Synopsis on

Evaluation of Ecological Flow Requirement in Downstream of Hydropower Project Through Hydrological Modelling and GIS approach - A Case Study of Beas River Basin in Himachal Pradesh, India

September - 2019

Submitted for registration in the degree of

Doctor of Philosophy

DEPARTMENT OF CIVIL ENGINEERING
CHITKARA UNIVERSITY
HIMACHAL PRADESH

Submitted by

Name: Saravanan. R,
Reg.No: PHDENG18052
Under the Joint Supervision of

Supervisor
Dr. C. Prakasam
Associate Professor
Department of Civil Engineering
Chitkara University
Himachal Pradesh

Supervisor
Dr. Varinder S Kanwar
Professor
Department of Civil Engineering
Chitkara University
Himachal Pradesh

Supervisor
Dr.M.K.Sharma
Scientist –E
Environmental Hydrology Division
National Institute of Hydrology
Uttarakhand

1. Introduction

Hydropower is the most economical and pollution-free form of power production. The main source of power production in Himachal Pradesh is hydroelectric and the present installed capacity in the state is around 3935 MW. The state has rich water resources and a high gradient profile, which makes it suitable to generate hydro-power. The rich water resources of the state include five major river basins, Yamuna, Satluj, Beas, Chenab, and Ravi, which have numerous streams and rivers. The state is reported to have the generating potential of more than 20,463 MW of hydroelectric energy. The Beas river with a length of 470kms flows from Rohtang in Manali to meet the Satluj river in Punjab has an identified hydropower potential of merely 6000MW. Environmental flows are the water that is left in a river eco-system or released into it for the specific purpose of managing the condition of that ecosystem. Failure to maintain such flows may lead to a decline in the health of the water-dependent ecosystem. Minimum flow is a general term used to describe a flow required to maintain some features of a river ecosystem. To tap this potential, the Himachal Government has already constructed several projects and large projects amounting to huge capacity are under construction in the Beas river basin. This implies that the river bed could be dry during the summer period or water scarcity period. Hence, there may arise a situation in which the ecosystem would not be able to sustain the riverbed ecology and riparian environment due to many factors. Therefore, there is a greater need to evaluate the requirements of the Environmental (Protection) Act, 1986; 15% of the minimum observed flow of the stream has to be released, to the downstream of diversion structure for the protection of flora, fauna, and aquatic life between intake and confluence point of tailrace and the stream.

Concerning about effects of most of the river degradation and dam impact, turned into a noteworthy public issue involving numerous researchers, lobbyist groups, and concerned individuals. The inability to maintain minimal flows may prompt the weakening of the subordinate ecosystem's water condition. The general term used to depict the flow that is necessary to maintain the river ecosystem's feature is minimum flow. Hydropower is standout amongst the most economical and nonpolluting wellsprings of energy. India ranks eighth in total energy creation of hydroelectric power. The environmental flow goes about as a principal factor to anchor the river ecological framework. Scarcely any nations have come to understand their regard as it helps in understanding and maintaining the health of the water subordinate ecosystem. E-flow esteems change as for some factors, for instance, topography, water resources, climatic and farming factors, and so on; every nation prescribes distinctive e-flow esteems corresponding to the aforementioned factors. Research work shows that there are up to 200 methodologies to regulate the presently existing e-flows and the methods are being suggested or employed in about more than 50 nations around the world. Hence, the selection of ecological flow assessment method will rely on various factors such as lack of data, implementation issues, etc., The administers of the hydropower dam or any water resources project only have an eye upon achieving the goals overlooking the environmental impacts or the imbalance that may arise due to the construction, operation and maintenance of any water resource project. We could take This infers that the river bed could be dry during the summer period or water shortage period. Subsequently, a situation may arise in which the ecosystem would not have the capacity to sustain the riverbed ecology and riparian condition because of numerous factors.

1.1. Environmental Flow

There isn't a remarkable definition of environmental flows yet. Environmental flows at times are called ecological flow, yet they approximately demonstrate a comparable meaning, both of them are genuinely utilized by us. According to Dyson et.al, (2003) an ecological balance is considered to be the necessary water management supplied inside a river, ocean, or wetland to put up with the environment and the dependent points where flows are controlled and challenging water usages are present. Tharme (2003) stated that the proportion of water that was left in the stream/ river/dam to the water important for the water's biological system/ ecosystem and to keep up the stream's health is called environmental flow. Environmental flows in like manner have another name or different definitions in different nations, for instance, instream flow, minimal flow, and so on. The prevailing national regulation, in the national level law, has not yet provided a sensible, practical, and legitimate course of water's action for the environmental flows in several nations. A handful of nations only has understood the criticality of non-inefficient vocations of water and have created specific regulation to accommodate it. At present, there is no international understanding especially stressed over environmental flows. Regulation of environmental flows in a couple of nations have influenced achievements or ventured to up.

The present research aims at evaluating the sufficiency of the proposed environmental flow norms for the hydropower projects in the Beas River basin and validates with the aid of GIS application. The recommendations are also expected to be provided based on the contingencies in the result.

2. Literature Review

The review paper presented here address the various aspects of environmental flow such as the method of e-flow assessment, application of GIS, E- flow modeling, Limitations in environmental flow assessment. The period of review of these papers are from 1970's – 2019, the papers are categorized into International, Indian status, further subdivided into review papers on decadal order followed by a critical review. This paper reveals the various methodologies used in environmental flow analysis. Critical reviews on each method are provided with help from published research works (journals, books, reports), etc.

The e-flow assessment is used to cope with the exploitation of water by the dam upon ecosystems or an administration tool to mitigate which depends on the various factors such as hydrologic, ecosystem, population, and water usage in the river flow.

2.1 International Status

Stalnaker, C.B., et.al, (1976) quoted that the ideal flows for the fish or invertebrates are estimated from the breakpoint curve between the wetted perimeter and the discharge. Loar, J.M., et.al, (1986) stated that the hydraulic parameter surrogates for factors of habitat that limit the river ecosystem, to build up a connection among natural surroundings and discharge from which to infer e-stream proposals. Bovee (1986) established the Instream Flow Incremental Methodology (IFIM) method referred to as the next level of EF assessment model depending on the physical as well as habitat parameters. It is based on simulating the species' response using the response to the biological, hydraulic, and data are known as (HSM) Habitat Simulation Methods. Cavendish, M.G., et.al, (1986) used the IFIM by taking the fish as the indicator species of river habitat. Jowett, I. G. (1989). The hydraulic parameter surrogates for factors of habitat that limit the river ecosystem, to build up a connection among natural surroundings and discharge from which to infer e-stream proposals. Tharme, R. E. (1996) surveyed various hydraulic simulation models and prominently used hydraulic rating methodologies to determine e-flow recommendations. Arthington, A.H., et.al, (1992) these alternative methodologies are distinct from solo-reason methods by the regular attribute that they intend to evaluate the e-flow's prerequisites of the aquatic frameworks' several interacting segments. Richter, et.al, (1997) used the (RVA) Range of Variability Approach strategy considering a hypothesis of aquatic ecology with respect to all hydrological variables to set a river ecosystem which is stream flow-based, an administration that targets at empowering of the river administer to plan and manage a long-term E-flow practice. The strategy is planned to be applied to rivers wherein the local aquatic biodiversity is preserved and common ecosystem capacities that are essential for the river administration targets are secured. King, J.M., et.al, (2000) stated that there are four essential sorts of flow-examination approaches in light of the hydrological method that was the most punctual. Tharme, R.E. (2003) gave a total audit of ecological flow methods in different countries. An overall survey of the present status of about 207 e-flow methods was found, from the 44 nations around the globe. Arthington, A.H., et.al, (2004) reviewed the papers researching/researched the environmental flow and found that over 200 methods for finding the ecological flows exist, that are used or made arrangements for use over the world in 50 nations or more. E-flow methodologies are utilized in Australia and southern Africa and dynamically in different nations are all-encompassing in their probability, remembering it is fundamental to bear the cost of water for oceanic ecologies from a source to the ocean and for all the biological parts which are water-subordinate. Acreman, M.C., et.al, (2004) divided the techniques into four kinds as the hydraulic habitat modeling, look-up tables, functional analysis desk-top analysis; No method is in a general sense superior to another; each may be sensible for different applications. Arthington, A.H., et.al, (2004) gave a short account of the progression of e- flow methods and characteristics of the individuals, providing most highlighting to methods such as holistic or ecosystem. O'Keeffe, J., et.al, (2009) provided the need for river and environmental supplies. The foundation of environmental flows was complete with the hypothesis associated with it and its restrictions. The main issues such as selecting a methodology, setting aims were deliberated. Finally, the valuation methods were deliberated with the application of the indicators. The book gives a complete understanding of Environmental flows and their significance for the river. Abbasov, R. (2010). Proposed a new methodology CREF (coefficient of the relative ecological factor of the water) by finding the ratio between the quantity of ecological flow to the observed flow in the river for the Kura basin river of Azerbaijan. Using this it is conceivable to assess e flow for all year time frame and also it is not assessed just for water measure stations yet in addition to mouths of little waterways. Poff, N.L., et.al, (2010) studied the 165 papers which were published over the last forty years, with an emphasis on the latest papers targeting at determining if the common associations can be drawn from the dissimilar research present in the review of literature that might update on the administration of environmental flows. Of all the papers reviewed, about 92% detailed the qualities that were diminished for environmental measurements that were recorded in answer to a different sort of stream modification, while 13% announced the expanded qualities. Fifty-five of the research works had information reasonable for quantifiable investigation of the stream modification's ecological response.

Gamma Tbilisi, (2011) assessed the e-flow as 1,75 m3/s for the Paravani River from Paravani Hydropower Project in Georgia. The ecological flow data is maintained monthly and published on the site (http://paravanihpp.ge/reports.html). Dunbar, M.J., et.al, (2012) joint the two extensive methodologies of hydraulic approach and habitat modeling to estimate the needs of the E flow for the Salmonids. The research work mentions that this modeling approach is trustable, on the progression of habitat suitability approach, which has chances of transferability, doubts, and relation to appliances at the population level. Kendy, E., et.al, (2012) investigated how 3 interstate river basins and 6 states in the USA are viably developing and found that the e-flow differs for every 6 states and 3 river basins by applying an e-flow method based on the region to water resource planning. Linnansaari, T., et.al, (2012) grouped the methods utilized in e-flow assessment into four general categories and their advantages and shortcomings were inspected. An ongoing pattern appears to recommend that there exists a growing affirmation that any method of e-flow utilized alone won't remain adequate for defining the e-flow in all circumstances; the holistic methods and outlines the progressively ordinary particularly in adventures that are huge in scale. Karakaya, N., et.al, (2013) measured the idea of e-flow for the Big Melen project of water transmission as a case study and specified that the method of e-flow necessity was used to monetarily significant waterways where concentrated fisheries happen and were depicted as the stream necessities' total that angles the interest of stocks. As of late, increasingly solid techniques for the necessities of ecological stream have been built up that include different natural components like other life forms' requests, the structure of the environment, and its capacity. Poff, N.L., et.al, (2013) highlighted the evolving challenges that e-flows involves, and purposeful the difficulties, that the systems amid the current time of speedy worldwide change. For a powerful commitment of the e-flows to a viable freshwater the executives on a worldwide scale, it must, fundamentally, move from a rebuilding center to one of climatic adjustment and other natural variety stressors, second, increment its scale from single destinations to entire waterway bowls, and third, expand its gathering of people to hold the social-biological manageability that balances out the requirements for freshwater protection with the prosperity of people in both creating and created economies comparative. Pastor, A.V., et.al, (2014) applied Tessmann, Tennant, Smakthin, Q90, the variable monthly flow method (VMF) for several places worldwide. The outcome demonstrates that the E-flow 37% of yearly discharge on average is essential and around 46% for short flow periods and 17% for the large flow periods are assessed as the mandatory Environmental Flows. Acreman, M., et.al, (2014) specified that the environmental flow can be attained in numerous different ways, maximum of which are grounded on either restricting alteration from the baseline of natural flow to uphold the biodiversity and the integrity of the ecology or flow regimes designing to attain definite service results which are ecological and ecosystem. Botelho, A., et.al, (2017) proved through the valuation studies' review on the impacts on the environment due to this technology, and the different environmental effects analysis related to the hydropower for particular contextual analyses that in actuality ought not to be utilized with advantage exchange in the hydropower plant have specific impacts. The paper determines the noteworthiness of the contextual analysis method, by defining significances concerning the alternate hydropower manufacturing offices. Ultimately, the paper determines that decision tests are mainly appropriate for estimating the perceived environmental impacts, being related to planning the arrangements. Yasi, M., et.al, (2017). Increased the environmental flow range from 9 to 35 percentage of Mean Annual Flow after assessing the eflow requirements for the Bukan Dam using nine eco-hydro methodologies for Urmia Lake from the Bukan Dam. Ceola, S., et.al, (2018) claimed that these e-flows must be identified on the basis of the regional and quantitative valuation for central Italy and estimate the habitat suitability's effects of two threatened in the near future fish species (i.e. Barbel and Chub). The result evidently displays that the regional scale calculations which were done quantitatively are feasible even when the observations of streamflow are completely missing at study sites, flows policies which are aprioristic may enforce releases that surpass the natural stream flows for long time intervals significantly(weeks, or months, unduly tightening-flow policies may hugely impact the productivity of hydro-power which is regional (15%and 42% losses on an annual and seasonal basis, individually), yet resulting in marginal or avoidable enhancements of the fluvial ecosystem. Operacz, A., et.al, (2018) exhibited the method of environmental flow estimations which is separated as water areas. The calculation path was additionally exhibited alongside the plausible inconveniences that were resulting from the operative lawful guidelines in Poland regarding the chances of carrying out the undertakings that exploit surface waters that are flowing. Volchek, A., et.al, (2018) did a relative analysis of the rate of the environmental flow by the instance of the Yaselda River in its Bereza section has been done with the usage of diverse methods of environmental flow valuation. The exceedance probability transfer technique seems to be the most capable one. It was concluded by the authors that to make it most effective, it is essential to do the area's zoning, by taking the parameters of exceedance possibility which are the characteristics of the area into account. Volchek, A., et.al, (2018) finished five diversified e-flow rates analyses for the Yaselda River. The even e-flow esteems are given by the edge methods across the year. The features of the approaches change consequently as these were formed in diverse economic and social circumstances. Arthington, A. H., et.al., (2018) authored a special issue that expands the extent of environmental flows and water science in theory and works on, offering twenty papers from scholastics, office researchers, and non-governmental organizations, each with crisp viewpoints on the science and management of environmental water allocations. Based on the papers, a critical review of environmental flow was given a result. Książek, L., et.al., (2019) analyze chose hydraulic and hydrological methods and determine the logically adequate and financially savvy approach to environmental flow within a segment of a mountain river with high naturalness, in the case of the Wisłoka. The hydraulic methods give lower estimations of environmental flow in correlation with the hydrological.

