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Srinagar Floods September 2014: A Case Study

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ABSTRACT

The main significance behind this research is that, its findings will show that climate change combined with urbanization increases the vulnerability of urban areas to flooding and economic damage. Srinagar has long history of occurrence of floods. The 2014 flood was very devastating killing hundreds of people and causing colossal loss to the infrastructure to the tune of INR 1 trillion. The government of Jammu and Kashmir on 29 September 2014 termed Kashmir floods as an international disaster. The Jhelum waters, that used to be the provider of life and sustenance, suddenly became a monstrously destructive force against the human life and the infrastructure that cohabit its backyards since millennia. Due to occurrence of such hazards various states has adopted mitigation and prevention as the essential component of their development strategies to cope with such natural disaster.

***Key words*:** Floods, Water index, Economy, Rescue operation, Srinagar

Srinagar is the largest city and the summer capital of the Indian state of Jammu and Kashmir. The latitude of Srinagar is 34.083656, and the longitude is 74.797371. It has an elevation of 1587 meters. The valley is located on the southwest by the Pir Panjal Range and on the northeast by the main Himalayas range. It is approximately 135 km long and 32 km wide, and drained by the Jhelum River [1]. The river passes through the city and meanders through the valley, moving onward and deepening in the Dal Lake. The city is known for its natural environment, gardens, waterfronts and houseboats. It is also known for traditional Kashmiri handicrafts and dried fruits. As of 2011 census, Srinagar city's population was 12, 19,51. The sex ratio in the city area is 888 females per 1000 males, whereas in the urban agglomeration it is 880 per 1000. Both the city and the urban agglomeration has average literacy rate of approximately 71%. The predominant religion of Srinagar is Islam with 95% of the population being Muslim and remaining 5% is composed of Hindu, Sikh, Buddhist and Jains. It has temperate climate with short warm summer and long cool winters. Temperature during summers in the month of July is 23-27 degree Celsius, while in winters temperature goes below freezing point. Srinagar receives rainfall from south west monsoon during summers with the wettest month March to May it receives around 85 millimetres of rain fall per month [2]. The study aims to achieve the following objectives:

- To trace the causes and effects of flood on socio-economic conditions
- To trace the evacuation measures taken
- To analyze the temporal changes in land use land cover

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MATERIALS AND METHODS

The data used in the present study is taken from secondary sources such as census 2011, Satellite data i.e., optical and thermal data, Spatial data from Google Earth, Digital Elevation Model from SRTM as a Source. Further processing of data was done through advanced digital image processing and GIS techniques, such as edge enhancement, colour compositing, generation of Slope, Aspect layer, Land use/Land cover identification overlay and logical operations.

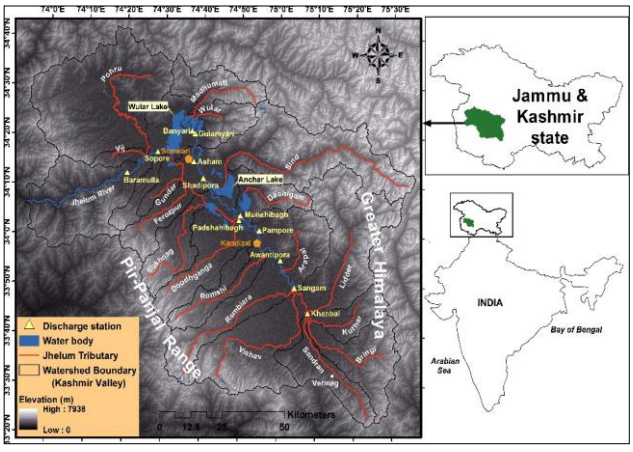


Fig 1 Location map of study area

RESULTS AND DISCUSSION

Reason for occurrence of flood in Srinagar city

According to the Centre for Science and Environment (CSE), India, the floods in Srinagar follow a recognizable

