BUILDING RESILIENCE IN THE FLOOD PRONE EDGE OF LESSER HIMALAYAN CITY, CASE OF SRINAGAR GARHWAL

MASTERS OF LANDSCAPE ARCHITECTURE

By

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2015MLA007

SCHOOL OF PLANNING AND ARCHITECTURE, BHOPAL

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MAY, 2017

Declaration

I **Saurav Parmar**, Scholar No. **2015MLA007** hereby declare that the thesis entitled "**Building resilience in the flood prone edge of lesser Himalayan city, case of Srinagar Garhwal"** submitted by me in partial fulfillment for the award of Master of Architecture (Landscape), in School of Planning and Architecture Bhopal, India, is a record of bonafide work carried out by me. The matter embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma.

Saurav Parmar

Certificate

This is to certify that the declaration of ____________________________________ is true to the best of my knowledge and that the student has worked for one semester in preparing this thesis.

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Submitted

In partial fulfilment of the requirements for the award of the degree of

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Under the Guidance of

Prof. Saurabh Popli

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NEELBAD ROAD, BHAURI, BHOPAL (M.P.) – 462030

MAY, 2017

UNDERTAKING

I "*Saurav Parmar, 2015MLA007, Masters Of Landscape Architecture*" have prepared a report titled "Building resilience in the flood prone edge of lesser Himalayan city, case of Srinagar Garhwal" under the guidance of "*Prof.Saurabh Popli*" for the purpose of in partial fulfillment of condition of masters of landscape architecture program at School of Planning and Architecture, Bhopal.

I am the sole author of the a fore stated work, and I hereby state that no part of the said report is plagiarized or otherwise taken from any other book, article, journal, internet report previously published or unpublished without proper attribution of authorship, to the best of my knowledge and belief.

I hereby indemnity my guide and school from any responsibility arising from charge of plagiarism or misattribution that may or may not arise due to errors of attribution of authorship or rights thereof on my part in this report hereby submitted.

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ABSTRACT

In the current scenario the occurrence of flash floods has caused the loss of infrastructure and livelihood in the disaster prone Himalayan region. Over time the cities have flourished and repeatedly destroyed by the several hazards, mostly by floods which are caused by glacial lake outbursts, high rainfall and landslides.
Hence the question pertains- “How the flood prone areas (case of Srinagar Garhwal) with urban context can live in these highly unstable and vulnerable zones while retaining the spaces for the river course and encroaching on it.

The answer lies in creating flood resilience which is defined as the ability of a system to resist or absorb disturbances (such as storm surges and cloudbursts) and to remain functioning under a wide range of flood wave or rainfall intensities. In this definition, continued functioning implies either withstanding the flood wave (resistance) or quick recovery with limited impact after being exposed to flood water (e.g. due to failure of the flood defense system. with the ultimate aim to avoid impacts from which recovery is extremely difficult. (Zevenbergen 2016)
The important aspect is to understand the way communities need to live in these zones under various stresses primarily focusing on floods.

The key idea is to remodel the city with the identification of risk zones so that this urban landscape undergoing various shocks can be mitigated shortly without disturbing the city connectivity to different areas and restore the natural habitat for river corridor that passes through it.
The study endeavors to determine the structure of the city and surroundings with respect to its physiography and focuses on the river system which has shaped the ever-changing landscape over the time. Also, it will examine the river edge zoning as per its vulnerability and with the participation of communities can turn the river edge into resilient recreational spaces for public at city level.

1. INTRODUCTION

1.1. UTTARAKHAND FLASH FLOODS (AN OUTLOOK OF DISASTER):

Uttarakhand as part of Eco sensitive Himalayan region, is extremely vulnerable to the natural hazards like earthquakes, landslides, flash floods, Glacial and landslide lake outburst, cloudbursts, avalanches, hailstorms, forest fire, etc. And have repeatedly caused disruption of livelihood at larger scale.

On June 16 2013, this mountainous region has suffered extreme weather event which further triggered series of natural hazards. Heavy rainfall and flash floods hit all the thirteen districts of the state which coincided with the peak tourist and pilgrimage season, significantly increasing the number of causalities and adversely affecting the rescue and relief operation. Over one Lakh people were stuck in various regions of the State due to damaged roads, Landslides and flash flood-induced debris. As per the latest report made available by the State Government on 09 May 2014, a total of 169 people died and 4021 people were reported missing (presumed to be dead).

India Monsoon Floods Claim 138 Lives

ilitary helicopters dropped mergency supplies on Vednesday to thousands of ourists and pilgrims stranded by flash floods that tore hrough towns and temples in orthern India, killing at least 38 people, officials said.

Thousands of people have lready been evacuated after loods and landslides caused y early monsoon rains rought devastation through he region in the Himalayan oothills, they said, AFP reorted.

"As of now we know that over 65,000 people are stranded," Home Minister Sushil Kumar Shinde told reporters in lew Delhi.

"We are commited to rescuing everyone now that the ains have stopped," the minister said, adding that the army as evacuated 5,000 people cut off by the downpour.

Torrential rains at least three times as heavy as usual have it the state of Uttarakhand, often called the "Land of the Gods," where Hindu shrines and temples built high in the ountains attract many pilgrims.

"At least 110 people have died. The state government and ... stranded near the submerged valleys and Hindu shrines," said Yashpal Arya, the disaster relief minister of Uttarakhand.

At least another 28 people have been killed in the neighboring states of Uttar Pradesh and Himachal Pradesh, officials said.

Authorities fear the death toll could rise, with emergency workers still unable to reach marooned villages, particularly in worst-hit Uttarakhand, five days after the rains hit on Saturday.

Houses, multi-storied buildings, cars, bridges as well as roads have been swept away or damaged after rivers burst their banks, forcing authorities to deploy 22 helicopters to evacuate people and drop essential food and other supplies.

Indian Prime Minister Manmohan Singh and president of the country's ruling Congress party, Sonia Gandhi, will fly over the disaster area to survey the extent of the damage.

Tourists have been travelling to Uttarakhand in recent weeks to undertake pilgrimages before some sites are shut down for the monsoon season, which does not normally start

Fig 1.1. Source: (Iran daily n.d.). June 20, 2013

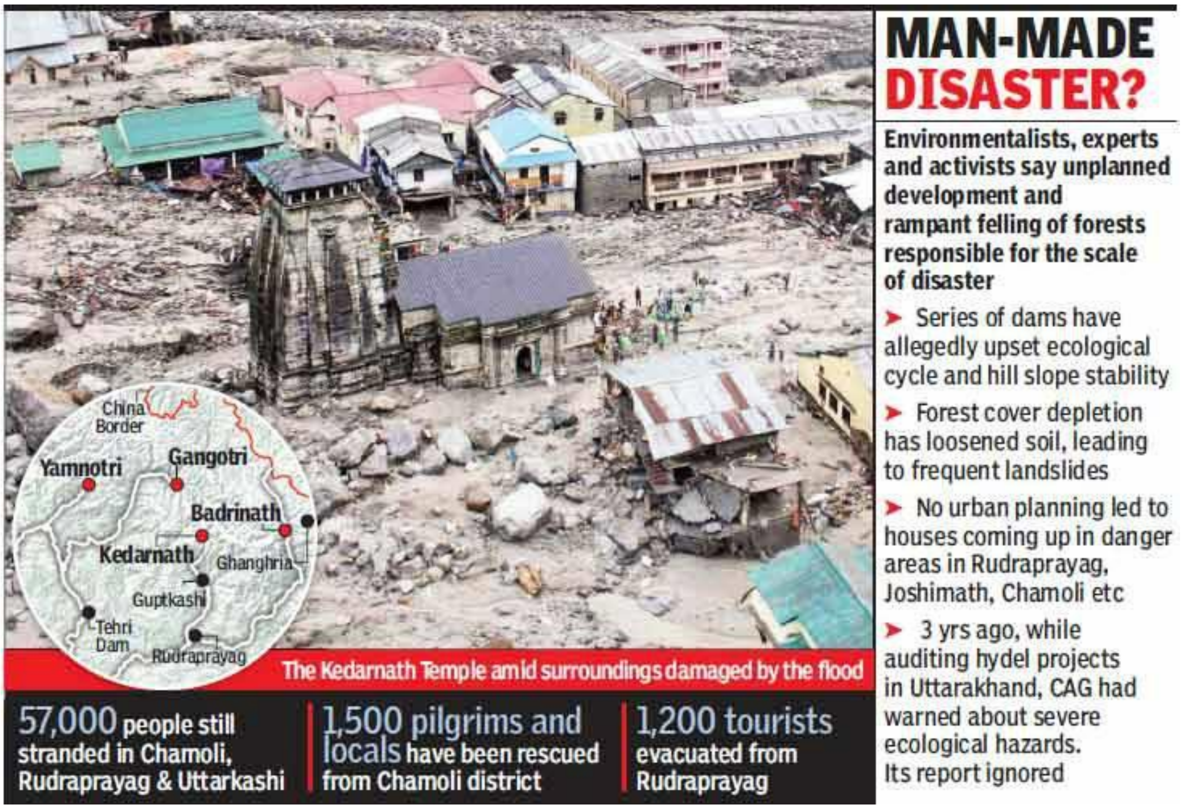

Fig.1.2. Source: (Times of India, June 20, 2013)

Fig.1.3. Source: (Down to earth, June 20, 2013)

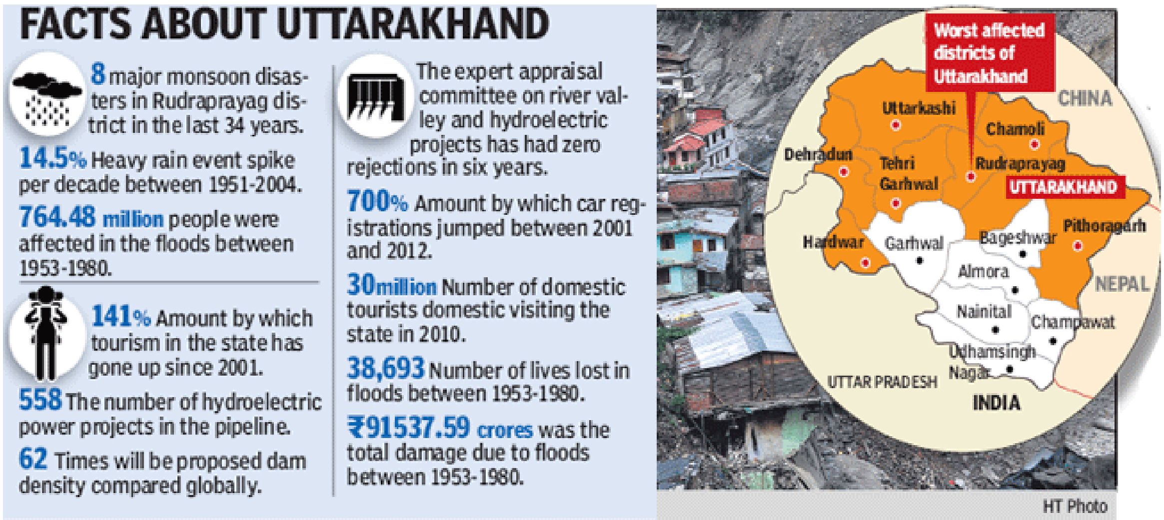

Fig.1.4. SOURCE: (Climate Himalaya, June24, 2013)

Facts about Flood, economy, tourism and loss:

8 Major monsoon disaster in Rudraprayag district in the last 34 years.

14.5% Heavy rain event spike per decade between 1951-2004.

764.48 million people were affected in the floods between 1953-1980.

141% Amount by which the tourism in the state has gone up since 2001.

558 The number of hydroelectric power projects in the pipeline.

62 Times will be proposed dam density compared globally.

700% Amount by which car registration jumped between 2001-2002.

30 million Number domestic tourists visiting the state.

38,693 Numbers of lives lost in floods between 1953-1980.

RS. 91537.59 crores was the total damage due to the floods in between 1953-1980.

Missing children, trafficking, biggest worries post-Uttarakhand disaster

State struggling to locate missing children, to bring back on track the life of nearly 2.5 lakh children

THE AFTERMATH

Smriti Kak Ramachandran

NEW DELHI: Official estimates peg the number of children missing in Uttarakhand post the flash-floods in June at 1,227 and as the State embarks on an exercise to assess its damage and rebuild what it has lost, it is not only struggling to locate these missing children but to also to bring back on track the life of nearly 2.5 lakh children who are currently out of school.

There are no schools to go to in flood-ravaged Uttarakhand, at least for now. While some have been entirely washed away, a large number are just dilapidated buildings and others have been transformed into shelters.

"The schools are still shut. We have begun the process of assessing the condition of school buildings and so far have found 180 such schools that need repair and rebuilding. The survey is underway and we still don't have the figures for severely-affected areas of Uttarkashi, Rudraprayag, Chamoli, Pithoragarh and Kumaon," Manisha Pawar, Secretary School Education, Uttarakhand told *The Hindu*.

Rehabilitation and counselling

The State Government is working out a financial package to rebuild schools and has announced a one-time grant of Rs. 500 per student to help them buy books and uniforms. "The district magistrates have been given the authorisation to decide when to open the schools. Depending on the weather forecasts and the conditions on the ground, they can take a call on whether schools can be reopened. Officially, all schools are shut till July 10. After that we will focus on how to make up for the lost days," Ms. Pawar said.

While the authorities are concerned about the disturbance to the academic calendar, non-government organisations are worried about the impact that the closure of schools will have on these students, and how the State will ensure their rehabilitation and counselling to deal with the trauma that they have had to face.

Step up vigilance

Organisations like the Bachpan Bachao Aandolan have also cautioned against possible child trafficking in the State. Chairperson of NGO Global March Against Child Labour and founder of Bachpan Bachao Andolan, Kailash Satyarthi said based on the experiences of previous natural disasters, he feared that Uttarakhand might turn out to be a hunting ground for child traffickers.

"I have seen this before during the tsunami, during the Assam and Bihar floods. Children who are orphaned or lose contact with their families become easy targets for the traffickers. In Bihar, during the Kosi floods, we rescued about 24 children from various places, including from trains," he said.

Urging the government to step up vigilance and monitor movement at railway stations, airports and bus stands, Mr. Satyarthi said the administration should take pre-emptive measures to ensure that the traffickers cannot make inroads into the State.

Vulnerable to trafficking

His concerns about trafficking are shared by the administration and other NGOs, though they are quick to point out that there have been no instances of children being trafficked so far. "Right now the focus is on finding the missing children. Of the nearly 600-plus deaths confirmed in Kedar Valley, nearly 30 per cent were children. As per the official data, there is only one girl child whose parents cannot be traced and she is currently in Doon Hospital," said Suresh Balodi, state manager, Plan India.

Child and women trafficking, he said, is a "possibility" given that a large number of families in several villages have lost their earning members.

"Young women, especially the ones who were recently married and have now lost their husbands; young children, out-of-school children are all vulnerable to trafficking. The administration and the social organisations working in the State will have to keep an eye on them and work out a plan for their rehabilitation to ensure that no instances of trafficking take place," Mr. Balodi stressed.

RESTORING INNOCENCE: The State Government is working out a financial package to rebuild schools and has announced a one-time grant of Rs. 500 per student to help them buy books and uniforms. PHOTO: AFP

Fig.1.5. Source: ((traffickingnews July 10, 2013.)

Inundation in flood plains encroached by settlements
Fig.1.6. Source: (thehindubusinessline July 15, 2013)

Dam in the upper reach of srinagar during floods
Fig.1.7. Source: (Dailymail June 18, 2013)

1.2 NEED FOR THE STUDY:

UKHIMATH DISASTER

‘Acting on scientific studies could have reduced losses’

MEASURES suggested by two studies after the 1998 disaster not implemented

Deep Joshi
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DEHRADUN: Many precious lives along with property worth several crores were lost to the massive cloudburst that hit Ukhimath area in Rudraprayag recently. Was the loss of such a gargantuan proportion preventable? It was, claim scientists who conducted two studies in the quake -prone area after it was hit by a massive cloudburst 14 years ago.

“I think several precious lives as well as property worth crores of rupees wiped out in the Ukhimath cloudburst on the night of September 13 could've been saved”, said Uttarakhand Space Application Centre (USAC) director Dr M M Kimothi who co-authored the twin studies.

According to him, the loss could have been prevented had the planners cared to implement the measures suggested by the twin scientific studies conducted in Ukhimath after the 1998 rainstorm. Kimothi dubbed the recent cloudburst as devastating in magnitude as the rainstorm that struck the area more than a decade ago.

“Like the recent cloudburst, the 1998 rainstorm also triggered a massive landslides in Ukhimath causing a huge loss of life and property”, said Kimothi, attributing the area's proneness to landslides to its “being tectonically active owing to its proximity to the Main Central Thrust (MCT) zone that is hardly a few miles away from that hill town.”

• Devastation after flash flood in Dangwari village in Ukhimath. HT FILE PHOTO

SCIENTIST SPEAK

“I think several precious lives as well as property worth crores of rupees wiped out in the Ukhimath cloudburst on the night of September 13 could've been saved”

“The loss could have been prevented had the planners cared to implement the measures suggested by the twin scientific studies conducted in Ukhimath after the 1998 rainstorm”

Kimothi, then a scientist at the Ahmedabad unit of the Indian Space Research Organisation (ISRO), was part of the teams that conducted the twin studies in Ukhimath subsequent to the massive 1998 rainstorm. Both the studies were conducted using satellite data, he said.

One of the studies clearly notes that villages falling in the Madhyamaheshwar sub-watershed (Ukhimath) reel under constant threat (of landslides). Noting further that looking at the nature of the terrain (Ukhimath) riddled by landslides there is an urgent need for rehabilitating them to safe locations, the study says it has identified 21 villages requiring rehabilitation. “In our study, we had also suggested that biotechnical measures be taken in Ukhimath area for slope stabilisation”, Kimothi said. “Had these and other suggested measures been implemented, the damage caused by the recent rainstorm in Ukhimath would've been far less in magnitude,” he noted.

The study also stresses the ‘urgency’ for initiating detailed scientific studies in the watersheds which are ‘proximal’ to MCT, to prevent the recurrence of loss of life caused by rainstorm as happened in Ukhimath. It also hinted that since Ukhimath was close to the tectonically active MCT zone, major rainstorm-induced landslides might occur there in future despite the area's thick forest cover.

Kimothi, while referring to another scientific report co-authored by him, said it suggested a number of scientific measures to prevent loss of life and property in the aftermath of the disasters. “For instance, it emphasises on the need to use state-of-the-art techniques like Global Positioning System (GPS) and communication tools like satellite telephones for speedy rescue operations,” he said while referring to the report titled ‘Landslide Induced Floods in the Upper Alaknanda Basin’ that was prepared in 2001 for a high level inter-departmental committee constituted by the union ministry of agriculture.

Roads catalyzed devastation: Expert

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PAURI GARHWAL: Recent information by the satellite eye has revealed a startling fact about the Ukhimath cloudboust on September 13. The satellite eye detected that the road connecting Mansoona village above Ukhimath also played a catalyst in enhancing the devastation caused by the cloudburst.

Director of Uttarakhand Space Application Centre (USAC) MM Kimothi said the satellite information showed that the cloudburst occurred at seven to eight places in the area and its impact on ground zero was much less than it was felt down the hill slopes.

The debris and the landslide gained momentum because of the road that meanders through some of these cloudsburst-affected areas.

THE SATELLITE EYE DETECTED THAT THE ROAD CONNECTING MANSOONA VILLAGE ALSO PLAYED A CATALYST IN ENHANCING THE DEVASTATION

In 1998, cloudbursts in Madmaheshwar valley near Ukhimath also took heavy toll on life and property.

Kimothi had been a member of the survey committee that had submitted a report to the government on the probable reasons behind the high devastation in the valley and its impact on life and property. It was suggested in the report that an intensive scientific study of the ecology should be conducted before carrying out any major construction work or laying roads in the hill slopes.

Fig.1.8. Source: (Climate Himalaya, June 19 2013)

1.2.1. TREND IN ANNUAL AVG. TEMPERATURE AND PRECIPITATION

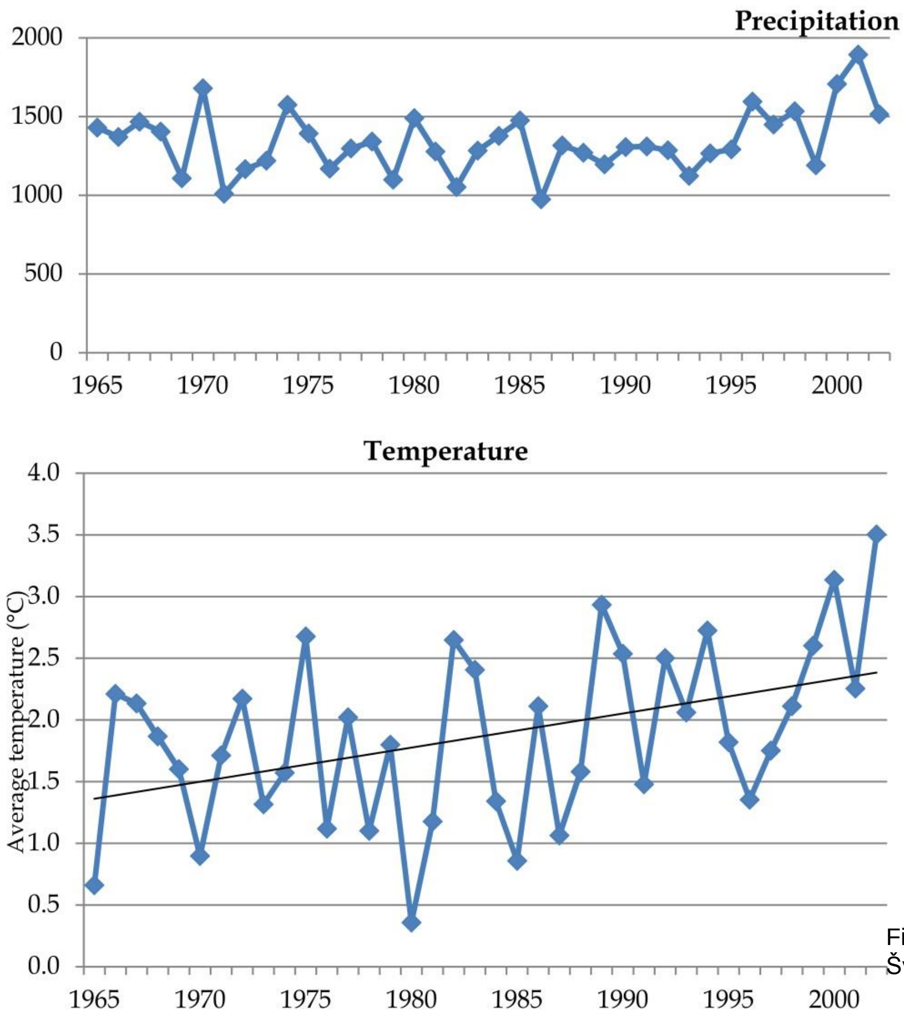


Fig.1.9.Source: Švajda et al., 2011

Trends in annual average temperature (in degrees Celsius) and annual total precipitation (in millimeters) from 1965 to 2002 at the meteorological station of Skalnate´ pleso (1751 masl), Slovak Institute of Hydrometeorology (Švajda et al., 2011).

1.2.2. SCIENTIFIC FACTS SHOWING THE EFFECT OF CLIMATE CHANGE IN HIMALAYA (Sandarp, June 25, 2013)

Unprecedented Climate Change in Himalayas (This section is largely based on ICIMODs report: The changing Himalayas – Impact of climate change on water resources and livelihoods in the Greater Himalayas)

a. Impact on Precipitation:

In many areas, a greater proportion of total precipitation appears to be falling as rain than before. "Flooding may arise as a major development issue. It is projected that more variable, and increasingly direct, rainfall runoff will also lead to more downstream flooding." (ICIMOD n.d.)

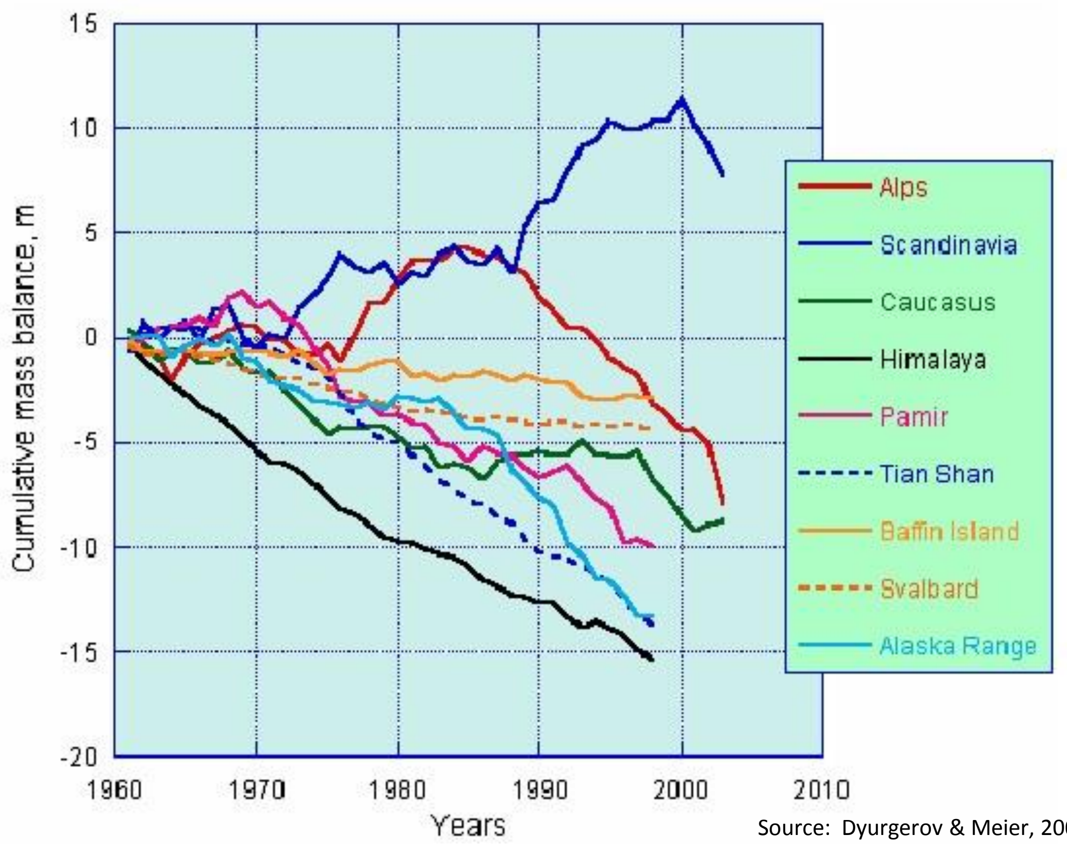
b. Retreating glaciers:

As compared to global averages, Himalayan glaciers are receding at a rapid rate. Retreat in glaciers can destabilize surrounding slopes and may give rise to catastrophic landslides (Ballantyne and Benn, 1994; Dadson and Church, 2005). Available studies suggest changes in climatic patterns and an increase in extreme events. An increase in the frequency of high intensity rainfall often leading to flash floods and land slides has been reported Fig.1.10.(Chalise and Khanal, 2001; ICIMOD, 2007a).

c. Higher frequency of flash floods and GLOF events:

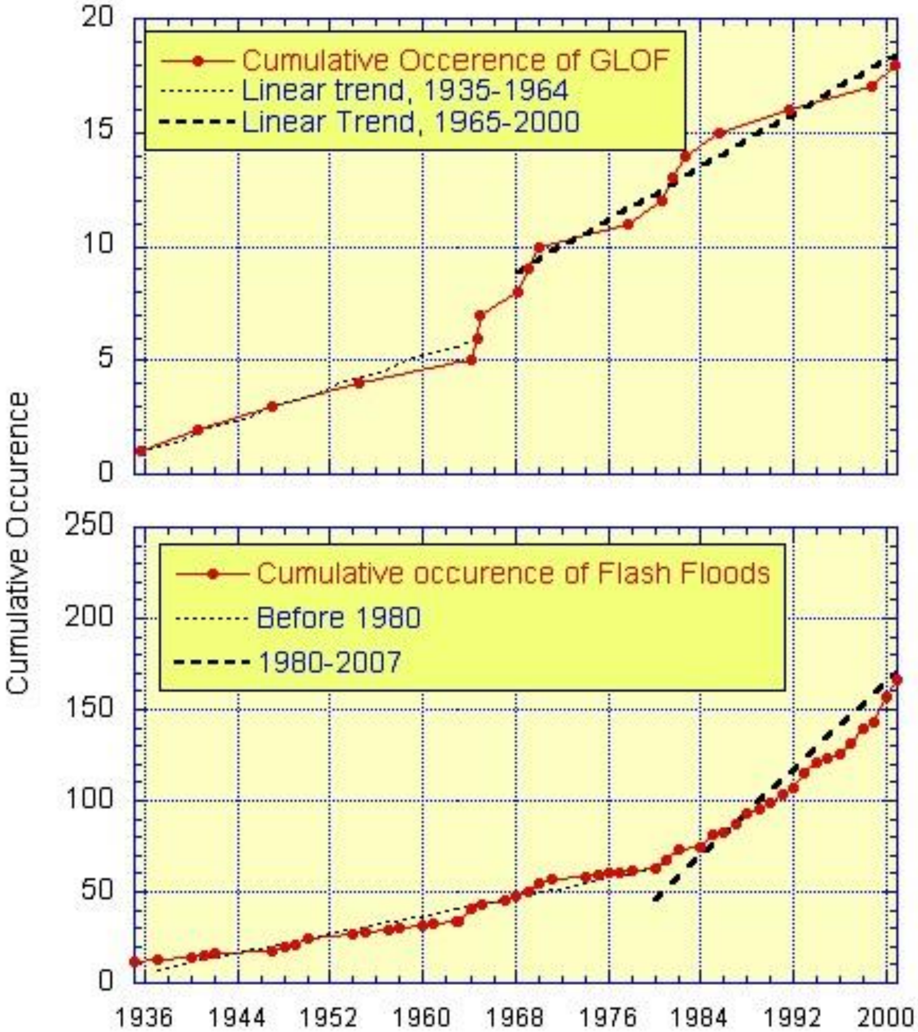
In the eastern and central Himalayas, glacial melt associated with climate change, has led to the formation of glacial lakes behind terminal moraines. Many of these high-altitude lakes are potentially dangerous. The moraine dams are comparatively weak and can breach suddenly, leading to the discharge of huge volumes of water and debris. The resulting glacial lake outburst floods (GLOFs) can cause catastrophic flooding downstream.

