ANALYSING THE IMPACT OF SAND MINING ON THE FLOW OF TAWI RIVER, JAMMU AND KASHMIR

A Project work Submitted to the Central University of Punjab

For the award of

Master of Science

In

Geography

BY

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May, 2018

DECLARATION

I declare that the dissertation/thesis entitled "ANALYSING THE IMPACT OF SAND MINING ON THE FLOW OF TAWI RIVER, JAMMU AND KASHMIR" has been prepared by me under the guidance of Dr. L.T. Sasang Guite, Assistant Professor, Department of Geography and Geology, School of Environment and Earth Sciences, Central University of Punjab, Bathinda. No part of this dissertation/thesis has formed the basis for the award of any degree or fellowship previously.

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CERTIFICATE

I certify that VISHABH SALGOTRA has prepared his dissertation entitled “ANALYSING THE IMPACT OF SAND MINING ON THE FLOW OF TAWI RIVER, JAMMU AND KASHMIR”, for the award of Master of Science Degree under my guidance. He has carried out his work at the Department of Geography and Geology, School of Environment and Earth Sciences, Central University of Punjab, Bathinda.

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ABSTRACT

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Department	:Geography and Geology
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Keywords	:Tawi river, Sand, Mining, Mapping, River flow.

The river Tawi in Jammu and Kashmir faces indiscriminate sand mining practice where large amount of sand is being mined from the river bed between Nagrota and Sidhra area. The increasing pace of urbanization and associated developments in Jammu City and nearby areas are responsible for this practice. The mining activity in Tawi river involves massive digging of river bed materials upto 3-4 mts depth with the help of heavy duty excavators used by the mining contractors, whereas, the Geology and Mining Department gave the permission to extract the materials up to 3 mts depth. Moreover, the sand mining has impacted the flow of river Tawi particularly between Nagrota and Sidhra. In this study, the locations of sand mining sites in Tawi river between Nagrota and Sidhra are mapped from 2007 to 2018 and an attempt made to analyse the possible impact of sand mining on the flow of river. The mapping is done by using GIS technique and a field visit is also carried out for acquiring the coordinates and photographs of present sand mining sites in river Tawi.

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I would like to express my deepest thanks to my supervisor **Dr. L.T. Sasang Guite**, Assistant Professor at Department of Geography and Geology, Central University of Punjab, Bathinda for his diligent guidance and patience throughout my research work. This thesis would not have been possible without his unmatched support and enthusiasm. I consider myself lucky as I got a chance to work under his supervision. I would like to express my sincere thanks to **Dr. Kiran K Singh**, Assistant Professor at the Department for her valuable suggestions and generous advices during my research work. I would like to thank to **Dr. Milan K. Sharma** and **Dr. Jitendra K. Pattanaik,** Assistant Professor at the Department for their valuable suggestions during my research.

I also express my thanks to **Mr. Amrit Pal Singh, Mr. Amandeep Singh, Mr. Prem Chand Kisku, Mr. Gaurav Kumar and Ms. Amandeep Kaur, scholars at the Department**, for their constant support and suggestions during the compilation.

My great thanks and appreciation also goes to Central University of Punjab for the provision of such great platform so as to accomplish my research work. I would also like to thank to laboratory attendant **Mr. Puneet K Arora** who help me during my work.

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Vishabh Salgotra

(Name and signature of student)

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CHAPTER 1

INTRODUCTION

1.1 Introduction:- The demand for construction grade sand has increased rapidly in many parts of the world due to the increasing economic development and growth of building activities. This, in many of the occasions has resulted in indiscriminate mining of sand from in-stream as well as floodplain areas which in turn, leading to severe damages to the river basin environments (Nandakumaran et al. 2014). Sand is used for different types of projects like land reclamations, construction of artificial islands and coastline stabilization, for constructing roads and buildings etc. Indiscriminate sand mining in many rivers across the world has become a serious issue. Basically, sand mining is a process of actual removal of sand from the foreshore including rivers, streams and lakes as well as from beaches, inland dunes and dredged from ocean beds and river beds. Environmental problems are said to occur, when the sand extraction rate exceeds the rate at which natural processes generate sand. People extract sand for economic as well as social purpose.

1.2 Impacts of River Sand Mining:- Sand mining in rivers can negatively affects the river morphology like river bed degradation, bank destabilization, deforms the river channel, mining can lead to the deepening of the river channel etc. (Ashraf et al. 2011). Excessive sand mining in the rivers is a threat to bridges, river banks as well as nearby structures and it also negatively affects the adjoining groundwater system. River sand mining can generate extra vehicle traffic in the adjoining areas like access roads cross the riparian zones, which in turn impacts the local environment. (iasscore.in)

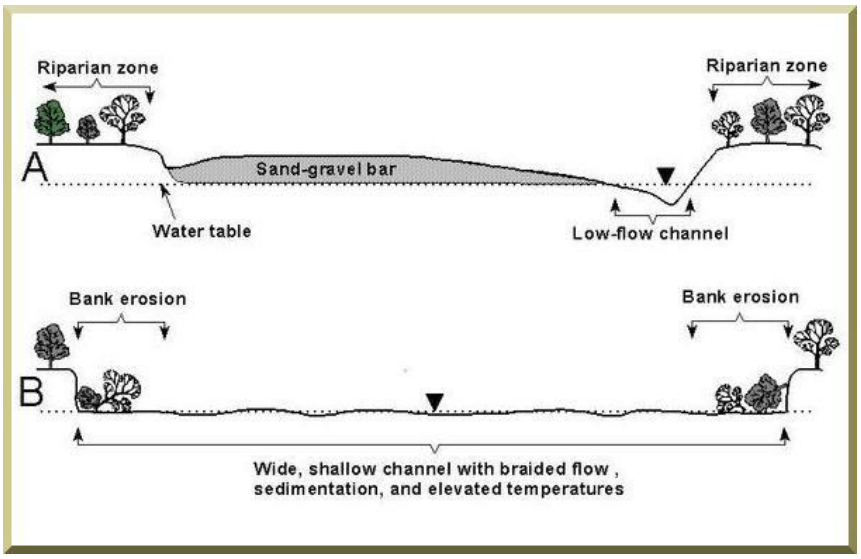


Figure.1:- Cross-Sectional Image of a River Channel showing Impact of Sand Mining on the River Channel. (Madyise, 2013)

Fig.1 shows the cross-sectional image of a river channel in which (A) part shows the sand and gravel bar on the river bed in relation to the low flow of the channel, riparian zone and water table. (B) shows the impact of excessive mining due to which the channel becomes wide and shallow followed by braided flow, river bank erosion, destruction of adjoining vegetation, sedimentation, lowering of water table as well as increase in the water temperature. The excessive mining of sand from the river bed increases the velocity of river flow due to which erosion of river bed and banks occur. (Madyise, 2013)

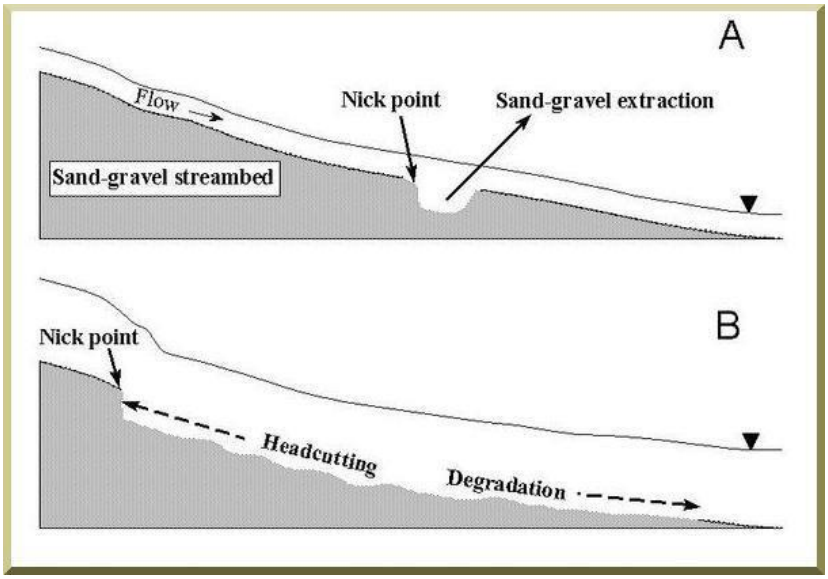


Figure.2:- Impact of in-stream sand mining on River Channel. (Madyise, 2013)

