Himalayan J. Soc. Sci. & Humanities ISSN: 0975-9891
Vol. 14, (2019) 19-27 DOI: https://doi.org/10.51220/hjssh.v14i1.3

Impact of Dam on Channel Morphology of Alaknanda River in Srinagar Valley (Garhwal Himalaya)

Sapna Semwal[1] and D.D. Chauniyal[2]

[1]Department of Geography, DBS (PG) College, Dehara Dun
[2]Department of Geography, HNB Garhwal University Srinagar (Garhwal),Uttarakhand

*Corresponding Author Email: devidattchauniyal@gmail.com

Received: 26.11.2019; Revised: 8.12.2019; Accepted: 28.12.2019

Abstract: Rivers play a significant role in the human activities all over the world. Increasing demand of water for drinking & irrigation and hydroelectricity, numbers of impacts can be seen in the rivers environment. The present paper focuses on the impact of Supana Dam on the channel morphology of Alaknanda River in Srinagar valley Garhwal Himalaya. The field investigation approach has been adopted for the present study. The impact assessment has been carried out into three categories i.e. (i) Impact of dam on channel morphology, (ii) Impact of dam on human environment and (iii) Anthropogenic impact on channel Morphology. The results of the study show that after the construction of dam positive and negative impact have been assessed. Due to the blockage of water and sediment flow the entire riverine environment has been changed. Channel morphological features are well exposed for geomorphological study. Changing pattern of land and water relationship destroyed the previous ecosystem balance. Besides this, dam is supplying cheapest clean, efficient and reliable energy generated by hydro-electric power plant. Other impacts of dam are loss of fauna and flora, quality of drinking water supply and concentration of pollution in downstream. Out of these large numbers of sand and gravel extraction activities has been started on the exposed channel bed. Although some positive and negative impacts are observed by the construction of dams but several measures have been suggested to mitigate the adverse impacts of a hydropower project in the present study area.

Key Words: Impact, Channel morphology, Alaknanda, Hydrology, Dam reservoir, Pollution

Introduction

River channels display widely varying characteristics in both space and time. Partly this reflects their geographical location within a particular fluvial system. However, it also reflects the interaction of a range of controlling factors, some of which may operate at the catchment scale, some of which may be more localized. Hydrology and sediment supply are both factors responsible for channel morphology and fluvial processes (Church, 1995). Hydro-morphology is characterized by the spatial complexity of a channel, which is caused by processes occurring in many interrelated scales in river connectivity. Anthropogenic activity has long been recognized as a controlling influence on stream morphology and bed material distribution by both geomorphologists and ecologists (Wolman, 1967, Leopold, 1968, Allan, 2004, Kang and Marsten, 2006, Poff et al, 2006, Urban et al, 2006, Levell and Chang, 2008).

Human role in transforming mountain environment of the Himalaya has been widely studied but changes in the hydro-morphology of Himalayan Rivers caused by human activity are not extensively documented. It has an impact on river ecology and is one of the most important factors shaping the habitat conditions of a river; therefore, it influences biodiversity and the functioning of a river's ecosystem. Noticeable changes in the hydro-morphology of rivers and streams are one of the results of human activity in mountain area.

According to Wohl (2006), human impact on mountain streams may result from activities undertaken in a stream channel that directly alter the channel geometry, dynamics of water and sediment movement, aquatic and riparian community. Human impact can also result from activities within the watershed that indirectly affect streams by altering the movement of water, sediment and contaminants into the channel. Human activities that directly change river habitat involve flow regulation, channel fragmentation with hydraulic structures, riverbank stabilization and exploitation of aggregates.

The study of river morphology accomplished in the field of fluvial geomorphology, the scientific term. A river regime is a dynamic equilibrium system; which is a way of classifying rivers into different categories. The term river morphology used to describe the shape of river channels and how they change in shape and direction over time. River morphology is the field of science dealing with changes of river form and cross-section shape mainly due to sedimentation and erosion processes (Chang, 1988). The morphology of a river channel is a function of number of processes and environmental conditions.