2.2 Indian Status

In India, E Flow assessment showed up in the late 1980s and first coined in 1992 as "minimum flow" by Center Water Commission. Smakhtin, V., et.al, (2004) first attempted to assess the amount of water vital for the health of freshwater ecosystems. It contains environmentally applicable high and low-flow components for 128 river basins. It suggests that the e flow should be part of global water evaluation. Smakhtin, V.Y. (2006) surveyed the E-flow prerequisites for the Indian River basins. After PC modeling has been done to know the extensive variety of factors involved to determine the e-flow, the report examines the points of interest and restrictions of the method and finishes up with suggestions for a more drawn out term e-flow research in India. Kumar, P., et.al, (2007) surveyed the impact of flow changes in the river for Nathpa Jhakri Hydroelectric (1500 MW) on the Satluj river using hydraulic habitat analysis resulting in a minimum water arrival of 7.0 cumec from the dam is proposed. Harish Kumara, B.K., et.al, (2010) attempted to estimate the present states of the water flow's health in the Bhadra River at Lakkavalli, Karnataka, and the criticalness of the ecosystem services through e-flows. Over 60% of the downstream occupants have changed their vocation occupations, and additionally migration level has increased in the fishermen networks. Rai, R.K., et.al, (2011) represented the various E flow estimation techniques for a river along with the pros and cons of their methodologies. In addition, a comparison was made between several hydrology approach techniques along with the habitat, water requirements for various contributing factors. Jain, S. K. (2012) talked about the different ideas of Environmental flows and their points of interest in the research paper. His research mainly includes the Evolution of E-flow assessment, Stages in the assessment of E-flow, and different factors and reasons governing the Environmental flow. He has examined different methodologies, for example, Hydro-science, Hydrology and Hydraulics, and Hydrological method. The paper is finished up with future difficulties in predicting E-flow and its need for a sustainable ecosystem. Dubey, A., et.al, (2013) calculated the e flow using Tennant, Lookup Tables at 4 gauging sites in the upper part of Narmada. Modified Tennant method is used to estimate on a monthly basis resulting in a variation from 50.6 to 73.5 cumec for Sandia etc. Soni, V., et.al, (2013) considered the Environment flows for the storm time frame (eighty percent of the total Indian rivers flows) of the Yamuna river of Delhi. The research directed presumed that half of the rainfall is vital for the vehicle of residue during the rainstorm season and 60% is required during the non-storm season. Dubey, A., et.al, (2013). Assessed the e flow using Tennant, Modified Tennant, and Lookup tables for Narmada's upper part of the river for the gauging sites located at four different locations. The results show that the Modified Tennant method is ideal for the estimation of the e-flow requirements for EFA on a monthly basis. Sundaray, P. (2013) environmental Flow (Doctoral dissertation) assessed the E flow for the downstream side of the Mahanadi river by analyzing daily discharge (24 years) using the FDC and RVA methods. FDC method includes 1-d, 3-d, and 7-d flow. The RVA is analyzed by IHA and calculates 33 IHA, 34 EFC (Environmental Flows Component), i.e., 67 statistical parameters. Bhattacharjee, A. (2014) assessed the E Flow using the RVA, FDC, and Tennant method, etc., for the Mahanadi River Basin. The low flow values were calculated using the Q95, 7Q10, Q90, etc. methods for 8 stations covering the Mahanadi river basin. Verma, R.K., et.al, (2015) used the three hydrological methods FDC, Tessman, Tennant for numerous Damodar river basin sub-watersheds, in the West Bengal and Jharkhand resulting in the minimum flow varying from 1.04 to 16.08 m^3/s as required to maintain the health of various watersheds in that river ecosystem. Kawde, S. K., et.al, (2016) done a literature paper and elaborate on the environments that prompt the phenomena ecological flow to be developed and then particularize on developing ideas, definition concepts. Johnson, J. A., et.al, (2017). Recommended a 26% of E-flow as requirement across the Godavari river below the polavaram dam. The physical habitat simulation model (PHABSIM) was utilized to understand the impact of the low flow upon the fishes and for this purpose, five fish species were chosen. The e flow estimation was done for these species by deriving a habitat suitability curves (HSCs). Dutta, V., et.al, (2017) combined e-flow theories and distinct a new framework for e-flow assessment. This research gave a case of the system connected to the Ganga River. The outcomes demonstrate a relationship between the flow profiles, ecological impacts & physical habitat. Tare, V., et.al, (2017) directed the E-Flows assessment using BBM methodology for the Ganga river in its upper stretch for three distinctive outrageous conditions, for example, high floods, rainstorm period, and lean period for specific animal categories named as keystone species.

The outcome demonstrates that for dry season E-Flows of 29%– 53% for a period of mid-October to mid-May for these regions were estimated. Bhattacharjee, N. V., et.al, (2018) did an analysis for the Middle Oconee River on how various models of habitat models like instream flow and various scenarios of water drawing influence habitat in Athens, Georgia. Historical release data are coupled with water drawing simulations for every withdrawal plan to examine exchange offs among ecological and social results Hydraulic models are connected to translate hydrologic simulations into habitat appropriateness for the following three conventional habitat types: shallow-quick, profound quick, and shallow-moderate. Dubey, A., et.al, (2019). Calculated the required e flow as 46%, 45.1 %, and 36.1% of the percentage of Mean Annual Runoff at the barman, Sandia, and Dindori station respectively of the Narmada Basin using (GEFC) Global Environmental Flow Calculator developed by (IWMI) International Water Management Institute, Sri Lanka. The National Green Tribunal (NGT arrange) passed a law that 15% of the e-flow needs to sustained in the stream/dam/ water resources during the lean period for preserving the health of the ecology after the "Ministry of Environment, Forest and Climate Change" with the reference ongoing Judgment articulated on river Ganga had guided 20% minimum condition flow to be maintained from Haridwar onwards in the perspective of the ordinary lean season flow adjacent to the nation will maintain minimum 15 % to 20% of the ordinary lean season flow of that river.

2.3 Environmental Flow Methodologies

The E-Flow assessment method can be categorized into four based on the input as Hydrological, Hydraulics, Habitat simulation, Holistic methods (Palau, A., et.al, 2012).

2.3.1 Hydrological method

Gippel, C. J. (2001) stated that the minimum flow was defined according to hydrological flow data based on an assumption that a complete set of flow data is essential to maintain the health of the ecosystem. E-flow is designed in such a manner that the natural river flow maintains a positive health and species habitat's native. It can be attained by considering the previous year flow data or historical data of flow prevailing in the ecosystems. Tharme, (2003) proved that there are various systems that depend fundamentally or exclusively on hydrological information for inferring E-flow recommendations. Lytle, D.A., et.al, (2004) explained the natural flow characteristics are the key parameter for this method in the water resource structure and operational aspects of water-dependent ecosystems. The flow variations for the recent historical period set a prototype for current ecological processes, mitigation, and to maintain the nature of biodiversity. Caissie, D., et.al, (2007) employed the Flow duration curve (FDC) methods to outline the extent of time rose to or surpassed a certain flow limit level in a specific river or area. The curve duration is evaluated based on data that was obtained in numerous years, ideally using records for more than 20 years. Flow limits are then identified from field data based on various expert knowledge that portrays the flow levels that supports biotic integrity. Mazvimavi, D., et.al, (2007) for Zimbabwe to measure the EFR (e-flow requirement) a desktop hydrological was used. The results show that the e-flow as ranging from 30 to 60 percentage of the average annual runoff in areas with lasting rivers, and for the dry parts of the nation with rivers it ranges between 20 to 30 percentage, which just flows during the wet season. Mathews et.al, (2007) used the (IHA) Indicators of Hydrologic Alteration which was established by The Nature Conservancy on the Green River during the ’90s at Washington using the combination with models of ecology that enables the flow-ecology hypotheses’ formation and testing, water formulation and preservation or renewal goals of the land. Beca, (2008) stated that considering the aquatic system’s needs, the e-flow has to be designed considering all the hydrological variabilities, morphology combined with the holistic approach of ecological based values. Ramakar Jha, K.D., et.al, (2008) used Low Flow Frequency to estimate the low flows under diverse climate scenarios in the Basin of the River Brahmani, located in Orissa, India. To comprehend and forecast the probable effects of change of the climate upon the river flow and water resources it is essential to fathom the multifaceted nature, the nonlinearity of the associations that happens among the atmosphere and the land surface, and to regard scale of reliance on which these associations are analyzed. Mandal, U., et.al, (2009) explored the FDC method, a regression-based model for Irish rivers that was established and utilized for predicting FDC for the ungauged catchment based on watersheds climatology and physiography data. Alcazar, J., et.al, (2010) assessed the e-flow using the Basic Flow methodology for river control which was developed because of inconsistencies in the hydrological arrangement of day by day using “simple moving average model” of the mean flows in the Silvan stream. The Basic Flow Methodology (BFM) provides a standard e-flow value and also a strategic management plan constituting the factors such as the biology of the river by providing input data as monthly inflow data. This methodology is commonly used in Spain for E-flow planning. Desai, A.Y. (2012) used the Desktop Reserve Model (DRM) for the study area in South Africa. There is likewise a suggestion that a future variant of the pressure-driven sub-model may incorporate the stream routine change impacts on channel geomorphology and sedimentology with the goal that situations of the stream the board can be additional proficiently assessed. Karimi, S.S., et.al, (2012) used a flow duration curve (FDC) method for the Shahr Chai River, Iran. It’s used when there is insufficient data for the e-flow assessment using the month to month flow data to build up an environmental FDC. Near outcomes show that an e-flow of 1.2 m^3/s which is approximately 23 percentages e-flow necessary for a healthy ecosystem. Fuladipanah, M., et.al, (2015) used FDC which was based on hydrology data to assess e flow in Gharasou River, Iran. Using FDC, Q90, and Q95 for diverse return periods were designed. The scale was fixed as 1-d, 3-d, 7-d, and 30-days to arrive at a minimum of everyday discharge of 0.7 m3/ s-1 using the Q95 index. Burneo, P.C., et.al, (2017) assessed the impact of 10% minimal flow discharge establish as a rule in the Machangara and Chulco rivers using the Base Flow Methodology (BFM) which have been blocked by the hydroelectric project. For the Machangara river for the rainy season, the minimal flow of 27-51 % of the (MAF) means the annual flow is evaluated, 29–42% in the arid season. Whereas for the river Chulco the minimal flow of 15 to 45% of MAF for the rainy, 15 to 36% for the dry season. Tan, G., et.al, (2018) used a new methodology distribution flow method (DFM) for the Yangtze River. Laterally with the DFM method, the EFI (Ecological Flow Index) was used to measure the E-flow with the help of "broadening kernel density estimation" and were compared with the traditional hydrological E-flow methods. Results show that the technique in like manner satisfies the genuine overflow request of waterway biological communities, shows predominance over the standard hydrological strategies, and exhibits high space-time fittingness and application regarding. Long-term or historical flow data are harnessed for calculation of e-flow in terms of hydrological methods. A wide range of flow data is collected in terms of range from daily to even for 30 years and their mean-flow data is recommended as E-flow value to preserve biodiversity. Hydrological methods such as Range of Variability Analysis, FDC, Tennant, DFM, Tessmann, 7Q, and Q50 flow approaches are the most widely recognized ones. The hydrological method has an unusual state of result precision in the examination with the other three strategies. Hydrological strategies, which rely upon logged data methods, are considered as delicate as for environmental information, lacking to clear up the ecological hydrological relationship.