pattern of heavy rainfalls that was previously seen in other parts of India: Mumbai (2005), Leh (2010) and Uttarakhand (2013). To be more precise as to what caused the floods, CSE indicated that the floods were caused by a combination of intense rain, mismanagement, unplanned urbanization and a lack of preparedness. Local scientists, Humayum Rashid and Gowhar Naseem, had indicated in 2008 that there was a breakdown of the natural discharge system in the valley that could prevent water from flowing out of the valley. The floods in Jammu and Kashmir were no different, causing tremendous devastation and loss of life, property, livelihood in addition to affecting the healthcare system adversely, which could lead to severe health issues in the population and more fatalities in the following days.

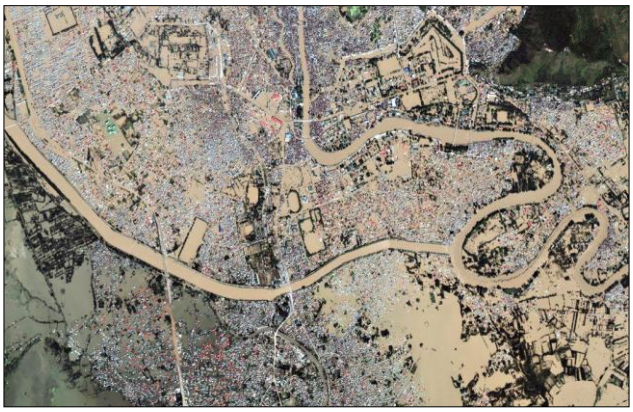


Fig 2 Aerial view of Srinagar city

Impact on health: As of 21st September 2014, the official death toll had already climbed to 285 and was expected to rise following further evacuation and assessment of affected areas. The initial deaths were caused by houses collapsing; people unable to escape the water and boats rescuing the stranded people capsizing. As the rescue efforts began, dead bodies were recovered from flood waters. The devastating effect on the healthcare delivery system of the state was probably the biggest casualty of the flood event. Out of the five major hospitals in Kashmir, situated in Srinagar, four were completely shut down due to the floods as floodwaters entered the hospital premises and even submerged several floors. Patients in these hospitals were evacuated early and shifted to the functional hospitals in the city, mainly the Sheri-Kashmir-Institute-of Medical-Sciences (SKIMS) - which is a large tertiary care teaching hospital in the J&K. Due to the submerging of main hospitals and markets in the valley, there was a heavy shortage of medical supplies. The areas of Srinagar marooned I n the flood waters have been declared as hotspots for the outbreak of communicable diseases by the health department and people have been advised to be cautious while dealing with water and food items. Filth and rubbish surfacing from receding floods festering in streets are seen all around. There is an ominous stench in the air. Poisonous mud smeared in streets and pavements is getting dry and creating dust with particles of chemicals, biological debris and harmful substances like cement, asbestos and other matter. Buildings affected by floods have developed fungus on walls. Post-Traumatic Stress Disorder (PTSD) was also on the rise in Kashmir after the worst ever flood hit the state.

Impact on economy: The devastating impact of the flood is most conspicuously visible in the economic dent born the valley. In the initial estimates by Associated Chambers of Commerce and Industry of India (ASSOCHAM), there was an initial immediate loss of around 5,700 crores INR or $92 million. These were only the initial figures and did not take into account the loss of financial wealth through lack of productivity, loss of livelihood and devastation of much of the private property. Former president of Federation of Chamber of Commerce, Kashmir, estimated an economic loss greater than 15 billion dollars, which is greater than the respective GDPs of almost 80 countries around the globe. The government of J&K on 29 September 2014 termed Kashmir floods as an international disaster. “Across the State, 125000 families have been affected due to floods. “According to a rough estimate, the housing sector in Kashmir has suffered losses over 30,000 crore INR while the business sector had suffered losses worth more than 70,000 crore INR”.