Fig.2 shows that the in-stream extraction of sand and gravels makes a pit on the river bed which in-turn lowers the stream bed and results in the formation of a nick point. Nick point acts as a change in the channel slope thereby increasing the channel gradient due to which the flow velocity or energy of a river increases. The nick point give rise to head cutting in the river bed which gradually moves upstream and cause degradation of river bed in the downstream. (Madyise, 2013)

1.3 Types of Sand/Gravel Mining:-

A. Skimming: - In this method, the gravels are extracted from the surface of gravel bars and normally it is done from 0.3-0.6 m (1-2 ft).

B. Dry pool mining: - Sand is excavated from the bed of the active channel or from dry temporary or ephemeral (seasonal) stream.

C. Wet-pool channel mining: - In this method, a pool is excavated in the active channel below the surface water in a perennial stream or below the river groundwater table.

D. Bar excavation: - This method involves the excavation of a pool at the downstream end and after excavation, the pool may be connected to the channel at its downstream and provide side channel habitat.

E. Channel wide instream mining: - In this case, the rivers which have highly variable flow regime, experiences the extraction of gravel/sand commonly from the bedload of streams.

1.4 Characteristics of River Sand Mining:- According to (Mathada, 2017), the river sand mining activity is characterized by deep and wide pits which are created during mining processes. These pits affect the natural flow of water into the river. Another characteristic of river sand mining is that, the access roads and tracks made by the vehicles entering into the river and moving on the river bed for extracting sand (Madyise, 2013).

1.5 Sand Mining at International Context:-

In China, largest quantity of sand is being mined from most of the rivers especially, from the middle and the lower reaches of the Yangtze river, the Pearl river delta

and the adjacent estuaries. This has resulted series of problems such as the degradation of the riverbed elevation, fall of the water level, exposure of the dike and bridge foundation as well as turbulent currents in waterways. The Dongjiang River in China, is also badly affected by the sand mining activity which was started in the 1980s and had caused a severe impact on the riverbed evolution and hydrology of the Dongjiang River. (JIA Liangwen et al. 2007)

The demand for sand in China is greater than anywhere else because of rapid urbanization and is said to be the biggest sand market. According to United Nations Environment Programme (UNEP), the demand for cement has increased by 400% over the past two decades. In the past four years, China has used more cement in comparison to US used in the entire 20th century. The Mekong river is another major source of sand for China's construction industry and dredging has taken place from years along the Mekong river. World Wide Fund (WWF) has estimated that, about 50 million tonnes of sand was extracted in 2011 alone from the Lower Mekong between Laos and Vietnam i.e much more than the river produces in a year. This resulted in the decline of riverbed by more than a metre in the delta between 1998 and 2008, allowing salt water to seep further into rice paddy fields and the entire delta to subside. (thethirdpole.net)

In Bangladesh, the local residents reported about the illegal sand mining from the rivers which are carried out with the support of elected public representatives. The construction companies install heavy machinery in the rivers and then they extract sand, affecting negatively not just the riverbed but the farms on the banks. The illegal extraction of sand is the root of riverbank erosion across the Ganga-Brahmaputra-Meghna delta that makes up most of Bangladesh. The sand which is extracted from the rivers is used for the construction industry. According to recent media reports, the illegal sand mining is excessive in Narayanganj, Tangail, Sirajganj, Munshiganj, Rajshahi and Manikganj districts and most of the rivers of Bangladesh either big or small are affected. (thethirdpole.net)

Nepal hosts most of the rivers, which are being mined for sand. One among them is Bagmati river, where the sand mining is banned by the Nepal govt. because of the collapse of bridge over this river in Kathmandu. A case study done by Tribhuvan University in 2007 said that the illegal riverbed mining supports 40%

of the total demand for sand in the Kathmandu valley. The study shows that the vegetative cover of aquatic environments is under serious threat due to the excessive extraction from the riverbed. This practice of uncontrolled sand mining has put the bridges in danger and leading to the lowering of the riverbeds. A study done on western Nepal's Tinau River revealed that the riverbed has been lowered by 2.5 metres in the last 15 years. (thethirdpole.net)

1.6 Sand Mining at Indian Context:-

Sand mining is a common practice in most of the rivers of India for example in Ganga and Yamuna, from where excessive sand is being mined, causing damage to the morphology of the rivers and making them more prone to disaster. One of the negative result of sand mining is that the bank erosion in these rivers has increased and it leads to one of the bridges over Ganga has become unusable. In Kerala also, the rivers are being mined to extract sand for commercial purpose and this practice has degraded the health of those rivers. Some of the rivers of southern Kerala like the pampa, the Manimala and the Achankoil has driven to the verge of death due to indiscriminate sand mining. (thethirdpole.net)

Same is the case with Tawi river in Jammu and Kashmir, where indiscriminate sand mining is a serious issue. Large amount of sand is being mined from the river Tawi river bed day and night between Nagrota and Sidhra area. The increasing pace of urbanization and associated developments in the Jammu City and nearby areas are responsible for this practice. The sand mining activity is going unabated even then the Government officials are not doing anything to stop it (Tribune News, 2016). Tawi river experiences over-exploitation of river bed materials due to which the river banks faces severe erosion which leads the habitations, land and property on the banks more vulnerable to the danger of floods. Tawi river faces massive digging of river bed materials up to 3-4 mts depth with the help of heavy duty excavators used by the mining contractors, whereas, the Geology and Mining Department gave the permission to extract the materials up to 3 mts depth. The rules and acts which are made to protect or conserve the water sources of Jammu are being disobeyed (Department of PHE and Irrigation & Flood Control, 2013). According to State Times News, 2017, there are also some construction activities which come and fall on either side of the Tawi

river and among them some are unauthorized. While passing through the urban areas, river Tawi is used for depositing untreated domestic sewage, garbage, animal excreta, dead animals, agricultural runoff (fertilizers and pesticides) and detergents without any restriction. The river experiences extreme floods during the time of rainy season and it is these floods, which results in the deposition of stones, mud, silt etc. in the form of sediments on the shores and riverbed carried by the river across for several kilometres. The regular dredging of the bottom and shores for extraction of sand and stones has altered the shoreline morphology of Tawi river (Sharma V, 2013).

1.7 Statement of the Problem:-

Tawi river is experiencing unabated and random sand mining practice from the past years. Every day, there is the sighting of tractor-trailers and tippers extracting sand from the river bed of Tawi. The over-exploitation of river bed materials has resulted in the habitations, land property on the banks highly vulnerable to the danger of floods. The increasing urbanization and other developmental activities in Jammu City and nearby areas resulted in excessive day and night mining in the Tawi river between Nagrota and Sidhra area. After 2014 floods, this practice of sand mining has picked up speed as the floods have brought large amount of sand from upstream areas. The contractors use heavy duty excavators to extract sand from the river bed upto the depth of 3-4 mts. which is against the limitations given by the Geology and Mining Department. Moreover, the sand mining practice has impacted the flow of river Tawi particularly between Nagrota and Sidhra. Thus, the present study is an attempt to analyze the possible impact of Sand mining activity on the changing flow of Tawi river between Nagrota and Sidhra, Jammu and Kashmir.