2.3.2 Hydraulic Method

Gippel, C.J., et.al, (1998) employed the most common hydraulic method, the wetted perimeter method to evaluate e-flow. The methodology is as per the fact that the basic least release ought to identify with the point where there is a break in the condition of the bend. Underneath this release, the wetted perimeter diminishes rapidly termed as a breakpoint. E-flow for the river stream is the breakpoint value. In terms of past data insufficiency, the wetted perimeter method can be handy. Hydraulic methods take into consideration several parameters related to the river such as the morphology of the river, discharge rate. The hydraulic geometry such as Stalnaker perimeter, width, depth, is surveyed for each cross-section. Extence, C.A., et.al, (1999) used the LIFE method which was developed in the UK using the 20 years' data of the ecological survey. LIFE evaluates the biotic response to the flow-dependent on species-level and family-level inclinations for flow speed conditions, recognizing that a few families include taxa with variable-flow necessities. The procedure for utilizing this data in the administration of stream flows is still a work in progress yet the procedure is accepted to be comprehensive and the LIFE methodology has the real favorable position of using the data gathered by prevailing biomonitoring programs. Liu, C., et.al, (2011) used Adapted Environmental Hydraulic Radius Approach in the Huvai River which created a method that utilizes hydraulic sweep as the surrogate for hydraulic habitat. The hydraulic span is determined using the Manning flow obstruction equation, surveyed or summed up cross-area and the biggest 'minimum ecological speed. Efstratiadis, A., et.al, (2014) investigated the minimal flow norms from the most downstream dam by measuring the wetted perimeter and coupling it with the (BFM) Basic Flow Method, appropriate for Mediterranean rivers, whose streams show robust erraticism through periods. The work shows the combination of these two could possibly produce a consistent result irrespective of the river flow data. Hydraulic rating methods utilize the river geometry parameters such as wetter perimeter, depth, and with to shape of the e-flow.

Calculating the geometrical parameters for each cross-sectional area marks as a disadvantage as it consumes a lot of data and time.

2.3.3 Habitat Simulation Method

Jowett, I.G. (1989) stated that the extension of hydraulic methods with habitat details are the Habitat methods. Hydraulic habitat is some of the habitat features, for example, depth and flow-related data such as velocity and habitat features such as flora, fauna, and habitual data. Habitat methods depend upon hydraulic models that anticipate how depth and velocity of water vary with respect to the discharge. These models depend on every species' scope of inclinations regarding the parameters that define the physical habitat i.e., current speed, profundity or substrate type, and so on. In view of the channel qualities, the measure of habitat for these species can be determined in relation to various flows. Leclerc, M., et.al, (1995) illustrated the IFIM methodology by learning of the habitation of the Moisie River (Quebec) for the fish habitat at two sites over a wide range of discharge measurements are accessible. Bovee, K.D., et.al, (1998) stated a result that based on the hydraulic conditions, the habitat methods build up flow requirements expected to meet explicit habitat prerequisites for biota. Thorn, P., et.al,

(2006) used the RHYHABSIM (River Hydraulic Habitat Simulation), a habitat-hydraulic model on River Kornerup for three small streams in eastern Denmark. The model results for a span of ten years were equated with the tangible flow data leading to the results that there is e-flow for the two the streams are sufficient for healthy brown trout river ecosystem every year and however it's insufficient for the third river. Palau, A., et.al, (2012) presented the BFM as a real-time application for the Silvan stream, a natural river stream flowing through mountain being obstructed by a hydroelectric project. The final result is reflected with respect to the physical habitation generated and compared with IFIM, using RHYHABSIM for physical habitat modeling. Koutrakis, E.T., et.al, (2018) applied (MesoHABSIM) mesohabitat simulation model to measure environmental flows in Nestos River, Northern Greece. Ecological flows of 10–15 m3/s by assessing the fish samples and hydro-morphological units were predicted as habitat suitability. Lester, R. E., et.al, (2019) Used the Murray Flow Assessment Tool, a situation-based habitat suitability model to evaluate the e flow by correlating the monitoring data of explicit key species (fish) against the model data. The author underwrites using simple, consistent combination procedures and constant weightings and re-examining the quantity of fish functional groups as simplifications to this model and in the improvement of comparative habitat appropriateness models somewhere else.

Habitat Simulation methodology is an easy and less labor implement method that could give quick information. It gives the results by relating the discharge and accessible habitat conditions. Broad data collection and utilization of specialists, surprising expense makes this method an inquiry for use.

2.3.4 Holistic method

King, J.M., et.al, (2000) developed a holistic approach called (BBM) Building Block Methodology for the Rusape River's E-flow, a Save River's tributary, in Zimbabwe, from results of various projects related to water resources in real-time. The methodology has helped the water administer to advance the e-flow assessment methodologies in a different and advanced approach as it focuses not particularly on a specific factor but on a wider factor from the bottom to the top approach. Subsequently, an EFR for maintaining river ecosystems was settled according to the examination area as the Ecological Reserve. Arthington, A.H., et.al, (2003) utilized the DRIFT for the Lesotho Highlands Water Project, Southern Africa. It offers an organized procedure for anticipating the biophysical, social, and financial results of changing a waterway's stream routine and should just be connected inside a versatile administration system where there is a real pledge to the age and utilization of new learning got from checking and research. Holistic methodologies rose up out of a typically applied origin. (King, J., et.al, 2003). The e-flow parts are recognized and portrayed as far as their extent, duration, timing, and recurrence. The yield is a depiction of a flow routine expected to accomplish and maintain a predetermined river condition. King, J., et.al, (2003) applied the DRIFT (Downstream Response to Imposed Flow Transformation) methodology utilizing experienced people's knowledge from various disciplines for advising on an e-flows plan for rivers. It has the principle that all major constituents of the ecosystem must be supervised and also it is an ordered technique for merging data of all sorts to maintain the health of the ecosystem. King, J.M., et.al, (2004) states that the BBM, gave away the driving force to the advancement of a few options comprehensive natural stream approaches, strikingly the DRIFT which is an interactive and situation based methodology intently used in exchanges that contains the solid financial part, significant while measuring subsistence utilization of waterway assets by riparian people groups.

In a holistic methodology, all three other methods are used and exceptionally vital flow attributes (high surges, base-flows, and so on.) are recognized. Bahukandi, K.D., et.al, (2013) recommended and provisioned the development of a BBM for the Suswa river of Dehradun district. It works on the principle of drawing post-examination suggestions from pro gatherings, for example, hydrologists, geo-morphologists, water quality specialists, sociologists, earthy people, and data innovation specialists. The given data sources help the learning-based framework in advancing aggregate discoveries (evaluation), suggestions are drawn thereof, measures to be taken and guidance, for the upkeep of least stream with the target of keeping up quality and amount of the river stream. The discerning of these methodologies is that all key abiotic, biotic divisions build up ecology to be directed, and additionally, that the complete scope of flow with their communal or spatial variance contains the-flows to be administered

This method requires vast logical ability, mind-boggling expense, and not operative makes one point in the side of weakness.

2.4 Environmental flow Modelling

Chalise, S.R., et.al, (2003) estimated minimal flow for the Hindu Kush–Himalayan (HKH) study area by using the water balance approach, the lives of people in that study area face increased water scarcity in the dry periods in both the aspects of quantity as well as quality. The difference between average evaporation and precipitation is the long-term annual runoff which provides the water balance principle. Korsgaard, L., et.al, (2007) developed a simple tool called MIKE BASIN to analyze the various ecological flow scenarios and arrived at suitable ecological flow requirements. This tool calculation of methodology was programmed in MS Excel. Shafroth, P.B., et.al, (2010) stated that two basic methods for refined learning, an estimate of environmental reactions to ecological flows are linking physical framework models to the ecological responses and exact relationships among the discharge flow through implementation and exploratory monitoring. After the model applications effects the exploratory discharges contribute to the versatile flow management in the BWR and also there is an advancement in local environmental flow standards. Lagerblad, L. (2010) in the Buzi river basin of Mozambique did a fieldwork case study and then modeling of the environmental flow requirements is collected. Further with the help of the Desktop Reserve Model by South Africa calculations done for the requirements of environmental flow. The must requirement of the result conclusion warns to maintain the ecological status with an average allocation of 57 % in mean annual runoff (MAR) at natural conditions (ecological category A) in Buzi River and also the study says that it is possible if there is low confidence level too. Pang, B., (2012) in Shaanxi province of Wei river did calculation for the flow of an ecology base and so developed a water quality model for this particular river basin to determine the self-purification flow in four scenarios which includes the present emission as one among them and the remaining three scenarios correspond to the pollution treatment with different scale of measurements. By the biological indicator method for an existing aquatic habitat, the flow demand is calculated. This result shows that the suggested technique is more reliable and appropriate for the Wei River in Shaanxi province to calculate the ecological base flow. McManamay, R.A., et.al, (2013) for the energy production implemented the environmental flows usually cost at a price and so identified the parameters which are necessary to balance the need of ecology in terms of hydropower context and followed by as duration, magnitude, timing, frequency, or rate of change of stream flows is a challenging one because there will be many competing users for the flow of ecological responses with not fully known flow changes. The study is determined to develop the potential of hydropower and for reaching further benefits than the environmental flow determination which can be done by the use of modeling applications, data, and geospatial layers. Theodoropoulos, C., et.al, (2015) to give defensible flow recommendations for the Environmental Flow Assessments (EFA) used Hydrodynamic habitat models which are worldwide. The evolution of Habitat modeling is from simplistic 1D to the advancement of 2D or 3D models of greater accuracy. Also in the data-driven hydro-ecological approaches, this will be offering a great basis and for the benthic macroinvertebrates followed by the development of a hydrodynamic habitat model the proposed methodology is good for an environmental flow assessment. Jayasiri, M., et.al, (2017) calculated the EF requirement downstream of the Deduru Oya reservoir using the developed approach. The outcomes were paralleled with the EF calculated using Sri Lanka Environmental Flow Calculator model developed by IWMI. A significant difference was seen between the EF calculated using the new method and the results obtained using the model developed by IWMI. Hence, it is recommended as further scope to improve and verify the findings of the new method. Kalumba, M., et.al, (2017) proved this by using Water Engineering Time Series Processing Tool (WETSPRO) in the Kafue Basin to extract the low and high flows which is an independent criterion for the facility of hydropower. To compare the low as well as high flows by the analysis for a long period of time scales, constructed the cumulative frequency distribution curves to show the variation. The water balance is periodically checked for every hydropower station with the river flow allocation by comparing of outflow water balance calculation (river flow) with the hydropower and river flow observations followed by the downstream consumptive water rights of every hydropower station. During the drought, the river flow ranges from 50 to 100 m^3/s which have been discharged from both the ITT and KGS stations vice-versa during the extreme flood events the river flow ranges from 1300 to 1500 m^3/s as an available data. Stamou, A., et.al, (2018) in Sperchios River of Central Greece experimented to see the environmental impacts by the cause of irrigation, water abstraction is done by the 3H-EMC Environmental Management Classes. With the criteria of lives of the main fish species of large and small chub, the hydrodynamic-habitat model calculations ranged from 1.0 m^3/s to 4.0 m^3/s correspondingly as discharge units. However, there is an indication by the hydrological modeling about the difficulty of achieving the discharges which are higher than the approximate values from 1.0 to 1.5 m^3/s and also the suggested legislation values significantly lower (0.4 to 0.5 m^3/s) and unacceptable from the viewpoint of an ecology. With the appropriate coupling algorithm, this proposed modeling approach of the same or similar to the modeling tools is applicable for any of the streams or rivers as a study area. El-Jabi, N., et.al, (2019) chose a method that best defines the flow of natural river i.e., flow metrics, to quantify the e flow and the hydrological features for New Brunswick river in Canada. The results revealed that low flows were all lower than the 10% Mean annual flow using the frequency analysis. The author suggested that the 70% Q50 methodology ought to be utilized with restraint in the season of summer as this technique delivered low flows of 15–16% of the Mean annual flow.