The experience hydrological engineers and managers can understand natural channel forms and fluvial processes through the study of fluvial geomorphology. Such information is a pre-requisite for carrying out environmental impact assessments and for developing environmentally sensitive design and management procedures to preserve riverine environments (Thorne, et al, 2005). The Shepherd and et al (2010) correlated geomorphic characteristics and sediment distribution within the forested, agricultural and urban land use conditions of first and second order streams of Illinois River watershed in USA. Stream morphology is an integration of geology, geomorphology, climate, habitat and disturbance regime over a range of spatial and temporal scales; hence identifying specific watershed responses to human action continues to be a challenge (Montgomery, 1999; Allan, 2004). Gregory (2007) applied fluvial geomorphology to river channel management in Uk which demonstrate that how geomorphologic research can be considered by planners. There is considerable potential for use of channel dimension data in planning-level models for resource and impact assessment. The channel dimension data is used to route flows and sediment through the basin (Allan and Arnold, 1994). Pradhan et al (2017) discusses the number of river interventions of Rengali Dam on Brahmani River in India.

Objectives of the study

The main objective of the present study is impact of Dam on channel morphology of Alaknanda River in Srinagar valley of Garhwal Homalaya.

Methodology

To achieving the objective of the present study, field observation, terrestrial photos, personal and official enquiries, research literatures etc have been used for the completion of work. Field investigation has been carried out in each and every aspects of the study since 2010. Pre and post impacts of construction of dam are observed throughout the channel course from dam sit to Kirtinagar. Longitudinal and transverse traverses have been conducted along and across the river in many sites.

Area of the study

The area investigated lies in the lower Alaknanda valley between Supana to Kiratinagar of Garhwal Lesser Himalaya. Geographically the valley is bounded by 78^0 45' 16" E to 78^0 49' 43" E Long and 30^0 12' 36" N to 30^0 14' 47" N Lat. The river Alaknanda flows (11.5km) in the center along with bow shape meander. The Alaknanda River formed very wide unpaired river terraces in which Srinagar Township and villages are located both the side of the river (Fig 1).

Himalayan J. Soc. Sci. & Humanities ISSN: 0975-9891
Vol. 14, (2019) 19-27 DOI: https://doi.org/10.51220/hjssh.v14i1.3

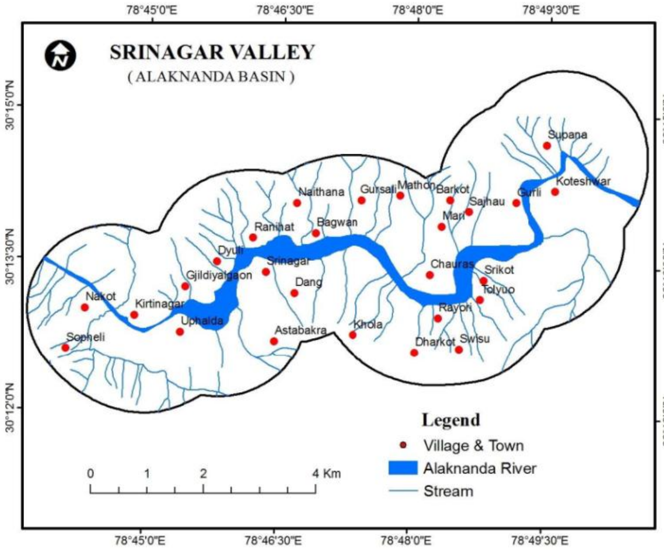

Fig. 1: Location of Srinagar Valley (Alaknanda Basin)

Alaknanda Hydro Power Company (AHPCL) was developed the 330MW Alaknanda (formerly Srinagar) hydroelectric project on the Alaknanda River in Uttarakhand, India. AHPCL, a GVK group company, is implementing the green field project pursuant to an implementation agreement signed on 10 February 2006 with the Uttar Pradesh and Uttarakhand Governments. The project was officially inaugurated in March 2014 and the first unit was successfully synchronized with the Northern Grid on 10 April 2015. The power house located on the surface and consists of four 82.5 MW Francies units, with a net head of 66m and design discharge of 560m^2/s. The turbine generator is a vertical shaft synchronous machine with a rated continuous output of 97.06MVA and a rated speed of 166.6rpm. The turbines are controlled by electro-hydraulic modern type governors.