Fig 3 Srinagar flood impact

He also stated that 5642 villages were affected across the State with 2489 in Kashmir valley, 3153 in Jammu division and 800 villages remained sub-merged for over two weeks. Giving details of the damages the Chief Secretary said more than 350000 structures – mostly residential houses – have been damaged in the floods, which were the worst in the state over the past 112 years. "The crop losses have been to the tune of 5611crore INR including 1568 crore INR losses to the horticulture sector," adding 6.5 lakh hectares of land has been affected by the deluge. "Over 10,000 milk animals and 33,000 sheep and got perished in the floods". Tourism infrastructure and government residential colonies have suffered losses to the tune of 5,000 crore.

Social impact: As the catastrophe has left thousands of people homeless and without their livelihood, it is understood that there are going to be numerous people set up in make shift camps around the valley. As the harsh winter approach, when the mercury often drops below zero, people are going to miss their concrete houses badly (not to say they don’t already). With more than a hundred thousand people without work, a societal turmoil is already a resounding possibility. Due to the closure of Jammu-Srinagar highway - considered the life of the state in terms of connectivity with the rest of the country – for more than two weeks, there was a dire scarcity of essential commodities including food and medicines. With some of the places still inaccessible by road, it is going to take time to get such supplies to these areas. Markets in the affected areas were almost entirely destroyed in terms of physical structures or the goods they carried.

Educational impact: The floods have adversely affected the education infrastructure in almost all the flood-ravaged districts and some schools need to be rebuilt as they have collapsed or suffered extensive damage, whereas others need major repairs. The deluge has completely destroyed thousands of school buildings while thousands of others have been partially damaged, rendering them unfit for schooling. According to official figures, out of 11526 primary and middle school buildings, 1986 have collapsed while 2685 were partially damaged. As per the departmental survey, 2397 students enrolled in different primary and middle schools have been left without buildings." The private schools have also reported the heavy loss to the infrastructure of more than 1500 school buildings". Another 450 schools in private sector have suffered extensive damage.

Rescue operation

In the wake of heavy monsoon rain and flash floods in Jammu and Kashmir, which have allegedly killed over four hundred and rendered hundreds of thousands homeless, the Indian Armed Forces were deployed in increasing numbers starting 2 September 2014 to conduct search, rescue, relief, relocation, humanitarian assistance and rehabilitation missions in Jammu and Kashmir. By 18 September, over 200,000 people were rescued from the various parts of Jammu and Kashmir by the Armed. The Armed Forces humanitarian assistance mission in response to the floods was named as mission "sahayata" Northern Command's humanitarian assistance to Civil authorities was named 'Operation Megh Rahat' The Indian Army, Air Force, and the Navy, committed large resources to the assistance mission including over 30,000 troops (21,000 in Srinagar, and 9000 in Jammu), 15 engineer task forces, 84 Indian Air Force fixed wing transport aircraft and helicopters naval commandos and rescue specialists, and Base Hospital, four field hospitals, over 106 medical detachments. Operation Megh Rahat", ended on 19 September 2014, but "Operation "Sadbhavna", the relief and medical assistance support, according to government press release continue in "close synergy with the civil administration and the police".

During the first few days the search and rescue operation were hindered by shortage of boats and bad weather. Boats were airlifted from all corners of India, including from far away Tamil Nadu. In the absence of civil boats, the army pressed into service its BAUTS, more appropriate for assault river crossings than rescue assistance during floods. By 11 September, there were 224 army boats and 148 NDRF's inflatable boats in the affected area conducting rescue and search operations. For those who were stranded on roof tops as flood water menacingly swirled around them, Air Force helicopters with IAF Garud Commandos help winch the stranded people to safety. Several hundred were rescued from roof tops. In some cases, the Indian Air Force (IAF) commandos had to break through the roof to rescue the trapped people.