2.5 GIS application, Environment Impact Assessment and Environmental Flow

Abbas, I.I., et.al, (2009) achieved that Environmental Impact Assessment (EIA), in turn, can be done holistically only through the technique of Geographic Information systems (GIS) and Remote Sensing (RS) then discussed sustainable development through environmental impact assessment, which is the best approach to study environmental impact assessment. Botelho, A., et.al, (2017) for an alternate facilitative hydropower production this paper demonstrated the importance in the approach of case studies and also defining the priorities with the help of previous specific case studies associated with the technology and analysis of every hydropower in the study area which had been benefiting transfer but that must not be applied for the sake of environmental impacts. Chand, H., et.al, (2016) did the research work during 2011 for investigating the impacts of Kol-dam construction by people and their total economy. Overall, there was a decrease in on-farm sectors (crop & livestock) ranged from 42.86 to 81.17 percent whereas an increase in off-farm income (jobs and private business) ranges from 13.33 - 48.33 percent had been observed from the affected villages. Hence it can be concluded that there was a loss of on-farm income resources like agricultural land and its associated resources i.e. important tree species and livestock. Gharehbaghi, K., (2018) used the Geographical Information System (GIS) software which confines and define to encapsulate all types of data into ecological, geological, environmental, biological, and physical information to study the EIA and its mitigation as the inclusive process which is accessible through the concerned communities and organizations, such as data collection, analysis of data and determination of data for the application development or construction approval. The improvement of the overall EIA and its mitigation process add up value to the strategy of mapping as well as approaches through the holistic environmental system. Hossein Yousefi Sahzabi (2004) did an attempt for the identification of some likely key factors on the impacts of drilling, operation, and geothermal exploration through the preliminary review to suggest the mitigation measures which can be of good potential for the possibility of environmental effects in the proposed project. The results suggested a reduction in the gas emission to the environment and also reduction methods for soil erosion as a measure on the areas such as water supply, disposal of effluent water with the detailed studies done during drilling and operation. Hirji, R., et.al, (2009) in the report framed the objective and tried to understand the e-flow behavior in the aspect of both the water practitioners and environmental experts drawn lessons from the experience for the implementation of environmental flows on the bank and effective integration in thee-flow through an analytical framework development. Advanced understanding and integrated operation and management for the water allocation in the sectors is the goal overall for the Environmental Flows in terms of Water Resources Projects as well as plans and Policies. Hoanh, C.T., et.al, (2010) observed the impacts of the discharge as far downstream as Kratie in Cambodia and assessed the further estimates of discharge shown through the model for UMB hydropower stations which are subjected to increase or decrease in the dry or wet season indicates the variability and its impacts are noticeable. In three studies of at least among the following hydropower stations such as Xiao wan, Dachaoshan, Jing Hong, Nuozhadu, Man wan, Gonguoqia, at Chiang Saen based on the model approach the study was conducted and estimated to predict that for the dry season the discharge (Dec-May) got increased by 60-90% and to wet season (Jun-Nov) got decreased by 17-22% that require as a result of water storage into the reservoirs in the wet season and utilized by the dry season. Lynne, Y. (2008) in this paper, the importance of an aquatic ecosystem which leads to the measures of the objective of ecosystem health in human society are studied. The complemented work based on river restoration is the consideration of the socio-economic impacts of dam removal on the basis of ecological impacts. With the help of property values on the local community and geographic information system (GIS), this analysis and examination on the removal of dam and impact measurements are done. Samanta, P. (2015) studied and witnessed the changes in the LULC of the study area due to the exploration in the field of coal and minerals which lead to severe adverse environmental impacts. To assess and monitor the activities of these environmental impacts through LULC changes can be evaluated, planning of environmental management done on surrounding villages and cities for the impacts caused by coal mining in the open cast-on biodiversity, water, land, human workers, air, and social impacts.

2.6 Limitations in assessing the environmental flow

The data deficiency regarding the routines of the flow is essential for supporting the natural abilities at both scales which are close and bowl, which speaks a massive hazard to the practical water the board. Chen, H., et.al, (2013) applied the models of the static eco path to estimate the e flow as the reason for time series data lack, the ecology data which is dispersed for many years in the past was studied and fashioned according to the typical ecological data which was standard such as quality of water, its level, and information on the fishery was used for the Baiyangdian study area in North China. Esselman, P., et.al, (2010) made an analysis that was contextual for Patuca River of how the asset and data restrain were tend to be in the advancement of the natural flow’s proposals in Honduras under a hydroelectric dam proposed.

Due to the requirement for data on the waterway's ecological flows on the parts which are ecological, social, and monetary have calculating issues. The flow proposal was generated by, connecting a procedure that has multiple steps such as hydrological examination and demonstrating, the accumulation of conventional ecological information (TEK) amid field trips, master counsel, and natural flow workshops for researchers, water supervisors, and network individuals. Junguo, L., et.al, (2016) used the information of the simulated stream for the appraisal of the E flow because of the information of the recorded stream's absence on the waterway stream. The proper strategy choice is compelled principally by the availability of data for a district, just as the nearby limitations as far as the time, the funding, capability, and intended help. Moore, M. (2004) specified even though there was a lack of information for a few regions, it can be told that it is acceptable assets, knowledge, and engrossment in the ecological flows that prevail in these locales, which in all probability makes it easier to develop the idea into innovative zones in the area. In any case, the number of assets, knowledge, and experience predicted to achieve this cannot be depreciated. Recollecting the constraints of the data, the degree of connecting to this idea varies over the important areas. Pastor, A.V., et.al, (2013) restricted the decision for EF techniques choice, for the inquiry was controlled to hydrological techniques in light of lack of information on reactions of the biological system to changes of the flow for world's maximum waterway bowls. The Eco hydrological information's absence leads to trouble in deciding minimum natural flow edges and tipping purposes of the numerous biological systems across the world in freshwater. Patsialis, T., et.al, (2014) recommended that this time series data lack can be overcome by making use of simulated discharges which are resultant from the IHA hydrology model for Western Macedonia. Penas, J.F., et.al, (2013) outlined a methodology for estimating the environmental flow similar to Europe's water framework directive for the estuaries which are well-mixed by using the hydrologic and climatic pattern which are coupled with the arithmetical modeling of the catchment area's salinity. The capacity for repeating this for a large portion of these methods is worrying due to the lack of required information and further to the contrasts between the considered estuaries. Tharme, (2003) the absence of the data which is accessible in particular cases, and the important l vulnerabilities which are logical is related to techniques accessible. Yue, S., et.al, (2018) reviewed that due to the lower fundamentals for information hydrological method is used, though the results are frequently unpleasing, the computations are straight, which makes it suitable for the streams which are poor in data.

Irrespective of the methods the other aspects restricting the growth and application of EFA are Lack of data in India, Lack of hydrological understanding– ecology, there is no shared technique, viewpoints related to Pollution, River–aquifer contact, Resource absence, Gap among the river researchers and policymakers, Poor execution.

2.7 Critical review

A massive collection of familiar methods exists for suggesting the e-flow needs. Therefore, there is no one particular method that is recognized as an overall method for EFA. All methods are evolving a step by step process. Varied strategies were integrated into the International and Indian status to the extent of determining the Ecological stream mandatory as a part of Environment influence studies and fish habitat inspects. Diverse procedures should be and are used for various purposes depending upon the interest points of the relevant analysis and the kind of issue intended. However, a single natural stream evaluation strategy does not suit all social, economic, hydrological, and ecological of a nation. Various factors must be measured for the use of individual strategies. The frequently cited reason for the operation of strategies depends on a methodology that is risk-based, suggesting that for stream-based decisions with more dynamic ecological, social, or financial pressures more uncertain procedures will be connected. Evidently, various features are put into thought for determining the e-flow, in light of which the method is selected. The Long-term or historical data flow is applied for calculating the e-flow in terms of hydrological methods. A wide range of data flow is collected in terms of range from day-to-day for 30 years and their mean-data flow is suggested as E-flow value to conserve biodiversity. Hydrological methods such as Range of Variability Analysis, FDC, Tennant, DFM, Tessmann, 7Q, and Q50 flow approaches are the most widely recognized ones. The hydrological method has an unfamiliar state of precision of the result in the examination with the other three strategies. The Hydrological techniques, which depend on methods of logged data, are measured as frail with respect to environmental information and are lacking to clarify the relationship of the ecology hydrology. The wetted perimeter technique is an outstanding method of all the other hydraulic approaches. With the help of a hydraulic rating approach, e-flow is shaped through numerous hydraulic variables of width, profundity, and wetted perimeter. An inspection of each cross-sectional area is a disadvantageous consequence concerning the time and the Habitat Simulation procedure is an easy and less labor implementation method that could give fast information. It provides the results by connecting the habitat conditions which are discharge and accessible. Wide-ranging data collection and application of specialists, the astounding expense makes this technique an inquiry for use. In a complete procedure, all three other approaches are utilized and exceptionally vital flow attributes (high surges, base-flows, and so on.) are recognized. This method needs huge logical ability, mind-boggling expense, and not functioning makes one point in the side of weakness. Out of the four systems, the Hydrological technique has an uneven state of result accuracy in the inspection with the other three strategies. Next is the hydraulic technique which reduces in light of the monotony in assessing the cross area of the waterway, with which the e-flow is managed. Hydrological techniques, which depend upon the logged data, are censured for being slightly alike to environmental information and are inadequate to explain the ecological hydrological relationship. Regarding the Hydraulic strategy, a cross-sectional area estimation at each cross-section prompts the negative results similar to the time and cost. Natural surroundings broadcast frameworks located second to hydrological EFMs at an overall scale, be that as it may, by virtue of Indian dimension, it positions third by water-driven as a result of awkwardness in the examination of the earth in the different area. The points of interest and difficulties of the strategy oscillate concerning various parts and factors. Hydrological and hydraulic strategies, for example, the Tennant Method and wetted perimeter strategy are pertinent for setting up minimum environmental demands for water resources management. It should be seen that these approaches give a fundamental low confidence‖ measure. These methodologies can be connected rapidly at incalculable to give a first check of the possible measures of water required to keep up nature in a given condition. The Building Block Methodology (BBM) can in like manner be used for quick assessments. Nevertheless, in order to use this strategy for quick e-flow assessments, month to month naturalized stream course of action is required. The Instream incremental methodology strategy using PHABSIM (Physical Habitat Simulation System) is a largely used technique for more intricate decisions e.g. the development of a hydropower plant or the setting of the deliberations limits from an environmentally touchy conductor. All in all, there is no one logic that should be used for setting up the e-stream ask. To develop the basic e-flow the expert should take into account the history and motivation behind the various strategies existing and need to utilize this information to settle on a sophisticated decision of the finest strategy to utilize.

3. Environmental Flow norms

Environmental flows in like manner have another name or different definitions in different nations, for instance, instream flow, minimal flow, and so on. At the law of national level, prevailing national regulation is, however, to provide a sensible, practical & legitimate course of action of water for ecological flows in several nations. At present, there is no international understanding especially stressed over environmental flows. Only a few nations have understood the criticality of non-inefficient vocations of water and have created specific regulations to accommodate it. Regulation of environmental flows in a couple of nations have influenced achievements or ventured to up. Chen, A., et.al., (2019) discussed the past e flow regulations for China. In China developed the minimal flow and e-flows have been officially viewed as ecological flow and the substance and connotations are as yet broadening. As of now, there are too numerous specialists related to e-flows and complicated authoritative reports in China which lead to ineffective implementation. The logical premise of e-flows is advanced from the relationship between hydrological alteration and ecological response, with the goal that the practices will be progressively holistic in China. Dickens, C., et.al., (2019) Drafted the guidelines/ rules/procedure for the water stress evaluation to aid countries by proving e-flow data and information These rules are based on the (GEFIS) Global Environmental Flows Information System and gives a minimum standard method and the procedure that will be utilized to generate the nation Environmental flow data that will make up the worldwide.

3. Environmental Flows Law and Guidelines in foreign countries

3.1 European Union (EU)

Acreman, M.C., et.al, (2010) states that although the WFD (Water Framework Directive) does not unequivocally indicate environmental flows, reasonable withdrawal percentage varies from 7.5% to 35 % of a total natural flow for the natural flow regimes. ("EU: DIRECTIVE 2000/60/EC, Official Journal of the European Communities (2000), 22.12.2000").

3.2 France

France is one of the first nations which give the quantifiable scope of qualities for Ecological flows in regulation. Souchon, Y., and Keith, P. (2001) cited that under the law legal/allowable ecological flow should be " One-fortieth of the ADF (Average Daily Flow) underneath water structures such as dams worked under the watchful eye of the law, One-Tenth of Average Daily Flow for a new building or for renewing the license) (http://wipo.int/portal/index.html.en).