1.8 Objectives:-

- Mapping of sand mining sites in Tawi River between Nagrota and Sidhra from 2007 to 2018.
- To analyse the change in the flow of Tawi river between Nagrota and Sidhra from 2007 to 2018.

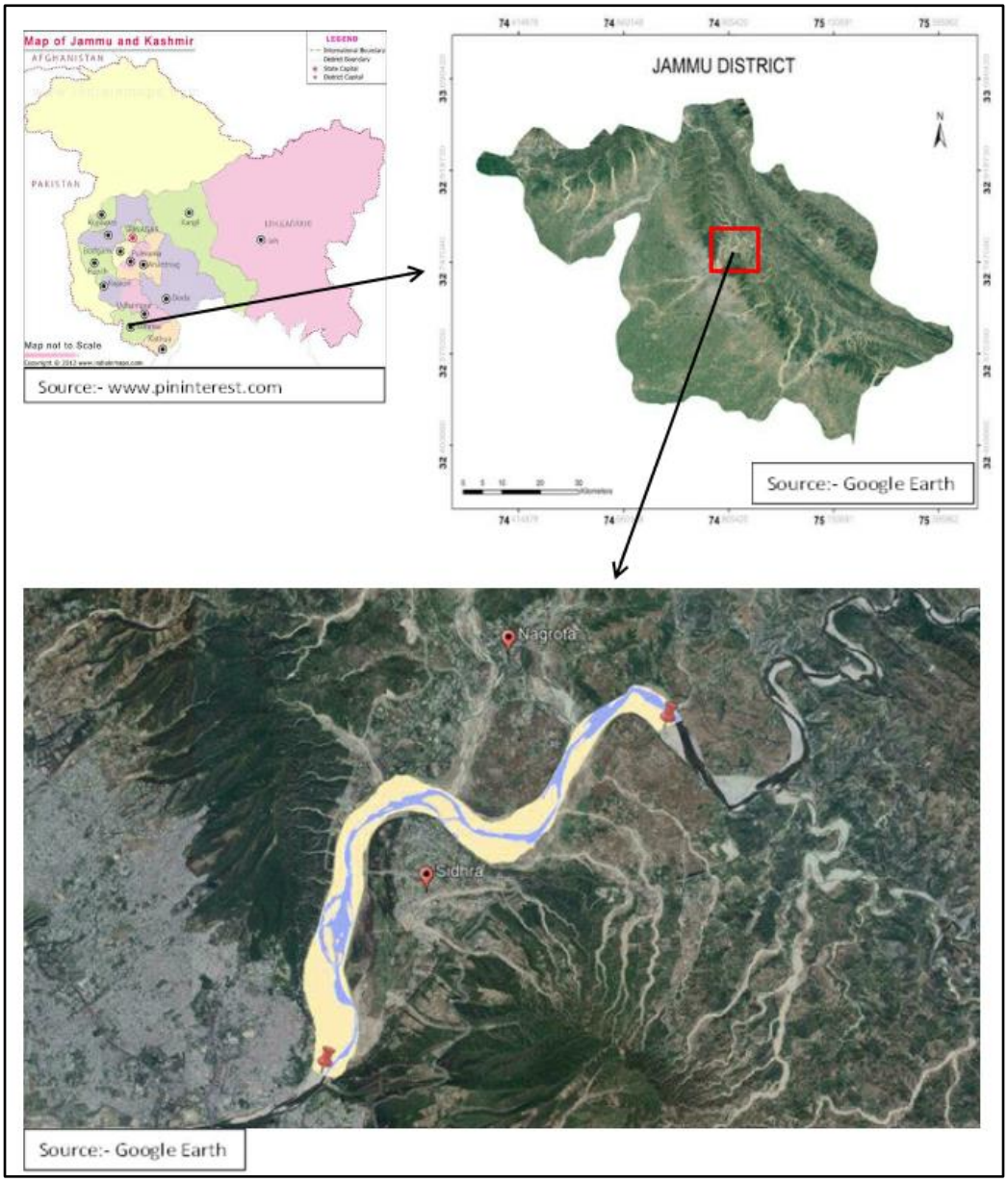
1.9 Research Question:-

- Has the rampant sand mining resulted in the changing flow of Tawi river?

1.10 Study Area:-

The River Tawi is a major left bank tributary of Chenab River and this river covers most of its journey through the steep hills. While passing through the study area between Nagrota and Sidhra, the river crosses the outer hills or foot hills of Jammu region and it follows a meandering course. The width of the river bed between Nagrota and Sidhra varies between 600-700 mts and its length between the same area is about 9 km. The study area lies between 32°46'03" N Latitude and 74°53'40" E Longitude. The area is located on uneven low valleys of Trikuta Hills and the average elevation of this area ranges between 336-412 mts above the mean sea level. The area lies in the north of Jammu City and is about 7.5 km away from the City. Like most of the rivers in the country, the Tawi River too is considered as sacred and holy. During the rainy season, the river brings huge volume of floods because of numerous small and large nullahs and streams falling into it. The river has a wide channel which fills with river water only during the rainy season and for the rest of the year the river follows its course in the form of a narrow flow.

The study area has humid subtropical climate where winters are cool with daytime average temperature of 2.5°C (36.5°F) and goes to freezing point at night. Summers are warm with daytime temperature of July reaches to 39°C (102.2°F). The average annual rainfall is around 720 millimetres (28 inches). The summer season starts from March to June followed by heavy rainfall during monsoons in the month of July whereas the winters start from December to February. Agriculture is being practised in the left side of Tawi river on the banks and in the floodplain areas while in the right side, some portion is covered with dense forest and some is under settlement, public infrastructures etc.



Map.1: Location of Study Area (**River Tawi**)

In most of the newspaper reports, the area between Nagrota and Sidhra is highlighted as the major concerning area regarding to sand mining activity in the Tawi river as well as this area is also mentioned by the different environmentalists and activists in their articles and RTI reports. A report of Jammu and Kashmir State High Court is too mentioning Nagrota and Sidhra area in context of sand mining practice in Tawi river. The report of Jammu and Kashmir Industries and commerce department shows that the area of Tawi river falling in downstream Nagrota village was under the influence of Un-actioned minor mineral sites.

CHAPTER 2

LITERATURE REVIEW

2.1 Literature Review 1:- Excessive sand mining in the rivers across the world has established as a serious problem. This practice is worsening the condition of the rivers by disturbing or changing the river morphology like river bed degradation, bank destabilization, deforms the river channel, deepening of the river channel and making them unsuitable to support vegetation and plant and animal diversity. The studies on excessive sand mining in the different rivers have been conducted by different researchers. In Kerala, the rivers of the Vembanad Lake catchment area are facing excessive sand and gravel mining. As the Vembanad Lake catchment area hosts the Kochi city, which is the fast developing coastal townships in South India, so, the rivers of this catchment area are degraded to the alarming rate. The rivers like chankovil, Pamba, Manimala, Meenachil, Muvattupuzha, Periyar and Chalakudy drains the Vembanad Lake catchment area. The fast pace of industrialization, urbanization and associated developments has increased the demand of construction grade sand in the State over the past few decades. The net reserve of sand in these rivers is very small as compared to the rivers in neighbouring states like Karnataka and Tamil Nadu. The method adopted for this research was Field surveying. The results indicate the change in bed forms of rivers. (Sreebha, 2008)