Social media in search and rescue

The Indian Army, for first time, used social media such as Twitter, WhatsApp, a messaging service, and Facebook, in its search and rescue operations, and to collate and feed Person Finder provided by Google to the army's public information office. According to Indian army's Major General Shokin Chauhan, who is head of public information office, "a dedicated team of two young officers" are handling the social media "practically around the clock". An estimated 12,000 people, according to the Indian army sources, were assisted on the basis of reports received over the social media.

Air transport in search and rescue

Because of the massive damage to surface communications, the rescue and relief effort was largely dependent on-air transport. Air transport support operations were conducted from air force stations and bases in Delhi, Bhatinda, Chandigarh, Jammu, Srinagar, and Avantipur. Helicopter support operations were conducted from Srinagar, Anantapur, Udhampur, Jammu, Pathankot and Sarsawa. Over 80 aircraft were deployed on the humanitarian assistance mission including 13 Chetak and 5 Advance Light Helicopters of the Army Aviation Corps. On 11 September, the IAF deployed its heavy-duty Mil Mi-26, the largest helicopter in the IAF inventory, from IAF 12 Wing, Chandigarh, to Awantipur Air Force base, Srinagar, with 12 tons of relief material, for relief and rescue missions in Jammu and Kashmir. Wing Commander G S Tung of 12 Wing said that the Mi-26 was especially designed to meet the heavy lift requirements of the IAF and has a carrying capacity of 30 tonnes".

In the first seven days, the army and IAF flew 1081 sorties, 100 to 120 sorties every day, moving 1411 tonnes of relief materials. Air transport operations included delivery of six large water filtration plants with a capacity to filter 1,20,000 bottles per day, engineering stores such as suction and submersible pumps, generator sets with mobile charging stations, communications equipment for the Department of Telecommunications and some of private companies such as Aircel. It airlifted the Base Transmitting Station of BSNL from Kargil to Srinagar. By 18 September 2014, over 80,000 affected people were airlifted including over 28,000 from Srinagar and 52,000 from other flood affected areas of Jammu and Kashmir; by IAF-, Army- and civil aircraft.

Navy in search and rescue

The Indian Navy Marine Commandos rescued 200 personnel at Haigaon on the Srinagar–Sopore highway, and assisted in rescue efforts near Pantha Chowk, Srinagar [3]. In addition to search and rescue assistance, naval medical team, and Diving Teams were placed on alert, ready to move, at New Delhi, Mumbai and Vishakhapatnam [4].

Medical support

The armed forces have deployed 80 medical teams. In addition, it has set up four field hospitals, one each in Awantipur, Pattan, Anantnag and Old Airfield. Over 20,000 patients have received treated at these facilities.

Repair and restoration of communication infrastructure

The floods and rain ravaged the roads and road communication severing road communication between Jammu and Srinagar, and Jammu and Poonch, and host of other roads. Restoration of communication was urgent priority task. Initially five task forces of Border Roads Organization (BRO), which included 5700 personnel, were mobilized. By 10 September, the Jammu–Poonch road was cleared, and road traffic between Batote and Kishtwar and Kishtwar - Sinthan Pass was restored.

Relief camps

To complement the rescue work, the Army established 19 relief camps, where the rescued persons were provided food, shelter, and medical assistance. In Srinagar region,

camps were at Badami Bagh Cantonment, Awantipur, Old Airfield, Sumbal, Chattargam and Jijamata Mandir.

Relief assistance

From the start of Mission Sahayata till 16 September, the Armed Forces rescued 2,37,000 persons, and airlifted and distributed 2,24,000 litters of water, 31,500 food packets and ready to eat meals, 375 tonne cooked food, 2.6 tonne of biscuit, 7 tonnes baby food, water purifying tablets, 8,200 blankets, 650 tents, to the affected civilian population [5].