The region's climate, which has been changing rapidly, will continue to do so in the future, with severe consequences for populations locally and downstream. Fig.1.10.(Sandarp,2013)



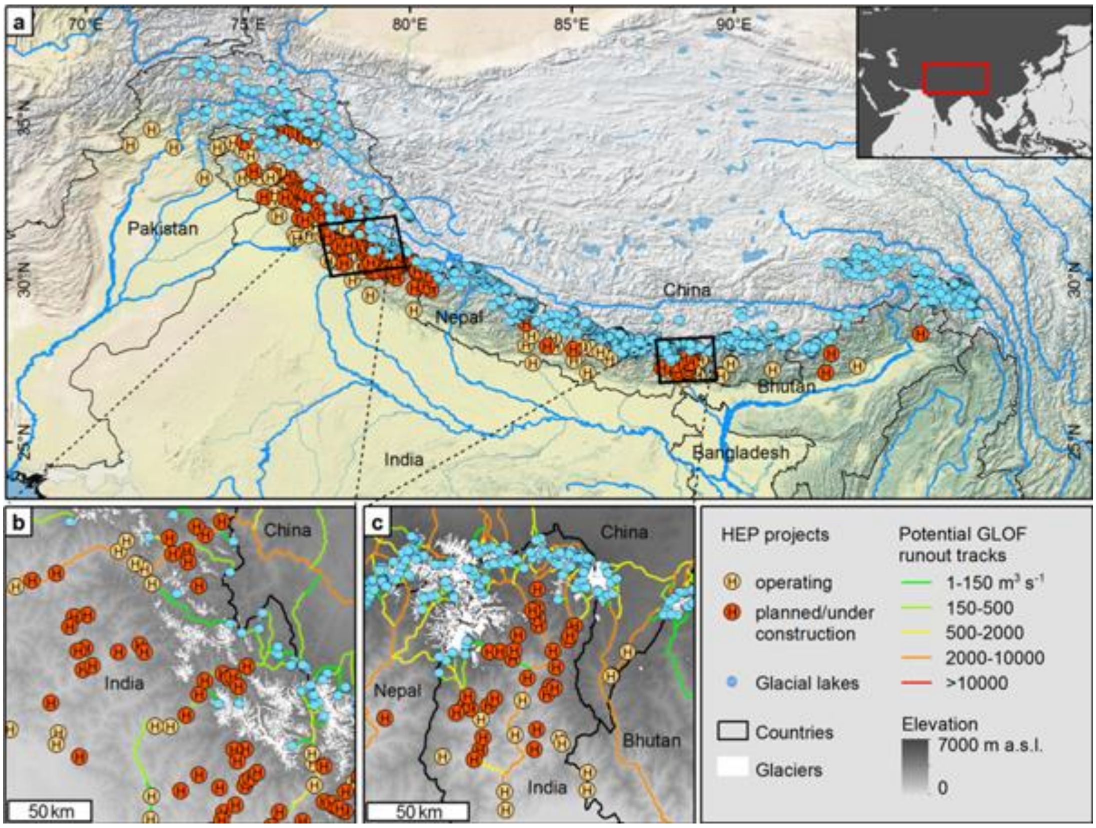
Source: Dyurgerov & Meier, 2005)

Fig.1.10. Rapid retreat of Himalayan Glaciers as compared to global averages



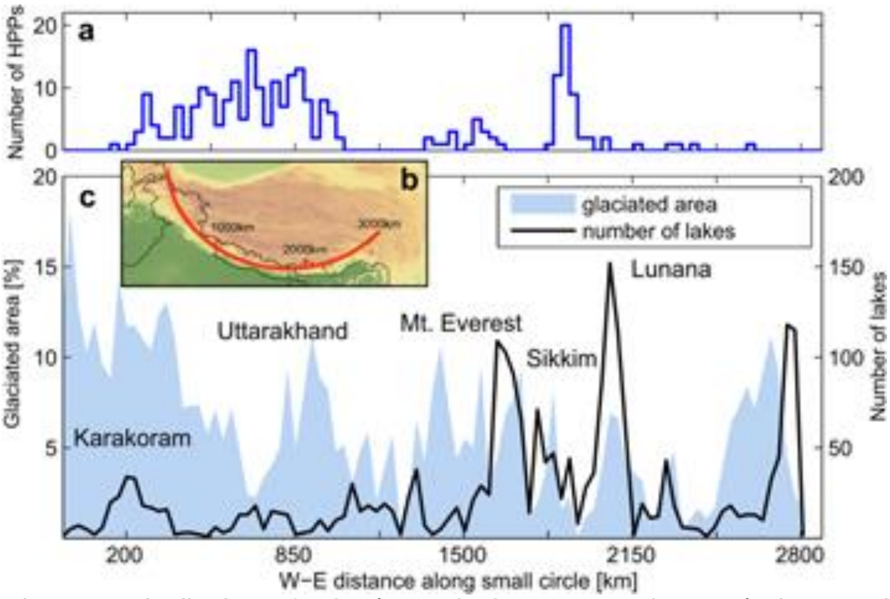
Source: (top, source NEA 2004), (bottom, source Xu Jianchu et al. 2007)

Fig.1.11. Rapidly increasing frequency of flash floods and GLOFs in Himalayas



Source: IOPScience July 8, 2016

Fig.1.12. Distribution of 2231 Himalayan glacial lakes and studied hydropower projects. (a) Overview map of the study area. Insets (b), (c) show GLOF tracks from glacial lakes in the Indian states of Uttarakhand (b), and Sikkim (c). Color scale of GLOF tracks refers to median estimate of modeled peak discharge (m^3 s^{-1}) averaged over 2 km channel segments. Where rivers accommodate multiple GLOF tracks, colors refer to the track with the highest peak discharge. Wolfgang Schwanghart, Raphael Worni, Christian Huggel, Markus Stoffel and Oliver Korup)



Source: IOPScience July 8, 2016

Fig.1.13. Distribution of Himalayan hydropower projects, glaciers, and glacial lakes. (a) Distribution of HPP sampled in this study along a small circle fitted to the axis of the Himalayan arc (inset (b)). (c) Percentage of glaciated area above 1900 m asl, and number of glacial lakes.

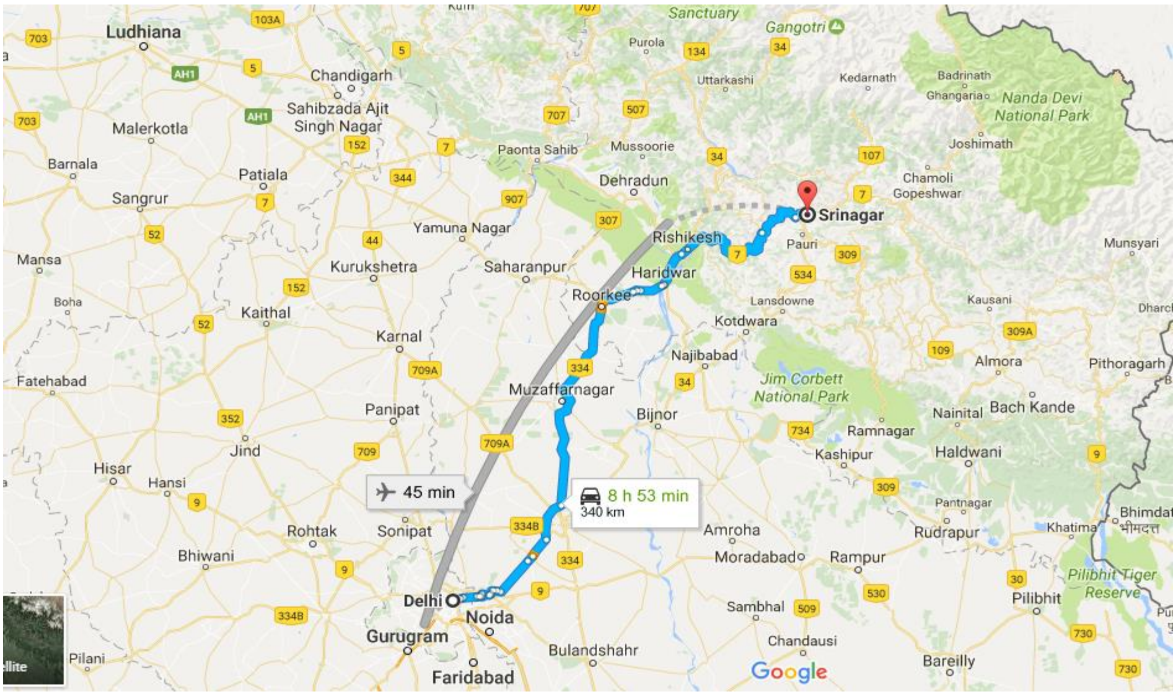
1.2.3. EFFECT ON THE DOWNSTREAM HIMALAYAN CITY, SRINAGAR GARHWAL

a. Location

Srinagar is one of the most populous and largest valley town in hilly Garhwal region of Uttarakhand because of its geographical location, and distance from the nearest plain cities. A town of historical importance, where Garhwal and Gorkha kingdom ruled for hundreds of years. It is located at 30.22°N 78.78°E.at the left bank of Alaknanda river with an average elevation of 560 meters in lesser Himalayas. It is reached by national highway NH58 from Rishikesh, Srinagar is about 100 km from Rishikesh which is the last city on the plains of Uttarakhand and from where the mountains start.

Unfortunately It is hard to find any ruins of the past in the present city because of continuous struggle to intact itself from the pressure caused by the floods in the Alaknanda river valley and in present context is deteriorated by the construction of dam in upper reaches. So in order to adapt itself from the floods, building flood resilience along the city becomes important.

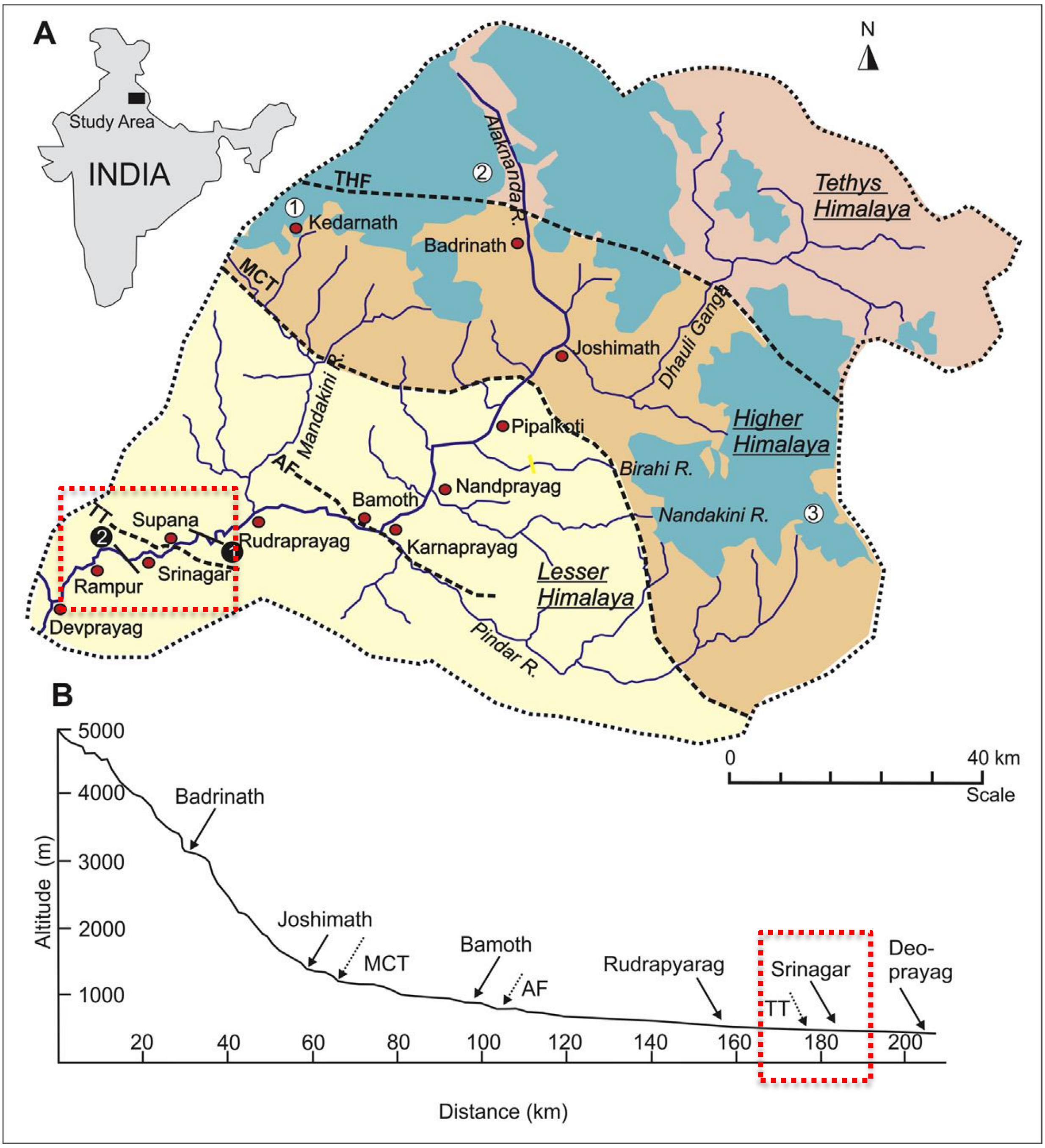
Which can be done by designing the in response to the flood plains, and watershed of region which involves public and is used as buffer space for the river and city.



Source: Google Map

Fig.1.14. Location map of Srinagar Garhwal from nearby cities.

b. Physiography location in Alaknanda basin:



SOURCE (Shipra Chaudhary a 2015)

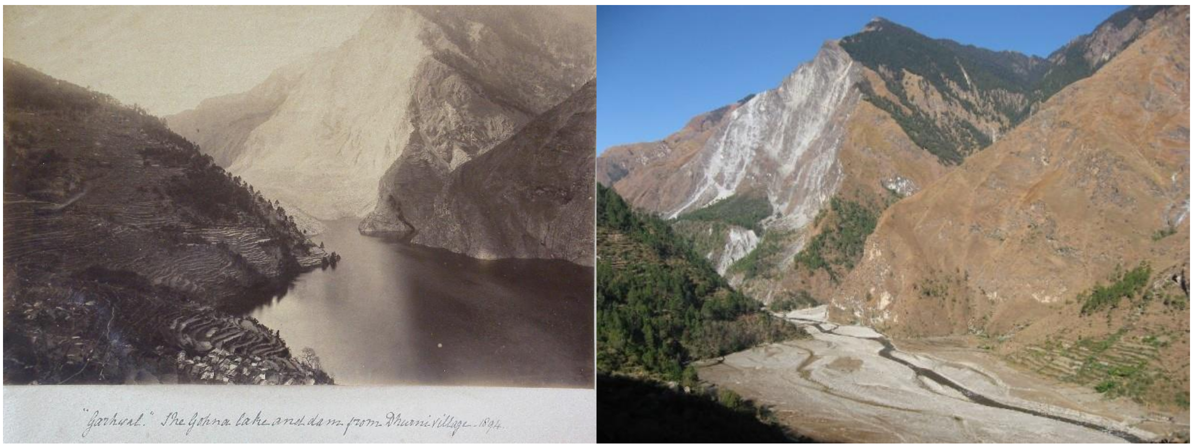
Fig.1.15. Formation of paleovalleys in the Central Himalaya during valley. (A) Map of Alaknanda River catchment showing major locations and regional faults along its course. Present study area around Tons Thrust (named as TT in the map). Black solid lines across the Alaknanda River represent two local faults: (1) the Kaliasaur and (2) the Kirtinagar Fault. Catchment glaciers namely Chorabari glacier (Mehta et al., 2012), Satopanth glacier (Nainwal et al., 2007) and Pinadari glacier (Bali et al., 2013) are marked as 1, 2 and 3 respectively. The bar across Birahi River is location of source of 1894 and 1970 floods in the valley. (B) Longitudinal profile of Alaknanda River (after Tyagi et al., 2009). Note the change in gradient after MCT particularly at Srinagar.

c. History of floods in Srinagar Garhwal

Uttarakhand Himalaya in general and Alaknanda and Bhagirathi valleys in particular have experienced one of the worst forms of disaster in recent times. Flash floods are common in the Himalaya, but the kind of destruction witnessed this time was unparalleled in recent history. Probably the worst causality of the century was the destruction of Kedarnath valley. According to the data published in various national dailies, nearly 4000 people were either killed or lost, 2232 houses were damaged, 1520 roads in different parts of Garhwal were badly damaged and about 170 bridges have been washed away. According to economists, the tourism industry in Uttarakhand will suffer a loss of ~12,000 crore rupees, which is around 30% of the state’s GDP.

In order to appreciate the sensitivity of the terrain towards unusual weather events like cloudburst, let us look into the genesis of two major flash floods, viz. 26 August 1894 and 20 July 1970. These floods are reasonably well documented. The 1894 flood occurred well before the commercial forest felling extended into the inner catchments of the Alaknanda, whereas the 1970 event occurred when the commercial forest felling was at its peak in the Alaknanda valley. However, both floods owe their genesis to the breaching of dams created by landslides on the tributaries of the Alaknanda river, a common geomorphic expression during unusual rainfall events in the monsoon-dominated Himalaya.

On September 1893, a tributary of the Alaknanda river called Birahi Ganga was blocked by ~5000 million tones of rock mass that rolled from 900 m high valley flank. The debris blocked the river forming a lake 270 m high, 3 km wide at the base and 600 m. (N. Rana, 2013)



1894 2016

SOURCE: (the-south-asian.com, June 2008)

Fig.1.16. Gohna lake dam in 1894 and 2016

Table 1. Timeline of major disaster and its effect on Srinagar town

Years	Natural calamity	Impacts on Srinagar (selected excerpts from study papers published in leading journals
1st Sep. 1803	**7.5 + magnitude Earthquake**	When Colonel Hardwicke visited this place in 1796, it was perhaps not in its prime, but contained (as he computed) 700 or 800 houses and a good bazar. When Messrs. Webb and Raper, In 1808, passed through it on their way to Badrinath, it had sunk deeply in importance, and was to all appearance rapidly advancing to decay. An Earthquake had occurred in 1803, which had done considerable injury: many houses were ruined, and the Rajah's palace was particularly shattered; and the encroachments of the river Alaknanda yearly destroy a portion of that which yet stands, threatening in time to sap the foundations of all. If there were so many earthquakes in the Garhwal Himalaya at regular intervals since the large earthquake of 1803 till 1817 followed by a lull period up to 1831, a possible explanation could be that aftershock sequence for the 1803 earthquake continued for ~ 14 years and in that case the 1803 earthquake could have been a major event.
24 Aug. 1894	**Gohna lake burst**	In 1893, a landslide — the largest known in central Himalaya blocked the Birahiganga to form a colossal 350 m-high dam. The lake behind the dam, now known as Gohna Tal, was 5 km long and 2 km wide. 10 months later, a part of the landslide dam toppled. **The sudden surge of water sent a tidal wave down the valley raising the level of the Alaknanda by 50 m at Srinagar some 100 km away,** and the entire town was washed away. Hours later, when the wave reached Hardwar, another 100 km away, the Ganga's level rose by nearly 4m.
Sep. 1969	**Kaliasaur Landslide**	In 1969, a huge landslide took place some 3 km upstream of the small market place of Kaliasaur and blocked nearly 3-4 of the width of the river. There was heavy rainfall during the week preceding the landslide with a flood in the river the day it occurred. Since 1969, the slide has become a menace for traffic.

Years	Natural calamity	Impacts on Srinagar (selected excerpts from study papers published in leading journals
20 July 1970	**Flood induced by cloud burst**	During July 1970, the Alaknanda valley witnessed the second major flood. This was attributed to a cloudburst on the southern mountain front in the Alaknanda valley (between Joshimath and Chamoli). According to an estimate, flood transported about 15.9 million tones of sediment within a day. The catastrophe was so large that it wiped out the leftover of the 1894 Gohna lake. Besides, 13 bridges were swept away and far away at Haridwar, around 10 km stretch of the Ganga canal was clogged with sediment and uprooted trees. **Again Srinagar town had to bear the brunt, virtually the lower town was completely destroyed by the flood.**
7-8 Sep. 2010	**Flood induced by cloud burst and glacial lake burst**	During September 2010 for the first time the lesser Himalaya witnessed such a large-scale slope mobilization either along the roads or around the towns with accelerated and unscientific construction over unsafe slopes in the last few years. It was observed that around 300 landslides of various dimensions riddled NH-58 in September 2010. Majority of them occurred south of the Main Central Thrust between the Alaknanda Fault (AF) and Saknidhar Thrust (ST). In addition, 20 urban settlements located along the highways were severely damaged. The chronic Kaliasaur landslide which had been dormant for a few years due to the efforts of various government agencies has now been reactivated.
16-17 June 2013	**Himalayan Tsunami**	The high flood caused morphological changes to the river, extending several kilometers downstream of the dam. The river carved out a new course to the right immediately below the dam and kept attacking the concave bank against the HNB University area scouring 100 m of the bank. **Deposition of fine sediment upto 7 to 8 m height occurred in Srinagar urban area, where velocity was lower of the order of 3 m/sec.**

SOURCE: (sandrp.wordpress.com, 2015)

1.3. URBAN RESILIENCE IN HIMALAYN CITIES

1.3.1. Urban resilience is the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience. (Global migration: resilient cities at the forefront100 resilient cities).

Himalayan cities are always under stress due to its high vulnerability to natural hazards. *"Forest fires, flash floods, earthquakes and landslides constantly affect communities in this region, and the impacts of climate change and human migration are only making them more vulnerable."*

— Alark Saxena, Director of Yale Himalaya Initiative

Cities are changing. Mass migration to cities is the new reality and it can exacerbate existing stresses - chronic issues that weaken the urban fabric, such as aging infrastructure, unemployment, food and water scarcity, inequality, and violence.

Failure to address these risks can exacerbate major disasters when they occur. It also represents a missed opportunity for a city to leverage the socio-economic and cultural capital of migrants, whose contributions can become fundamental resources for building urban resilience.

The idea is rather than resisting we need to embrace it, If this is acknowledged and plans are made to anticipate and respond to the potential pressures of mass migration on urban systems, the arrival and presence of newcomers will be less likely to be perceived as a threat. Mass migration can instead be seen as an opportunity to improve a city's structure and its communities.

Karen Seto said. "It is important to understand where and how these settlements are changing — and what kinds of lands are being converted from agricultural use to urban settlement — because that affects vulnerability."

1.3.2. Srinagar as a resilient city

Srinagar itself is one of the most populous town in the region. This city acts as a major link between cultural and tourist nodes for the locals and outsiders. In case of extreme events the city is under chronic stresses from hazards and its effects. Mass migration from villages and small towns have put pressure on the city with limited buildable land. As city fabric is expanding the encroachment along the lower flood plain is visible, which was disrupted by the recent floods of 2013. So it is important to understand the vulnerability of the edges and its relation with city network which extends to other part of the region and city itself. The resilience will enable the city to act in response to floods and will help city to embrace it by giving it the space it needs.

1.4. ROLE OF LANDSCAPE ARCHITECT IN BUILDING URBAN RESILIENCE

The planning and design of storm water systems is a very common component of landscape architecture. The profession brings its design and ecology lens to storm water projects aiming to provide richer solutions compered to solely engineering options. This is not saying that engineering options are poor. It is suggesting that storm water projects can benefit from design professions such as landscape architecture.

In order to mitigate the impacts of climate change, we need to understand not only the site and its larger landscape, but the interaction of land, water, and temperature, and how they all function by using the natural protection of wetlands, dunes, and maritime forests. Much of the damage caused by flooding is from developing land that is in flood zones: valuable with great waterfront views, but in flood plains that should be free of development, functioning to contain flood waters. In designing the built environment, landscape architects are called upon to mitigate risk. Though risks vary in type, scale, and cause – from natural disasters to terrorism – most risks have a common denominator: ultimately transcending individual structures and occurring at a landscape scale.

As landscape architects, it's imperative that we learn from nature and use our knowledge of environmental processes in designing places that can reduce risk, adapt to climate change, and function as great public open space that is ecologically and aesthetically rich. Before we begin the planning and design of creating resilient places, we need to take into account the risk factors of any given place. Designing for the last disaster is never the best plan. (Donna Walcavage 2016)

1.5. AIM

Proposing measures at policy and design level to make the Srinagar city resilient to flood by strengthening river bank system.

1.6. OBJECTIVES

- Guideline on the basis of vulnerability mapping of the Alaknanda river in Srinagar catchment basin.
- To demarcate the buffer zone along river and in the micro catch basin.
- To bring people and river together through riparian edge by designing a proposal in one of one vulnerable area.

1.7. SCOPE AND LIMITATION

- The scope for study is limited to Srinagar town and its site catchment and will focus on the vulnerability of city edges with different land use by marking different buffer zone.
- It will give design proposal to one specific vulnerable zone by creating recreation spaces due of time constraints.

1.8. METHODOLOGY

1.8.1. PRE SITE VISIT

a. Literature review

It will help in identifying the level of risk that are present in the region and interconnectedness of these multidimensional risk, which once break can paralyze the whole system by affecting nature and its inhabitant.
Identifying the risk natural or human induced, that can danger the existence of Srinagar as a cultural, educational force in the region.

b. Case studies

The world is progressing by creating flood resilient urban cities with some example which have included public and have understood and acknowledged the natural system while adapting to it. The synthesis will help in understanding the ways resilience can be achieved with the context of the lesser Himalayan city Srinagar Garhwal.

1.8.2. SITE STUDY AND ANALYSIS

a. Site analysis

The landscape layers Climate, Geology, Hydrology, Soils, Physiography, Geomorphology, Vegetation, Wild life, Land Use, Agriculture development, Master plan with supporting graphical representation should be collected or prepared with respective departments.

b. Urban site suitability analysis

Flood in response to geomorphology.

Land Use in catchment in response to geology, soil and geomorphology

Slope analysis

Impact areas

Master Plan in response to flood

Vegetation

1.8.3. DESIGN INTERVENTION

Site selection for urban park

Plan and Section

2. LITERATURE STUDY

2.1. DISASTER RISK

Disaster risk is expressed as the likelihood of loss of life, injury or destruction and damage from a disaster in a given period of time.
(UNISDR Global Assessment Report 2015)
Disaster risk is widely recognized as the consequence of the interaction between a hazard and the characteristics that make people and places vulnerable and exposed. Disasters are sometimes considered external shocks, but disaster risk results from the complex interaction between development processes that generate conditions of exposure, vulnerability and hazard (UNISDR, 2009a). Disaster risk is therefore considered as the combination of the severity and frequency of a hazard, the numbers of people and assets exposed to the hazard, and their vulnerability to damage (UNISDR, 2015a).
Intensive risk is disaster risk associated with low-probability, high-impact events, whereas extensive risk is associated with high-probability, low-impact events.