2.2 Literature Review 2:- Another study was done on the Neyyar river, Thiruvananthapuram, Kerala. There is excessive sand mining since 1990 due to economic development and rise in liberalized housing schemes from the banking sector for building constructions. The study reveals that the sand mafia even purchased the private lands to extract the sand which are adjacent to the river banks. The excessive extraction of sand from these lands results in river water enters into that part and makes the area a part of the river due to which the neighbouring people have to sell their land holdings for sand extraction. The method used was Field survey in the selected sites using. The result shows that the extraction of sand from the neighbouring areas of the river banks has negatively changed the land. The sand mining in the adjoining flood plain areas has resulted in widening of the river channel to the mining sites, the river course

has changed, agricultural land is negatively affected, there is a loss to government and private properties, the arable lands are transformed into wastelands. (Shaji J, 2014)

2.3 Literature Review 3:- Dacosta and Mathada, 2017 has made a significant study on the sand mining activities along the Nzhelele river in Limpopo province of South Africa. There is an increasing trend of sand mining activities due to the high demand of sand. Residential and commercial construction activities are increasing in that area and this have triggered the demand for sand. The methods used were mapping of sand mining sites along the Nzhelele River, visual observation. The results indicated that some sand mining activities has transformed the land use of an area to that of less value or no value at all. (Mathada, 2017)

2.4 Literature Review 4:- A sand mining study was conducted by Nguyen Mau Dung, 2011 in Cau river in Bac Ninh Province, Vietnam. There is indiscriminate sand mining in Cau river Sand mining in Cau River which has become more and more serious in recent years due to the high demand for river sand by the construction industry in Bac Ninh province and in nearby provinces. As a result of which, the Cau River is facing a series of problems like erosion of river banks, lowering of water table, loss of the aquatic habitat and destruction of bridges, dikes and roads along the river. The methods used were the field survey, observing the sand mining sites. The research revealed that illegal and indiscriminate sand mining in Cau River has caused serious riverbank erosion in some sections and there is a decline in agricultural land. The erosion of riverbanks has decreased the cultivation areas and decreased crop production. (Dung, 2011)

2.5 Literature Review 5:- The increasing urbanization is the major cause for sand demand in Cauvery and Kabini river basins and is responsible for unsustainable extraction of sand from dried river paths. Presently, the extraction of sand sand is permitted up to three feet, but it is being extracted even up to 25-30 ft. The method used is field surveying. The result shows that the unsustainable mining declines the agricultural practices. (H.T et al. 2014)

2.6 Literature Review 6:- A study shows that there is indiscriminate sand mining in the Kallada river, Kerala and the sand is being sent to the neighbouring state,

Tamil Naidu. The methods adopted were the Foot survey (by walk) of study site to analyse the extent of damages to bridges and deviation of river route. The observation result shows that the damage was caused to bridges and there is the deviation of river route due to sand mining. (John, 2009)

2.7 Literature Review 7:- The case studies on sand mining and gravel extraction activity in Gaborone has done by Tariro Madyise, 2013. Gaborone is growing at an alarming rate. The soil components are extracted excessively by the people without considering the impact on the environment. There is overexploitation of soil due to which, deep pits are left on the bare ground and on the other hand, rivers are widening daily. Mining has become a daily view where the tipper trucks can be seen carrying sand from rivers. There is an arisen of problem of riverbed and bank degradation due to the excessive removal of river sand from Metsimotlhabe and Ditlhakane rivers. The methods used are field visits for visual observation of impacts of sand extraction. The results showed that there is deepening of Metsimotlhabe and Ditlhakane river banks due to sand mining. (Madyise, 2013)

2.8 Literature review 8:- A case study of Periyar river, Kerala, southwest India shows that there is indiscriminate mining of sand from the Periyar river to meet the increasing developmental needs of the state over the years. The Periyar river hosts the Kochi City and its satellite townships, which is one of the fastest developing urban centres of South India where the demand for building materials including sand for constructions is very high. The river experiences excessive sand mining all along the main channel as well as the tributary and distributary systems, which leading to severe deformation of the fluvial network. The study includes extensive field surveys in the entire channel networks of the Periyar River Basin for mapping locations of instream and floodplain sand mining. The study revealed that the Periyar river is negatively affected by the mining activity in particular and the small rivers are also degraded considerably over the past few decades. There is a massive decline in the bed of Periyar river basin which drains Kochi city, which is a direct result of uncontrolled sand extraction for meeting developmental requirements. In some cases, the river banks are excavated for obtaining the fine aggregates of sand because of the demand in the construction

sector. There is also widening of the river channel due to the mining activity. (Shieka E J et al. 2014)

2.9 Literature Review 9:- A research done on sand and gravel mining in the Lower Mekong river where increasing economic activities and associated development demands huge amount of sand for construction of roads, land reclamation, building levees above the flood level etc. The major demanding regions of sand are Thailand, Vietnam and the lowland areas of Cambodia where sand is excessively drawn from the riverbed as well as the delta region of Mekong river is the another extractor of river sand for making its road network flood proofed. Some countries have banned the exportation of river sand but, the demand is shifting to the countries with low income like Cambodia. The methods employed are field surveys using GPS for taking the location of extraction sites and there is the use of Google Earth background for locating the extraction sites. The results show that Cambodia was the largest extractor of sand during 2011-2012. There is mining in the downstream reach all along the Mekong river except between Kompong Cham and Stoeng Treng and basically, extraction takes place on the lateral bars, banks and in the channel itself. The extraction has incised the riverbed upto 1-3 mts and the erosion of river banks is another negative outcome of extraction in that study area. (Bravard et al. 2013)

2.10 Literature Review 10:- The Karachi City demands huge amount of construction grade sand and this demand is met from the Malir river. The mining operation in the Malir river results in the destruction of local vegetation and after mining and transportation of sand, the sites left unreclaimed. The extraction process in the Malir river includes the use of Bulldozers, tractors, scrapers and font loaders due to which the scenic landscape of that area has destroyed. The methods in this research include the use of GPS to record the coordinates for the location of sand mining sites, the field photographs are taken of the study area and there is a field visit observation of the study area to examine the impact of sand mining on the physical environment. The field visit observation has revealed that there is shallow and deep cutting of sand in the form of terraces. The extraction of sand in that area has caused the destruction of vegetation and there is the weakening of river banks which leading the banks to collapse. (Husain V, 2017)

CHAPTER 3
METHODOLOGY

The portion of Tawi river falling between Nagrota and Sidhra is selected for the study which have a length of 9 km. This study area of river Tawi is considered into two parts, one is the Northern part which is near to Nagrota and another one is Southern part which is very close to Sidhra. Both primary as well as secondary data has acquired to conduct the present study.

3.1 Secondary Data:-

- Google Earth Pro app is used from where the different features in Tawi river are digitized on the basis of three different selected years i.e 2007, 2010 and 2018. These features include river channel, river flow, sand bars and sand mining sites, which are digitized by using point and polygon tools of Google Earth.
- The data acquired for the study belongs to pre-monsoon period of each year i.e 1/28/2007, 1/30/2010 and 4/25/2018. This is done to exclude the flood impact and to easily identify and locate sand mining sites.
- The sand mining sites are identified on the basis of some characteristics of river sand mining like deep and wide pits which are created during mining processes and the access roads and tracks made by the vehicles entering into the river and moving on the river bed for extracting sand.
- The different features in river Tawi which are digitized are stored in the form of KML layers and these KML layers are processed in GIS software for composing maps of three different years i.e 2007, 2010 and 2018.
- Four types of maps are prepared by using this software, the first type consist of location maps of sand mining sites on the river bed of Tawi, the second type consist of a superimposed location map of sand mining sites, the third type is for the river flow of Tawi and the fourth type of map is almost same as that of second type, which comprises the superimposed map of Tawi river flow.
- The other sources of secondary data are newspaper reports, articles, RTI reports, report of Jammu and Kashmir High Court and the published report

of PHE & Irrigation and Flood Control Department and unpublished material sources.