It is run by the company GVK through its subsidiary Alaknanda Hydro Power Company Limited (AHPCL), and has benefitted from CDM funds. The Hydel plant has been developed as a run of the river project. According to the Power Purchase Agreement, 88% of the energy generated will be purchased by the Uttar Pradesh Power Corporation Limited while the remaining 12% will be given free of cost to Uttarakhand state. Dams and reservoirs can be used to supply drinking water, generate hydroelectric power, increase the water supply for irrigation, provide recreational opportunities, and flood control. However, adverse environmental and sociological impacts have been identified during and after reservoir constructions. The environmental consequences of dam are numerous and varied, and includes direct impacts to the biological, chemical and physical properties of rivers channel bottom and stream-side (or riparian) environments.

Results and Discussion

Basically, following main impacts of dam construction are experienced on the physical and cultural environment of the study area-

Impact of Dam on Channel Morphology

The physical works in three dimensions: Longitudinal, lateral and vertical – and by dynamism, which shapes channel form and connectivity. In the study of present rivers, especially looking at how channel morphology changes with time, there are some main physical factors described that affect the channel morphology.

(i) After the construction of Supana dam the river bed and bar surfaces are more exposed and new island and channel bars are appeared on the river bed. Dam has been reduced the sediment load in downstream. The exact impacts are a function of river competence and capacity relative to the alteration in the sediment regime. If the channel is unable to move its sediment load then sedimentary processes dominate channel response. Only fine sediments has been supplied during the over flooding in rainy season. Transportation of boulders pebbles and gravels have been suspended because of low water discharge. Therefore, deposition of sand and silt can be observed on the point bars and lateral bars at Srikot, SSB and Sriyantra Tapu.

(ii) The point, channel bars and banks of the river are being stabilized simultaneously. The alteration process of bars and channel course has been stopped.

(iii) The depth of the pool also decreased and refills are more roaring. The depth of pool at Srikot, Kilkileswar, Ranihat and Sriyantra Tapu has been decreased about 1 to 2 m. The river channel can be across at riffles because of the low depth and width of water.

(iv) Changes can be observed in flow variability of water. The water quality also being changed because of stagnation of water on the pools rather than continuous flow. It can be identifying at just down of Chauras suspended bridge.

(v) The pools are alternating with dry stretches for about nine months from November to June.

(vi) Micro climatic changes can also be experience after the construction of dam. The temperature of river bed and stagnated water also is increasing in day time because of the reduction of continuous flow of water. Although it is a matter of further investigation but some changes can be identified at many localities.

(vii) It is noted that due to the suspension of channel water, the channel length and width has been reduced at Srikot and Sriyantra Tapu. Therefore, sinuosity index is decline.

Impact of Dam on Human Environment

The positive and negative impact on human environment by the construction dam has been assessed in this section.

Positive Impact of Dam

Dams and reservoirs can be used to supply drinking water, generate hydroelectric power, increase the water supply for irrigation, provide recreational opportunities, and flood control. Following are the major advantages of dam

(i) It is supplying clean, efficient and reliable form of energy. After the construction of Supana dam 330mw hydroelectricity is generated continuously out of which 13% supplied to the state development of Uttarakhand. Electricity generated by hydro-electric power plants is the cheapest electricity generated.

(ii) It does not emit any direct pollutants or greenhouse gases.

(iii) Dam prevents floods to downward stream. In future flood affected area will be reduce and will protect the life and properties of the people.

(iv) The hydroelectric canal of Chauras from Supana to Power house is a very potential site for recreation and site scene**.** It will useful for tourism development in coming time.

(v) Hydroelectric canal supply water for local drinking needs to the villagers which are located on the right bank of the river.

(vi) Behind the dam there is a 25km long reservoir which is also a very potential site for recreation and site scene. Large numbers of tourists are visiting reservoir lake from Supana to Dhari Devi.

(vii) A dam also holds back sediments that would naturally stop the siltation and river bank erosion in downstream. It will reduce the siltation problem at ITI, Bhaktiyana, Sriyantra Tapu and Diwuli village.