Disaster risk has many characteristics. In order to understand disaster risk, it is essential to understand that it is:
Forward looking: the likelihood of loss of life, destruction and damage in a given period of time
Dynamic: it can increase or decrease according to our ability to reduce vulnerability
Invisible: it is comprised of not only the threat of high-impact events, but also the frequent, low-impact events that are often hidden
Unevenly distributed around the earth: hazards affect different areas, but the pattern of disaster risk reflects the social construction of exposure and vulnerability in different countries
Emergent and complex: many processes, including climate change and globalized economic development, are creating new, interconnected risks (preventionweb)

2.2. INTERCONNECTEDNESS OF MULTIDIMENTIONAL RISKS

THE URBAN DOMINO EFFECT: A CONCEPTUALIZATION OF CITIES' INTERCONNECTEDNESS OF RISK,

The influence of cities on disasters:

factors that influence disaster risk are: (a) hazards; (b) location-specific vulnerabilities; (c) disaster response mechanisms and structures; and (d) disaster recovery mechanisms and structures (Wamsler 2014).

All urban sectors are exposed to disasters and climate change. Table 1 illustrates how they are impacted.

Urban sector	Disaster impacts- further increased urban risks
Housing, recreation and cultural heritage	Destruction of housing, which is typically most affected by disaster. Damage to, or loss of parks and other recreation sites (playground in flood prone areas). Damage to, or loss of heritage sites, having negative effects on people's identity, tourism and thus cities economic development. Damage to, or loss of land and real estate. Modification of the landscape (due to changes in the course of rivers or slopes, etc.) Population density increases (e.g. environmental refugees) and overpopulation due to housing stock. Increased depreciation and wear of construction materials due to greater climate variability.
Water and sanitation	Damage to, or destruction of, water and sanitation Infrastructure. Negative impacts on the availability and quality of water, which aggravate conflicts between end users. Contamination of drinking water wells . Overburdened wastewater and sanitation systems.

Urban sector	Disaster impacts- further increased urban risks
Energy	Destruction of power lines and other energy infrastructure. Reduced cooling efficiency of thermal power due to higher air and water temperatures and / or lower water levels. Changes in wind power and hydropower (Due to change in precipitation and wind pattern, etc.) Increase and/ or changing demand for heating and cooling, leading to increased energy use and blackouts. Electricity failure and power outages that disrupt other vital urban services such as health care, transport and water supply).
Transportation and telecommunications	Destruction of roads, railways, bridges, pipelines, data sensors and telecommunication networks. Poor road/ transport condition (due to heat, ice, wind, etc.) and more accidents (due to insecure thought fares).
Environmental and natural resource management	Impacts on the urban ecosystem that are directly linked to human wellbeing. (e.g.. temperature, air quality, humidity, vegetation growth and disease vectors such as mosquitos). Impact of drought and/ or new pests on urban vegetation(due to a warmer climate). Impacts on natural protection against disasters (e.g. permeable surfaces and wetlands)
Social and public services	Damaged or destroyed health care units and schools. Impacts on the provision of health and social care, education, police, fire fighting and emergency services (due to changing risk patterns and direct impacts on service provision).

Table 1: Impact of disasters and climate change on urban sectors that lead to increasing risk.

Source: Adapted from Wamsler 2014.

SOURCE: Christine Wamsler and Ebba Brink Lund University Centre for Sustainability Studies (LUCSUS), January 2014

2.3. DISASTER RISKS PRESENT IN ALAKNANDA CATCHMENT

2.3.1. LOCATION OF ALAKNANDA BASIN:

The Alaknanda river Basin is characterized by hilly terrain, deep gorges and river valleys. The region is broadly divided into four major divisions

(i) The Great Himalayan Ranges . (ii) Alpine and pasture land (iii) Middle Himalaya (characterized by high concentration of population) and (iv) River valleys (characterized by mushrooming service centers and institutions).

Among the major rivers of India, the Alaknanda River and its tributaries (Dauli Ganga, Vishnu Ganga, Nandakini, Pindar, Mandakini and other numerous perennial streams) originate and flow here. The drainage pattern is of sub-parallel and dendritic type, which is mainly structure controlled. Deep transverse gorges are the Characteristic Features of the Alaknanda river basin of Garhwal Himalayas vary from subtropical (e.g. Dehradun) to alpine (e.g. Mana). Alaknanda basin with 10882sq. Km. is located in southern slopes of the outer Himalayas. (BW Pandey and A S Prasad, 2016)

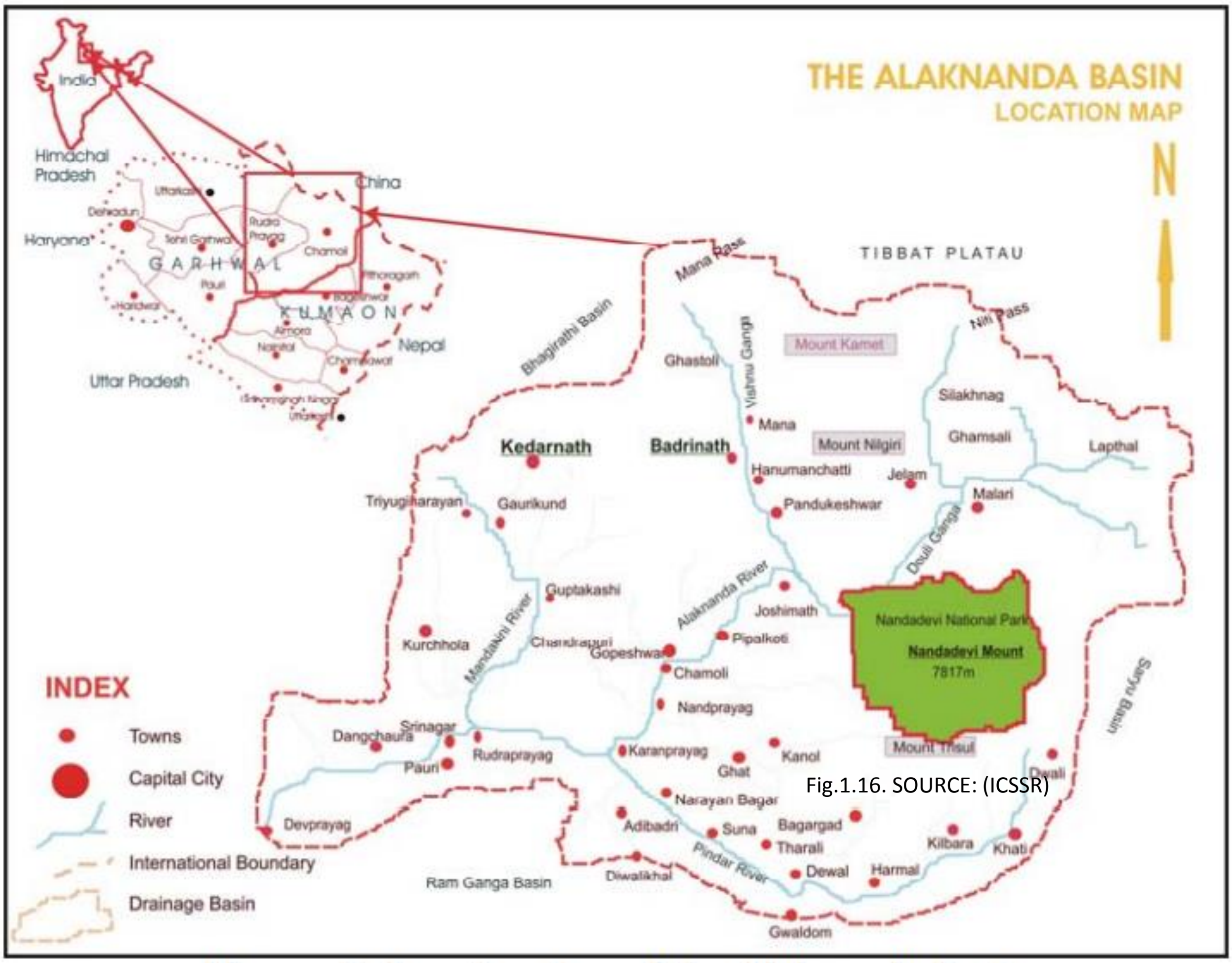


Fig.1.16. SOURCE: (ICSSR)

Fig.2.1. Location Map of the Alaknanda Basin and major towns near in river valley

2.3.2. CLIMATIC CONDITION IN ALAKNANDA BASIN

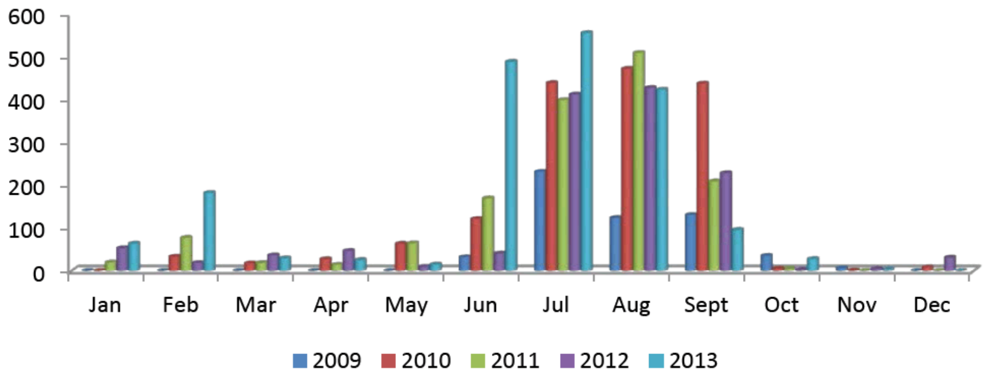


Fig.2.2. Avg. Monthly rainfall (mm) in Upper Alaknanda valley for last 5 years. Exceptionally high rainfall in July 2013 can be observed. (Source data: IMD).

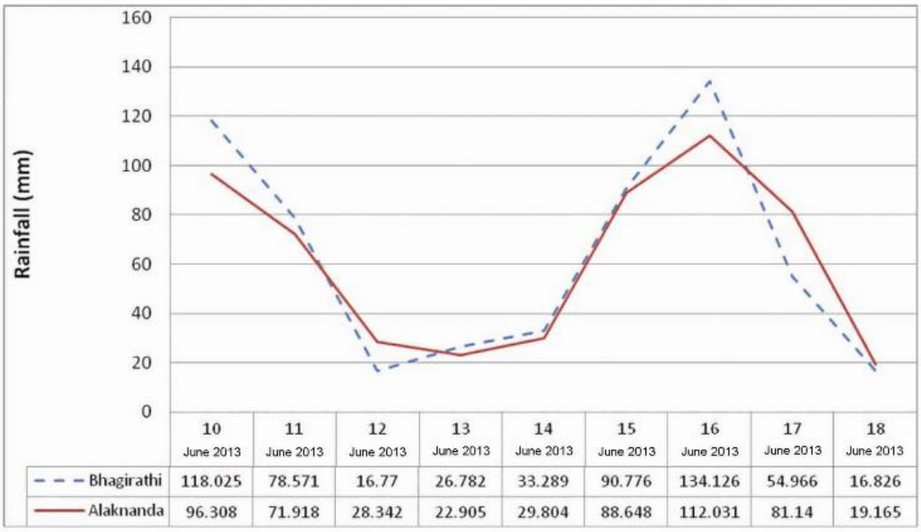
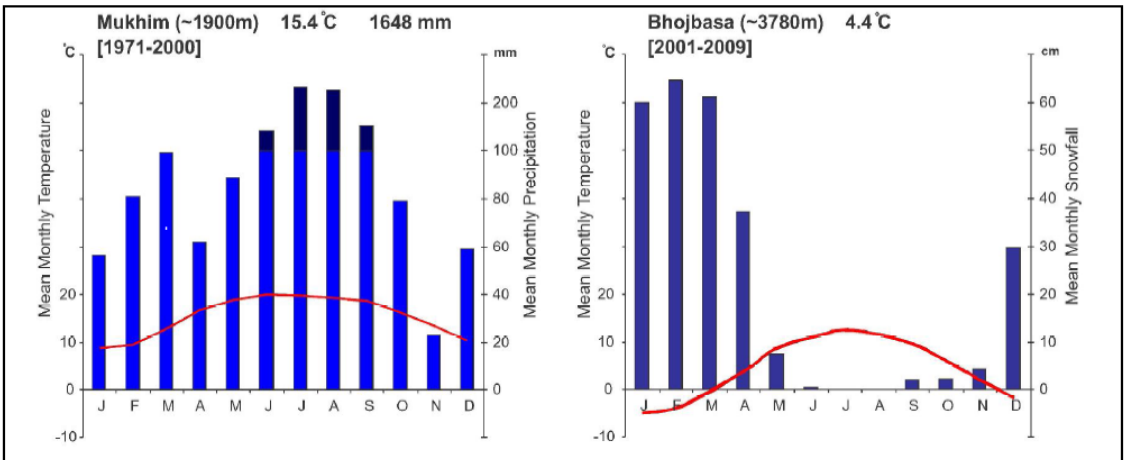


Fig.2.3. Temporal distribution of rainfall in the Bhagirathi and Alaknanda catchments during the flood event . (SOURCE: TRMM data).



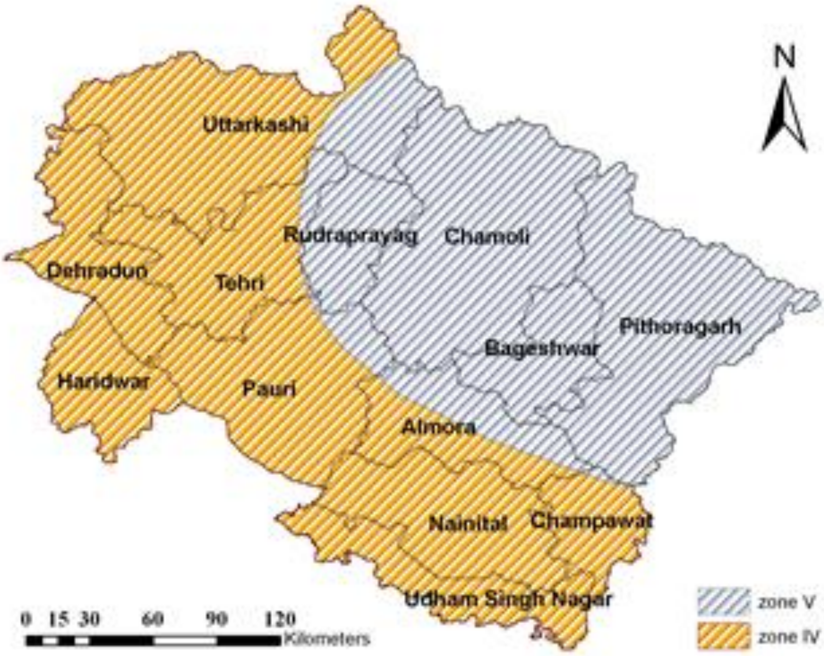
Data sources: Indian Meteorological Department (IMD) and Snow and Avalanche Study Establishment (SASE).

Fig.2.4. Climatic diagrams of mukhim and bhojbasa stations. SOURCE: Data sources: Indian Meteorological Department (IMD) and Snow and Avalanche Study Establishment (SASE).

The mean annual air temperature (MAAT) of Mukhim station, Garhwal Himalayas (~1900 m a.s.l. ~70 km aerial distance from the snout of Gangotri Glacier) is 15.4 °C and annual precipitation is 1648 mm.

2.3.3. HAZARD AND VULNERABILITY IN ALAKNANDA CATCHMENT

a. Earthquake:



SOURCE: (NDMA)

Fig.2.45 Uttarakhand earthquake zoning , The majority of Alaknanda catchment basin (grey hatch) comes under zone V, creating the highest recorded earthquake in history,

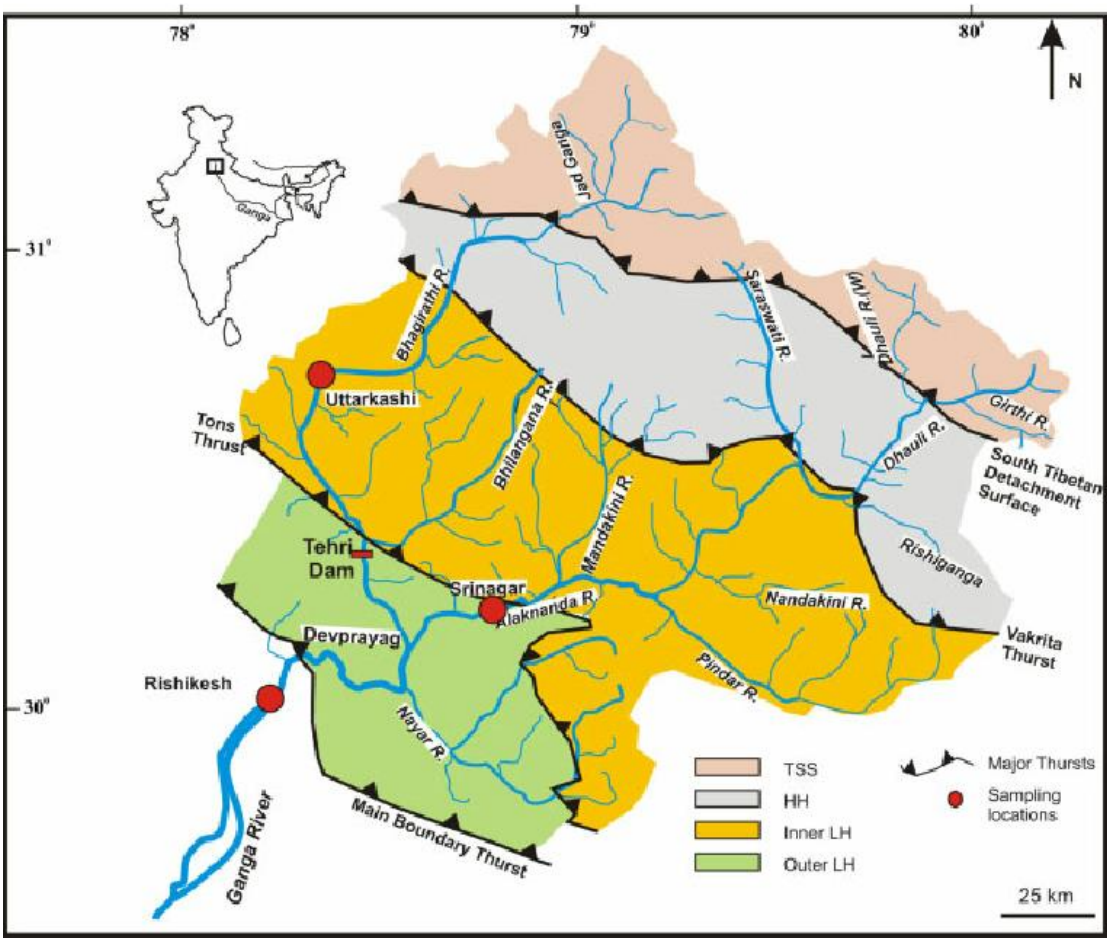
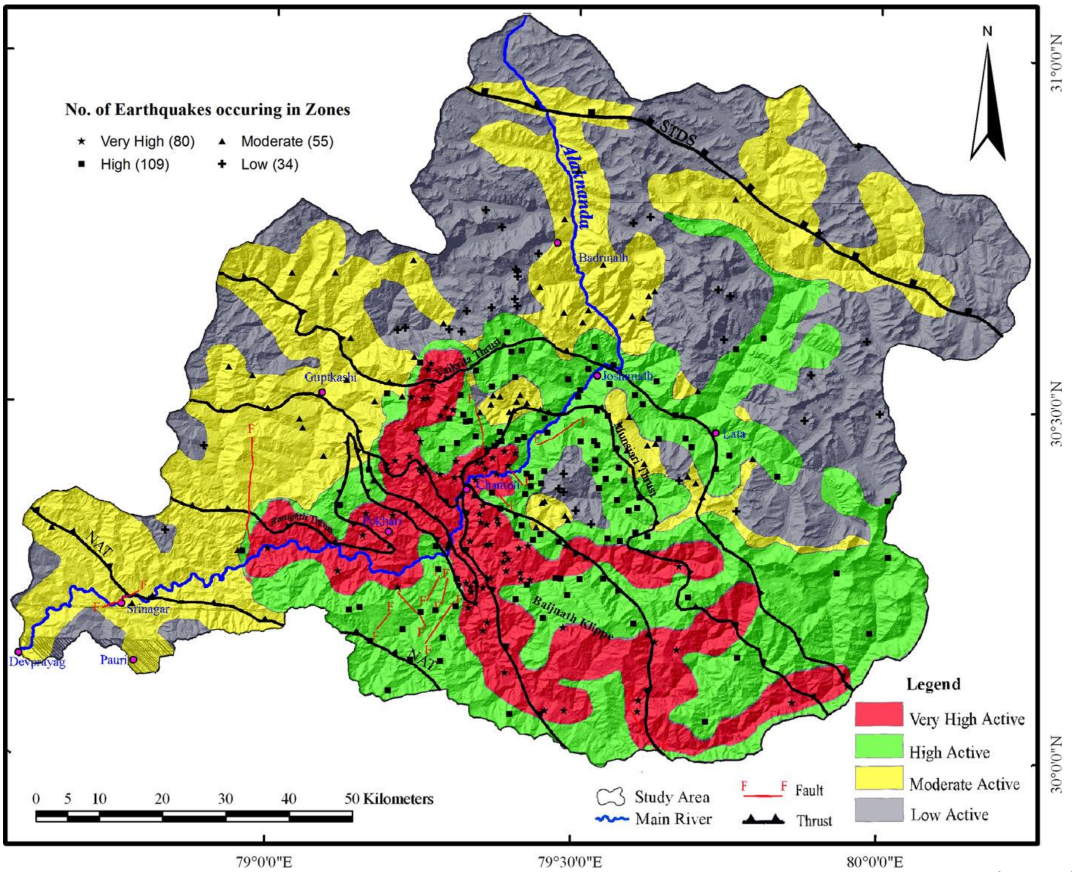


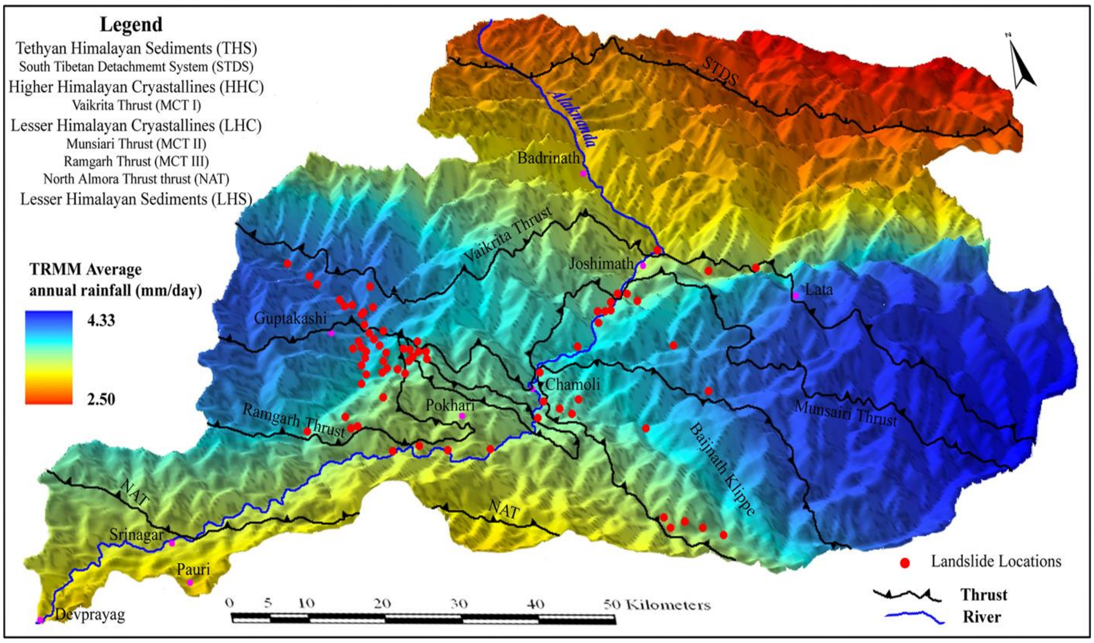
Fig.2.6. Lithology of the drainage basin of the Alaknanda basin. SOURCE: Bickle et al ., Research gate, 2003



SOURCE: (NDMA)

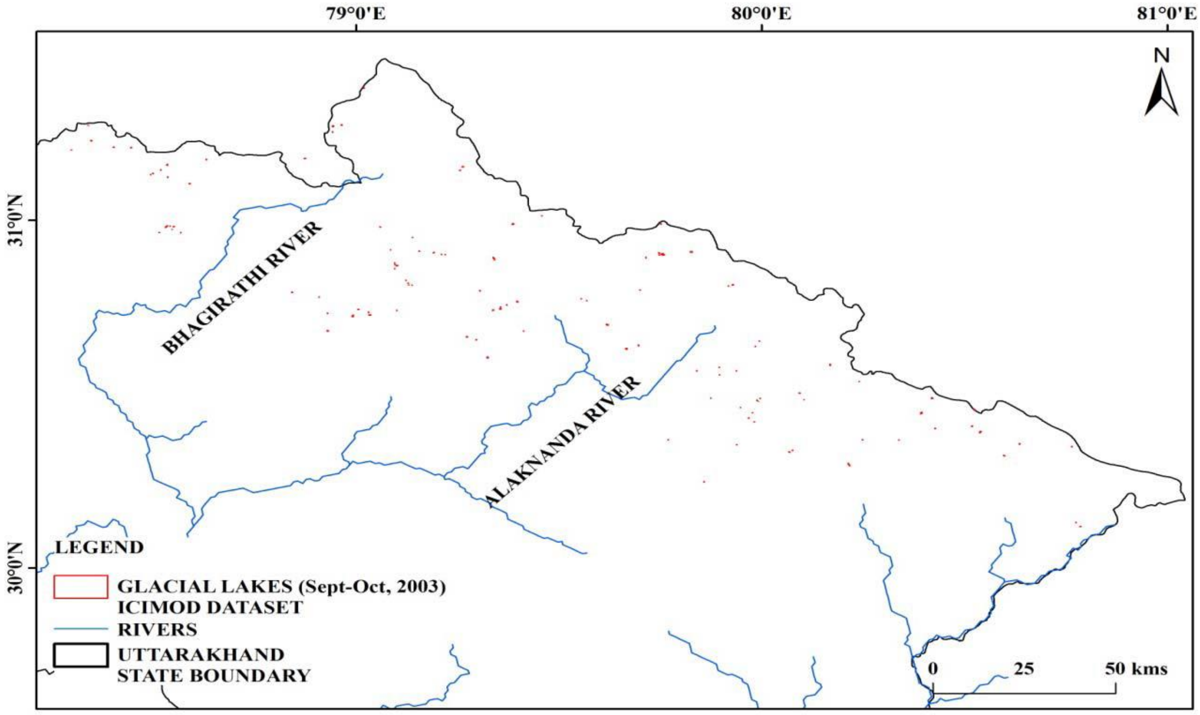
Fig.2.7. Morpho-tectonic active map showing the areas of tectonic activity given to Morphometric analysis, Vf analysis, HI (Hypsometric Integral) analysis and tectonic studies of the study area. The earthquake data from International Seismological Centre (ISC) reveal that highest number of earthquakes have occurred in high (109) and very high (80) zones.

b. GLOF and flash floods



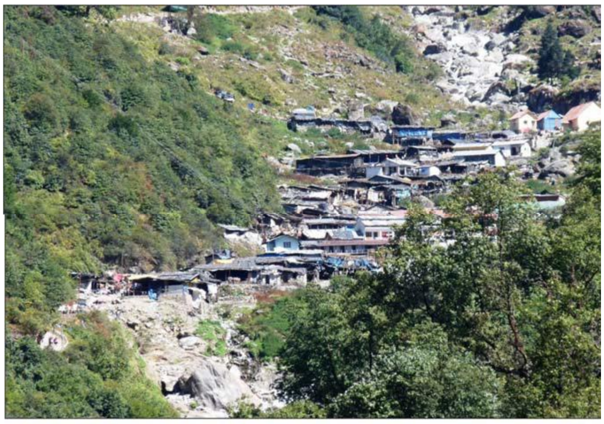
SOURCE: (NDMA)

Fig.2.8. 3D tilted average annual rainfall (mm/day) map of Alaknanda river basin for 1998–2012 procured from TRMM data showing landslide occurrences with relation to thrusts in this region.