3.2 Primary Data:-

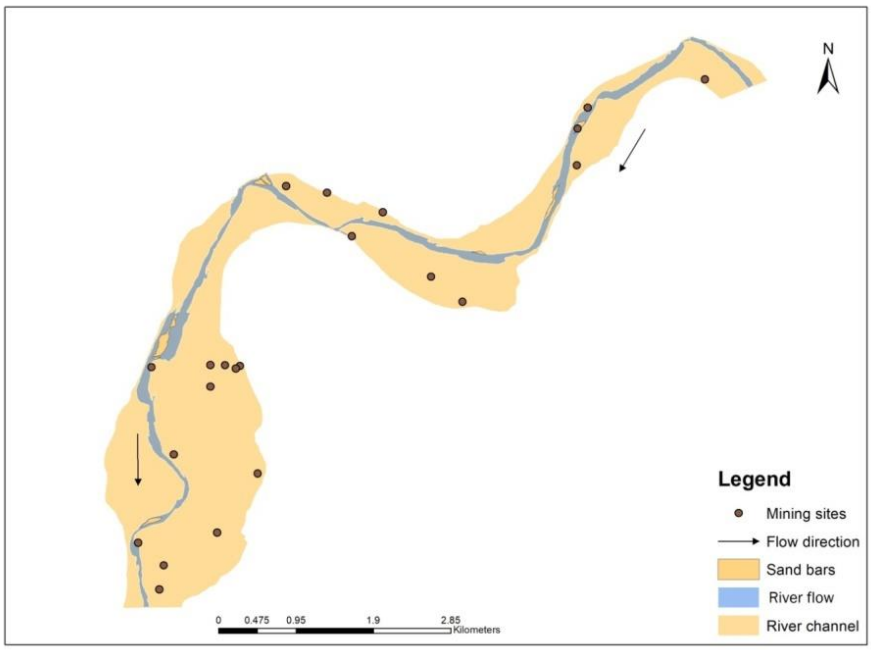
- There is a field visit to river Tawi during the research work in the month of April remembering that the data should be of pre-monsoon period along with GPS device.
- The GPS device is used for taking coordinates of present sand mining sites in Tawi river between Nagrota and Sidhra.
- A digital camera is used for taking the photographs of present sand mining sites.
- The survey started from southern portion (near Sidhra) of Tawi river covering area in the right side of river flow upto northern part i.e near to Nagrota then again it started from the northern part covering area falling in the left side of river flow and the survey ended at the same place from where it was started, but in the right side of river flow.

CHAPTER 4
RESULTS AND DISCUSSION

Mapping of Sand Mining Sites and Changing River Flow:-

4.1 Mapping of Sand Mining Sites:- In this section, the locations of sand mining sites of three different years naming 2007, 2010 and 2018 are mapped and separate map is prepared for each year. A superimposed map is also prepared in this section which involves the overlay analysis of sand mining sites of three different selected years. This section involves the analysis of increasing or decreasing concentration of sand mining sites in Tawi river from 2007 to 2018 and reason behind:

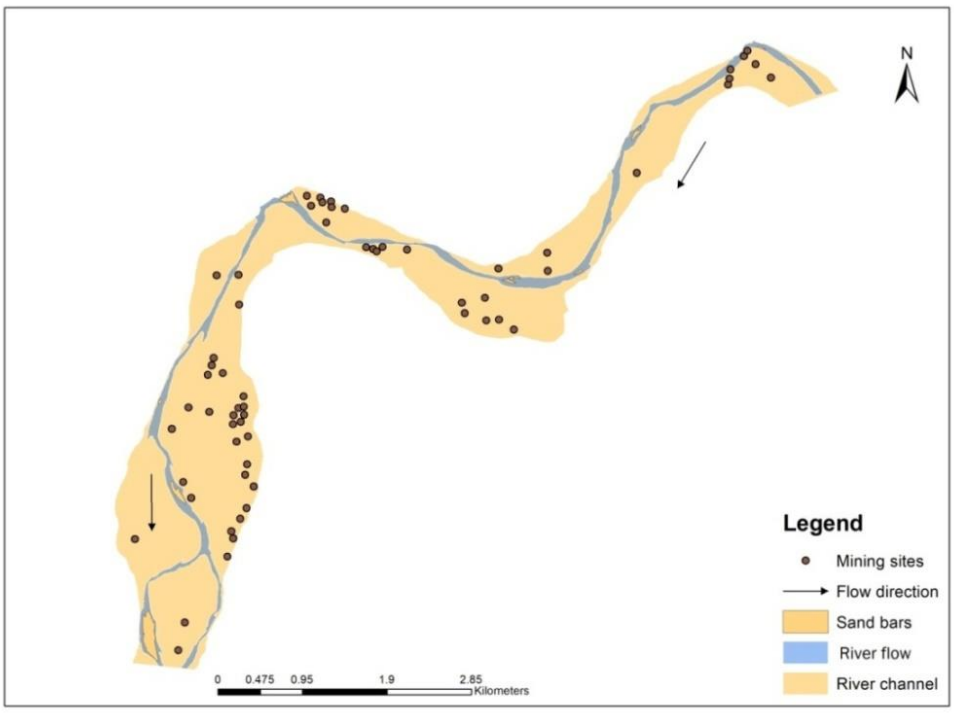
4.1.1 Location Map of Sand Mining Sites in 2007:- There are a total of 22 sand mining sites in Tawi river in the year 2007 between Nagrota and Sidhra area (Map.2). In the northern part of the study area, close to Nagrota, there the locations of sand mining sites are sparse on the river bed as shown in this Map. The difficult and long routed accessibility to the river from the main roads connecting the cities is the reason behind the existence of less sand mining sites in the northern part because, if we move northward, the adjoining areas to Tawi river seem to be remote and hilly.



Map.2:- Map showing the Locations of Sand Mining Sites in the year 2007.

Whereas the southern portion of the study area, which is close to Sidhra has more sand mining sites as compared to its contrary northern part and the concentration of the mining sites lie on the left side of the river flow. The reason is, easy accessibility to the river bed from the highway which passes over the Tawi river through the Sidhra bridge. The second reason is that the Jammu city is very close to this southern part as this city is a home to maximum construction and developmental activities. In general, the maximum concentration of mining sites lies on the river bed of Tawi which is an example of in-stream (dry pit) sand mining.

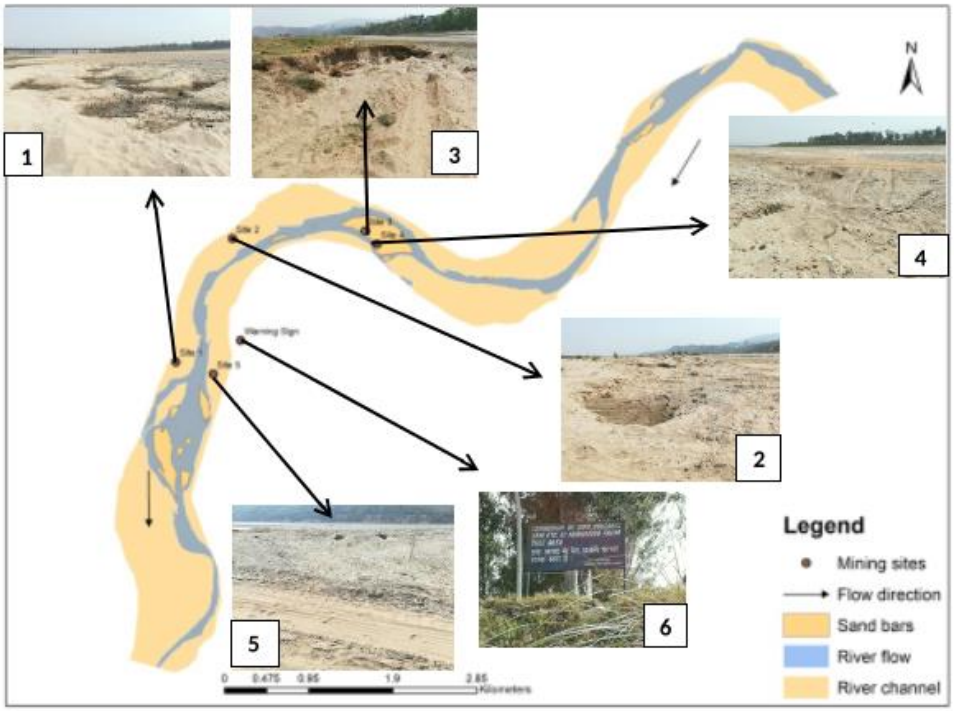
4.1.2 Location Map of Sand Mining Sites in 2010:- There are about 62 sand mining sites in Tawi river between Nagrota and Sidhra area in the year 2010, which indicates that there is maximum rise in the sand mining activity up to this year (Map.3). Even those parts of Tawi river which are less accessible mainly, which are in the northern portion of the study area (close to Nagrota) shows increased trend of sand mining activity in this year with the help of off-road accessibility to the river bed. The sand mining sites in the northern part can be seen on all over the river bed.