Negative Impact of Dam

However, adverse environmental and sociological impacts are identified during and after Supana dam and reservoir constructions. Some of the impacts are experienced below-

(i) The construction of Supana dam completely changes the relationship of water and land, destroying the previous ecosystem balance which will take hundreds of years to create.

(ii) Dam restricted sediments that are responsible for the formation of bars supply of sands and gravels downstream.

(iii) A dam holds back sediments that would naturally replenish downstream ecosystems.

(iv) Downstream of the dam the flow rate in the river has been reduced and depend upon the amount of compensation flow. Due to decreased water discharges, water temperature will rises in daytime and decline sharply at night. Rooted plants will grow in the riverbed due to the decrease in water volume.

(v) After the construction of dam the entire river system has been changed from dam site to Kirtinagar. The alteration of a river's flow and sediment transport downstream of a dam often causes the greatest sustained environmental impacts. Life in and around a river evolves and is conditioned on the timing and quantities of river flow. Disrupted and altered water flows can be as severe as completely de-watering river reaches and the life they contain. Yet even subtle changes in the quantity and timing of water flows impact aquatic and riparian life, which can unravel the ecological web of a river system.

(vi) River bed deepening will also *lower groundwater tables* along a river, lowering the water table accessible to plant roots. Altering the riverbed also reduces habitat for fish that spawn in river bottoms, and for invertebrates.

(vii) Large dam have led to the extinction of many fish and other aquatic species, the disappearance of birds, wetland and erosion of banks, and many other immitigable impacts.

(viii) Spread of Disease**-** Dam reservoirs in sub tropical Srinagar valley, due to their slow-movement, are literally breeding grounds for mosquitoes, snails, and flies, the vectors that carry malaria, schistosomiasis, and river blindness.

(ix) Species Extinction- As fisheries becomes an increasingly important source of food supply of some local people. More attention is being paid to the harmful effects of dams on many fish and riverine mammal populations. In fact, riverine ecology needs heavy rainy season flows as it is during this time that many fish species breed.

(x) Effect of dams on fish migration- Usually fish migrates from upstream to downstream and vice versa. For example Stone Carp and Catfish migrate up to low and low to up but due to the fragmentation of river channel the fish cannot sweep downstream during the monsoon flow. A dam will obstruct the route of the long and mid-distance migratory fish. Long distant migrants such as *Tor* sp., *Bagarius, Pseudeutropius, Clupisoma* and *Anguilla,* and mid-distance migrants *N. hexagonolepis* and *Labeo* species are most affected by a dam (Shrestha, 1995).

(xi) Impacts on biodiversity downstream: By interfering with river flows, dams adversely affect downstream flora and fauna. It is seen that the river flow during winter and summer season from November to June becomes dry and partially curtail rainy season from July to October. Their impact downstream is negligible or even, sometime, positive. Due to the shortage of water flow, ability of the ecosystem to regenerate habitat stagnates.

(xii) *Impact on drinking water supply*- There is also huge water losses from the diversion of canal and construction of reservoir. The variation and reduction in water flow in the river adversely affects water availability downstream, both from surface sources and because of inadequate recharging of groundwater. The water pumps of Srikot, Ghasya Mahadev, Ufhalda and Ranihat directly affected. The water level has been gone to down. The whole system requires new set up.

(xiii) Impact on quality of water: The fresh and continuous water supply has been suspended by the construction of dam, so that hot, polluted and storage water being supply to the people. It can create many diseases in surrounding environment.

(xiv) Pollution- Reduction and variation in the flow of the river also results in the increased concentration of pollutants downstream, during dry seasons.

Potential for Disaster

(i) Dam failure: Dams occasionally break causing catastrophic damage to downstream population and ecosystems. The failure of the dam, where the structure collapses and allows the reservoir to partially or totally drain out is a very serious problem in the mountain areas. There are many causes of dam failure. It can be due to engineering errors, faulty design or construction, use of sub-standard materials, over-topping due to surplus water, glacial lake burst, and natural disaster or because of severe earthquakes.