Life after flood

As pumps are in place to clear out the remaining deposits of water around the city and a colossal cleaning operation has been commissioned, people have who suffered the brunt of the massive floods have been placed in makeshift tents until further action is taken in regard to a more permanent accommodation option. Healthcare delivery institutions are slowly being pushed towards being fully functional and it may be months before this is realized. Meanwhile, people continue to support each other as aid pours in from different parts of the world. Considering the magnitude of the disaster, it is safe to say that it may take decades and billions of dollars to reconstruct what has been damaged and rehabilitate those who have badly affected. The next few years are going to be crucial as people will struggle through possible epidemics, poverty, and hunger in the hope of things getting better [6].

Temporal change

The land use/ land cover classification of Srinagar city and its environs during pre-flood (June 2014) and post flood (September 2014) situation was analysed in order to deduce the immediate and long-term impacts of flood inundation condition over varied land uses/ cover.

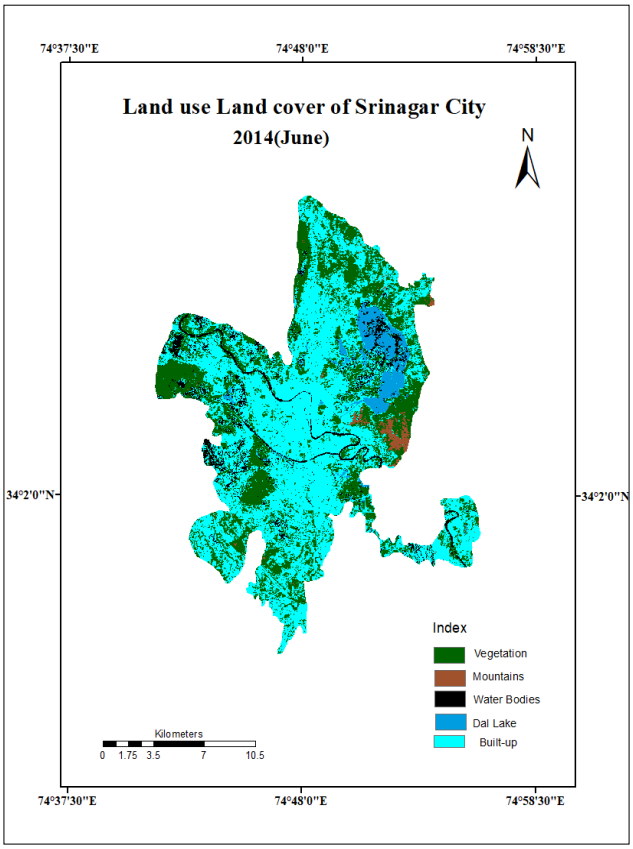


Fig 4 Land Use/ Land Cover - June 2014

Land use/ land cover mapping

The pre-flood LULC mapping using LANDSAT 7 ETM+ satellite image (dated 10th June 2014) exhibits that agriculture land was the major LULC class covering 113.34 km^2 (38.73% of total area) followed by aquatic vegetation (74.83 km^2; 25.57%), water bodies (44.44 km^2; 15.19%), terrestrial vegetation (40.92 km^2; 13.98), settlement (12.73 km^2; 4.35%) and others (6.38 km^2; 2.18%) in 2014 [7].