SOURCE: (ICIMOD)

Fig.2.9. Mapped glacial lakes.



SOURCE: (Joshi Mayank, 2008)

Fig.2.10. Location of Rambara town before Kedarnath disaster.

Fig.2.11. Location of Rambara town after Kedarnath disaster

GLOF present at the upper catchment of Alaknanda basin is major risk in the region . Recent example of breaching of Chorabari GLOF in Kedarnath led to the flash flood in the downstream, Extensive rainfall with cloud burst and flash floods created situation of landslide in the valley, the most vulnerable areas are cities which are settled in the catchment along the river banks.

Glacier lakes are an increasing threat in the hilly regions. Outbursts of such lakes individually or in combination with rainfall run-off will cause severe damage to the downstream environment. Development of flood forecast models in conjunction with the flood inundation simulation models can provide flood alarms in the floodplains, which is an effective non-structural method of flood damage mitigation.

c. Hydropower electric project in Alaknanda basin.

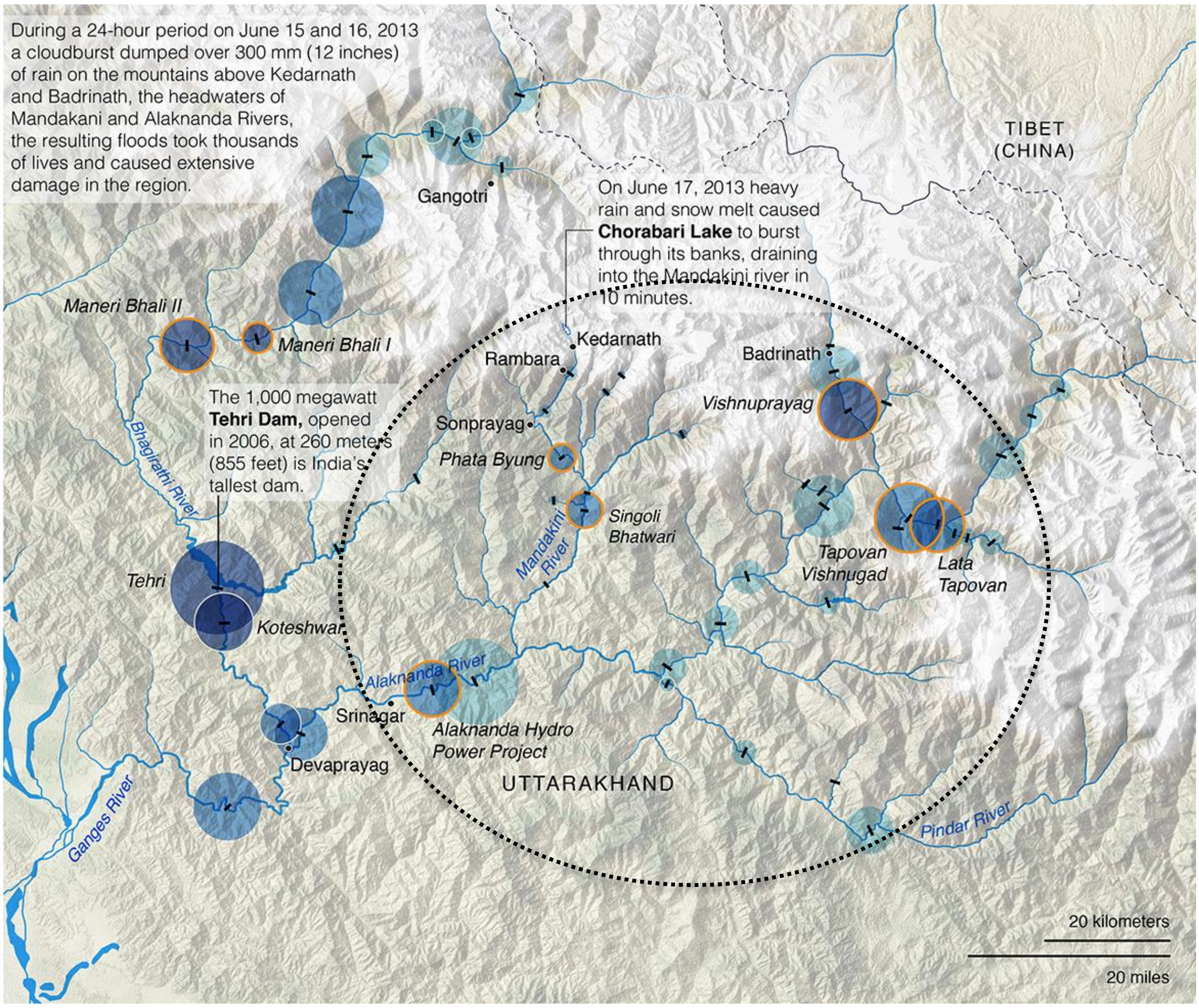
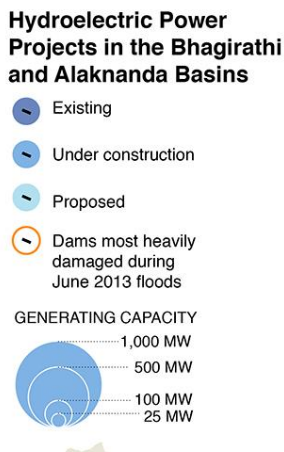


Fig.2.12. Damaged Uttarakhand dams. Source: www. Circleofblue.com, 2014



The 400-megawatt Vishnuprayag Hydroelectric Project, upriver from Srinagar along the Alaknanda River, was buried beneath 20 meters of rubble that also filled its water storage lake and likely wrecked the mouth of the penstock, the pipe that transports water to the powerhouse downstream.

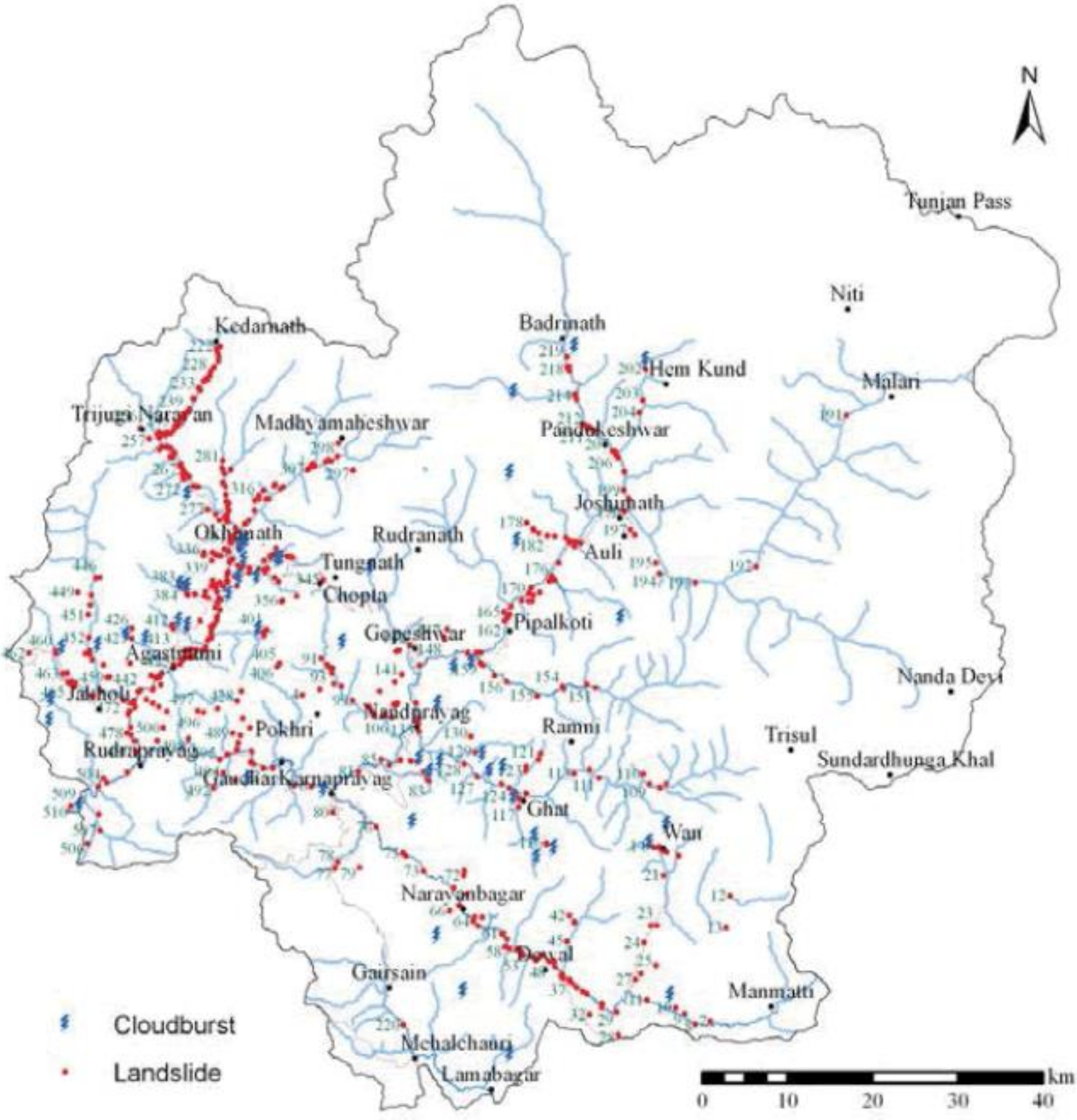
A second dam under construction on the Mandakini River, the 76-megawatt Phata-Byung Hydroelectric Project, washed away.

The 99-megawatt Singoli-Bhatwari Hydroelectric Project downstream on the Mandakini, a major tributary of the Alaknanda, was so aggressively pummeled by boulders that big chunks of concrete were gouged out of its base and the patches of steel reinforcing rods of two support towers were bent like broken fingers. The powerhouse and turbines of the 330-megawatt Alaknanda Hydro Power Project in Srinagar were inundated with mud and silt just weeks before it was scheduled to begin operating. (SOURCE: April 2, 2014 By Keith Schneider)

Fig.2.13. Huge muck dump next to SHEP
SOURCE: (SANDARP, 2015)

Fig.2.14. Dam destroyed in Vishnuprayag
SOURCE: (Circleofblue, 2014)

d. Alaknanda catchment a and landslide inventory:



SOURCE: (Journal of Geology & Geophysics, 2016)

Fig.2.15. Landslide and cloudburst inventory map of the area are highest in the river banks marked by red dots.

2.3.4. DEMOGRAPHY IN THE ALAKNANDA CATCHMENT

a. Taluk wise population structure

Rural population accounts 88.6% of the total population. Remaining 11.3% population is urban. In Tharali, Gairsain, and Pokhari taluks, urban population is zero. Ukhimath taluks accounts 0.6, Rudraprayag 1.5, and Devprayag taluk registers 3.1% urban population. The highest percentage of urban population is found in Srinagar taluk (39.4%) followed by Joshimath taluk (37.2%) and Karanprayag (25.8%). Chamoli taluk accounts 23.4% and Pauri taluk accounts 17.3% urban population.

Taluks	Average Family Size	Rural Population	Rural Population	Urban Population
Joshimath	4	773	62.7	37.2
Chamoli	4	964	76.5	23.4
Karnaprayag	4	1013	74.1	25.8
Tharali	5	1088	100	0
Gairsain	5	1129	100	0
Pokhari	4	1112	100	0
Ukhimath	4	1071	99.3	0.6
Rudraprayag	4	1139	98.4	1.5
Devprayag	4	1143	96.8	3.1
Srinagar	**4**	**937**	**60.5**	**39.4**
Pauri	4	1156	82.6	17.3
Total ARB	**4**	**1071**	**88.6**	**11.3**

Table. SOURCE: (Census of India 2001)

2.3.5. ANTHROPOGENIC FACTORS

a. **Anthropogenic impact on hydrological hazards, landslides, and soil erosion in Alaknanda river basin of Garhwal Himalaya,** Bindhy wasini pandey, Abhay shankar prasad, April 2016.

Aim:

To formulate sustainable development strategy for the development of Alaknanda river basin.

Objective:

To find out the land use/cover change detection for three time periods (1990, 2009, and 2015).

Conclusion:

i. growth of tourism, unchecked rapid increase of roads, hotels, shops and multistory housing in ecologically fragile areas and unplanned construction.
ii. Rapid growth of hydroelectricity dams and forest land diverted for hydro power that disrupt water balances.
iii. Large scale deforestation to the tune of around 16,082 acres of forest which was felled between the years of 1959 to 1969.
iv. New road construction and hydroelectric power project in the upper catchment of the Alaknanda River led to the destruction of innumerable oak, pine, rhododendron, and deodar trees.
v. Increase in agricultural land area was observed through, whereas open forest and riverbed areas decreased.
vi. The erosion rate in Alaknanda river basin has tremendously increased due to various manmade reasons. Mining, grazing, development activity, installation of hydroelectric power station, deforestation, unscientific agricultural activities etc.

There are certain signals like forecasted heavy rainfall. Seismic activity combined with Landslide vulnerability can predict the estimated time and possible consequences.
The community has to be trained to recognize the signals and act upon it.
Preparation of landslides hazard maps for locating areas prone to slides could probably be the first step for mitigation and prevention of damage in landslides.
Land and agricultural resources of Alaknanda basin face many impediments in the way of development. All the impediments can be classified into three categories i.e. Physical, socio-institutional and techno-economic.

2.4. RISKS IN SRINAGAR GARHWAL

The recent inundation has left defenseless Srinagar town out in open to face the music of potential future floods, seismic calamity and climate change. Here, it is imperative to mention two corresponding agitations about concerns of local people living upstream & downstream of SHEP and underlining potential threats and high vulnerability of Srinagar town downstream of SHEP

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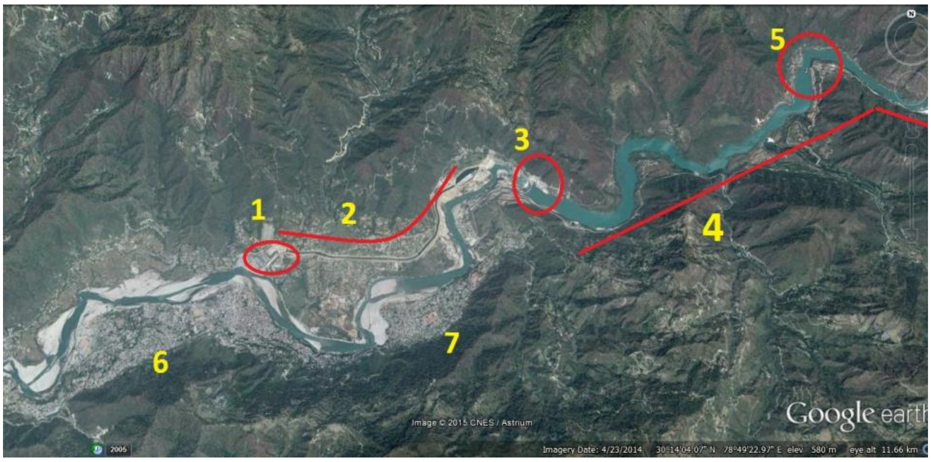
2.4.1. SRINAGAR DAM



SOURCE: (*Google imagery, April 2014*)

Fig.2.16. SHEP head, 2. Project canal, 3.Dam, 4.16 km long reservoir,
5. Dhari devi temple 6. Srinagar, 7. Srikot

Revised project parameters for 330 mw project

Location	*Srinagar, Pauri/ Tehri Garhwal, Uttarakhand*
Catchment Area	*Srinagar, Uttarakhand*
River	*11100 sq. km*
Nature of Project	*Run of the River (RoR)*
Capacity	*82.5X4=330 MW*
Submergences Area	*324.074ha*
Affected Forest Land	*338.36 ha*
River Bed Level	*545 m*
Full Reservoir Level	*605.5 Meter*
Dam Height	*90 m*
Design Drawl	*560 cumecs*
Design High Flood Discharge	*19200(26400 peak flood spill in flood) cumecs*
Construction Period	*2008 to April 2015*
Construction Cost in crores (approx.)	*4000*

SOURCE: (*SANDARP, 2015*)

2.4.2. SEVERE SOIL EROSION PROCESS

16 km linear SHEP reservoir has caused severe soil erosion process in the vicinity of Dhari village which is sitting opposite to Dhari Devi temple. despite commissioning of SHEP in May 2015, construction of Dhari village bridge is left incomplete since 2012 drastically hampering the mobility of villagers to nearby market places including Srinagar town. Kaliasaur is one of the main problem that is disrupting the national highway.

2.4.3. CONCERN ON THE DURABILITY OF FLOOD PROTECTION CONCRETE WALL

Many gigantic concrete cubes of old stud wall were seen caving in and the rest of stud wall is destined to collapse as mighty Alaknanda continue to crave in forming a semi-loop current. As a result, many residential units of Tiwari colony adjoining areas including the ancient Badrinath (II)temple are under erosion threat.

2.4.4. CHANGE IN ALAKNANDA RIVER FLOW PATTERN

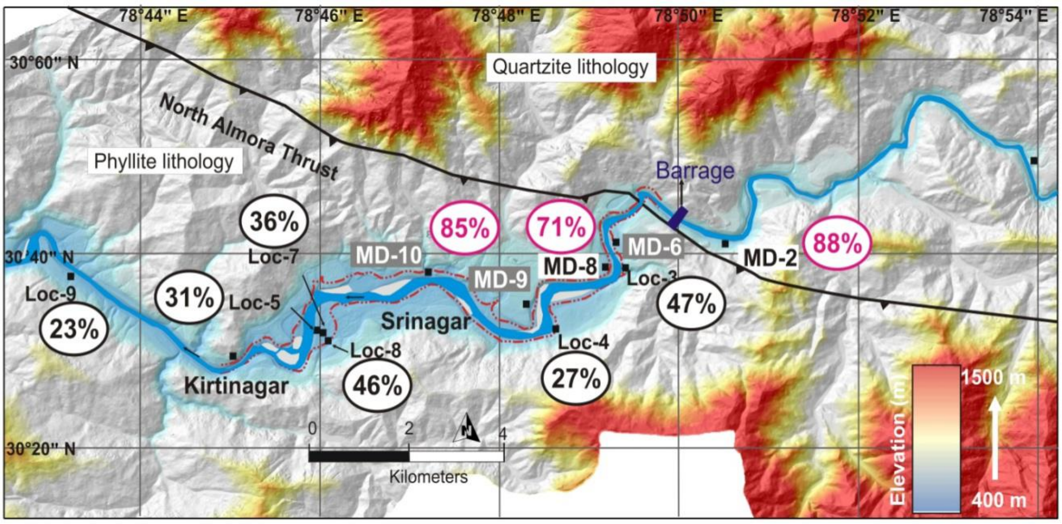
Post June 2013 gush, Alaknanda River profile has changed notably. The main current of the river has taken a great shift towards town invading the base of higher banks on the side of Srinagar. The pre-June 2013 path of Alaknanda River has been blocked by several feet thick sheet of medium size boulders and debris dumped diverting the entire current towards Srinagar.

2.4.5. ALAKNANDA RIVER AS A WASTE DUMP YARD

Considerable amount of solid and liquid waste from Srinagar town is reaching the Alaknanda River. The worst part is that, Srinagar nagar Palika has officially created a waste dump site and constructed a Sewerage Treatment Plant (STP) next to Alaknanda River, which are technically very much inside the river.

2.4.6. MUCK DISPOSAL

the muck was deposited all over *Srinagar* as high as NH 58. Even after all this, there is a huge muck dump till today just outside SHEP providing recipe to another disaster. Issues of rehabilitation, additional land submergence and landslides are still unresolved.



SOURCE:(Env. Degradation report)

Fig.2.17. The geochemical analyses of the muck kept at various locations indicate dominance of phyllite rocks. In the flood sediments collected along river below the barrage indicate that the phyllite contribution (from muck) varies from 47% to 23% implying significant contribution of muck in raising the river bed. Black ellipsoid is the percentage of phyllite in flood sediment. MD is the percentage of phyllite in muck dumping sites.

SOURCE:(Env. Degradation report)

SOURCE: (SANDARP)

Fig.2.18. Overburden and muck dump along Alaknanda upstream of Srinagar.

2.5. CONCLUSION

Srinagar town is seismically highly susceptible to disasters since it lies between Main Central Thrust (in north) and Saknidhar Thrust ST (in south). Moreover it is close to Alaknanda Fault upstream Rudraprayag and closer to North Almora Thrust upward Srinagar. The 1803 earthquake had razed the city to ground and threat of a long overdue big seismic event is looming large upon Uttarakhand. Moreover Alaknanda valley has been highly vulnerable to repeated landslide and lake bursts induced catastrophic events. E.g. 1894 the Gohna Tal Lake burst (1894) historic floods (1970). Construction of SHEP in violation of environmental and geo-ecological concerns has further compromised disaster vulnerability of *Srinagar* town. *(Bhim singh rawat (we4earth@gmail.Com) SANDRP, 2015)*

3. CASE STUDY

3.1. A FRAMEWORK FOR URBAN CLIMATE RESILIENCE (UNISDR)

Resilience elements	Priority interventions proposed in city resilience strategies
Infrastructure systems	• Flood monitoring and early warning systems. • Storm- and flood-resistant housing. • Hydrological and hydraulic modeling studies to guide flood prevention investments. • **Flood shelters Rainwater harvesting.**
Ecosystems	• Mangrove restoration and protection. • **Watershed planning and forest protection.** • **Groundwater recharge.** • **Biological river bank stabilization.**
Agent capacities	• Build awareness of climate risks. • Engage communities in resilience planning. • Build climate change issues into school curriculum. • Train community groups and local government in disaster risk management and response. • Improve public health surveillance Alternative livelihoods to increase choice for peri-urban poor.
Institutions	• Water demand management Limit development rights in floodplains. • New local government coordination and technical support organizations. • Improve public information on flood hazard and evacuation. • Improve climate forecasting and warning services Engage communities in climate resilience planning.

Table 4. ACCCRN city proposed interventions in relation to resilience framework elements.

SOURCE: Stephen Tyler & Marcus Moench, (08 January 2016) Adaptive Resource Mgmt Ltd, 2207 Arbutus Rd, Victoria, British Columbia, V8N 1V2, Canada; ISET, Boulder, CO, USA

2.2. CASE STUDY: FLOOD RESILIENCE YANWEIZHOU PARK, JINHUA

(Turenscape Landscape Architecture, December 2014)

2.2.1. SITE INTRODUCTION

Jinhua, a city with a population of over one million, has one remaining undeveloped natural riparian wetland of more than 64 acres where the Wuyi River and Yiwu River converge to form Jinhua River, this wetland is called Yanweizhou, literally meaning "the sparrow tail".

Beyond Yanweizhou, riparian wetlands have been disrupted by the construction of an opera house. These river each over 100 meters wide divide the densely populated communities in the region, Which results in the inaccessibility, the cultural facilities, in the adjacent to Yanweizhou underutilized. The remaining 50-acre (20 ha) riparian wetland was fragmented or destroyed by sand quarries (Figure 3.6).The existing wetland is covered with secondary growth dominated by poplar trees (Populous Canadensis) and Chinese Wingnut (Pterocarya stenoptera) that provide habitat for native birds like egrets.

2.2.2. SITE CONDITIONS:

The site conditions posed four major challenges to the landscape architect:

- How can the **remaining patch of riparian habitat be preserved** (Figure 3.1) while providing amenities to the residents of the dense urban center.

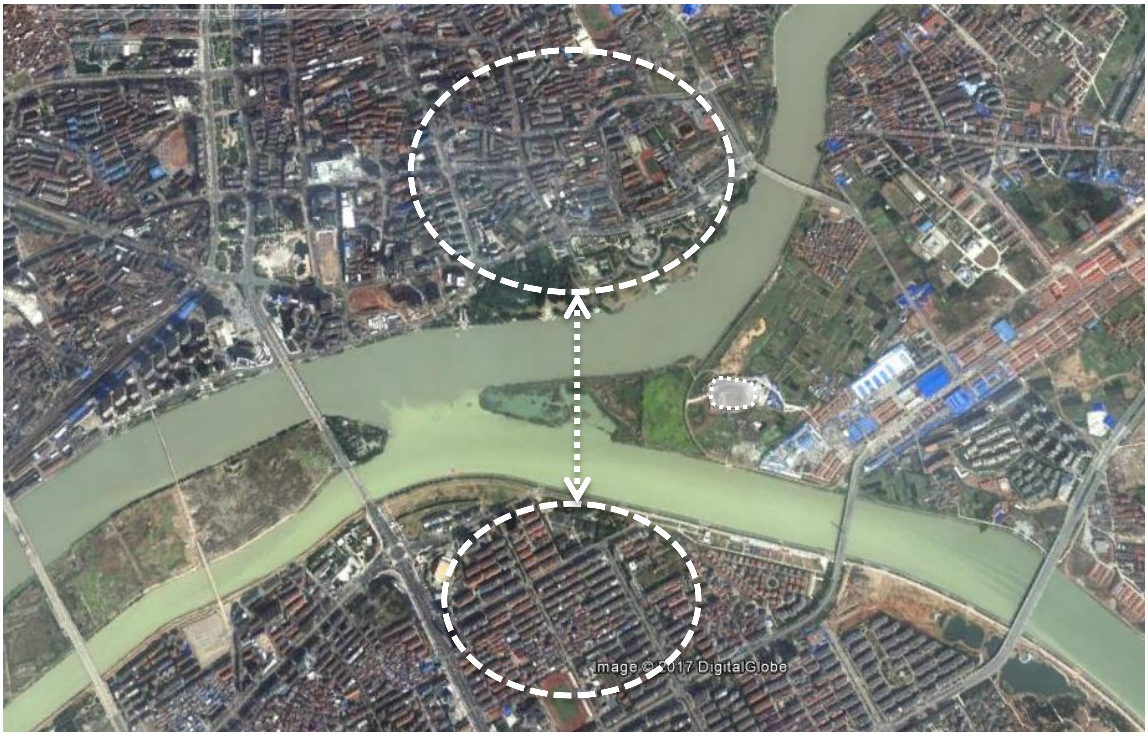
- What **approach to flood control should be used .**

- How can the existing organically shaped building be integrated into the surrounding environment **to create a cohesive landscape** that provides a unique experience for visitors?

- Finally, and most importantly, how can the separated city districts be connected to the natural riparian landscape **to strengthen the community and cultural identity** of the city of Jinhua (Figure 3.2)?

Riparian wetland   Opera house   SOURCE: Google Earth (March, 2003)

Fig.3.1. Satellite imagery showing remaining patch of riparian wetland with organic opera house of Yanweizhou, Jinhua, China.



SOURCE: Google Earth (March, 2003)

Fig.3.2. Connection needs to be developed between two separate district divided by river to restore the cultural identity.

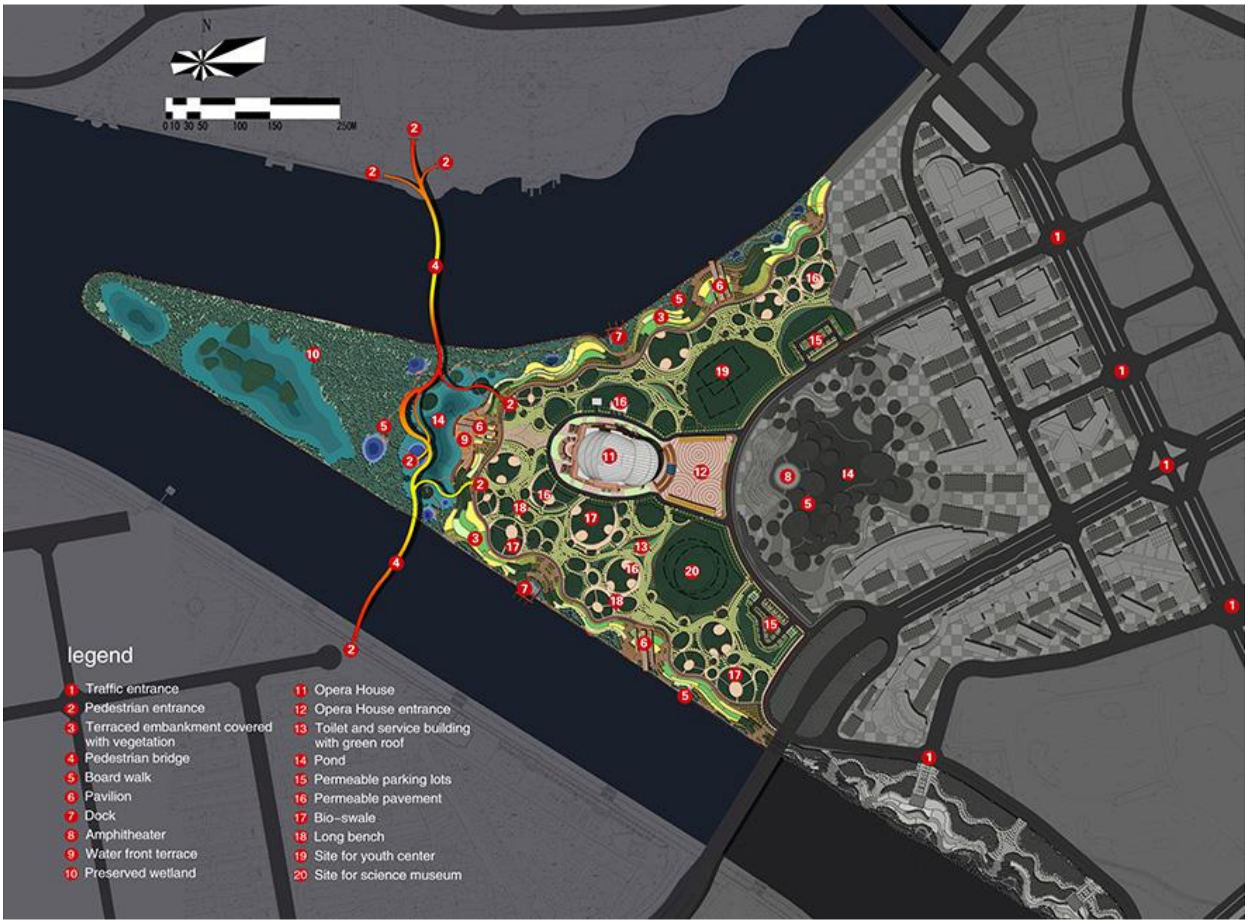


Fig.3.3. The site plan for a Yanweizhou park.