3.3 The United Kingdom

According to the Souchon, Y., & Keith, P. (2001). e-flow are termed as "minutest satisfactory flows. After that, the rule is being followed successfully. It is as such that the agency/ authority can determine/ decided the minimal flow based upon the commendable flow and constraints in relation to that individual. The methodology for determining the flow also varies accordingly with the measuring point at which the flow is determined (http://www.regulation.gov.uk/ukpga/1963/38/contents).

3.4 Germany

According to the Water (Federal Water Act-WHG), March 2010, rewrote Germany's water regulation based upon stretched out legislative forces conceded to Federalism Reform of Federal Government. WHG essences the ecological flow for ecological consideration. Like the United Kingdom, the minimal flow depends upon various factors which are a matter of debate in legalizing a definite minimal flow.

3.5 Switzerland

Switzerland which is a part of the European Union has separate norms as the Swiss Water Protection Act circles up precise ecological flow regards for diverse ordinary flow rates, that have to be preserved or increase in some cases, based upon ecological and geographic factors. It focuses on maintaining the health of the water-dependent ecosystem and provides sufficient water for livelihood (http://www.bafu.admin.ch).

3.6 The United States

In the US E-flow is named In-stream flows. The administration of dam, lake, or any such water resources in each locality can determine and maintain their own instream flow norms with respect to their environmental characteristics. HMSO, "Water Resources Act 1963," 1963 estimated e flows for six different states and river basins in the state for their adequacy of ecological flow. Florida Law necessitates the environment department or state water administration of the district to set up Minimum flows based on their requirements. (http://www.swfwmd.state.fl.us)

3.7 Australia

The act of water in 2007 in Australia does not give an unequivocal need to ecological watercourses of action; anyway, it necessitates that ecological water is given indistinguishable constitutional affirmation from inefficient water benefits. To cite from Halliday, I., & Robins, J. (2001) the agreement confines exchange rights related to water distributions besides the usage of water for the river ecosystem's health Australian Capital Territory government issued E-Flow Guidelines (2006) in Australia, according to which extreme flow events can occur at times of rare cases to maintain the ecosystem from extinction.

3.8 South Africa

E-Flows are termed as "ecological save" in South Africa, which are regulated as law by the South African National Water Act (NWA).1998, South Africa made the NWA effective considering the water needed to maintaining ecosystem (ecological hold) and human needs (ecological spare) (Van Wyk, E., et.al, (2006)). The law acknowledged that the ecological hold is the water essential to guarantee the river ecosystems the spare implies both the sum and nature of the water termed as an ecological spare.

3.9 Minimal flow norms in India

Setting up a standard environmental flow involves many procedures and considerations such as ecosystem, water needs, future, etc., having investigated administration and methods of main rivers in the nation. Initially, the definition of a river is provided followed by a delineation of the prevailing legitimate & institutional estimates that influence the state of rivers in India. There are different laws and related institutions that have persisted fruitless and challenging. Recently National Green Tribunal passed an act upon the minimal flow.

In India, E Flow assessment showed up in the late 1980s and first coined in 1992 as "minimum flow" by Center Water Commission. There was no essentialness given for the E flow assessment as there were no management methodologies encompassed as an issue of goliath certainty. In 1999, Supreme Court guided the legislature to ensure an ecological flow of $10m^3/s$ of the Yamuna River (New Delhi). In 2001, the administration amended the law regarding the economical flow as a demonstration, paving the course for the researches to manage this topic in a broader start. From 2005, many types of research in view of the distinctive E flow methodologies were outlines with reference to the methodologies followed in other nations. Each one of these investigations oversees river flow alone and considers diverse methodologies to restore the riverine ecosystem. India has a couple of imperative estuarine areas including the Ganges– Brahmaputra delta, Mahanadi, Krishna, Godavari, Cauvery, Zuari. Notwithstanding this various EIA of Hydropower dams were examined in understanding the economic flow in the Indus River equestrian. Most of these rivers are dammed and the freshwater inflow into the estuary is truly constrained.

Table no 1 Minimum flow prerequisites

Year	Minimum flow stipulations
1999	10 m^3/s of Minimum flow in the river Yamuna.
2007-08	10% of the minimal flow in the water resources structure designed.
2010	20% of the minimal flow
2012	EAC asked the river administer to employ a neighborhood community people to check up on the maintenance of minimal flow in the water system.
2017-2018	NGT orders to maintain a minimum 15 % to 20% of the ordinary lean season flow of that river.

3.10 NGT (National Green Tribunal)

The (MoEF) Ministry of Environment, Forest and Climate Change done river basin investigation of 6 river basins and upon thinking about the Ministry has recommended the minimum flow of the river to be 18% of the ordinary of lean season flow of the river. In some situations, it was stated to be even 20%. The Tribunal on the ongoing Judgment articulated on river Ganga had guided 20% minimum condition flow to be maintained from Haridwar onwards in view of the ordinary lean season flow also the country will maintain a minimum of 15 % to 20% ordinary lean season flow of that river.

3.11 Environmental flow for various activities in India

Table 2 E-flow Recommendations for various projects

Project	Recommendation
Nathpa Jhakri Hydropower Project (1500 MW) (Kumar, P., 2009.)	7 m^3s^{-1}
Rampur Hydropower Project (RHEP) (412 MW) (DHI, 2006)	4 to 10 m^3s^{-1}
The Upper Ganges basin (WWF (Worldwide Fund for Nature), 2012)	Water has to maintained at a level of 70% all the time and during drought period at least 30% should be maintained
Yamuna River through Delhi (Soni, V., et.al, (2013)	50–60% of the total flow.
Mahanadi River Sundaray, P. (2013)	The environmental flow at Andhiyakore 0.388 m^3/s, Bamnidhi 23.19 m^3/s, Baronda 0.213 m^3/s, Basantpur 36.28 m^3/s, Ghatora 0.04 m^3/s, Kantamal 14.72 m^3/s, Kesinga 5.12 m^3/s, Kurubhata 0.9 m^3/s, Tikerpara 298 m^3/s, Manendragarh 0.43 m^3/s, Rajim 0.99 m^3/s, Salebhata 0.7 m^3/s, Simga 1.5, Sundergarh 0.96 m^3/s.
Kumbh Mela at Triveni Sangam, Allahabad (WWF (Worldwide Fund for Nature), 2013)	225m^3/s.

Ram Ganga venture on Ram Ganga River at Kalagarh	4.70 cumecs
Cauvery River (Durbude, D. G.,et.al, (2014))	The resultant minimal flow at these location ranges from Belur (0.07- 9.05) m^3/s Hadige (1.67-33.40) m^3/s Akkihebal (1.18 - 19.59) m^3/s Kollegal (18.24-364.88) m^3/s .
The Ganges River (Akter, J. (2010).	a minimum of 542 m^3/s flows is required during April and an extent 22715 m^3/s is required during August and September

3.12 Role of Various Agencies

(I) Government Sector

The minimal flow isn't maintained in the river of the hydropower extends in Himachal Pradesh, latest news on the Hydropower ventures. Currently, the government is aiming to increase the production of the hydropower potential overviewing the environmental effects upon the ecosystem and also the mountain communities depending upon it. Hence as a role of government, it should keep an eagle's eye in maintaining the e-flow in the dam while planning, executing the hydropower projects.

(II) Non-Government sector

Our study area Beas river basin in Himachal Pradesh comprises of hydropower ventures possessed by both the public and private corporations understood that owing to inadequacy in maintaining the minimal flow. These organizations subsequently met up intentionally and tried to shape a water basin level association. Regardless of power production, the private sector must run hand in hand with the administration sector in preserving the ecosystem of the mountain networks.

(III) Individuals

With the reference of many contextual analyses of healthy environmental communities' close hydropower projects, the key is that the approach of the project is bottom up, starting at the network level. The people group can't simply depend upon the legislature and private institutions at all conditions subsequently the network individuals must assume up the liability in preserving the ecosystem.

3.13 Research Gap

Different strategies were incorporated in International and Indian status as far as deciding the Ecological stream required as part environment affect studies and fish habitat studies. Diverse techniques ought to be and are utilized for various purposes relying upon the specifics of the contextual analysis and the kind of issue to be tended to. Be that as it may, no single natural stream evaluation strategy suits all social, economic, hydrological, and ecological inside a nation. Various factors must be considered for the usage of distinctive strategies. A generally utilized basis for the usage of strategies depends on a hazard-based approach, implying that for stream choices with more noteworthy ecological, social or monetary dangers more complex techniques will be connected. It is obvious that numerous factors are mulled over for deciding the biological stream, in light of which the technique is chosen. Out of the four techniques, Hydrological method has an abnormal state of result exactness in examination with other three strategies. Next is the hydraulic method which shorts because of the monotony in estimating the cross area of the waterway, with which the e-flow is computed. Hydrological techniques, which depend on recorded data methods, are condemned for being frail as far as environmental information, and are deficient to clarify the ecological hydrological relationship. Regarding Hydraulic strategy, an examination of each cross-sectional area prompts negative outcomes as far as time and cost. Natural surroundings reproduction systems positioned second to hydrological EFMs at a worldwide scale, however, on account of Indian level, it positions third by water driven because of trouble in the investigation of the environment in various area. The points of interest and impediments of the strategy vary concerning numerous components and factors. Hydrological and hydraulic techniques, for example, the Tennant Method and wetted perimeter strategy are relevant for setting up the least environmental demands for water resources management. It ought to be noticed that these methods give an underlying ―low confidence gauge. These procedures can be connected quickly at countless to give a first gauge of the possible amounts of water required to keep up nature in a given condition. The Building Block Methodology (BBM) can likewise be utilized for fast appraisals. Be that as it may, so as to utilize this strategy for fast e-flow evaluations, month to month naturalized stream arrangement are required. The in-stream incremental procedure strategy using PHABSIM (Physical Habitat Simulation System) is a generally utilized technique for more intricate choices e.g. the development of a hydropower plant or the setting deliberations limits from an environmentally touchy conduit. In conclusion, there is no philosophy that ought to be utilized for setting up the e-stream request. To build up the fundamental e-flow the specialist ought to consider the history and motivation behind the different strategies accessible and must utilize this learning to settle on an educated decision of the best strategy to utilize. This efficiency level is based on the research conducted upon river flow and fish habitat estimation. In terms of Hydropower usage upon the water present in the dam and their impact upon the ecosystem, the study is limited. A critical review was done for the various methodologies and research gap was jotted out. The present work uses all the methods to calculate the e flow required and validate the sufficiency of the NGT norms. Questionnaire survey is involved in the decision making and recommendations in order to consider various aspects of the environmental flow. This helps in understanding the necessity and amount of low flow to be provided in the study area spatially and temporally. In previous researches, GIS was incorporated with any one of the methodologies to find the e flow. Present research involves GIS approach for validation of the 15% of necessary ecological flow spatially and temporally for which the ecological flow is assessed by the nominal e flow assessment methods.

