 4**

**Deluged Paradise in Pictures.**



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