Map.3:- Map showing the Locations of Sand Mining Sites in the year 2010.

Whereas in the southern portion of study area (close to Sidhra), the location trend of sand mining sites is similar to the year 2007 i.e the maximum concentration of sand mining sites is found in the left side of the river flow. But, as discussed above there is an increase in the trend of sand mining activity in the southern portion also. The increasing urbanization in Jammu city as well as in the adjoining town areas is the cause of increased sand mining activity in Tawi river (Tribune News, 2016). The area lying close to Sidhra i.e the southern portion seems to be worst affected by the sand mining sites during this year, which in turn can easily cause the deformation of the river channel.

4.1.3 Location Map of Sand Mining Sites in 2018:- There are a total of 5 sand mining sites identified in Tawi river in the year 2018 as shown in Map.4, which indicates that there is a maximum decrease in the concentration of sand mining sites in Tawi river between Nagrota and Sidhra area upto this year. There are only two sand mining sites are found in the northern portion of study area i.e near to Nagrota, among them both the sites are large in size. On the other hand, there are three sand mining sites found in the southern part of study area which is close to Sidhra and among them, one site is large while other two sites are small in size.



Map.4:- Map showing the Locations of Sand Mining Sites in the year 2018.

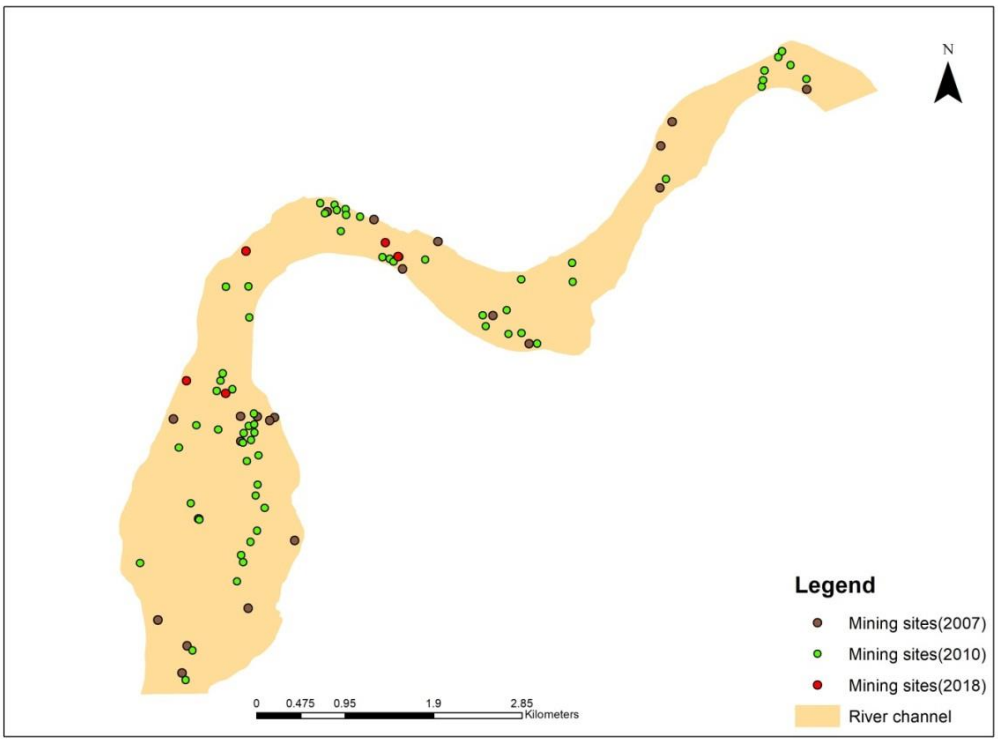
Photography Source: Field Survey, 2018.

The decreased concentration of sand mining sites in Tawi river upto the year 2018 has its direct link with the newspaper reports of the years 2015-2017 as well as the RTI reports filed by the activists who are against Tawi river mining, which shows that there were strict actions taken by the State High Court during these years to stop the excessive mining of sand from the Tawi river. A report of Jammu and Kashmir High Court shows that the Division Bench of State High Court has directed the Jammu police department to install check posts along the Tawi river within the area from Nagrota to fourth Tawi bridge to stop the illegal extraction of sand (J&K State High Court, 2017).

There is another report of Department of Public Health Engineering, Irrigation & Flood Control, 2013 which shows that a meeting was held by the Minister of PHE and Irrigation and Flood Control in his chamber in the year 2013. In this meeting, the Minister discussed the issue of over-exploitation of river bed materials from the Tawi river with the officers belonging to different governmental departments of Jammu and Kashmir state and directed them that the extraction of river bed materials from the river Tawi should not be done outside of set rules, acts as well as guidelines like Water Resources (Regulation & Management) Act, 2010, Jammu & Kashmir Water Resources (Regulation & Management) Rules, 2011 and Supreme Court guidelines. As the location coordinates of sand mining sites of the year 2018 are acquired by visiting to study area by using GPS device. So, those parts of Tawi river are avoided, which are thought to be very remote or inaccessible within the study area i.e mostly in the northern portion. The photographs of sand mining sites are also taken with the help of digital camera. Images (1, 2, 3, 4, 5) in (Map.4) showing sand mining sites (1, 2, 3, 4, 5) in Tawi river and the 6th image showing Warning Sign Board which is installed near Sidhra Bridge. The field visit observation reveals that a proper embankment is made on the left bank of Tawi river in the southern portion i.e close to Sidhra, which was a home to the majority of sand mining sites during the years 2007 and 2010. The warning sign board posted near Sidhra bridge indicates that the sand mining activity is prohibited in this area. Instead of this, two mining sites among five, are found near the bridge but, the thing is that these sites are small in size.

4.1.4 Superimposed Location Map of Sand Mining Sites in (2007, 2010, 2018):- A separate map is prepared in which the sand mining sites of three different years i.e

2007, 2010 and 2018 are overlaid to better understand their locations in relation to each other as well as their increasing and decreasing concentration during these three different years (Map.5).