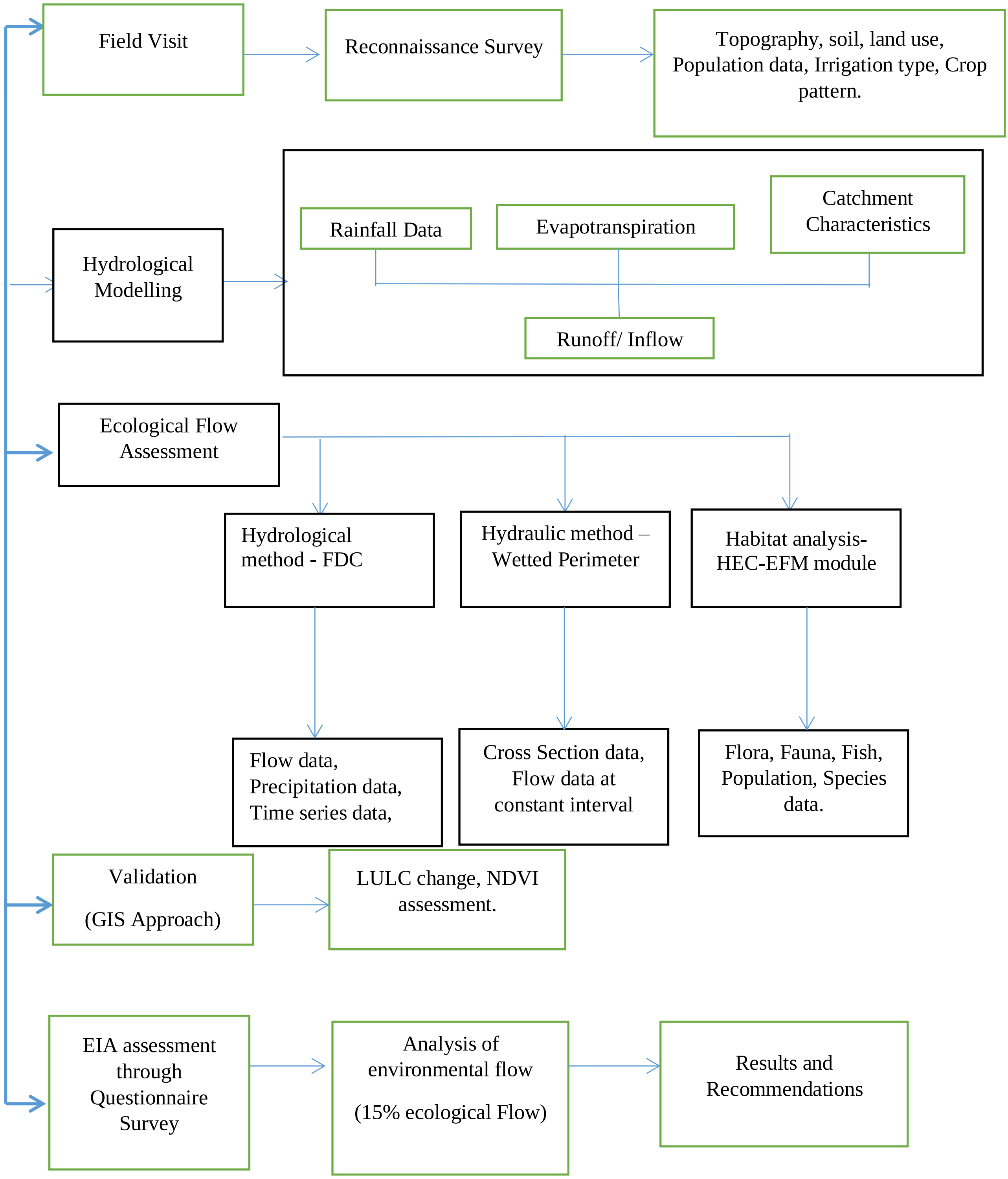
4. Objectives

- ✓ To evaluate the sufficiency of 15% minimal flow in the downstream by hydrological modeling and Environmental flow methods for the Larji, Pandoh and Binwa hydropower projects in the Beas river basin.
- ✓ To assess the changes in the environment due to the construction and operation of the selected Hydropower project and validate the Environmental flow requirements using the GIS application.
- ✓ To evaluate the impact in the study area using the questionnaire survey in the downstream side of the hydropower projects focused particularly on the farmers and downstream habitats.
- ✓ To suggest the suitable environmental flow norms based on the various environmental, habitual, hydrological factors and also recommendations.

5. Research Methodology

To assess the environmental flow, suitable. and a recent method, a literature survey was carried out. It comprises of the methods chosen for hydrological, hydraulic, and habitat analysis. Initially, a field survey has been done to primarily evaluate the existing ecosystem, by conducting a survey about the survival of the ecosystem in the locality. For the flow data, rainfall-runoff modeling has been carried out to derive the inflow data from the rainfall data. For the hydrology method, FDC has been used, which incorporates the flow data from the previous years to result in the ecological flow. The wetted perimeter method plots the graph between the cross-section data and flows in a particular region. The habitat analysis uses HEC-

EFM to model the river for its habitat assessment. In addition to this, the water quality of the river is also assessed to derive the impact of the hydropower project. Building Block Methodology in Figure No.17 involves all the data to arrive at a holistic approach to provide



ecological flow with different scenarios. The combination of these methods finally provides a result, with which the sufficiency of 15% of the average lean season flow for the hydropower dam is determined. The change in the environment due to the construction, operation, and maintenance of the dam is assessed by using GIS applications. The LULC pattern change and

NDVI has been studied to understand the environmental impact of spatially and temporally.

Technology and Techniques used

- ✓ Rainfall-Runoff modeling to assess the inflow data from the rainfall data using the NAM model.
- ✓ Flow Duration Curve (FDC) assesses the ecological flow under Hydrological Method.
- ✓ HEC-EFM to model the watershed and assess the Environmental flow requirements.
- ✓ Wetted Perimeter Method using the Hydraulic method.
- ✓ Bureau of Indian Standards (BIS),2012 prescribed analysis for water quality assessment of the river.
- ✓ GIS Technique is used to evaluate and validate the environmental impact.

Database

Data type	**Source**	**Purpose**
Topography map	Survey of India	To delineate the watershed boundary of the Beas river basin. To delineate the basin boundary of the selected hydropower projects.
Soil map	Soil and Land Use Survey of India	To derive the soil texture and type for the rainfall-runoff modeling. The NAM parameters were given based on the soil type.
Digital Elevation Model	ASTERDEM (https://earthdata.nasa.gov/)	For the rainfall-runoff modeling, the elevation data is required. DEM has been used for that purpose.
Landsat	Landsat 8 (https://earthexplorer.usgs.gov/)	To assess the land use land cover change in the basin before and after construction.
LISS IV	NRSC	To assess the vegetation index using the Normalized difference vegetation index method
Rainfall	IMD Pune	To derive the flow data using the NAM model.
Evapo-transpiration	http://waterdata.iwmi.org/	To derive the flow data using the NAM model.
Hydrology	Flow data from the rainfall-runoff model	To evaluate the environmental flow using various methods.
Hydraulic	Field measurements and DEM	To evaluate the environmental flow using various methods.
Water quality	Himachal Pradesh Pollution Control Board and Field data	To evaluate the water quality of the river To evaluate the environmental flow based on the quality of the water.
Flora, Fauna	Various literatures, Wildlife Institute of India	To evaluate the environmental flow using the habitant method.
Other data	Population Data, Irrigation Type, Crop Pattern.	To understand the existing ecosystem.

6. Study Area

The Beas River originating from the upper Himalaya's Beas Kund is a Ravi river's tributary is Indus basin's one of the major rivers. It originates from the Himachal Pradesh (Rohtang pass) till Punjab State (Hoshiarpur District) in the east-west direction of about 12,560 sq. km as the catchment area of which 777 sq. km is a glacier. The important tributaries include Parbati, Sainj, and Tirthan. Downstream, the Uhl, Neugal, Juni, Gaj, and Chakki are the critical tributaries. The Palampur, Dharamsala, and Kangra are high rainfall zones (June and October) that contribute water to the Beas river catchment area in terms of rainfall of about 14,800 MCM. The river is the sustenance of the general population of Himachal Pradesh in light of the fact that it is a significant wellspring of new water supply and the horticulture.

From the point of perspective on aquatic life and fish fauna, especially it's the streams which are significant in light of the fact that they fill in as spawning grounds. Indeed, the Department of Fisheries has drawn up a negative rundown of streams in the Beas for hydropower development from the point of perspective on the plausible impact that these tasks would have on Beas' fish population and migration.

7.1 Ecology

The climate fluctuates from temperate at the origin to sub-tropical downstream. The Beas catchment has rich cedar (Himalayan Moist Temperate) timberlands in the Kullu District and deciduous sub-tropical blended woods in Mandi and Kangra. The main tree species are alpine, sub-alpine, walnut, birch, spruce, fir, deodar (over 3,000 m) are environmentally significant, for what it's worth in these zones that rivers are initiated from the icy masses. Vegetation is generally bushes and herbs with intermittent temperate region's tree. Significant kind of species watched contains Atis, Kutki, hexandrum, juniper, birch, willow, artemisia and so on. Incline grasses happen on the southern viewpoints on soak slants while Riverine woods happen in temperate and subtropical zones. These happen in thin belts along streams. Subtropical riverine is dominated by Prunus, Pyrus, Girardinia, and Berberis. Economic trade of medicinal plants is the most significant action in Parbati, Sainj and Tirthan Valleys just as the catchment close to the Dhauladhar district and is essentially related to the neighborhood economy – to the tune of from 0.54 to 2.92 lakhs per annum. The medicinal species are Bankakiri, Atish/Patish, and Karu. The Kullu District additionally falls in the apple plantation zone. The broad grasslands and underneath snows line. The Snow Leopard is also seen but rarely other than in the extreme interiors of the park, so too for the Himalayan Black and Brown Bear. The Great Himalayan National Park (GHNP), lying within the Parbati valley, is home to a rich variety of mammals such as the Himalayan Tahr, Bharal and Musk Deer. The lower hills of the park are home to the Serow and Ghoral. Birds with spectacular plumage like the Monal pheasant and the rare western Tragopan are found here. Apart from these rare birds the Himalayan Griffon, the Lammergeier, the Golden Eagle, the Slaty-headed Parakeet, and the Great Himalayan Barbet also call this park home. Butterflies belonging to the high altitudinal species are also commonly found here. The vegetation alongside the river banks mainly contains such species of Rrubenia, Salix, Conifers Alnus. The climatic condition in the agricultural area is pleasant for the production of crops like apple, potato, chuli, wheat ginger in Rabi season.

7.2 Economy

The economy of the district is principally agrarian with over 80% of the working population occupied with rural exercises. The terrain in the locale is undulating with differed agro-climatic conditions. The surface of soil changes from sandy topsoil to dirt soil and the shade of the dirt differs from darker to dim dark colored. By and large, the dirt is acidic in nature and the terrain with the exception of in the valley undulating. In any case, the agro-climatic condition gives a scope of possibilities to growing money crops. Wheat and potato cultivation, as a piece of yearly/money crops in the past, has been supplanted with apple plantations. In Kangra, the tributaries originating in the Dhauladhars are feeders for kuhls that support irrigation for paddy cultivation in the locale. The holdings are little and the creation is extremely low. Cultivation is beyond the realm of imagination by tractors in light of the fact that the fields are little and terraced.

7.3 Hydropower Development

The Beas basin’s hydropower potential has been recognized to be 5995 MW. On the Beas and its major tributaries like Parbati, Malana, Sainj, Uhl, Binwa and Neugal, approximately 27 Hydroelectric Projects(HEPs) of more than 6 MW capacity are either commissioned or under construction/planned. Starting upstream, the big projects include the 192 MW Alain Duhangan, 520 MW Parbati III and 800 MW Parbati II; Malana I and II (100 MW); 100 MW Sainj and 990MW Pandoh-Dehar project. After Pandoh dam, the river completely dries up and with streams like Uhl, Binwa, Awa, Neugal, Luni and many other small streams joining the river, Beas is once again rejuvenated. However, three new ventures planned on the Beas are currently pretention a genuine threat to the last stretches of the free fluid motion, yet as of now generously drained Beas. These activities, situated between Pandoh Dam and Pong dam with Punjab, are the 141 MW Thana-Palaun, 78 MW Triveni-Mahadev and 66 MW Dhaulasidh venture (Himdhara Environment Research and Action Collective, 2013).

Hydropower Generation Performance in Beas River Basin

The Indus River Basin's major river basin of 20,303 sq.km catchment area and 460km total length rises from Rohtang Pass in Kullu and through a valley from Larji to Talwara and enters Punjab to bump into the Sutlej at Harike. The project wise generation data of large hydropower project with an installed capacity of the basin in the latest year. Under the Himachal Pradesh/ Himachal Pradesh State Electricity Board Ltd., Bassi (60 MW), Larji (126 MW) are operational. Likewise, Himachal Pradesh/Bhakra Beas Management Board owns the Dehar (990 MW), Pong (396 MW) hydropower projects. The Punjab/ Punjab State Power Corporation Limited maintains the Mukerian (207 MW), Shanan (110 MW) hydropower projects. Himachal Pradesh/Malana PCL operates both Malana (86 MW) and Malana- II (100 MW) projects. Allain Duhangan (192 MW) is under the control of Himachal Pradesh/AD Hydro PVT. Binwa (6 MW), Gaj (10.50 MW), Baner (12 MW), Khauli (12 MW), Dehar (5.00 MW), Maujhi (4.50 MW), Raskat (0.80 MW), Baragran (3.00 MW), Aleo (3.00 MW), Marthi (5.00 MW) are the list of other projects (up to 25 MW) under operation. Uhl-III 100 MW, Sainj 100 MW, Khauli-II 6.60 MW, Parbati-II 800 MW, Parbati-III 520 MW, Patikari 16 MW, Neogal 15 MW, Lambadug 25 MW, Baragaon 11 MW, Fozal 9 MW, Baner-II 6 MW, Parbati-I 750 MW, Kilhi-Bal 7.50 MW, Dhaula-Sidh 66 MW, Thana-Plaun HEP 141 MW, Triveni Mahadev 78 MW, Nakthan HEP 520 MW, Gharopa 99 MW are the list of proposed and under construction / EAC TOR Approved projects in the basin in Himachal Pradesh.

Source: State of India's rivers for India rivers week 2016, Himachal Pradesh.

7.4.1 Selection of Hydropower project

Selection of Hydropower project

Among the various hydropower projects in the Beas River basin, based on the following factors three hydropower projects are chosen for the study. The factors include the installed capacity, Location, Livelihood, Type of agency/owner, Type of Project, River, Occupation of the locale, farming capacity, etc., The chosen hydropower projects are Larji Hydropower Project, Binwa Hydropower Project, Pandoh Hydropower Project.