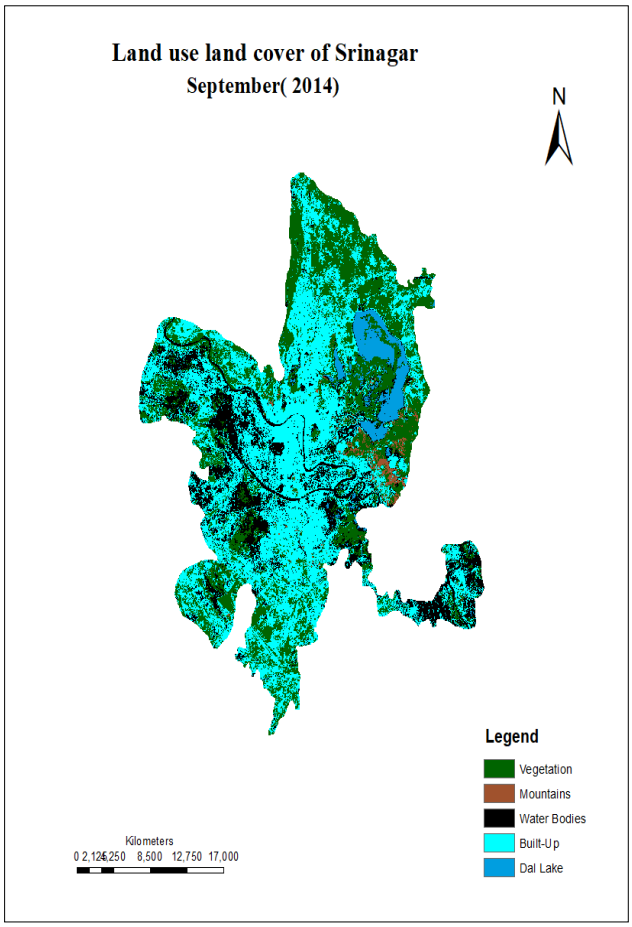


Fig 5 Land Use/ Land Cover - September 2014

Impact of flood inundation (September 2014) on land use/ land cover

Satellite image of 10th September 2014 was used to map flood inundation in the study area. The total of 88.77 km^2 (30.3%) was observed inundated covering primarily in the central part of the study area. Whereas the non-inundated area located in the north and south-eastern part having higher elevation covering 203.87 km2 (69.6%) Satellite image of 10th September 2014 was used to map flood inundation in the study area. inundated covering primarily in the central part of the study area (69.6%).

Normalized differential water index

The NDWI is most appropriate for water body mapping. The water body has strong absorbability and low radiation in the range from visible to infrared wavelengths. The index uses the green and Near Infra-red bands of remote sensing images based on this phenomenon. The NDWI can enhance the water information effectively in most cases. It is sensitive to built-up land and often results in over-estimated water bodies [8].

Values description: Values of water bodies are larger than 0.5. Vegetation has much smaller values, which results in

distinguishing vegetation from water bodies easier. Built-up features have positive values between zero and 0.2 [9].