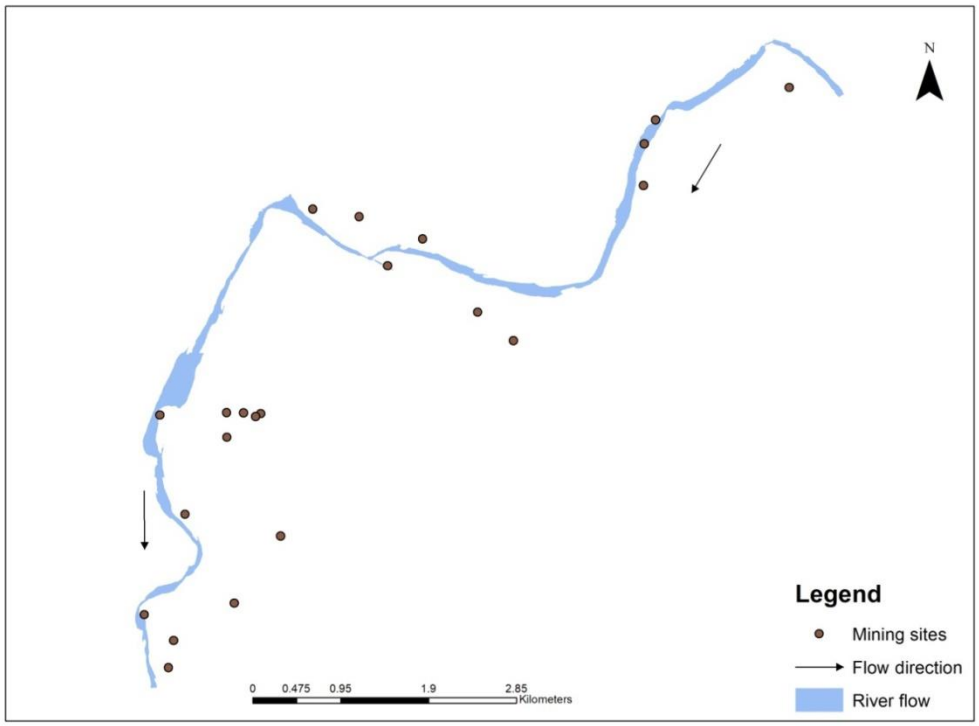


Map.5:-Superimposed Location Map of Sand Mining Sites in (2007, 2010, 2018).

The sand mining sites of three years are assigned with three distinct colors for better identification. The practice of sand mining is conducted randomly on the river bed between Nagrota and Sidhra and the year 2010 experiences the maximum concentration of sand extraction activity on all over the river bed.

4.2 Sand mining Sites and Changing River Flow:- This section involves separate maps preparation for river flow of three different years i.e 2007, 2010 and 2018 along with sand mining sites of each year. An overlay analysis is also done in the fourth map of this section by preparing a superimposed map of river flow of three different years. In this section, the change in the river flow from 2007 to 2018 is analysed and the relationship shown between the practice of sand mining on the river bed of Tawi and its possible impact on the changing river flow:

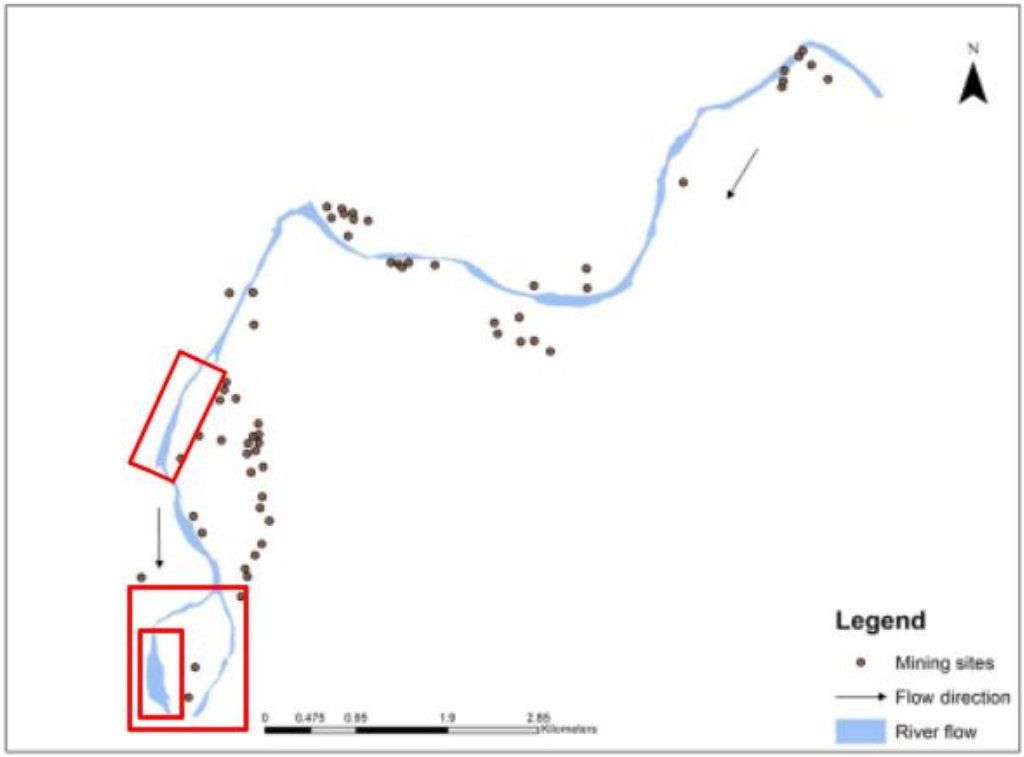
4.2.1 Map of River Flow in 2007:- The flow of Tawi river remains shallow (Map.6) for most of the time in a year while at the time of rainy season or monsoons, it expands and fill the river channel with fast flowing and disastrous floods.



Map.6:- Map showing the Flow of Tawi River in the year 2007.

The extraction of sand in large amount on the river bed can easily cause the river flow to deviate from its path or provide it high potential for deviation through the gravel/sand removed sites (Kleynhans, 1999). Excessive sand mining creates deep and wide pits on the river bed which ultimately affect the natural flow of river water (Mathada, 2017). Even there are many sand mining sites which are very close as well as present within the river flow on the exposed sand bars (Map.2).

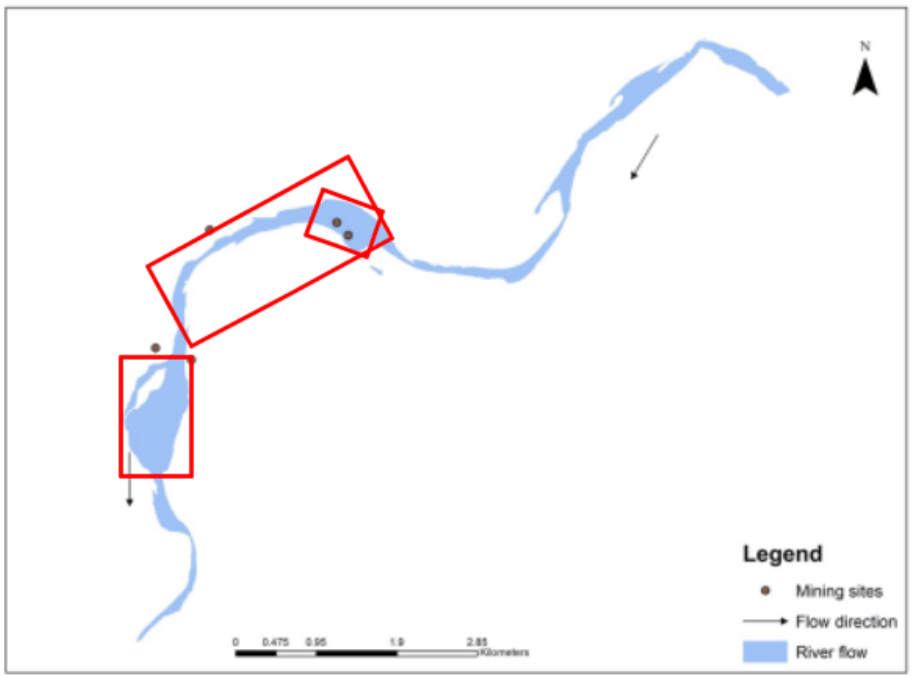
4.2.2 Map of River Flow in 2010:- Map.7 shows that there are minor changes in the flow of Tawi river at two locations in the southern portion of study area. The first location is marked with narrowing of river flow but, in 2007 the river flow at this location was wide. At second location, there are further two changes took place in the river flow; the first change indicates the bifurcation of river flow into two flows because of the presence of a sand bar and the second change also have the same reason to occur i.e bifurcation of river flow due to a sand bar (Map.3).