(ii) Impacts of sudden release of water: **E**xcessive rainfall or over-filling of reservoir may make it necessary to suddenly release large quantities of water from the reservoir in order to protect the dam structure. Such sudden releases can be disastrous for people living downstream, for their crops and for entire ecosystems. Reportedly, such releases occurred from Supana dam, in 17th June, 2013 (Rana, et al, 2013). Huge amount of water from the dam was suddenly released and it washed out SSB training campus, agricultural land of Diuli village, silted ITI flood plain and undercut the Chauras campus in Srinagar valley.

(iii) Similar fears are being widely expressed about the Tehri dam. According to a presentation made by the MoEF to the Prime Minister of India, if the Tehri dam burst, in less than an hour and a half, the water would hit Rishikesh and Haridwar and wipe out these two cities.

(iv) The sudden filling of reservoirs with millions of gallons of water has caused seismic instability and causes tremors and minor earthquakes.

(v) The silt which is retained in the reservoirs is also a major geological issue as this causes the damage in riverbanks downstream.

Anthropogenic Impact on Channel Morphology

The environmental consequences of anthropogenic activities are numerous and varied, and includes direct impacts to the channel morphology. It depends upon the morphological characteristics of the river channel which include channel plan form, cross section characteristics, gradient of the channel and accessibility. Keeping in view the problems of present study area followings major impacts of human environment on channel morphology are noticed-

Impact of Mining on the Channel Bed

(i) After the construction of **S**upana Dam the 11.5 km channel bed from Supana to Kirtinagar has been dried up. The accessibility on the channel bed has been increased because of low level of channel water. Large numbers of sand and gravel extraction activities has been started on the channel bed. The main localities of mining are Srikot, Ranihat, SSB and around Sriyantra Tapu. The impact of sand and gravel mining can be observed in the forms of incision of channel bed, diversion of channel course, collapse of river bank and changing face of middle, lateral and point bars. Desertification environment has been created on the channel bed.

(ii) Out of mining activities, construction of road to the mining sites, bridges and dumping of dam road constructed excavated material on the bank of river are major human activities. Dumping material is the most dangerous sites for hazard and flood. In 17 June 2013 Kedanath tragedy wash out the dumping material at Chauras as a result that material was damaged the SSB campus and lower Bhaktyana.

(iii) Encroachment: Due to the low level of flood water, local people started to construct their residential houses on the former flood plain. The tendency of encroachment is continuously increasing which can face serious problem in future.

(iv) Dumping of Garbage and waste: Srinagar Township is the biggest in the Garhwal region. Numerous kinds of urban garbage and waste are through in the river banks. Out of these some polluted Nalas (Srikot, Ghasiya Mahadev and Ganga Darshan) are also joined in the stagnated water of river. Due to the construction of reservoir the direct flow in the dry reach has been stopped and the polluted water also mixed with stagnated water which raises the pollution in the channel water. That stagnated water is supplied using pump scheme to the local people. The most polluted zone of the study area are Srikot, Ghasya Mahadev, Horticulture garden, Kamleswar Mahadev and Kirtinagar.

(v) Recreational and Rafting activities are also increasing in some sites of the river bank. The tourists spread plastics bag and eating waste around the river banks which raise the environmental problems.

Recommendation mitigation measures

Several measures have been suggested to mitigate the adverse impacts of a hydropower project in the present study area-

(i) Release proper compensation flow downstream**-** There may be a dewatering effect downstream during the dry season due to the flow diversion and damming of the river. There should be release more compensation water flow water according to local needs. Compensation flow for the conservation of micro flora, aquatic insects and fish in the dewatering zone should be within 10-20% of the regular flow. The commitment should be decided before the construction of dam. Negligence in the release of compensation flow should be taken very seriously by the administration.

(ii) Eradication of desertification**:** The surrounding environment of the river channel may deteriorate due to shortage channel water. To maintain the temperature of the environment, good quality of water and maintaining well-functioning downstream aquatic habitats plantation should be started. Artificial plantation is one of the effective measures for maintaining a cool environment, cooler bottom and good quality of water in the channel. This helps to maintain uniform temperature and vertical distribution of dissolved oxygen.