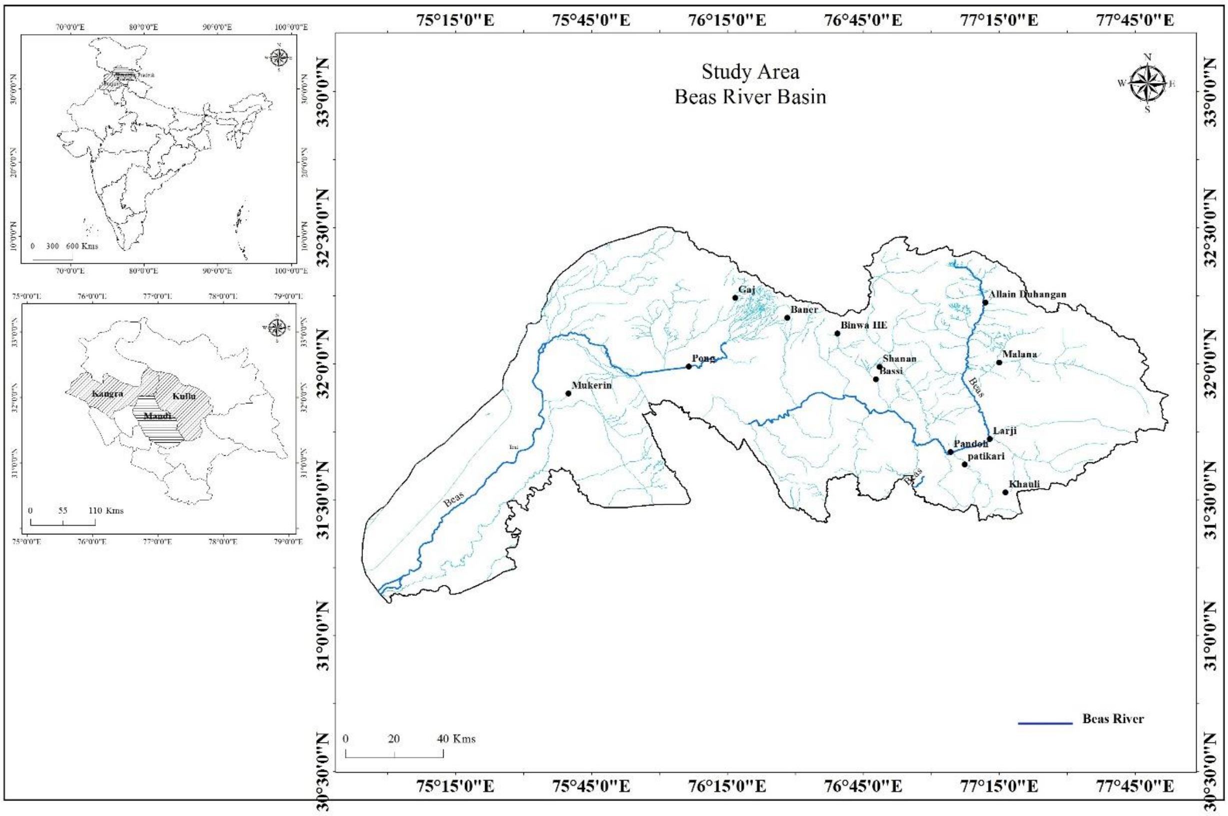


Figure no. 1 Study Area – Beas River Basin

7.4.2 Larji Hydropower Project

Larji Hydro-power project has an installed capacity of 126 MW. It is located on Kullu district of Himachal Pradesh at 2299 m MSL altitude and possessed by HPSEB. The catchment area of the H.E project is extended over an area of 4921 sq.km. The project was accomplished in September 2007. The catchment experiences precipitation due to the southwest monsoons and the western disturbances that bypass the northwest part of the country at the time of winter as well. The region's flora is mainly constituted of various broadleaves species such as Kosh, Khanor, Walnut, and Kharusu. This comprehension of medicinal plants can also be seen in this range. Due to the intrusion of expansion activities like road construction, water supply scheme, etc., there is a high level of soil erosion affecting soil integrity. The livelihood of the people in the region is cultivation, agriculture, horticulture and rearing of sheep and goat. The Larji reservoir's storage capacity is 230 ha-m, which is sufficient for operating the power station at full installed capacity for more than four hours in a day during lean periods. The project will facilitate energy generation of 587 Gigawatt-hours in 90% reliable year pattern of flows.Since the project is on the river Beas, its standard slope is calculated when the river emerges from the Rohtang, to cover a distance of 28.9 km up to Manali there is a fall of 77m/km. The catchment area falls in the Kullu district of major part and a part in Mandi, i.e., Seraj Forest division, Parvati forest division, Kullu forest division, Great Himalayan National Park, Kanawar Sanctuary, Khokhan Sanctuary, part of Panarasa Forest Range of Mandi Forest Division. It covers a distance of 38.6 km from Manali to Kullu, and there is a fall of 15.6m/km. Soil erosion is the disparaging process for the soils, which may be defined as the wearing away of the earth's surface by breakdown and transportation of the soil by water, ice, wind. The catchment area for Larji hydropower project is cut off from heavy rainfall region around Dharmashala in the west by a high ridge, running north-south, Uhl river east.

7.4.3 Binwa Hydropower

Binwa watershed is situated between 76° 34′ 08″ to 76° 45′ 53″ E longitude and 31° 53′ 15″ to 32° 11′ 58″ N latitude in Kangra district of Himachal Pradesh., comprising of a bit of Lesser Himalayas and Shivalik hilly slopes. It has a place with Agro-Eco Region i.e., Western Himalayas, warm sub sticky to humid Ecoregion with dark-colored backwoods and podzolic soils (Sehgal J, Mndal DK and Mandal C. 1992). The watershed extends finished an area of around 340.1 km^2 with an altitude varying from 600 to 4286 m directly above MSL. Binwa watershed is addressed by wet temperate climate with a yearly rainfall ranging from 1757 to 2798 mm. The mean greatest and minimum temperature ranges were from 24.2˚C to 27.7˚C and 13.7˚C to 14.6˚C, separately. The amount of precipitation is gotten during the rainstorm time period. Generally, the periods from 26th March to 18th June and 8th October to 10th December remain dry. The watershed is characterized by the closeness of udic soil moisture administration and thermic temperature administration.

The cultivation land located on fluvial-frigid and fluvial makes use of gravity hydroelectric project channels (kuhls) for the project purpose. Paddy-wheat is the most common cropping arrangement in these areas. Indeed, even in irrigated areas, crops confront dampness stresse much of the time on the grounds that the kuhls have bigger command area and more drainage misfortunes during movement. The upper part of porches and cultivated slope slants are under the rainfed maize-wheat arrangement. Agriculturists develop local crops such as maize, paddy, and wheat in the watershed. Reportedly the yields of maize, paddy, and wheat ran from 15 to 20 q ha-1. Tea gardens are discovered just in mid-slope soil zone.

7.4.4 Pandoh dam

Pandoh dam of 2134 m in length,457m in width and a depth of 15.58m are situated in Mandi district of 134 hectares' catchment area encompassed by Shivalik mountains at 899 m altitudes. The lake pursues a strait and expansive course between three soak slope slants. The wellsprings of water to the lake are watershed, atmospheric inputs, and base flow. For the generation of hydroelectric power, an earth-shake fill dam was developed in 1977. The common fish in Pandoh Lake include Schizothorax richardsonii, Tor putitora, Salmo trutto fario, Labeo dero, L. dyocheilus, and some hillstream fish present in the lake. The Pandoh Block of Mandi district is surrounded by temperate forests. These forests are having high diversity that supports a variety of flora and fauna. · The forests contain adult trees of Oak, Pine, Cycas, etc. They are mainly gymnosperms. Other types of the lower group of plants (bryophyte and pteridophyta) and high order plants (angiosperms) are a common occurrence. This region is very important in terms of commercial production of apple and cherry. The grass of Cannabis sativus is common in the occurrence which is a source of bhang, ganja, churus, etc.

Figure no.2 Binwa HE project

Figure no.3 Larji HE project

Figure no.4 Pandoh Downstream

7. WORK PLAN

First Year		**Second Year**		**Third Year**		**Work Progress**
00-06 Months	07-12 Months	13-18 Months	19-24 Months	25-30 Months	31-36 Months	Work will be done
						Course Work, Literature review, Study area selection, data, Field survey, Finalize Research methodology.
						Questionnaire Survey, Data collection from various Governmental organizations, Preparation of data for analysis
						E flow analysis, Validation using GIS, Questionnaire Analysis Post field verification, Prepare the report and submit recommendations.

8. Expected Outcome

1. Evaluation of environmental flow for the hydropower project sites selected.
2. Modelling of small watershed using hydrological modelling technique.
3. Validation through GIS application for the need of 15% of the minimum ecological flow in the downstream.
4. Analyzing the impact in the downstream using the questionnaire survive.
5. Proposing the final result and recommendation based on the above objectives.

Acknowledgment

The research work done is a part of DOES&T, Himachal Pradesh funded research project. We would like to express our sincerest gratitude to DOES&T, Himachal Pradesh for funding this research project.

References

1. Abbasov, R. (2010). Assessment of Ecological Flow for Mountain Rivers of the Kura Basin. In Survival and Sustainability (pp. 1369-1379). Springer, Berlin, Heidelberg.
2. Acreman, M. C., & Dunbar, M. J. (2004). Defining environmental river flow requirements? A review. *Hydrology and Earth System Sciences Discussions*, *8*(5), 861-876.
3. Acreman, M. C., & Ferguson, A. J. D. (2010). Environmental flows and the European water system directive. *Freshwater Biology*, *55*(1), 32-48.
4. Alcázar, J., & Palau, A. (2010). Establishing e-flow regimes in a Mediterranean watershed based on a regional classification. *Journal of Hydrology*, *388*(1-2), 41-51.
5. Arthington, A. H., Kennen, J. G., Stein, E. D., & Webb, J. A. (2018). Recent advances in environmental flows science and water management—Innovation in the Anthropocene. *Freshwater biology*, *63*(8), 1022-1034.
6. Arthington, A. H., King, J. M., O'keeffe, J. H., Bunn, S. E., Day, J. A., Pusey, B. J., ... & Tharme, R. (1992). Development of an holistic approach for assessing e-flowrequirements of riverine ecosystems. In *Proceedings of an international seminar and workshop on water allocation for the environment* (Vol. 69, p. 76). The Centre for Water Policy Research, University of New England: Armidale, Australia.
7. Arthington, A. H., Land and Water Resources Research and Development Corporation, Arthington, A. H., & Zalucki, J. M. (1998). *Comparative evaluation of e-flowassessment techniques: review of methods*. Canberra: Land and Water Resources Research and Development Corporation.

8. Arthington, A. H., Tharme, R., Brizga, S. O., Pusey, B. J., & Kennard, M. J. (2004). E-flowassessment with emphasis on holistic methodologies. In *Proceedings of the second international symposium on the management of large rivers for fisheries* (Vol. 2, pp. 37-65). Bangkok, Thailand: FAO Regional Office for Asia and the Pacific.
9. Beca. (2008). Draft guidelines for the selection of methods to determine ecological flows and water levels. *Report prepared by Beca Infrastructure Ltd for Ministry for the Environment*, 145.
10. Bhattacharjee, A. (2014). *Environmental flows-detailed assessment of the rivers of mahanadi basin of india* (Doctoral dissertation).
11. Bhattacharjee, N. V., Willis, J. R., Tollner, E. W., & McKay, S. K. (2019). *Habitat Provision Associated with Environmental Flows* (No. ERDC/TN-EMRRP-SR-85). ERDC Vicksburg United States.
12. Botelho, A., Ferreira, P., Lima, F., Pinto, L. M. C., & Sousa, S. (2017). Assessment of the environmental impacts associated with hydropower. *Renewable and Sustainable Energy Reviews*, *70*, 896-904.
13. Bovee, K. D., Lamb, B. L., Bartholow, J. M., Stalnaker, C. B., & Taylor, J. (1998). *Stream habitat analysis using the instream flow incremental methodology* (No. USGS/BRD/ITR--1998-0004). GEOLOGICAL SURVEY RESTON VA BIOLOGICALRESOURCES DIV.
14. Caissie, D., El-Jabi, N., & Hébert, C. (2007). Comparison of hydrologically based instream flow methods using a resampling technique. *Canadian Journal of Civil Engineering*, *34*(1), 66-74.
15. Cavendish, M. G., & Duncan, M. I. (1986). Use of the instream flow incremental methodology: a tool for negotiation. *Environmental Impact Assessment Review*, *6*(4), 347-363.
16. Chand, H., Verma, K. S., & Kapoor, T. (2016). Environmental Impact Assessment of Kol-Dam Hydropower Project-A Case Study from Himachal Pradesh, India. *Current World Environment*, *11*(1), 167.
17. Chen, A., & Wu, M. (2019). Managing for Sustainability: The Development of Environmental Flows Implementation in China. *Water*, *11*(3), 433.
18. Chen, H., Ma, L., Guo, W., Yang, Y., Guo, T., & Feng, C. (2013). Linking water quality and quantity in environmental flow assessment in deteriorated ecosystems: a food web view. *PloS one*, *8*(7), e70537.
19. Costa, M. R. D., Mattos, T. M., Fernandes, V. H., Martínez-Capel, F., Muñoz-Mas, R., & Araújo, F. G. (2015). Application of the physical habitat simulation for fish species to

assess environmental flows in an Atlantic Forest Stream in South-eastern Brazil. *Neotropical Ichthyology*, *13*(4), 685-698.