Map.7:- Map showing the Flow of Tawi River in the year 2010.

In the northern part of study area, the flow remained unchanged. It is observed that increasing sand mining activity generate extra vehicle traffic on the river bed of Tawi which involved heavy machinery like Bulldozers, Tipper-Trucks as well as Tractor-Trailors. These vehicles while moving on the river bed crosses the river flow at some places and created tracks even under the flowing water which can be easily seen in the Satellite Imagery because of the shallowness of river flow. The continuous vehicle movement on the river bed causes compaction of soil because of the stress generated by loaded trucks and tractor-trailors which ultimately reduces the ability of the soil to absorb water and this result in more runoff and erosion (Bindhusri, 2015).

4.2.3 Map of River Flow in 2018:- Map.8 shows the present status of river flow which indicates that there are major changes took place in the flow of Tawi river up to 2018. The changes in the river flow took place at two locations out of which some portion of first location falls in northern part of study area and the rest of the changes have their imprints in southern portion.

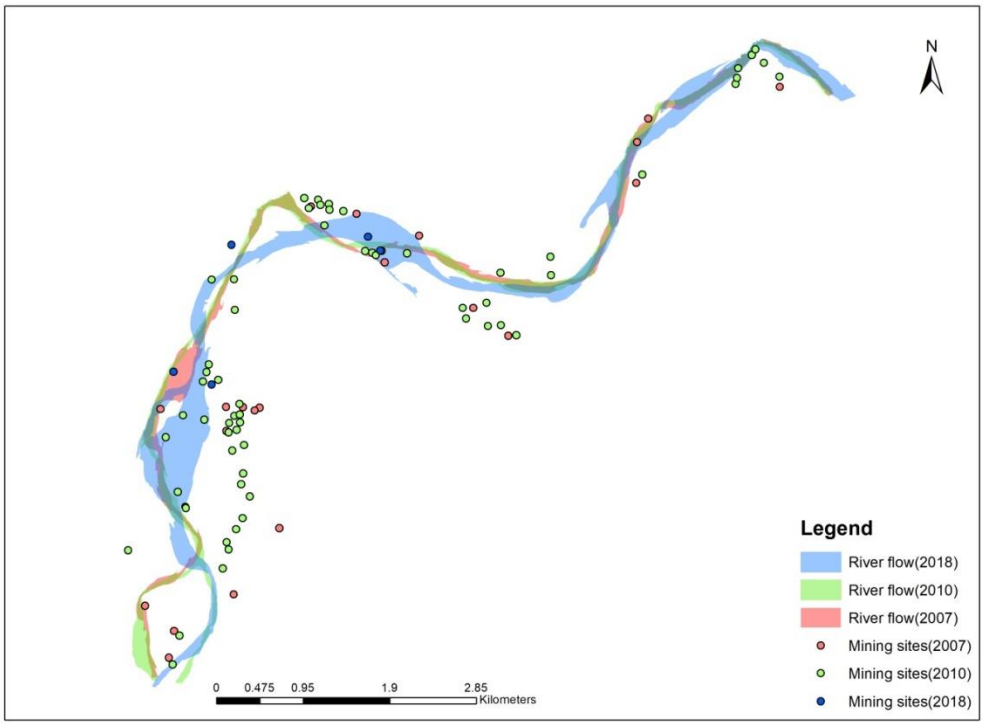


Map.8:- Map showing the Flow of Tawi River in the year 2018.

The first location is marked with further two changes in river flow; the first change which took place in northern part of study area shows the bifurcation of river flow due to the presence of a sand bar (Map.4) and second change showing the complete migration of river flow from that position where it was flowing in 2010. At the second location, there is also the bifurcation of river flow into more than two flows due to the presence of sand bars (Map.4) but, the big change is that the river flow has changed its route from extreme right to the centre of river bed.

4.2.4 Superimposed Map of River Flow in (2007, 2010, 2018):- In the case of second objective also, a separate map is prepared which involves the overlay analysis of river flow of three different years of the study i.e 2007, 2010 and 2018 along with mining sites of each year. The river flows of these three years are assigned with distinct colors and the similar process is applied to the mining sites of each year for better identification. This map is prepared for better understanding of the changing pattern of river flow and its relationship with the sand mining activity during these three years. The resultant map come up with final result which shows that the major changes in the river flow of 2018 are the product of sand mining activity which has been practiced there in the past years. It means that the sand mining practice in Tawi river has impacted the river flow. On

the other hand, the minor changes in the river flow of 2010 are not the result of sand mining activity. It is analysed that the trend of excessive sand mining practice in the Tawi river has continued up to 2014 and from 2015 onwards, this trend has started decreasing because of the strict actions taken by the Jammu and Kashmir Government.



Map.9:- Superimposed Map of Tawi River Flow in (2007, 2010, 2018).

But, this river experience floods every year at the time of monsoons which are marked with high velocities and have the capacity to easily damage or erode anything which lies in their path. It is analysed that the uneven sand mining practices on the river bed of Tawi caused the river water to flow through the sand removed sites or through deep and wide pits which are created during mining processes because, (Kleynhans, 1999) the extraction of sand in large amount on the river bed can easily cause the river flow to deviate from its path or provide it high potential for deviation through the gravel/sand removed sites. The river flow of the year 2018 has experienced major changes mostly in its southern part due to the sand mining activity. One thing is revealed from the study that changes in river flow occurred only in those parts of Tawi river where the sand extraction activity took place continuously for years.

Chapter 5
CONCLUSION

The sand mining practice in river Tawi increased in number from 22 to 62 during the years 2007 to 2010 because of lacking in strict rules, easy accessibility to that area, the other contributing factor is high sand demand. It is analysed that southern portion holds more number of sand mining sites in all the three selected years in comparison to northern part. This trend of excessive sand mining practice in the Tawi river has continued up to 2014. The mining sites reduced to 5 in number up to 2018 because of the activeness shown by State Government against this unabated practice. According to the report of PHE and Irrigation & Flood Control Department, 2013 as well as the different newspaper reports of 2015-2017, it is clear that the time period of 2013-2017 marked with the strict actions taken by State Government to stop unabated mining practice in river Tawi. There is also a big role of activists and environmentalists in making an influence on State Government to work progressively to stop the practice of excessive mining in Tawi river. The actions taken by State Government against sand mining involved the installation of check posts at various locations along Tawi river and patrolling by Police personals. Even the sand mining activity has reduced up to 2018 but its impact on the river flow can be seen.

The analysis shows that the year 2010 is marked with normal changes in river flow mainly in the southern part which is not the result of mining activity whereas, the year 2018 showing major changes in the flow of Tawi river because of excessive sand mining took place on the river bed. It is analysed that the rampant sand mining practice resulted in changing river flow of Tawi. The present study explained the relationship of sand mining activity in Tawi river and its possible impact on the changing river flow between Nagrota and Sidhra. According to which the major changes in river flow occurred only in those parts of Tawi river where the sand extraction activity took place continuously for years. The study analysis showed that uneven creation of deep and wide pits on the river bed caused the river water to flow through excavated areas which ultimately resulted in changing river flow. It is also analysed that the sand mining practice has impacted the river flow mostly in the southern part of study area.

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