2.2.3. DESIGN STRATEGIES: RESILIENT LANDSCAPE

a. Adaptive Tactics to Preserve and Enhance the Remnant Habitats

Minimum Intervention in existing riparian sand quarries

The first adaptive strategy was to make full use of the existing riparian sand quarries with minimum intervention. In this way, the existing micro-terrain and natural vegetation are preserved, allowing diverse habitats to evolve through time. The biodiversity of the area was adapted and enhanced through the addition of native wetland species. This enrichment, particularly of species that provide food for birds and other wildlife, increases biodiversity.

Water Resilient Terrain and Planting Design

Due to its monsoon climate, Jinhua suffers from annual flooding. For a long time, the strategy to control flooding was to build stronger and taller concrete floodwalls to yield cheap land for urban development. These walls along the riverbanks and riparian flood plains severed the intimate relationship between the city, the vegetation, and the water, while ultimately exacerbating the destructive force of the annual floods.

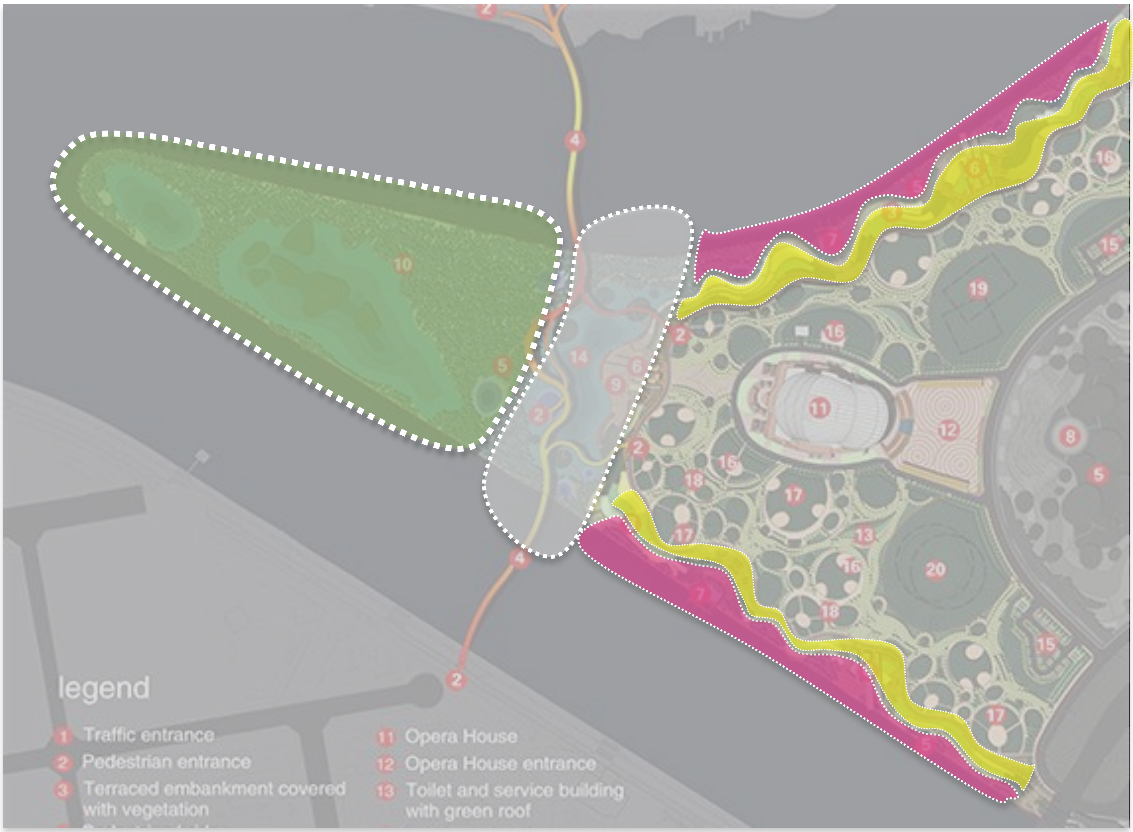


Fig.3.4. The existing wetland was preserved with no intervention and existing riparian sand quarries With minimum intervention as these are part of river ecosystem and needs to be free of human intervention

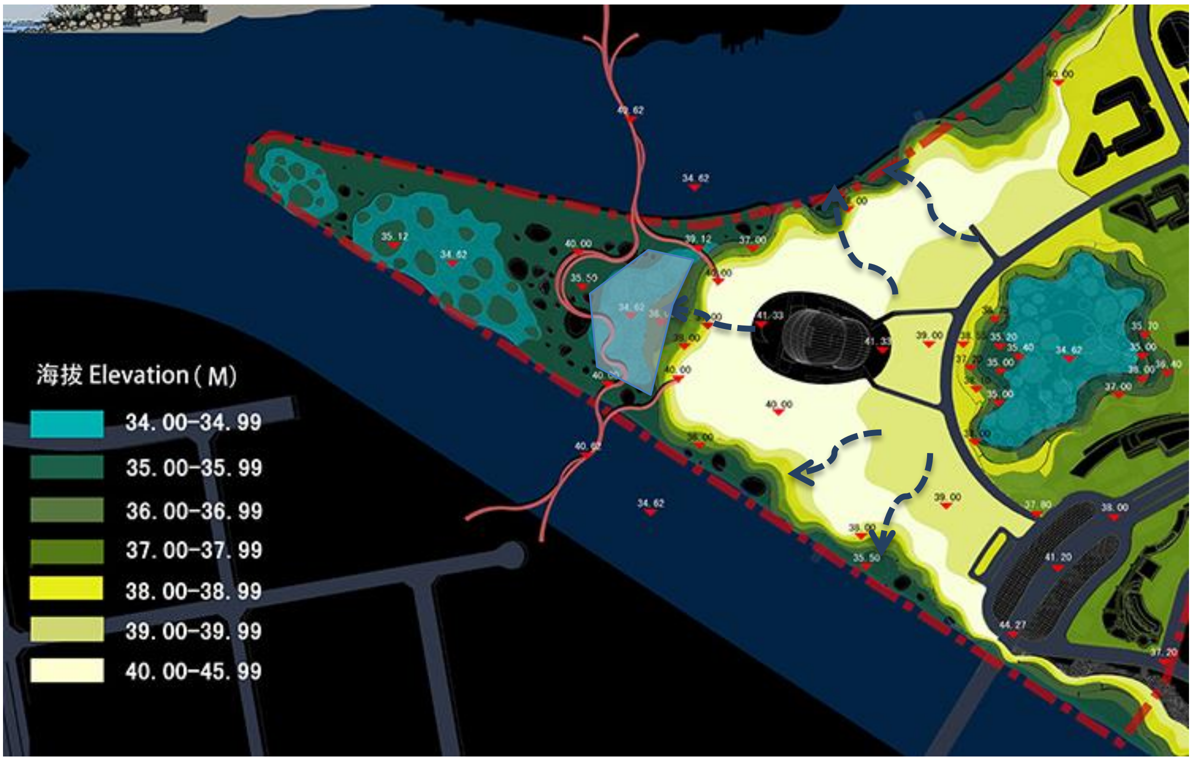


Fig.3.5. Grading Plan according to topography of the site.

b. Water-resilient terraced river embankment

Hard high walls have been built (Figure 3.6), or were planned to be built, to protect the last patch of riparian wetland (Yanweizhou) from the 20-year and 50-year floods. These floodwalls would create dry parkland above the water, but destroy the lush and dynamic wetland ecosystem.

The landscape architect devised a contrasting solution, and convinced the city authority to stop the construction of the concrete floodwall and to demolish others. Instead, the Yanweizhou project “makes friends” with flooding by using a cut-and-fill strategy to balance earthwork and by creating a water-resilient terraced river embankment (Figure 3.7) that is covered with flood adapted native vegetation.

Floodable pedestrian paths (Fig.3.10) and pavilions are integrated with the planting terraces (Fig.3.11), which will be closed to the public during the short period of flooding. The floods bring fertile silt that is deposited over the terraces (Fig.3.9) and enrich the growing condition for the tall grasses (Fig.3.12) that are native to the riparian habitat. Therefore, no irrigation or fertilization is required at any time of the year. The terraced embankment will also remediate and filtrate the storm water from the pavement above. Although the design and strategies employed address only a small section compared to the hundreds of kilometers of river embankment, **the Yanweizhou Park project showcases a replicable and resilient ecological solution to large-scale flood management.**

c. Water resilient Inland Area

Integration of water permeable surfaces

the inland area is entirely **permeable** in order to create a water resilient landscape through the extensive use of gravel that is reused material from the site (Fig.3.13). The gravel is used for the pedestrian areas, the **circular bio-swales** are integrated with tree planters (Fig.3.17), and **permeable concrete pavement** is used for vehicular access routes and parking lots. The inner pond on the inland is designed to encourage river water to infiltrate through gravel layers (Fig.3.19). This mechanically and biologically improves the water quality to make the water swimmable.

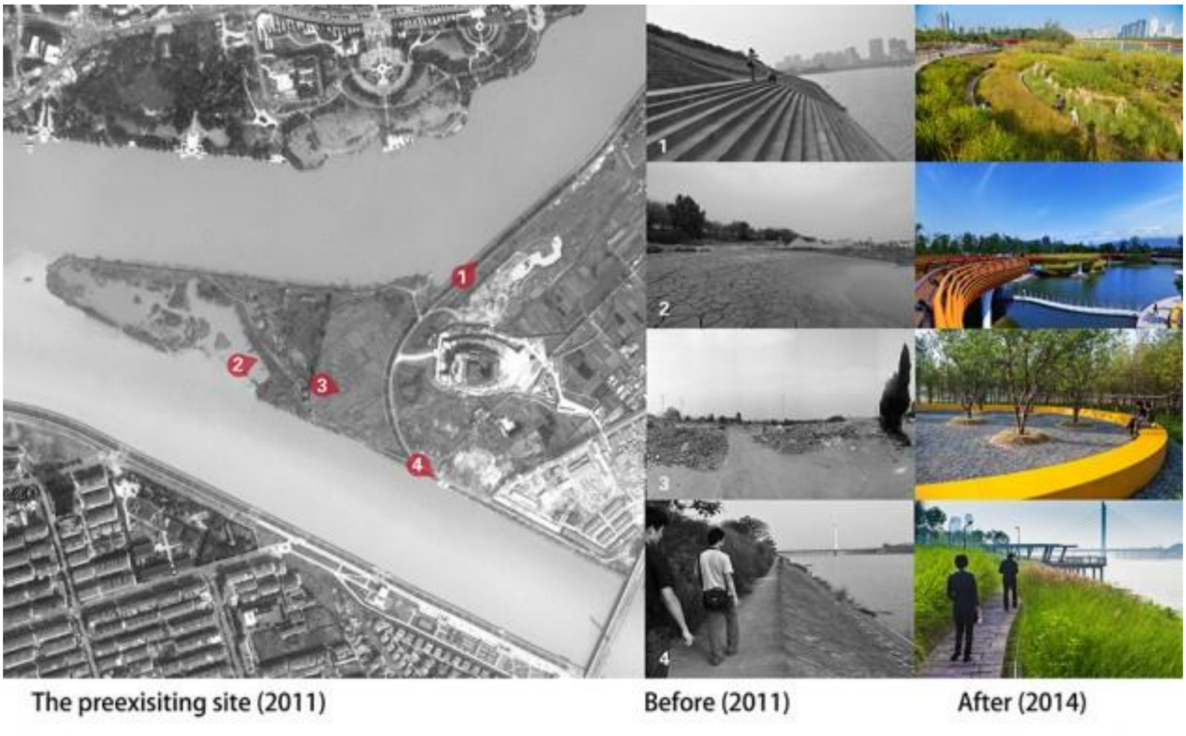


Fig.3.6. Pre-existing Conditions (before) and Transformations (after). The existing site was a riparian wetland ruined by sand quarry and concrete floodwalls. The resilient design strategy dramatically transformed the site by making the site accessible and connecting the segregated city.

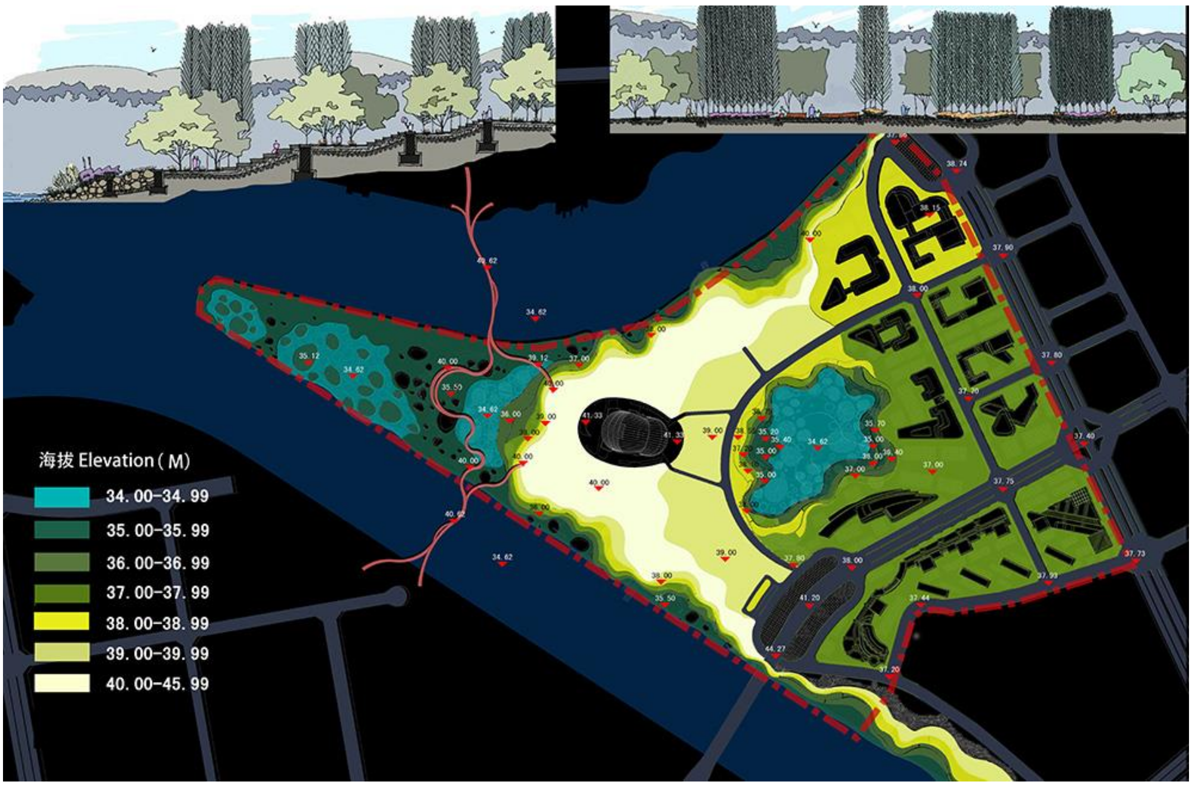


Fig.3.7. Grading Plan and Section: Flood walls are removed and a cut and fill strategy is used to create terraces to make the site cooperate with flooding. The design is 100% permeable. The surfaces include gravel surfaces for pedestrians, bioswales for planting, and permeable concrete for automobile use.

Fig.3.8. An aerial view of the park during the monsoon season showing a 20-year flood and testifying to the flood resilient design. Note the uninterrupted connection of the city through the bridge (the view is toward the west, photo: May, 2014).

Fig.3.9. An aerial view of the park during the dry season, note the lush tall grasses covering the terraces on the embankment. The terraces are enriched by silt deposited during the flood season (view is toward the west, photo: November, 2014).

Fig.3.10. The flood-adapted boardwalk integrates the path system with the terraces. This path affords visitors an intimate naturalistic experience over the riparian vegetation. The elevated boardwalk is just above the five-year flood level (view is toward the southwest).

Fig.3.11. The beautiful terraced embankment was built by removing the concrete floodwall and through a cut-and-fill strategy that balances the earthwork on-site. The terraces create a flood resilient zone that allows people to enjoy the lush tall grasses adaptive to the seasonal floods.

Fig..3.12. The terraced embankment in flood resilient zone is accessible through stairs and paths along the top of terrace walls for emersion within the varied texture, color and movement of the lovely grass panels (view is toward the east).

Fig..3.13. Water resilient material used in paving.

d. Resilient Pedestrian Bridge

Connecting cultural identity

A pedestrian bridge snakes across the two rivers, linking the parks along the riverbanks in both the southern and northern city districts, and connecting the city with the newly constructed Yanweizhou Park within the river (Fig.3.3 and 3.14).

The bridge design was inspired by the local tradition of dragon dancing during the Spring Festival. For this celebration many families bind their wooden benches together to create a long and colorful dragon that winds through the fields and along narrow dirt paths. The Bench Dragon is flexible in length and form as people join or leave the celebration. The dragon bends and twists according to the force of human flow. Like the bench dragon in the annual celebration the “Bench Dragon Bridge” symbolizes not only a form of celebration practiced in Jinhua area, but is a bond that strengthens a cultural and social identity that is unique to this area .

Flood resilient bridge

The new bridge is elevated above the 200 year flood level, while the ramps connecting the riparian wetland park can be submerged during the 20 year and larger floods. Floodwaters cover the park for a very short period of time. The bridge also hovers above the preserved patch of riparian wetland and allows visitors an intimate connection to nature within the city.

Flexible access for residents

The many ramps to the bridge create flexible and easy access for residents from various locations of the city in adaptation to the flow of people. The landscape architect designed the bridge to reinforce the festive, vernacular tradition, but also as an art form with a bold and colorful combination of bright red and yellow tones (Fig.3.16). that are strengthened by night lighting. All together 700 m long, the bridge is composed of a steel structure with fiberglass handrails and bamboo paving. The main bridge is five meters wide, with four meter wide ramps.This bridge is officially named Bayong Bridge (Bridge of Eight Chants), after eight famous poems written in ancient times about landscapes surrounding the site. **It is truly a resilient bridge that is adaptive to river currents and the flows of people while binding city and nature, future and past.**

Fig.3.14. The terraced embankment in flood resilient zone is accessible through stairs and paths along the top of terrace walls for emersion within the varied texture, color and movement of the lovely grass panels (view is toward the east).

Fig.3.15. The Bayong Qiao bridge flys above the former sand quarry and connects the city with nature. The former sand quarry has been transformed into a pleasant park that allows people to have intimate contact with the remnant patch of the wetland forest.

Fig.3.16. With multiple ramps aligned to the flow of people, the Bayong Qiao bridge is more than a physical link. It is a social connection that helps to build the community by creating a gathering space for families and residents who walk, jog and chat together on the bridge.

e. Resilient Space for a Dynamic Experience

The large oval opera house (designed by the Zhejiang Architecture Institute) posed significant challenges for the landscape architect. First the building shape tends to repel rather than embrace the user and landscape (Fig.3.3). Finally, the designers were challenged with the problem of how to integrate the singular flood proof big object into the floodable, riparian waterfront. The design uses curves as the basic language, including the curvilinear bridge, terraces and planting beds, concentric paving bands of black and white, and meandering paths that define circular and oval planting areas and activity spaces. The dynamic ground of the pavement and planting patterns define circular bioswales and planting beds, densely planted with native trees and bamboo, bound by long benches made of fiberglass (Fig.3.17). The circular bioswales and planting patches resemble raindrop ripples on the river. These curves and circles are the unifying pattern language that integrates the building and the environment into a harmonious whole. The reverse curves simultaneously refer to the shape and scale of the building while forming a contrasting shape that is human in scale and enclosed for more intimate gatherings. They also reflect the weaving of the dynamic fluxes of currents, people and material objects that together create a lively pleasant and functional space.

Fig.3.17. Circular bioswale. The surfaces include gravel surface bioswales for planting, and permeable concrete for automobile use.

Fig.3.18. This pavilion provides a dramatic viewpoint as it extends above the 200-year flood level. The pavilion features a detailed view of the pond water feature and expansive views of the river, the city and the Bayong Qiao bridge.

Fig.3.19. The inner pond on the inland is designed to allow water to infiltrate from the river through the gravel layers that make the otherwise dirty river water swimmable (kids playing in the pond, summer, 2014).

2.3. TRADITIONAL TECHNIQUES IN FOR STORM WATER MANAGEMENT

2.3.1. Traditional methods used in managing storm runoff

Himalayan Eco-zone	Traditional water harvesting systems	Description	Found in
Western Himalayas	Kul	Water channels in mountain areas	Jammu, Himachal Pradesh
	Naula	Small ponds	Uttarakhand
	Kuhl	Headwall across a ravine to divert water from a natural stream for irrigation	Himachal Pradesh
	Khatri	Chambers carved in hard rock for storing water	Himachal Pradesh
Eastern Himalayas	Apatani	Terraced plots connected by inlet and outlet channels	Arunachal Pradesh
Northeastern Hill Ranges	Zabo	Impounding runoff	Nagaland
	Cheo-oziihi	Channels from rivers	

Kuhls in Wester Himalaya

Kuls was constructed across a ravine to divert the waters of natural flowing streams (khud) through a canal to the fields. About 20 ha could be irrigated by a community kuhl. The water would flow from field to field and surplus water would drain back to the khud. The kohli or water tender distributed and managed the water.

The contour channels called ***guhls*** were used extensively. Streams were dammed by temporary barriers to divert water into these channels.

(SOURCE:Rainwaterharvesting.org/Rural/Traditional3.htm)

Fig.3.20. The kuhl (left) is diverted from the glacier-fed stream (right). SOURCE: (indiawaterportal August 2014)

Fig.3.21. Kuhls carry glacial melt to fields for irrigation. SOURCE: (indiawaterportal August 2014)

Fig.3.22. Dry stone check dam, Silalekh
SOURCE: (www.gramya.in August, 2013)

Fig.3.23. Stone pitched pond,
SOURCE: (www.gramya.in August, 2013)

Fig.3.24. Kuhls carry glacial melt to fields for irrigation. SOURCE: (www.gramya.in August, 2013)

Fig.3.25. Dry stone check dams,
SOURCE: (www.gramya.in August, 2013)

Fig.3.26. Staggered contour trenches.
SOURCE: (www.gramya.in August, 2013)

SOURCE: (Watershed Management Directorate August, 2013)

4. BUILDING FOOD RESILIENCE

4.1. OBJECTIVES

In order to create flood resilience, the participation of government organization and public becomes highly important to mitigate these events as it put question mark on the very own existence of the social system.

4.1.1. Risk Mapping in Alaknanda catchment basin at policy level

- Detailed study of level of risk zone in Alaknanda catchment has to be identified and mitigation of these risk on regional, village and city level should keep communities at center.
- Mapping of risk zone on the basis of Natural and man made disaster such as accidents, landslides, Cloudburst, Flood inundation, Infrastructure(Quality of roads and built-up etc., which is basic requirement for preparation of vulnerability mapping in Alaknanda catchment.
- Extreme flood events and its disaster impact assessment needs to be prepared as valley has numerous dams built on the Alaknanda and its tributaries.
- Demarcation of buffer areas in Alaknanda catchment basin.
- Urban centers which are located in the valleys needs to adapt resilient infrastructure from future floods.
- Regulation of traffic and tourism activity has to be maintained according to identified risks zones based on risks and its interconnectedness which will minimize loss in case of disaster.

4.1.2. Risk Mapping in Srinagar catchment at policy level

a. Vulnerability Mapping

- Factors which establishes vulnerability
- Level of vulnerability (zoning)

b. Buffer zoning

- Factors which determining the buffer zone
- Flood Inundation
    - Topography with respect to streams.
    - Geomorphology
- Existing and disturbed riparian zone
- Vulnerability zoning

5. SITE STUDY

5.1. DEMOGRAPHICS

At the 2007 India census, Srinagar had a population of 80,000.

Males :- 55%

females:- 45%.

At the 2012 census Srinagar had a population of 1,50,000.

Males:- 52%

females :-48%.

(en.wikipedia.org/Srinagar Garhwal)

5.2. CLIMATE

Srinagar is the warmest place in the Garhwal Hills in summers as it is at low elevation of just 560 m. and the temperature reaches 45 °C on some days from May to July. In winters the temperature can fall to 2 °C in December and January (en.wikipedia.org/Srinagar Garhwal)

5.3. GEOLOGY

Most of Srinagar town comes under phyllite, the bed rocks can be seen at multiple parts where river turns sharply, most of the location have been turned into flood plains and phyllite has been covered by the Small boulders and silt load that is deposited from quaternary period. In the Srinagar area the NAT (North Almora Thrust) is also known as Srinagar fault (Mehdi et.al. 1972).location of dam is also created at the mouth of the river which then spread across the valley with gentle motion i.e.. 2-3 m/sec. this rock type also gives strength to control the river of this magnitude as the rock structure allows it to be made. (HNBU, 2001).

5.4. PHYSIOGRAPHY AND HYDROLOGY

Alaknanda river deposited the sedimentation and thus creates flood terraces and less gradient slopes over the time, The formation of Srinagar and Srikot city on flood plains range back to quaternary period. Srinagar Garhwal has established itself as one of the main node in Garhwal Himalaya and works as a cultural and economical force in the region. These two flood plain further get modified by the smaller streams that divide Srinagar city in three different micro catchment basin, areas where streams meet brings silt, clay and small boulders with itself, areas which are occupied by different land use create hazardous situation making it more vulnerable as flood inundation is shown in the hydrology map.

5.5. SLOPE ANALYSIS OF SRINAGAR CITY

Lower portion of the city comes under flat terrain occupy 18.6 % of city area.

5 deg.:- 18.9%: agriculture, city residential area, parks

5-16 deg. :- 20.8% city residential area, barren land

16-31 deg :- 24.8% forest and barren land, rural agriculture land

31-42 deg :- 22.6% forest and barren land, rural agriculture land

42- 50 deg :- 7.6% forest and barren land

50 deg :- 5.3% barren land with sparsely distributed pine forest

(source: Srinagar bhu patrak map, 2001)

5.6. GEOMORPHOLOGY AND SOIL

Presently Srinagar town is developed on third river terrace and sub terraces in higher elevations. The terrace both fill and strath type in the Alaknanda River valley developed by varying global climate and regional tectonics of Himalaya. Aggradation phases apparent along the river were responsible for the formation of a maximum of 6 terrace levels in the valley. The oldest terrace (T6) , with the representative section near Srinagar, formed during first phase of aggradation between 25 and 17 ka.