(iii) Provide and supply fresh and good quality of water to the downstream population from the reservoir by the use of pipe line.

(iv) Maintain well-functioning downstream aquatic habitats.

(v) Development of fishery ponds on the dry channel bed for fulfills the local fish demand.

(vi) Fish passages should be created to aid in the migration of the fish.

(vii) Mining on the river bed should completely ban.

(viii) Environmental conservation by plantation should be started along the canal, dumping and desertification sites.

(ix) To aware the local people of Srinagar Township about their environment that do not pollute the river banks and do not through the garbage and waste in the river.

(x) The Ghats (Banks) should be well maintained by the construction of retaining walls, stairs and gardening, so that the tourist can freely move along the river sites near the Srinagar Township.

References

Allan, J.D. 2004. Landscapes and rivers capes: the influence of land use on stream ecosystems. *Annual Review of Ecology, Evolution, and Systematic*, 35: 257–284.

Allan, P.M., Arnold J.C., 1994. Down Stream Channel Geometry for Use in Planning-Level Models. *Journal of American Water Resource Association*, Vol. 30, Issue 24, Pp663 671.

Chang, H.H., 1988. Fluvial Processes in River Engineering (M). Johm Wiley and Sons, Mew York, P432.

Church, M, 1995. Regime Geomorphic Response to River Flow Regulation: Case-Studies and Time-Scales. *Regulated Rivers-Research & Management 11 (1): 3-22.*

Gregory, K.J., et al, 2007. Applying fluvial geomorphology to river channel management: Background for progress towards a palaeohydrology protocol. School of Geography, University of Southampton, Southampton SO17 1BJ, UK.

Kang, R.S, & Marsten R.A. 2006. Geomorphic effects of rural-to-urban land use conversion on three streams in the Central Redbed Plains of Oklahoma. *Geomorphology*, 79: 488–506.

Leopold, L.B., 1968. Hydrology for Urban Land Planning: A Guidebook on the Hydrologic Effects of Urban Land Use. *US Geological Survey Circular*, 55, 21.

Levell, A. P, & Chang, H., 2008. Monitoring the channel process of a stream restoration project in an urbanizing watershed: a case study of Kelley Creek, Oregon, USA. *River Research and Applications* 24, 169–182.

Montgomery, D.R., 1999. Process Domains and the River Continuum. Journal of the American Water Resources Association 35: 397–410. Montgomery DR, Buffington JM. 1997. Channel-reach morphology in mountain drainage basins. *Bulletin of the Geological Society of America* 109, 596–601.

Poff, N.L, et al, 2006. Hydrologic variation with land use across the contiguous United States: geomorphic and ecological consequences for stream ecosystems. *Geomorphology* 79, 264–285.

Pradhan, C. et al, 2017. Impact of River Interventions on Alluvial Channel Morphology. *Journal of Hydraulic Engineering* Vol. 25, Issue 1, PP 87-93.

Rana, N. and et al, 2013. Recent and past floods in the Alaknanda valley: causes and consequences. Current Science Vol. 105, No. 9, 10 November, 2013.

Shepherd, S. et al, 2010. The effect of land use on channel geometry and sediment distribution in gravel mantled bedrock streams, Illinois River watershed, Arkansas *Journal of River Research and Applications* VL – 27, 857-866.

Shrestha, J., 1995. Enumerarion of the fishes of Nepal. Biodiversity Profiles Project. His Majesty's Government of Nepal/Government of Netherlands. *Euroconsult, Arnhem, The Netherlands.* P150.

Thorne C., R. and et al, (editors), 2005. Applied fluvial geomorphology for river engineering and management. Published by Somalia Water and Land Information Management System Somalia.

Urban, M.C. & et al, 2006. Stream communities across a rural-urban landscape gradient. *Diversity and Distributions* 12, 337–350.

Wohl, E., 2006. Human impacts to mountain streams. *Geomorphology,* 2006, 79, 217–248.

Wolman, M. G., 1967. A cycle of sedimentation and erosion in urban river channels. *Physical Geography,* 49: 385–395.

Internet source- Impact of Dam on river. www.fao.org/docrep/005/y3994e/y3994e0i.htm