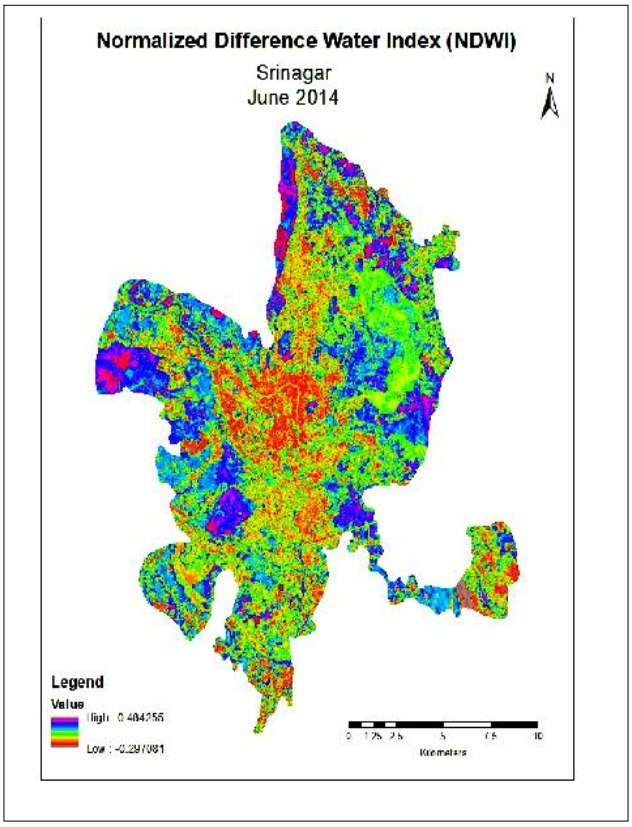


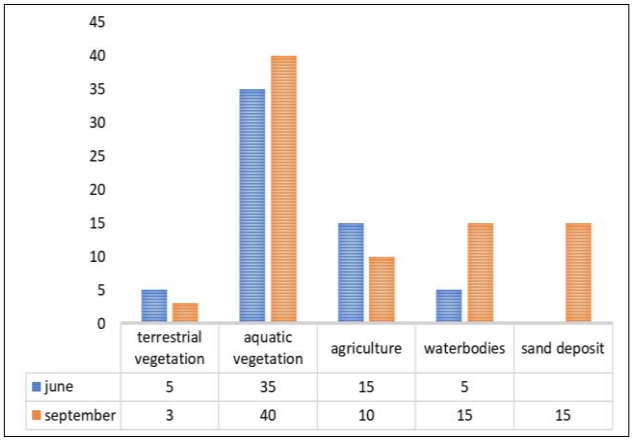
Fig 6 NDWI - Srinagar June 2014

The Normalized water differential index in this study is based on USGS classification system Landsat vii. Satellite image of 10th September 2014 was used to map flood inundation in the study area. The total of 88.77 km^2 (30.3%) was observed inundated covering primarily in the central part of the study area. Whereas the non-inundated area located in the north and south eastern part having higher elevation covering 203.87km. The flood inundation map (10th September 2014) was overlaid on the pre flood LULC map (25 June 2014) to understand the flood inundation on the different LULC class. The result depicted that 3.13 km^2 (3.5%) of terrestrial vegetation was inundated during 25th August 2014 (Table 5). The maximum inundation was calculated in the Aquatic vegetation with 34% of total area with least inundation in settlement with 0.4% of total area. The agriculture class was mostly affected by the flood as 15.6% of total area inundated [10].

(a) LANDSAT OLI satellite image (as viewed on 10th September 2014: during flood situation) and (b) flood water inundation map. To deduce the significant flood impact long after flood situation (August 2014), the flood inundation map was overlaid on the post flood LULC map (September 2015). It depicts that aquatic vegetation was most affected class as 38.09 km^2 was inundated (42.9% of total inundation) followed by water bodies 21.88 km^2 (24.6), agriculture 6.52 km^2 (7.3%), Terrestrial vegetation 1.9 km^2 (2.1%) along with settlement inundated of 0.42 km^2 (0.5% of total inundation) during 13th September 2015.

Water inundation: This exhibits that the settlement area is in upper part of the Wular lake and the bank of lake are higher in comparison to lake making settlement are much safer. 18.19 square km (20.5%) was covered by sand deposit during the post flood situation [11].

Class	Area in Km^2	Percent of total area
Water (Inundated area)	88.77	30.33
Land (Non-inundated area)	203.87	69.67
	292.64	100