The remaining 5 terraces (T5eT2) are cut and fill in nature and were formed during the second phase of aggradation. The river attains its maximum width near Srinagar , where three paleovalleys (Supana, Kilkileshwar and Uphalda) are found, Here the river gradient is low (1.5 m/km) as compared to other locations (10e3m/ km), and thus this region acts as a sediment depo-centre within the Alaknanda valley. Srinagar Garhwal city is on the banks of Alaknanda river which brings sandy alluvium soil to its plains, Color of these soil is light brown. (Pradeep Sachdeva, Jan 17, 2015)

5.7. LAND USE

Srinagar city expanded in flood plains, Main city centre is developed along the national highway in biggest river terrace. The lower and upper terrace of third level have land use of institutional, Commercial administration, educational, hospitals which has affected city limits. Lower portion have residential areas mostly because of the less value of land as it is vulnerable to the flood inundation from storm water and river as well. The rate development of city is highest in the second and fourth terraces. The sub urban areas are developed along the national highway from eastern an western side of the city center. (HNBU 2001)

5.8. VEGETATION

Srinagar valley has mixture of tropical to temperate climatic vegetation. Hundreds years ago Srinagar valley had mixed forest typology, but with spread of civilization few of the native species survived. The vegetation structure depends upon the temperature variation, rainfall, humidity and topography.(HNBU 2001)

a. Riparian vegetation

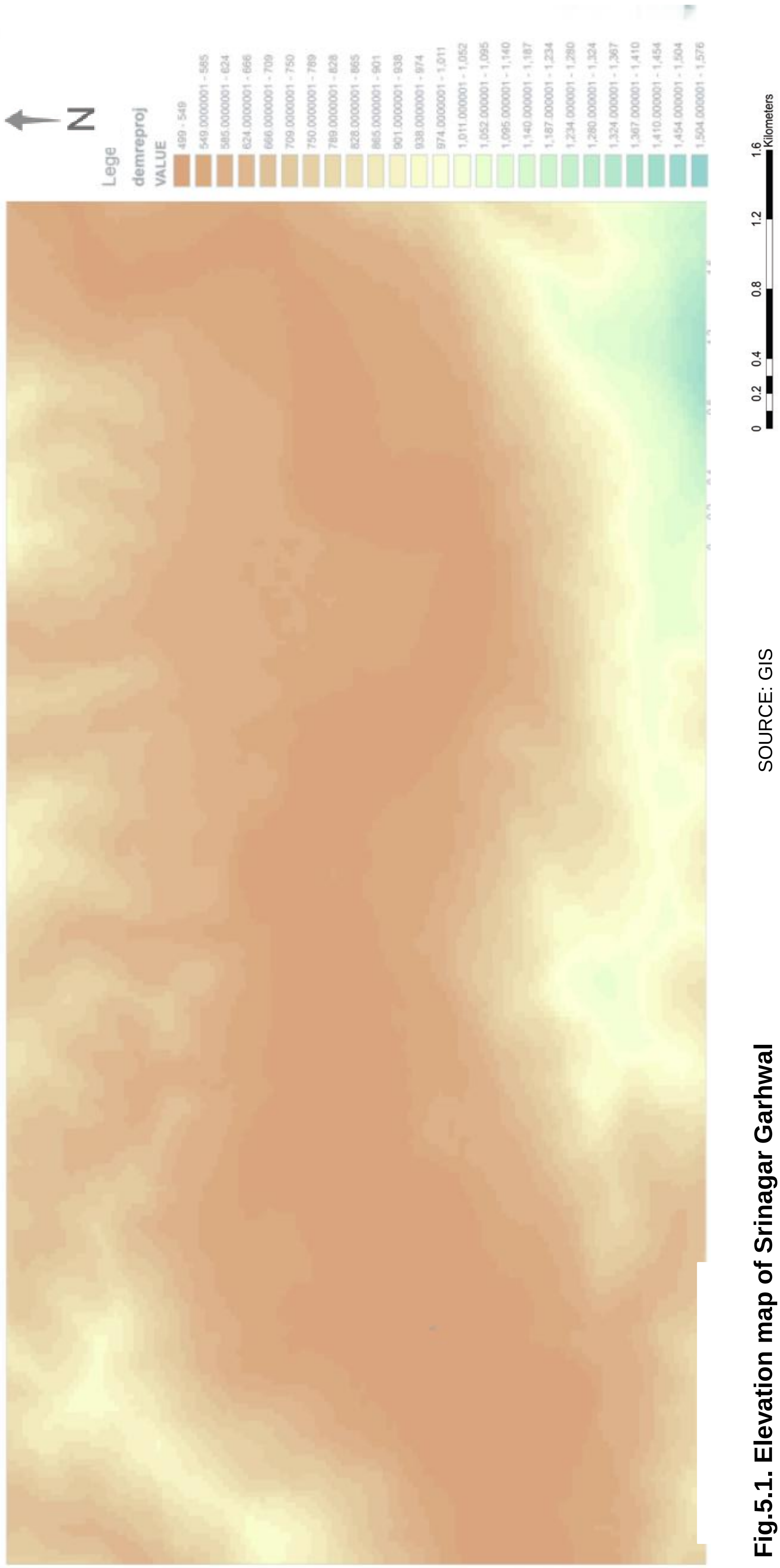
Anogeissus latifolia, Leucaena leucocephala, Acacia nilotica, Acacia adstringens, Aegle marmelos, haldina cordifolia, Dalbergia sissoo, Albizia lebbeck, Erythrina variegata, Eucalyptus tereticornis, Ficus auriculata, Grevillea robusta, Moringa oleifera, Morus alba, Desmodium oojeinense, Oroxylum indicum, haldina cordifolia, Azadirachta indica, bauhinia purpurea, Bombax ceiba, Butea monosperma, Callistemone citrinus, Jacaranda mimosifolia, Albizia lebbeck, pennisetum purpureum, panicum dactylon, Digitaria didactyla etc.

(Deptt. Of Botany, HNBU)

b. Vegetation in Srinagar city

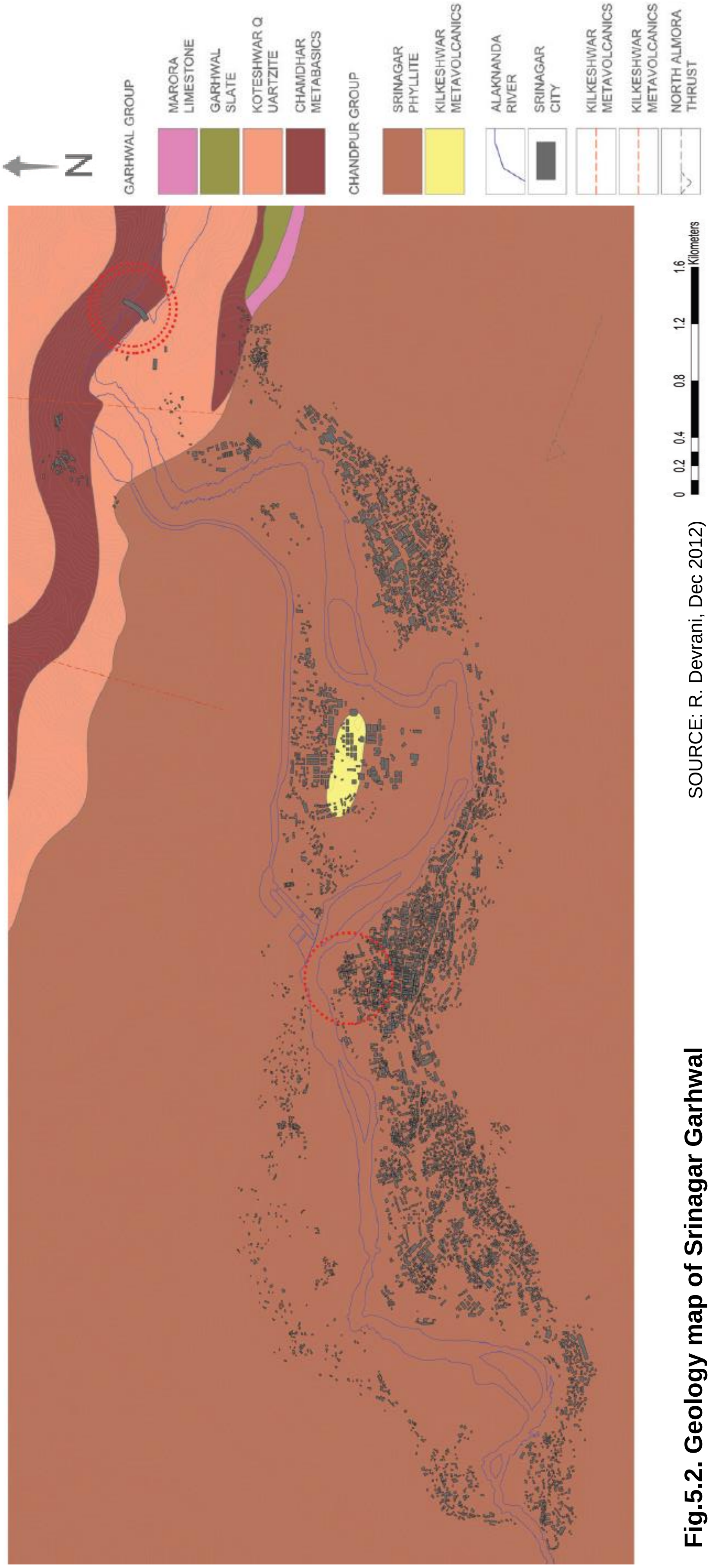
Vegetation in Srinagar city	Percentage	Location
Ficus Reigiosa, Ficus Benghalensis	3.3%	Peripheral Boundaries of the city
Fruit trees Mangifera indica Artocarpus heterophyllus(Jackfruit) Syzygium cumini (Jamun) Prunus persica (Peach) Citrus reticulata (Orange) Litchi chinensis (Litchi) Carica papaya (Papaya) Musa paradisiaca (Banana) Punica granatum (Pomegranate)	46.5%	Within city majorly in residential wards and some can be found scattered along the river in the riparian zone.
Timber wood Dalbergia sissoo (Sheesham) Toona ciliata (Toon) Eucalyptus spp (Eucalyptus) Pinus roxburghii (Pine)	21.6%	This is with in the city along the roads and in government owned areas.
Other Grewia laevigata (Bhimal) Celtis australis (Khadeek) Ficus glomerata (Timla) Morus nigra (Black mulberry) Sulla (Hedysarum coronarium) Palmata Forsk(Bedu)	28.3%	Majorly In the boundaries of city limits and with in city also.
Ornamental	0.3%	These are the new additions for the beautification of city, can be found in the residential spaces

SOURCE: (HNBU, 2001)



SOURCE: GIS

Fig.5.1. Elevation map of Srinagar Garhwal



SOURCE: R. Devrani, Dec 2012)

Fig.5.2. Geology map of Srinagar Garhwal

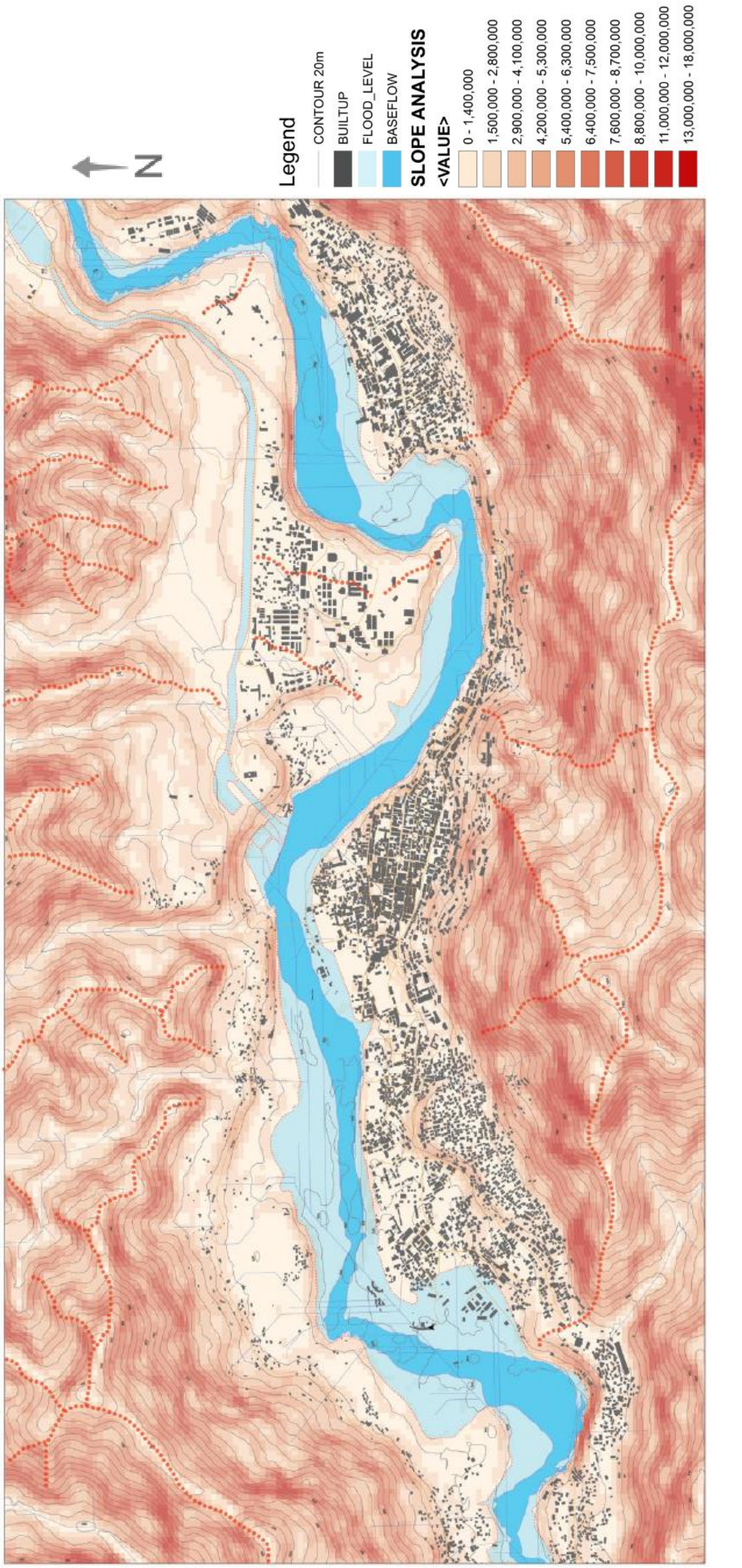


Fig.5.3. Hydrology and Slope analysis in Srinagar catchment

SOURCE: GIS

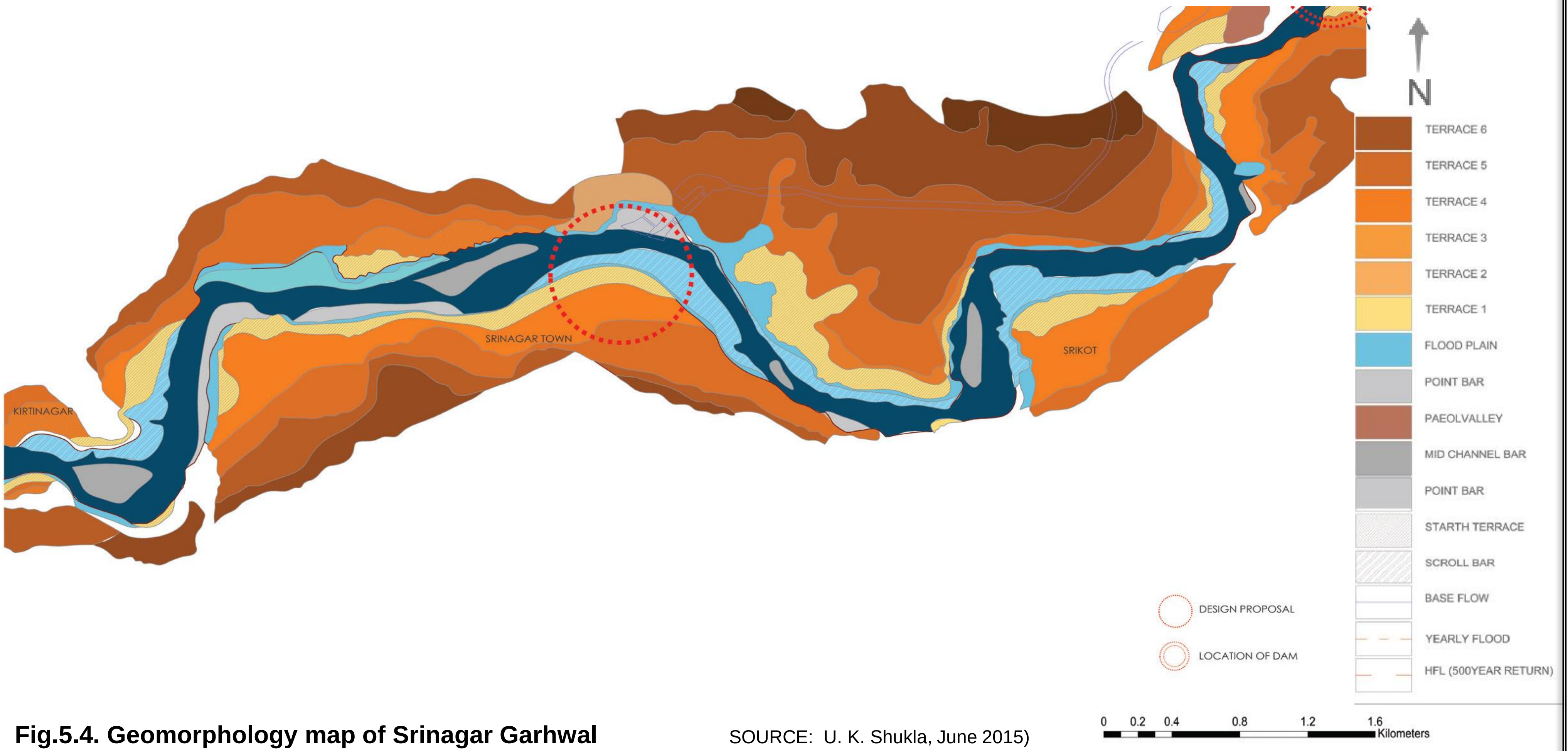


Fig.5.4. Geomorphology map of Srinagar Garhwal SOURCE: U. K. Shukla, June 2015)

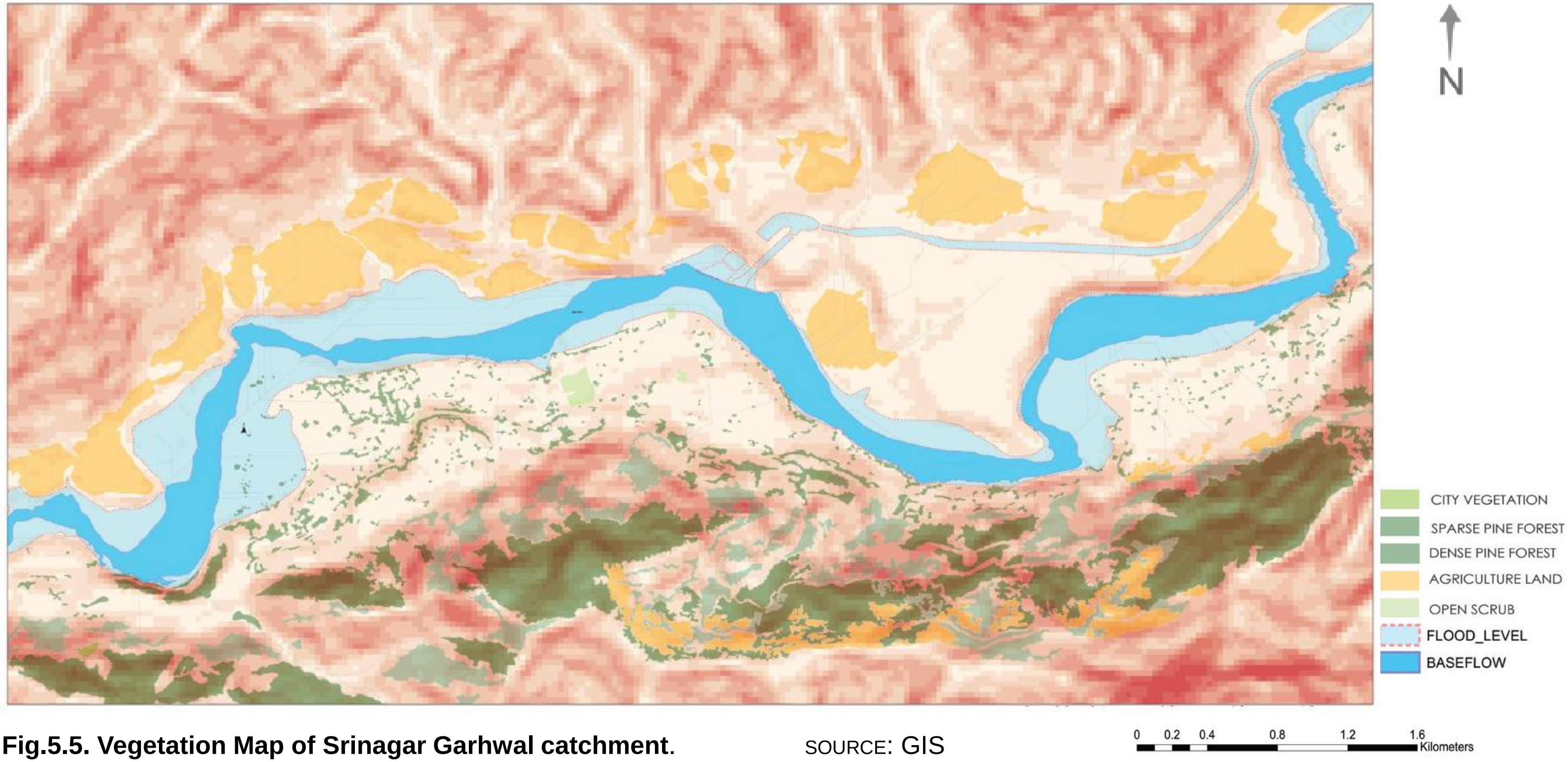
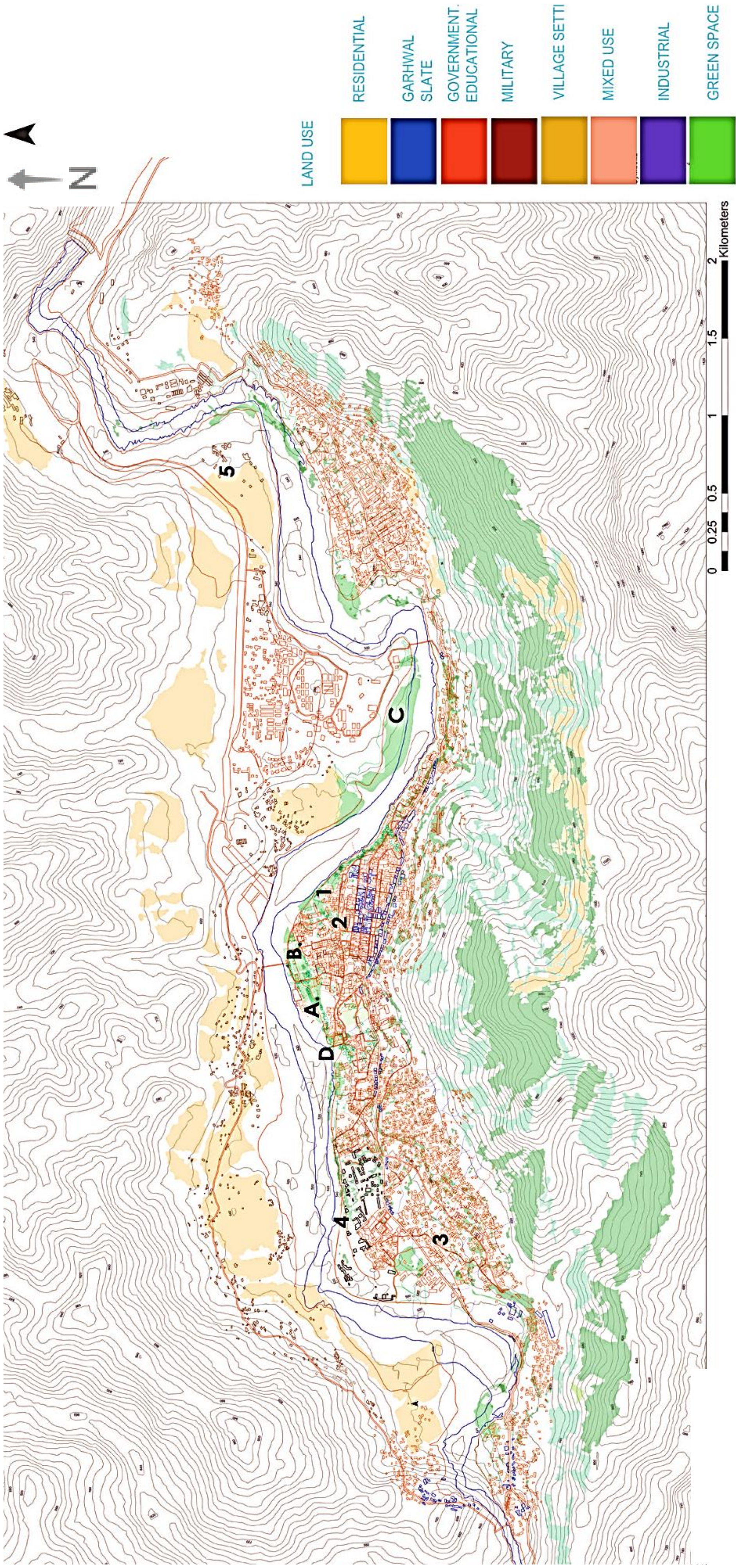


Fig.5.5. Vegetation Map of Srinagar Garhwal catchment. SOURCE: GIS



SOURCE: GIS

Fig.5.6. Land use map of Srinagar Garhwal.

6. URBAN SUITABILITY ANALYSIS

6.1. FLOOD IN RESPONSE TO GEOMORPHOLOGY

These quaternary deposits have created six terraces in this Srinagar Garhwal region. Old Srinagar town was situated in the second river terraces, which was destroyed by historic floods of 1894. The lower terraces are highly modified by the sedimentation and erosion process during extreme flooding event in Alaknanda catchment, With the reports on climate change these events are going to be common as Himalayan region comes under eco sensitive zone, which puts pressure on the se vulnerable land governed by communities during flood events.

Studying the Geomorphology and topographic map we can assume the river terrace up to second level to be highly vulnerable given its age and the damage caused by recent and historic floods, So mapping of geomorphological change in 100 year flood event will contribute in the further development of the city. This map will include varying levels of vulnerable areas soon to be affected by floods and other risks.

6.2. LAND USE IN CATCHMENT IN RESPONSE TO GEOLOGY, SOIL AND GEOMORPHOLOY

The lower and upper terrace of third level have land use of institutional, Commercial administration, educational, hospitals which has affected city limits. Lower portion have residential areas mostly because of the less value of land as it is vulnerable to the flood inundation from storm water and river as well. The rate development of city is highest in the second and fourth terraces. The sub urban areas are developed along the national highway from eastern an western side of the city center. The national highway runs in 3rd terrace but is affected when it cross Srinagar towards Kirtinagar**,** where inundation in recent flood caused problem by disconnecting upper reaches of Srinagar town from lower reaches causing long stretches of traffics within city

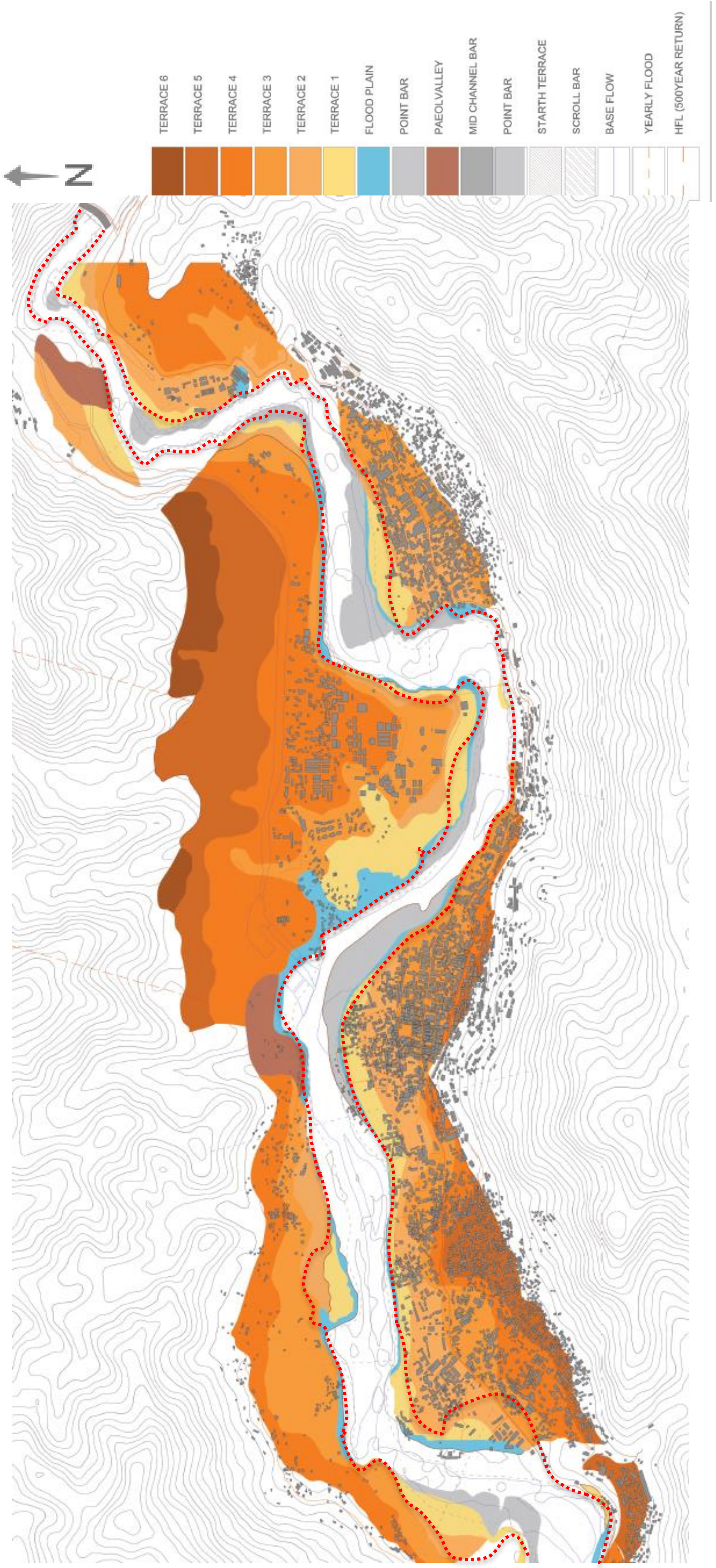


Fig.6.1. Floods in response to the geomorphology and settlement.

6.3. IMPACT AREAS

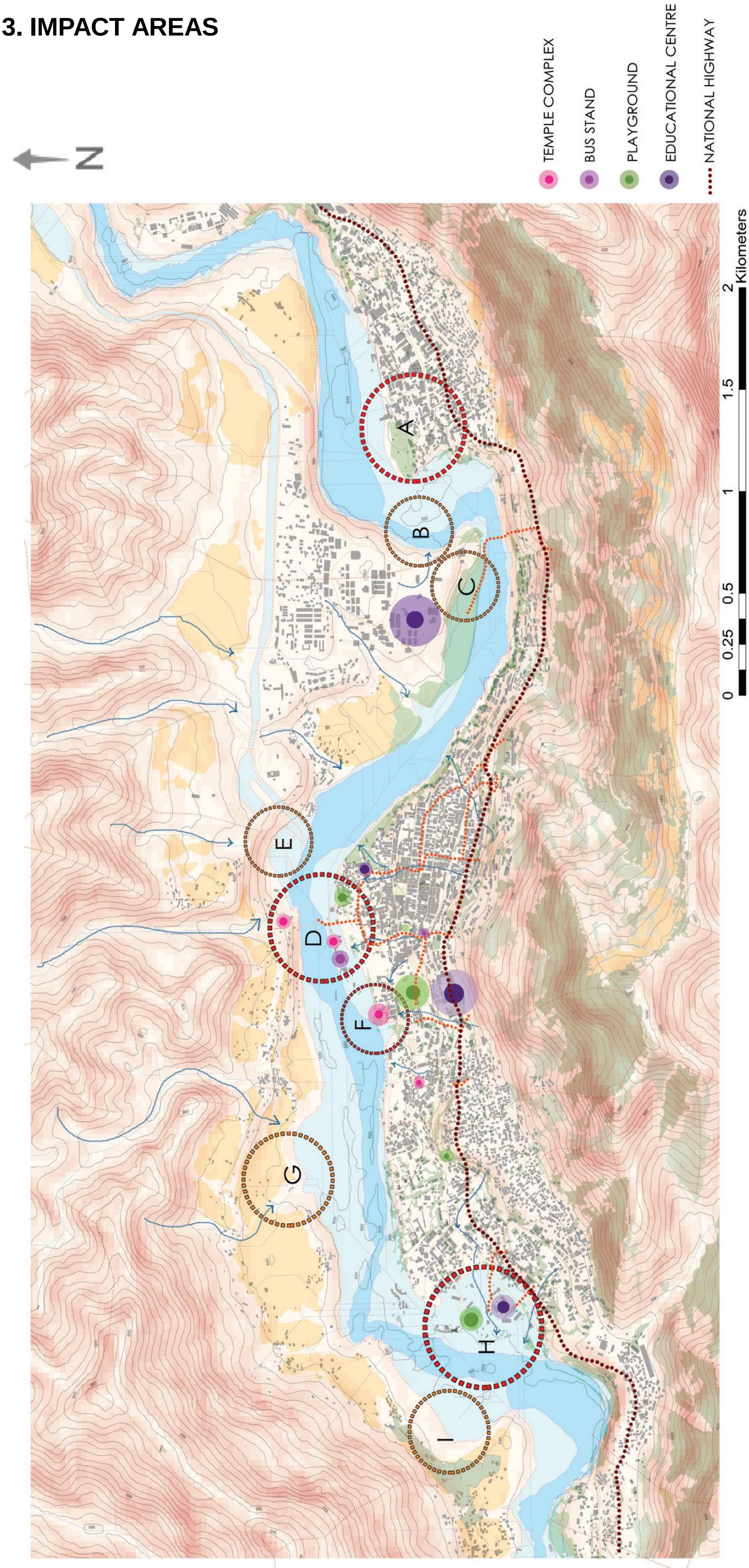
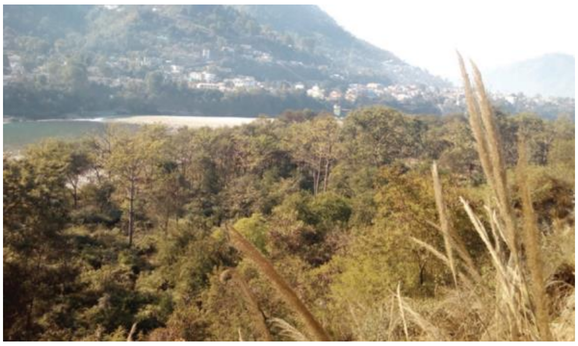


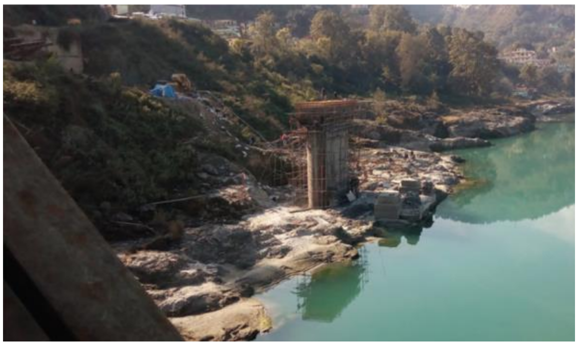
Fig.6.2. Impact areas in the Srinagar city from Alaknanda river.

A. Sedimentation at the Srikot area. New flood terrace can be seen, some of the area was inundated during 2013 flood, this sits on the lowest of flood plain.

B. Toe erosion at the bank. This was highly directed towards the muck disposal at the bank which further increased the sedimentation yield in the lower plain

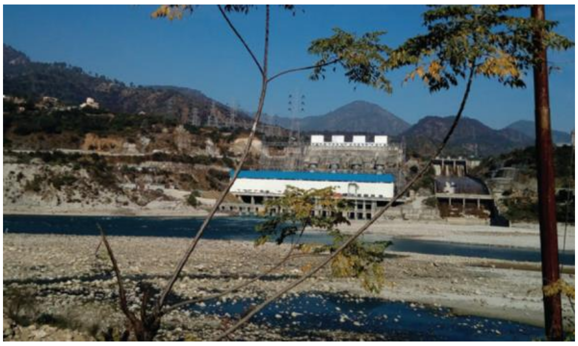


C. Typical riparian buffer which include the plant community of bombex Ceiba, delbergia Sisoo, Albizia Stipulata, Dendrocalamus Strictus, Pennisetum purpureum. is under pressure because of Illegal forest cutting which further threaten the buffer.



Exposed bedrock turns the river in other direction ,generally low density settlements are present in these areas

D. Concrete retaining wall creates ecological problems between water and land. In a long run it is failure as dead load increases with base flow. Important public transport route goes in this zone with one bus stand.



E. During the floods the gates release high volume of water which further affects this edge. It is highly fertile zone but destruction of riparian forest cover makes it susceptible to flood.

F. This is towards the way to temple, which is susceptible to erosion.

G. Flood water attacking the crop field in the lower portion of village.

H. Sedimentation yield was highest in this portion, created meters of silt deposition in this area. Retaining wall of concrete has been constructed sometimes ranging up to 7 m from base level.

I. Srinagar phyllite is exposed at the mid section of the river which further extends upwards, diverting the course of river and further attacking SSB area, nit campus shown in image H.

7. ISSUES AND STRATEGIES

7.1. MASTER PLAN IN RESPONSE TO FLOODS

The proposal of Master Plan-2001 was not in alignment of the recent flood inundation, The effect are visible in present context. Riparian zone is degraded by land use of residential and military area in lower river terraces. Recent floods have marked its territory in these existing land use, which strengthens the claim of loose perspective of river ecology in the failed development plan.

Sedimentation yield was highest near the military areas but master plan does not acknowledge the role of buffer areas along the river instead has encroached by constructing building in these sensitive zones. Important city nodes are also present in flood inundation part of Srinagar city, e.g.. Shiva temple, Bus stand, Important institutions. Bridge connecting Tehri Garhwal district and Srinagar Garhwal near Chauras was submerged during flood event.

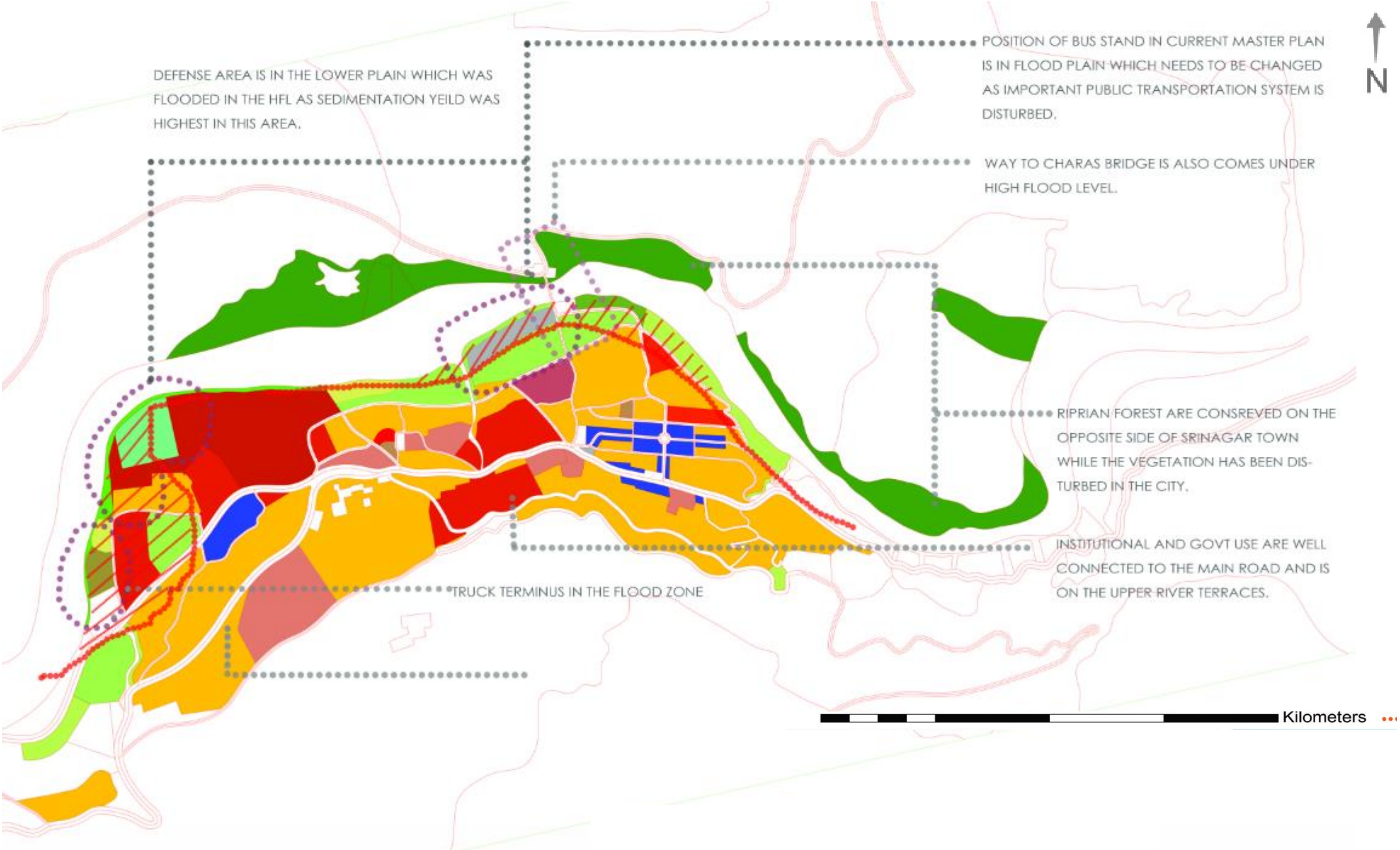


Fig.7.1. Srinagar city master plan-2001 and its response to flood. SOURCE: UHUDA,

7.2. ASSESSING THE VULNERABILITY ALONG THE ALAKNANDA BANK IN THE CATCHMENT

For the assessment of buffer areas in the catchment, vulnerability mapping needs to be prepared by analyzing of impact areas and landscape layers with respect to floods. This will give understanding of this landscape and helps in determining the policies and intervention for flood resilience. The Urban suitability analysis suggest that the edge of the river has to be protected and it should be categorized on the basis of its vulnerability.

The vulnerability zone are thus divided in three levels.

B.L. :- Base level

Y.F.L. :- Yearly flood level

H.F.L. :- Highest flood level

Vulnerability zone (On the basis of Landscape layer analysis)			
High vulnerability Zone:	Toe erosion, Public infrastructure (roads, buildings, village and urban settlement).	Inundation, Public infrastructure (roads, buildings, village and urban settlement), Erosion.	Toe erosion, Inundation, Streams (from surface runoff), Public infrastructure (roads, buildings, village and urban settlement).
Moderately vulnerability zone:	Toe erosion , Agriculture land.	Inundation, Erosion, Storm water runoff.	
Less vulnerability Zone:	Inundation, Agriculture land.	Inundation, Erosion, Storm water runoff.	

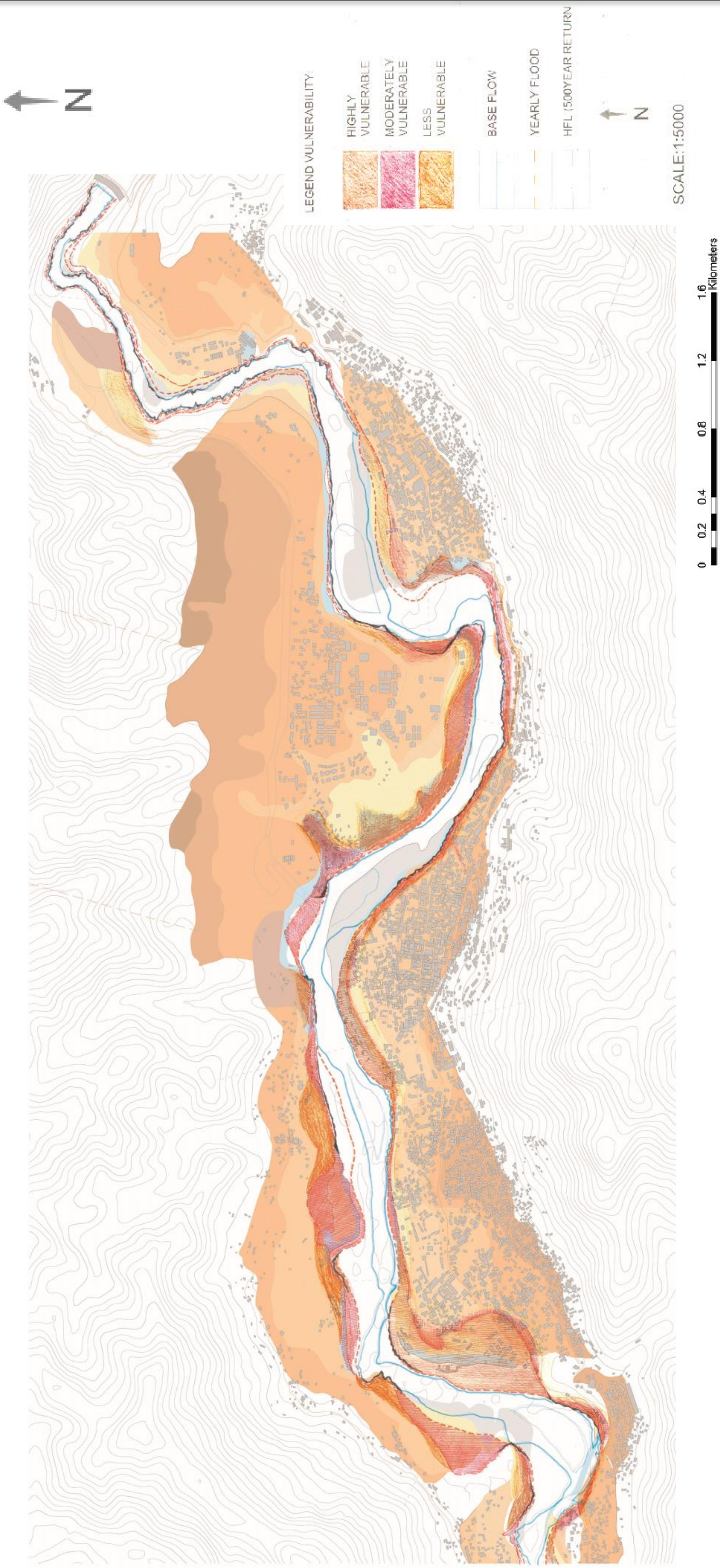


Fig.7.2. Vulnerability Mapping

Fig. 7.3. Buffer Mapping

7.3. Guidelines: For Riparian buffer zone.

Vulnerability zone (On the basis of impact Areas and land use, Geomorphology mapping)	Riparian buffer zone		
	Zone - I (BL-YFL)	**Zone - II** (YFL-HFL)	**Zone - III** (HFL+)
High vulnerability zone:			
I. Toe erosion II. Public infrastructure	• This should be left for river course. • H.F.L. edge should be designed by protective measures which helps in maintaining the ecological relationship between land and river. • No muck disposal on the • Steep slope.	• Flood resilient terracing anchored by gabion wall. • H.F.L. to limit in this zone. • Flood resilient planting • community. • Porous surface if walkways are provided	• Flood resilient terracing anchored by of gabion wall. • H.F.L. to limit in this zone. • Flood resilient planting community. • Porous surface material and public spaces which allows only bicycles and walkways.
I. Inundation II. Public infrastructure III. Erosion	• Protecting the flood plain and demarcating the new one. • Flood absorber gabion mattress anchored in the river bed.	• This is where riparian forest needs to be regenerated by river action and plantation of resilient riverine planting community in modified flood terraces.	• Riparian forest needs to be regenerated by sedimentation and plantation of resilient riverine community in modified flood terraces.
I. Toe erosion II. Inundation III. Streams IV. Public infrastructure	• Space for flood plain, protected measurers • (Gabion mattress, gabion wall keeping angle of repose at the bank). • Storm water outlet marked on all side by gabion wall and protected valleys.	• Flood terraces, riparian forest cover to be increase so pioneer planting species to be introduced. • Terrace needs to be modified.	• Developing public spaces as river park. • Resilient planting scheme, walkways porous, ramps need to be provided to access the lower range. • Important views to be conserved and viewpoints. • Storm water collector.

Vulnerability zone (On the basis of impact Areas and land use, Geomorphology mapping)	**Riparian buffer zone**		
	Zone - I (BL-YFL)	**Zone - II** (YFL-HFL)	**Zone - III** (HFL+)
Moderately Vulnerability zone:			
I. Toe erosion II. Agriculture land	• Protection from gabion wall to protect agriculture land.	• Resilient plant community • Strip cropping with agriculture land protected by gabion wall at the edge of modified flood terraces.	• Agriculture field with planting layers in strips.
I. Inundation II. Erosion III. Storm water runoff	• Protecting this zone by not intervening in it.	• Flood terraces anchored by gabion wall, soil stabilizing plant community	• Storm water runoff needs to be collected and moved in gabion wall check dams which retards the velocity of smaller streams) forest layer with hedge grows, grasses, and soil stabilizing trees in the upper portion).
Less vulnerability Zone:			
I. Inundation II. Agriculture land	• No intervention required, as sedimentation recreate terraces and should be left as it is.	• Resilient plant community • Strip cropping with agriculture and to be protected by gabion wall at the edge of modified flood terraces.	• Agriculture field with planting layers in strips.
I. Inundation II. Erosion III. Storm water runoff	• Protecting this zone by not intervening in it.	• High fertile zone, so pioneer species will developed with some added plantation.	• Strip cropping and forestry in the agricultural zone.

8. DESIGN INTERVENTION

8.1. Bringing Resilience in the edge of Srinagar city through Design Intervention

The growing fabric of city demands the need for enough spaces to accommodate its people, which results into encroachment primarily in the low cost lands, by default the flood plains gets directly affected by this requirement damaging the riparian buffer and fatalities caused by flash floods.

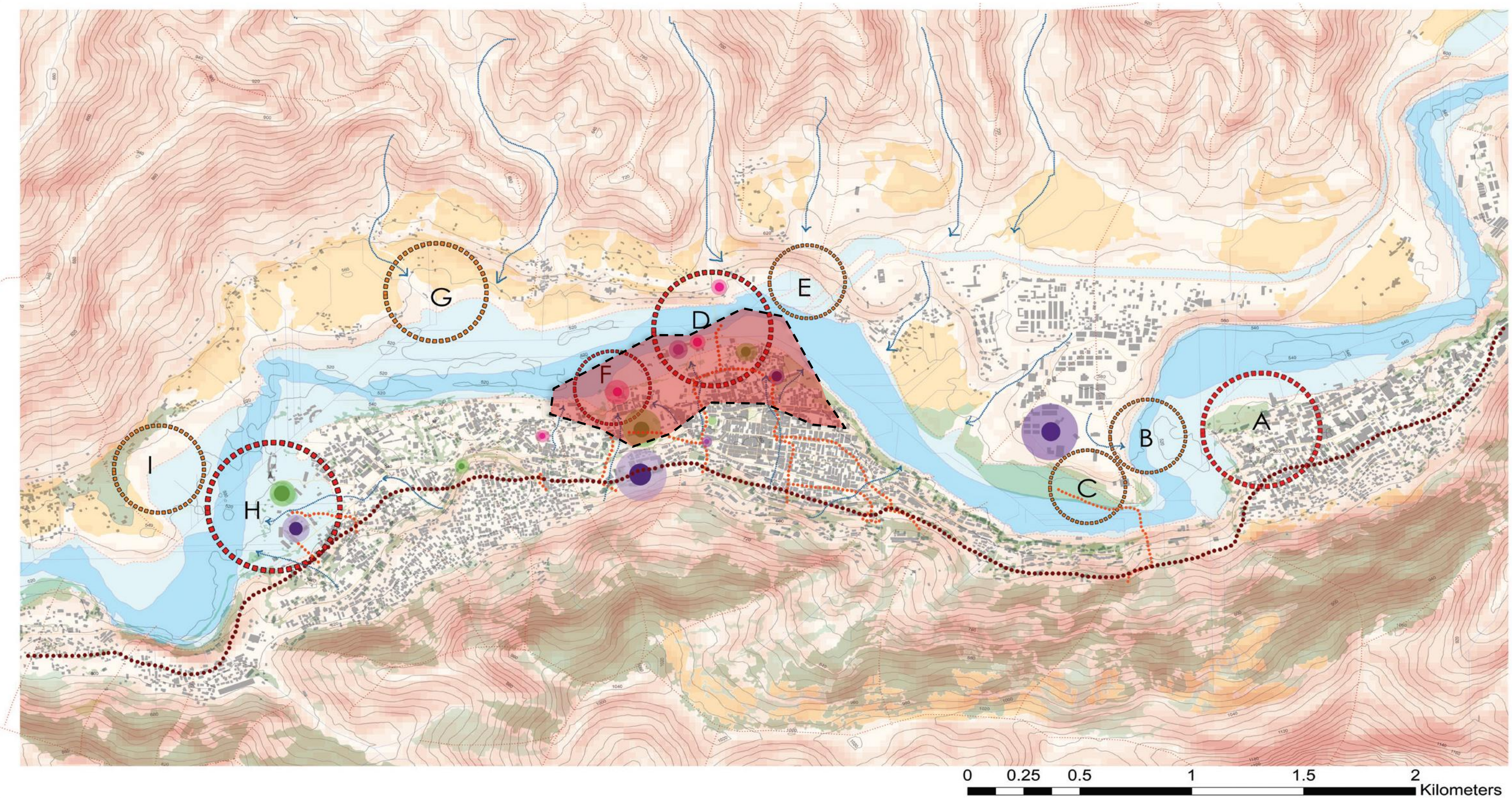
8.1.1. Factors determining the need for resilience in the site:

a. Location of important nodes: The demarcated area has various public spaces which can be protected and further enhanced through intervention, The selection criteria for the site is to provide area for city have buffer zone which can be facilitated into recreation areas.

b. Increase in the encroachment along the flood plain: Urban fabric has sprawled along the edges as well, these are the low priced lands which encourages encroachment. Many of these properties had been washed away during floods as well. So through policies we can propose these lands to be free of human settlements and give room for the river.

c. Potential riparian zone: Existing public spaces along with riparian vegetation can create dynamic balance between need for the buffer spaces and public necessities.

d. Need of recreational spaces in the city fabric: By providing public recreational zones in these areas, we can recreate lively public spaces along the river edges and also by providing large green cover as well.



The area demarcating red coded zone has various public spaces such as temples, Shamshan Ghats, Playground, Bridge connecting to other district from city centre, Potential riparian zone as a buffer in city edges.

1. **Residential Block**
2. **Temple complex**
3. **Ghats**
4. **Shamshan Ghats**
5. **Chauras Bridge**
6. **STP**
7. **Bus stand**
8. **Bicycle and car Parking**
9. **Riparian vegetation**
10. **Viewing decks**
11. **Raised walkway**
12. **Storm Water channel**
13. **Orchard**

Fig.8.1. Design Intervention along the edge.

Fig. 8.2. Section showing Urban park in response to flood level

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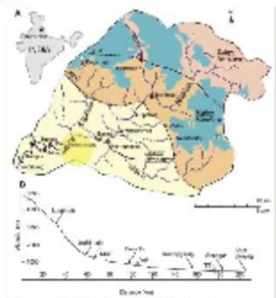
JURY SHEETS

BEFORE FLOOD

AFTER FLOOD 2013

2.



DRAINAGE MAP OF ALAKNANDA RIVER BASIN

3.

1.

2.

DESTROYED BUILDINGS IN THE LOWER AREAS OF TOWN.

3.

LOCATION OF SRINAGAR GARHWAL FROM DELHI

TITLE OF THESIS:

BUILDING FLOOD RESILIENCE IN THE FLOOD PRONE EDGE OF LESSER HIMALAYAN TOWN. CASE OF SRINAGAR GARHWAL.

INTODUCTION:

AIM:

OBJECTIVES:

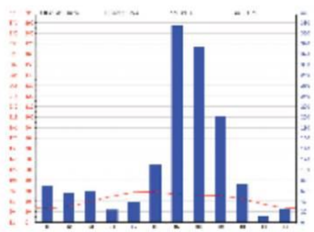
BASIN.

TO DEMARCATE THE BUFFER ZONE ALONG RIVER AND IN THE MICRO CATCH BASIN. TO BRING PEOPLE AND RIVER TOGETHER THROUGH RIPARIAN EDGE BY DESIGNING A PROPOSAL IN ONE OF ONE VULNERABLE AREA.