Water inundation June and September 2014

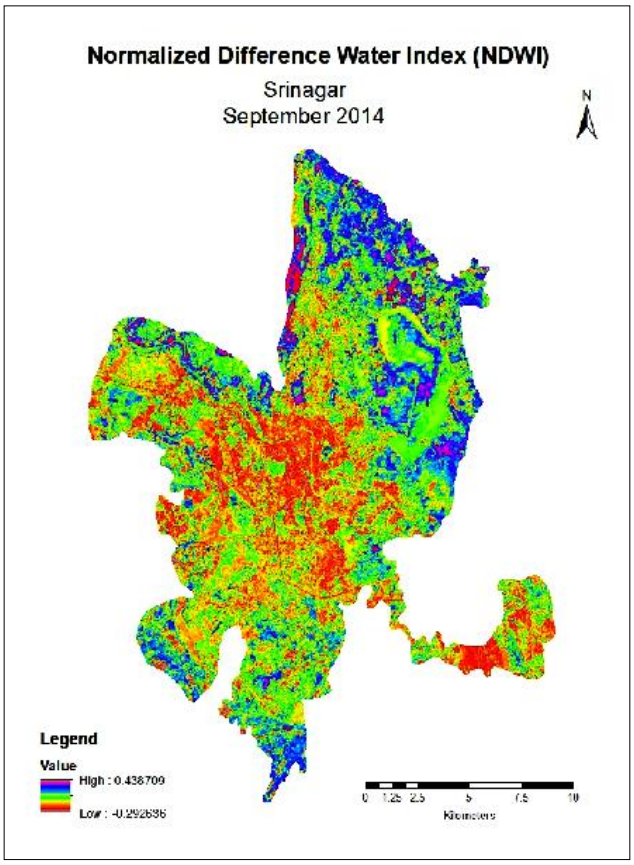


Fig 7 NDWI - Srinagar September 2014

To deduce the significant flood impact long after flood situation (Aug. 2014), the flood inundation map was overlaid on the post flood LULC map (Sept. 2015). It depicts that aquatic vegetation water regularly for the cultivation of crops whereas the wasteland and scrub land are also found in the same scenario. Aquatic vegetation are lying in the water so the inundation in this class was obvious and transforming the water quality parameters influencing the lake ecosystem. The

high siltation leads to formation of sand deposit covering 20.5% of total area, which were primarily agriculture land and aquatic during pre-flood situation [12].

CONCLUSION

In the present study, the impact of flood inundation in varied LULC classes was studied to understand the immediate and long-term impact of flood (2014). The study shows that total 88.77 km^2 area was inundated due to flood. The comparative assessment between pre and post flood situation indicated changes with increase in the aquatic vegetation (69.0%) and decrease in terrestrial vegetation (23.7%), agriculture (43.7%), water bodies (39.9%) and others (16.1%). Due to lesser impact of flood on settlement, the said class increased by 27.8% during 2014-2015primarily in the higher locations. The 22.76 km^2 area of sand deposits was observed during post flood period, which leads to decrease in area of aquatic vegetation, agriculture and water bodies. The pre-flood LULC mapping exhibits that agriculture land was the major LULC (113.34 km^2), followed by aquatic vegetation (74.83 km^2), water bodies (44.44 km^2), terrestrial vegetation (40.92 km^2). The flood inundation was observed in 88.77 km^2 area, which primarily inundated aquatic vegetation (34.06 km^2), water bodies (35.38 km^2) and agriculture (13.89 km^2). As flood inundation in water bodies and aquatic vegetation was observed as a natural process having insignificant impact over human settlements rather affected the lake ecosystem. The 0.36 km^2 (2.82%) of area under settlement located immediate to Jhelum River was inundated, indicating that the most of the population resides on the safer part in the region. The post flood situation was analyzed with respect to the land use/land cover change as a part of flood inundation impacts. The study exhibits that the major part of agricultural land, terrestrial vegetation and others LULC classes were primarily affected and decreased (63.86 km^2, 31.21 km^2, 5.36 km^2, respectively). On the contrary, majority of said LULC classes were covered by sand deposits (22.76 km^2) influencing the ecosystem process of lake environment. It also came into focus that 39.94% under water bodies were converted into sand deposits (17.75 km^2). This sand deposits detriment the aquatic vegetation and agricultural area even unbalancing the aquatic life of lake. These changes and post flood situation exhibit the impact of catastrophe flood on the biodiversity of water bodies. This work is multi-temporal dataset approach, which revealed changes due to flooding is accurate therefore can be adopted by the government to formulate measures to combat ill effect of flooding in highly fragile natural lake ecosystem. Future studies can be taken up to compare changes in natural and manmade lake (Dal Lake) ecosystem during flood in. Thus, the study provides information related the disastrous flood occurred in 2014 and its impact on socio economic condition. The major land system changes brought by the flood is also studied.

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