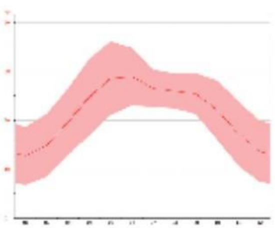
HISTORY:

DEMOGRAPHICS:

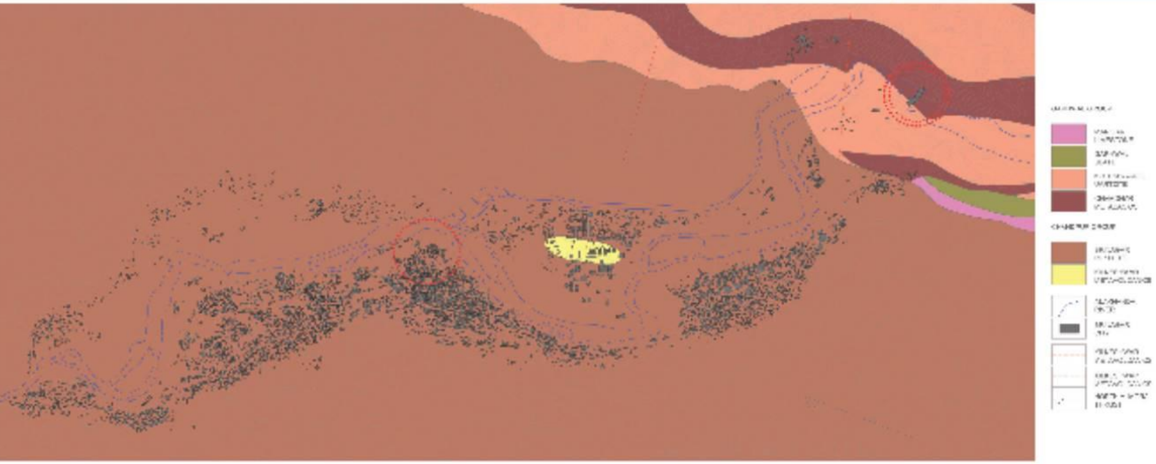
CLIMATE:



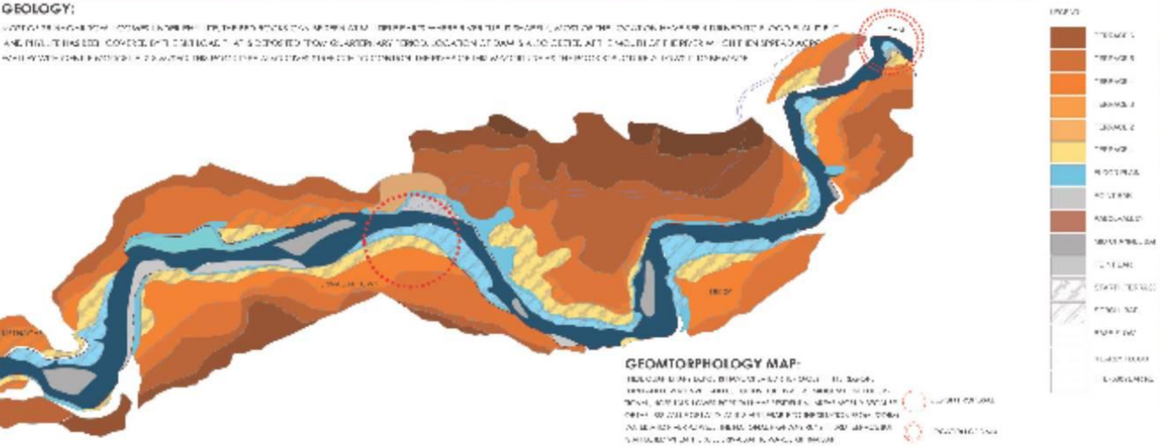
CLIMATE GRAPH



TEMPERATURE GRAPH



GEOLOGY:



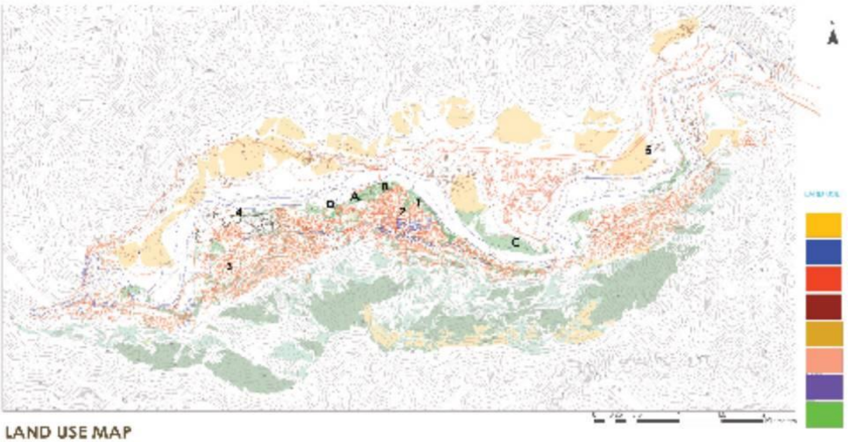
GEOMORPHOLOGY MAP:

HYDROLOGY:

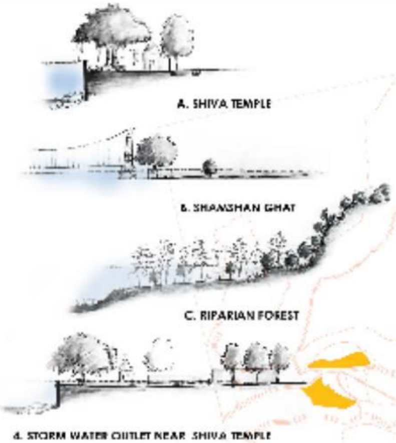
SLOPE ANALYSIS

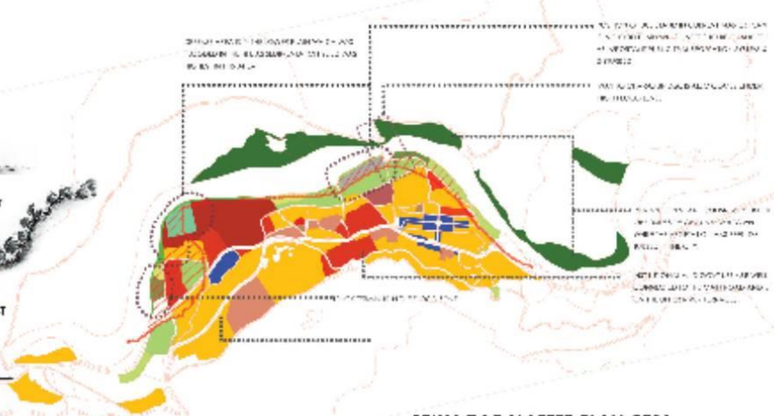
VEGETATION:

ELEVATION MAP



LAND USE MAP





SRINAGAR MASTER PLAN-2011

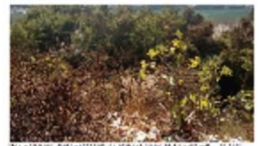
1.

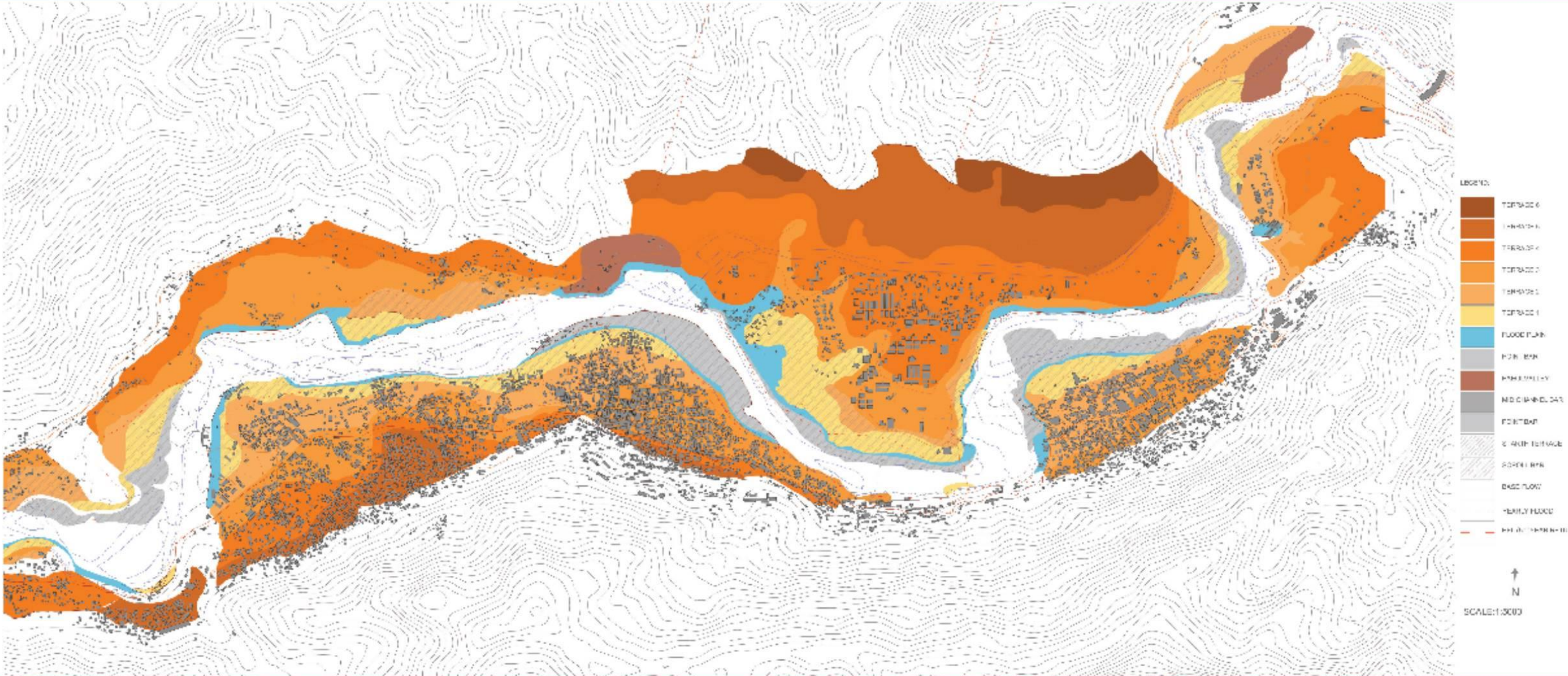
2.

3.

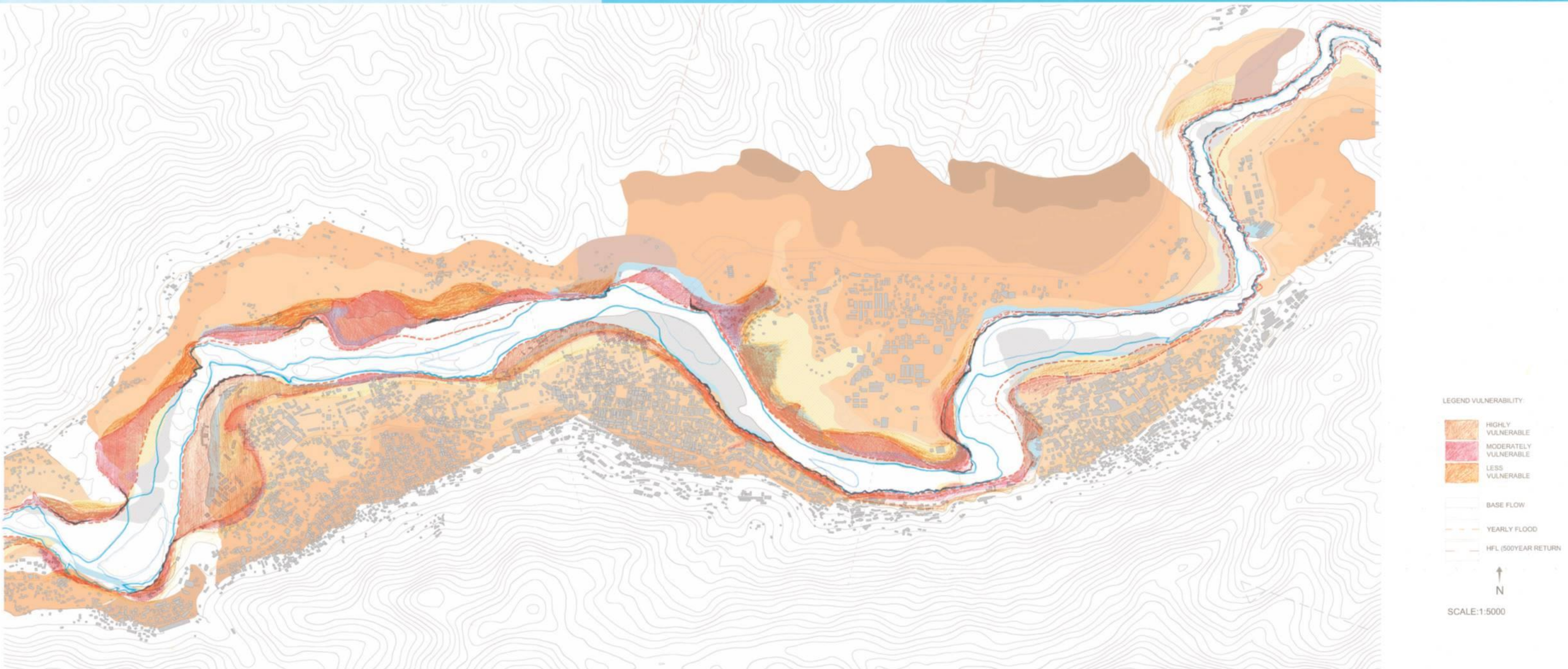
4.

5.



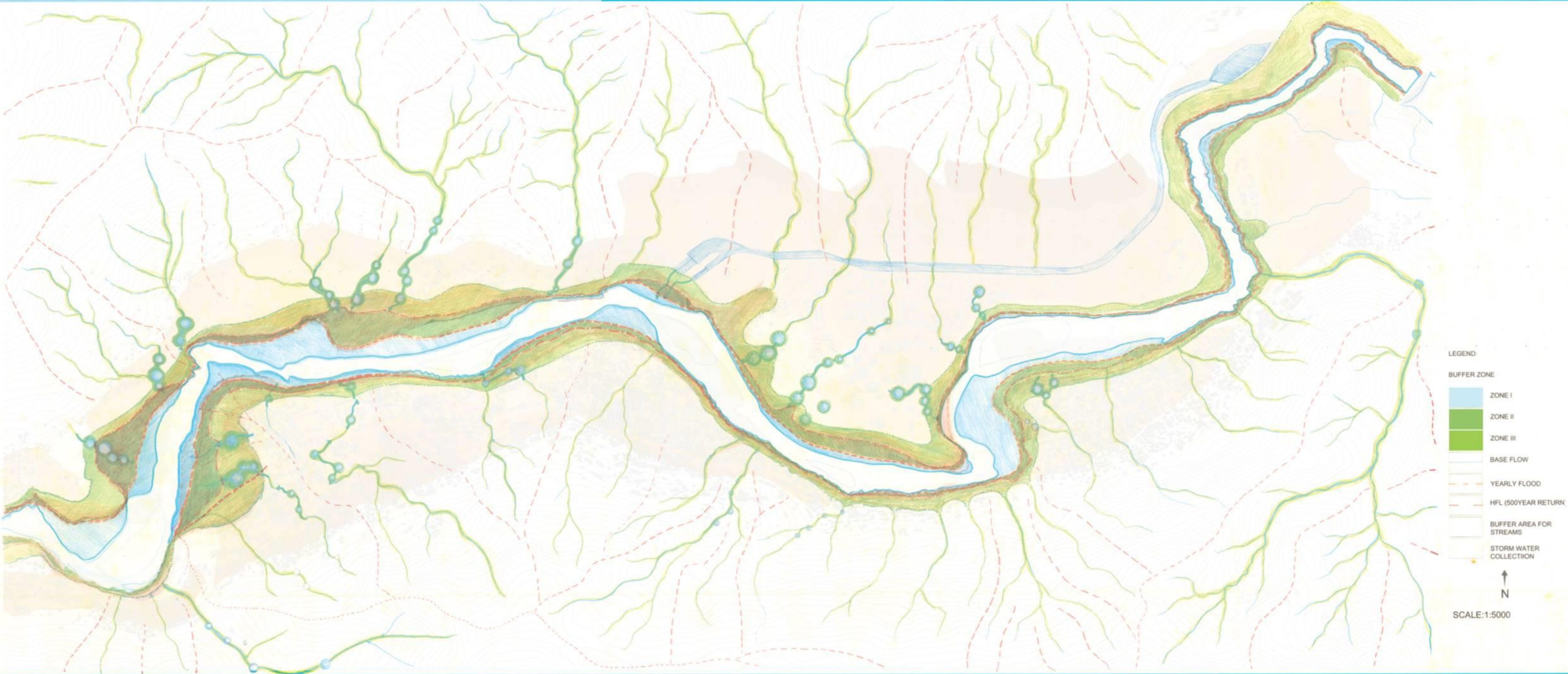


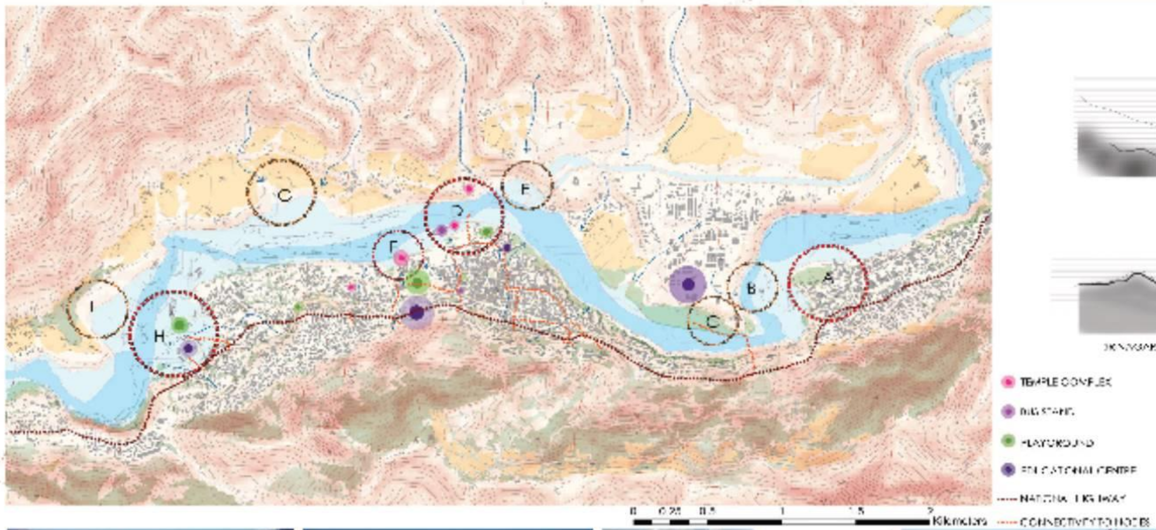
Geomorphology map

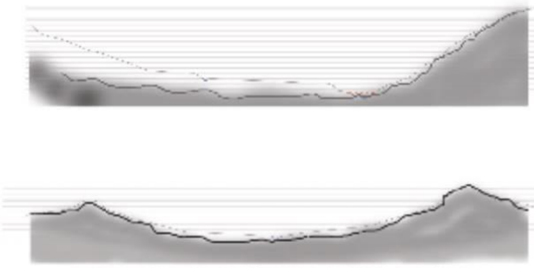


OVERLAY OF GEOMORPHOLOGY MAP, FLOOD INUNDATION AND IMPACT AREAS

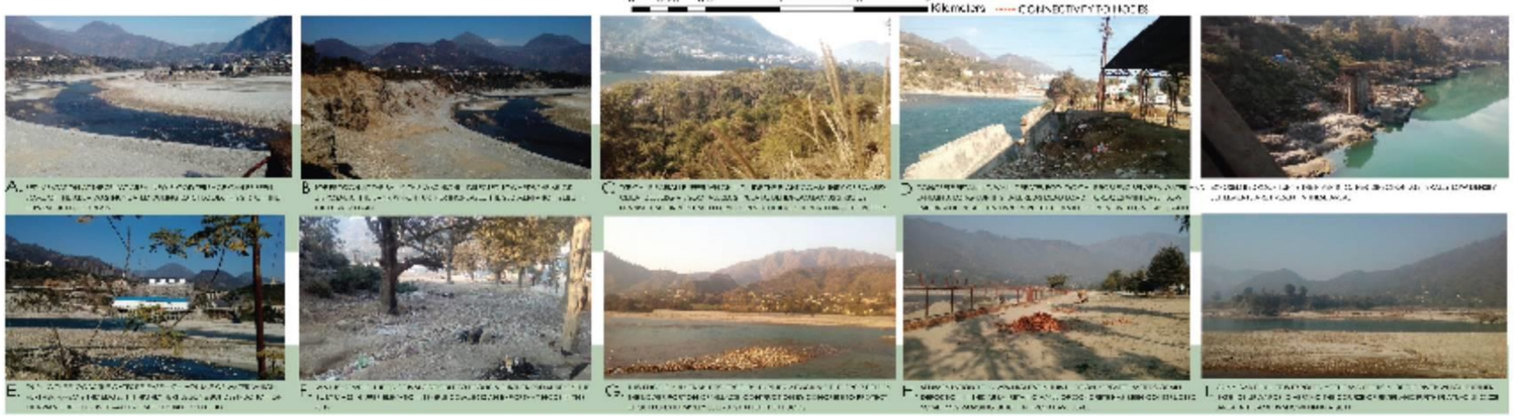
STRATEGY MAP FOR RIPARIAN BUFFER ZONE ALONG THE BANK OF ALAKNANDA RIVER







SRINAGAR MID SECTION SHOWS THE DISSECTED HILLS AND STEEP PHYLLITE ROCK SYSTEM



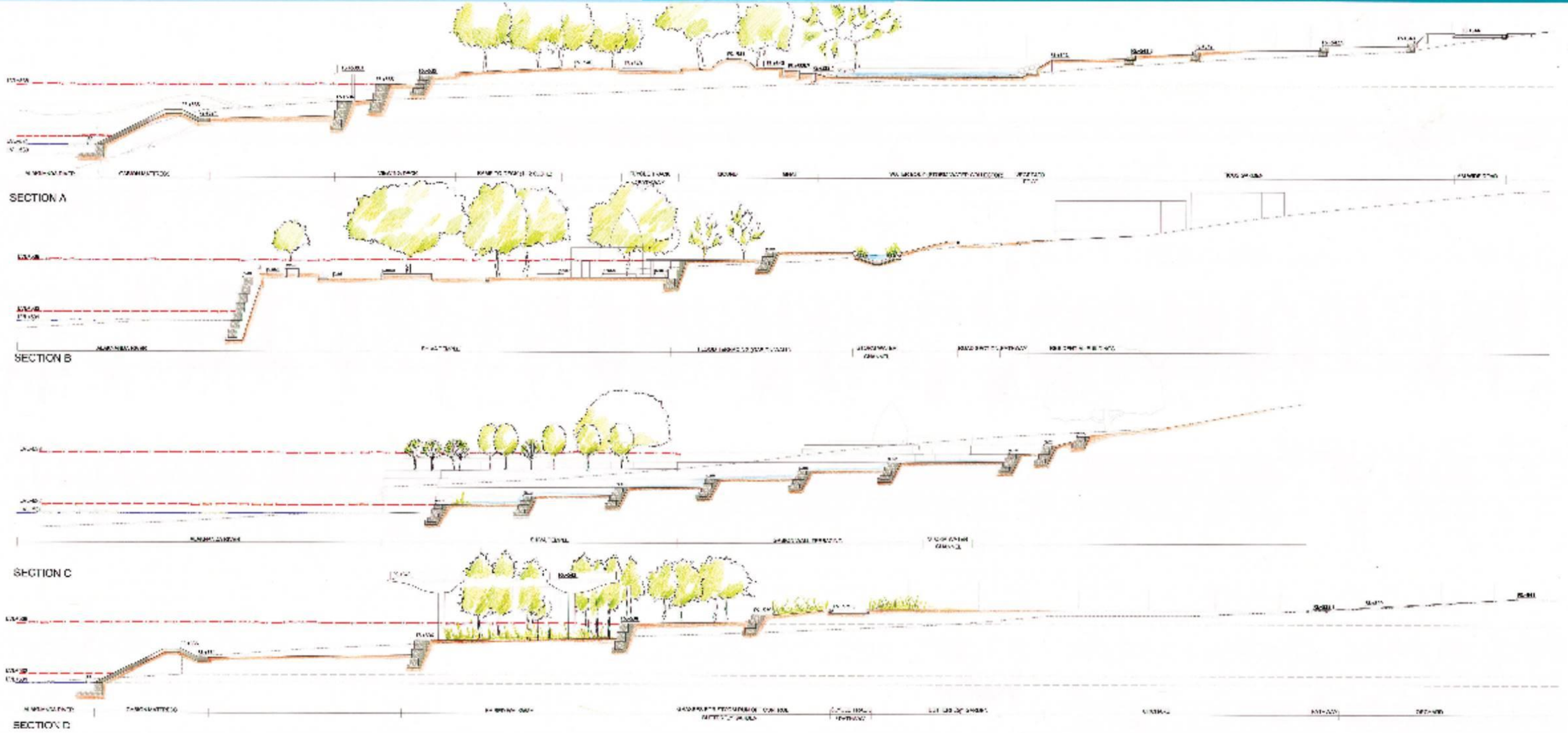
VULNERABILITY ZONE [illegible]	RIPARIAN BUFFER ZONE		
	ZONE - I [illegible]	ZONE - II [illegible]	ZONE - III [illegible]
HIGH VULNERABILITY ZONE			
TOE EROSION PUBLIC INFRASTRUCTURE (roads and buildings village and urban settlement)	THIS SHOULD BE LEFT [illegible] ... BETWEEN LAND AND RIVER. NO MUCK DISPOSAL ON THE STEEP SLOPE.	FLOOD RESILIENT [illegible]	FLOOD RESILIENT [illegible]
INUNDATION PUBLIC INFRASTRUCTURE [illegible]	PROTECTING THE FLOOD PLAIN [illegible]	[illegible]	[illegible]
TOE EROSION + INUNDATION STREAMS (from surface runoff) PUBLIC INFRASTRUCTURE (roads and buildings village and urban settlement)	SPACE FOR FLOOD PLAIN PROTECTED MEASURES (GABION MATTRESS, GABION WALL KEEPING ANGLE OF REPOSE AT THE BANK), STORM WATER OUTLET, MARKED ON ALL SIDE BY GABION WALL AND PROTECTED VALLEYS.	FLOOD TERRACES ANCHORED BY GABION WALL RIPARIAN FOREST COVER TO BE INCREASED BY PIONEER PLANTING SPECIES NEEDS TO BE INTRODUCED. TERRACE NEEDS TO BE MODIFIED.	DEVELOPING PUBLIC SPACES AS RIVER PARK WHICH INVITE PEOPLE AND VILLAGE IT CREATES GREEN AND BLUE CORRIDOR ALONG THE BANK. RESILIENT PLANTING [illegible] WALKWAYS POROUS, RAMPS NEED TO BE PROVIDED TO ACCESS THE LOWER RANGE. IMPORTANT VIEWS TO BE CONSERVED AND VIEWPOINTS TO BE DEVELOPED. STORM WATER COLLECTOR THROUGH GABION WALL CHECK DAMS
MODERATELY VULNERABILITY ZONE			
TOE EROSION AGRICULTURE LAND	PROTECTION FROM GABION WALL TO PROTECT AGRICULTURE LAND	RESILIENT PLANT COMMUNITY STRIP CROPPING WITH AGRICULTURE AND THIS LAND NEEDS TO BE PROTECTED BY GABION WALL AT THE EDGE OF MODIFIED FLOOD TERRACES.	AGRICULTURE FIELD WITH THREE STOREY PLANTING LAYERS IN STRIPS.
INUNDATION [illegible] STORM WATER RUNOFF	[illegible]	[illegible]	[illegible]
LESS VULNERABILITY ZONE			
INUNDATION AGRICULTURE LAND	NO INTERVENTION REQUIRED AS SEDIMENTATION [illegible] AND SHOULD BE LEFT AS IT IS.	RESILIENT PLANT COMMUNITY STRIP CROPPING WITH AGRICULTURE AND THIS LAND NEEDS TO BE PROTECTED BY GABION WALL AT THE EDGE OF MODIFIED FLOOD TERRACES.	AGRICULTURE FIELD WITH THREE STOREY PLANTING LAYERS IN STRIPS.
INUNDATION [illegible] STORM WATER RUNOFF	PROTECTING THIS ZONE BY NOT INTERVENING IN IT.	[illegible] DEVELOPED WITH SOME [illegible] PLANTATION.	[illegible]

SITE PLAN

BUILDING RESILIENCE IN THE FLOOD PRONE EDGE OF LESSER HIMALAYAN TOWN, CASE OF SRINAGAR GARHWAL

SCALE- 1:500

SAURAV PARMAR(2015MLA007)


SECTION A
SECTION B
SECTION C
SECTION D