20. Costa, R. M. S., Martínez-Capel, F., Muñoz-Mas, R., Alcaraz-Hernández, J. D., & Garófano-Gómez, V. (2012). Habitat suitability modelling at mesohabitat scale and effects of dam operation on the endangered Júcar nase, Parachondrostoma arrigonis (river Cabriel, Spain). *River Research and Applications*, *28*(6), 740-752.
21. De-sheng, H. U. (2010). Water for the Eco-environment: A Perspective from International Law. *Journal of Xi'an Jiaotong University (Social Sciences)*, *2*, 017.
22. DHI, 2006. Managed river flows for RHEP. New Delhi: DHI Water and Environment.
23. Dickens, C., Smakhtin, V., Biancalani, R., Villholth, K. G., & Eriyagama, N. (2019). Incorporating environmental flows into" water stress" indicator 6.4. 2: guidelines for a minimum standard method for global reporting.
24. Dubey, A., Kant, D., Singh, O., & Pandey, R. P. (2013). A comparative study of environmental flow requirement approaches using hydrological index methods. *Journal of Indian Water Resources Society*, *33*(3), 20.
25. Dubey, A., Singh, O., Shekhar, S., and Pohshna, C., (2019). Assessment of Environmental Flow Requirement using Environmental Management Classes-Flow Duration Curve for Narmada River. International Journal of Current Microbiology and Applied Sciences (IJCMAS).8(1): 891-897.
26. Dunbar, M. J., Alfredsen, K., & Harby, A. (2012). Hydraulic‐habitat modelling for setting environmental river flow needs for salmonids. *Fisheries Management and Ecology*, *19*(6), 500-517.
27. Durbude, D. G., Jain, C. K., & Singh, O. (2014). Assessment of E-flows for a river in Southern India using hydrological index methods. Journal of Indian Water Resources Society, 34(3), 82-90.
28. Dutta, V., Sharma, U., & Kumar, R. (2017). Assessment of river ecosystems and environmental flows: Role of flow regimes and physical habitat variables. *Climate Change and Environmental Sustainability*, *5*(1), 20-34.
29. Dyson, M., Bergkamp, G., & Scanlon, J. (2003). Flow: the essentials of environmental flows. *IUCN, Gland, Switzerland and Cambridge, UK*, 20-87.
30. El-Jabi, N., & Caissie, D. (2019). Characterization of natural and environmental flows in New Brunswick, Canada. *River Research and Applications*, *35*(1), 14-24.

31. Esselman, P., & Opperman, J. (2010). Overcoming information limitations for the prescription of an environmental flow regime for a Central American river. *Ecology and Society*, *15*(1).
32. EU: DIRECTIVE 2000/60/EC, Official Journal of the European Communities(2000), 22.12.2000
33. Extence, C. A., Balbi, D. M., & Chadd, R. P. (1999). River flow indexing using British benthic macroinvertebrates: a framework for setting hydroecological objectives. *Regulated Rivers: Research & Management*, *15*(6), 545-574.
34. Gharehbaghi, K., & Scott-Young, C. (2018, March). GIS as a vital tool for Environmental Impact Assessment and Mitigation. In *IOP Conference Series: Earth and Environmental Science* (Vol. 127, No. 1, p. 012009). IOP Publishing.
35. Gippel, C. J. (2001). Hydrological analyses for e-flowassessment. *Proceedings of MODSIM 2001*, 873-880.
36. Gippel, C. J., & Stewardson, M. J. (1998). Use of wetted perimeter in defining minimum environmental flows. *Regulated Rivers: Research & Management: An International Journal Devoted to River Research and Management*, *14*(1), 53-67.
37. Halliday, I., & Robins, J. (2001). Environmental Flows for Sub-tropical Estuaries. *Final Report FRDC Project*, (2001/022).
38. Herrera, I. A., & Burneo, P. C. (2017). E-flowassessment in Andean rivers of Ecuador, case study: Chanlud and El Labrado dams in the Machángara River. Ecohydrology & Hydrobiology, 17(2), 103-112.
39. Hirji, R., & Davis, R. (2009). *Environmental flows in water resources policies, plans, and projects: findings and recommendations*. The World Bank.
40. Hoanh, C. T., Jirayoot, K., Lacombe, G., & Srinetr, V. (2010). Comparison of climate change impacts and development effects on future Mekong flow regime.
41. Jain, S. K. (2012). Assessment of e-flowrequirements. Hydrological processes, 26(22), 3472-3476.
42. Jain, S. K., & Kumar, P. (2014). Environmental flows in India: towards sustainable water management. Hydrological Sciences Journal, 59(3-4), 751-769.
43. Johnson, J. A., Sivakumar, K., & Rosenfeld, J. (2017). Ecological flow requirement for fishes of Godavari river: flow estimation using the PHABSIM method. CURRENT SCIENCE, 113(11), 2187-2193.
44. Jowett, I. G. (1989). *RHYHABSIM: river hydraulic and habitat simulation. A computer manual*.

45. Junguo, L., Qingying, L., & Hong, Y. (2016). Assessing water scarcity by simultaneously considering environmental flow requirements, water quantity, and water quality. *Ecological Indicators, 60*, 434-441.
46. Karimi, S. S., Yasi, M., & Eslamian, S. (2012). Use of hydrological methods for assessment of e-flowin a river reaches. *International Journal of Environmental Science and Technology*, *9*(3), 549-558.
47. Kawde, S. K., Jain, M. K., & Durbude, D. G. (2016). ENVIRONMENTAL FLOWS ASSESSMENT: A REVIEW. *J. Indian Water Resour. Soc*, *36*(3).
48. Kendy, E., Apse, C., & Blann, K. (2012). A practical guide to environmental flows for policy and planning. *Nat Conserv*.
49. King, J. M., Tharme, R. E., & De Villiers, M. S. (2000). *E-flowassessments for rivers: manual for the Building Block Methodology* (p. 340). Pretoria: Water Research Commission.
50. King, J., Brown, C., & Sabet, H. (2003). A scenario-based holistic approach to e-flowassessments for rivers. *River research and applications*, *19*(5-6), 619-639.
51. Książek, L., Woś, A., Florek, J., Wyrębek, M., Młyński, D., & Wałęga, A. (2019). Combined use of the hydraulic and hydrological methods to calculate the environmental flow: Wisloka river, Poland: case study. *Environmental Monitoring and Assessment*, *191*(4), 254.
52. Kumar, A. (2010). Environmental flow requirement for a water resources development project.
53. Kumar, P. (2009). E-flowassessment for a hydropower project on a Himalayan river.
54. Kumar, P., 2009. Environmental flow assessment for a hydropower project on a Himalayan river. Thesis (PhD), Indian Institute of Technology Roorkee, Roorkee.
55. Kumar, P., Chaube, U. C., & Mishra, S. K. (2007, October). Environmental flows for hydropower projects—a case study. In *International conference on small hydropower-hydro Sri Lanka* (Vol. 22, p. 24).
56. Kumar, P., Chaubey, U.C., and Mishra, S.K., 2007. Environmental flows for hydropower projects— case study. In: Proceedings, International Conference on Small Hydropower, 22–24 October 2007 Kandy.
57. Lester, R. E., Pollino, C. A., & Cummings, C. R. (2019). Testing an environmental flow-based decision support tool: evaluating the fish model in the Murray Flow Assessment Tool. Environmental modelling & software, 111, 72-93.

58. Liu, C., Zhao, C., Xia, J., Sun, C., Wang, R., & Liu, T. (2011). An instream ecological flow method for data-scarce regulated rivers. *Journal of Hydrology*, *398*(1-2), 17-25.
59. Liu, X., Lian, Y., Huang, J. H., Ke, S., Zhang, J., & Wang, X. (2009). Environmental Flow of the Yellow River.
60. Loar, J. M., Sale, M. J., & Cada, G. F. (1986). *Instream flow needs to protect fishery resources* (No. CONF-8608120-1). Oak Ridge National Lab., TN (USA). Environmental Sciences Division.
61. Lytle, D. A., & Poff, N. L. (2004). Adaptation to natural flow regimes. *Trends in ecology & evolution*, *19*(2), 94-100.
62. Mazvimavi, D., Madamombe, E., & Makurira, H. (2007). Assessment of e-flowrequirements for river basin planning in Zimbabwe. *Physics and Chemistry of the Earth*, *Parts A/B/C*, *32*(15-18), 995-1006.
63. Moore, M. (2004). Perceptions and interpretations of" environmental flows" and implications for future water resource management: A survey study.
64. National green tribunal principal bench New Delhi M.A. No. 879 of 2013 and M.A. no. 403 of 2014 in original application no. 299 of 2013
65. O'Keeffe, J., & Quesne, T. L. (2009). Keeping rivers alive: a primer on environmental flows. *Keeping rivers alive: a primer on environmental flows.*
66. Palau, A., & Alcázar, J. (2012). The basic flow method for incorporating flow variability in environmental flows. *River research and applications*, *28*(1), 93-102.
67. Pastor, A. V., Ludwig, F., Biemans, H., Hoff, H., & Kabat, P. (2014). Accounting for environmental flow requirements in global water assessments. *Hydrology and Earth System Sciences*, *18*(12), 5041-5059.
68. Pastor, A. V., Ludwig, F., Biemans, H., Hoff, H., & Kabat, P. (2013). Accounting for environmental flow requirements in global water assessments. *Hydrology & Earth System Sciences Discussions, 10*(12).
69. Patsialis, T., Skoulikaris, C., & Ganoulis, J. (2014). Ecological flow for integrated planning of small hydropower plants: a case study from Greece. In T. M. Daniell, H. A. J. VanLanen, S. Demuth, G. Laaha, E. Servat, G. Mahe, … D. Ruelland (Eds.), *Hydrology in a Changing World: Environmental and Human Dimensions* (Vol. 363, pp. 469–474).
70. Penas, J. F., Juanes, J. A., Galvan, C., Medina, R., Castanedo, S., Alvarez, C., & Barcena, J. F. (2013). Estimating minimum environmental flow requirements for well-mixed estuaries in Spain, Estuarine, Coastal and Shelf Science.

71. Räsänen, T. A., Someth, P., Lauri, H., Koponen, J., Sarkkula, J., & Kummu, M. (2017). Observed river discharge changes due to hydropower operations in the Upper Mekong Basin. *Journal of hydrology*, *545*, 28-41.
72. Reiser, D. W., Wesche, T. A., & Estes, C. (1989). Status of instream flow legislation and practices in North America. *Fisheries*, *14*(2), 22-29.
73. Richter, B., Baumgartner, J., Wigington, R., & Braun, D. (1997). How much water does a river need? *Freshwater biology*, *37*(1), 231-249.
74. Ruef, A., & Bratrich, C. (2007). Integration of the EU's Water System Directive and the greenhydro standard. Improving the Aquatic Environment in River Systems Affected by Hydropower Generation.
75. Sahzabi, H. Y. (2004). Application of GIS in the environmental impact assessment of Sabalan geothermal field, NW-Iran.
76. Samanta, P. (2015). Impact Assessment and Changes Analysis of Land Use and Land Cover Due to Open Cast Coal Mining Activity: A Case Study of Ranigunj Coal Field Area. *International Journal of IT, Engineering and Applied sciences Research (IJIESAR)*, *4*(5), 17-27.
77. Sharma, R. H., & Shakya, N. M. (2006). Hydrological changes and its impact on water resources of Bagmati watershed, Nepal. *Journal of Hydrology*, *327*(3), 315-322.
78. Smakhtin, V. Y. (2006). *An assessment of e-flowrequirements of Indian river basins* (Vol. 107). IWMI.
79. Smakhtin, V., Revenga, C., & Döll, P. (2004). A pilot global assessment of environmental water requirements and scarcity. *Water International*, *29*(3), 307-317.
80. Smakhtin, V.U. and Anputhas, M., 2006. An assessment of EF requirements of Indian river basins. Colombo: International Water Management Institute, Research Report 107.
81. Soni, V., Shekhar, S., & Singh, D. (2013). E-flowfor Monsoon Rivers in India: The Yamuna River as a case study. arXiv preprint arXiv:1306.2709.
82. Soni, V., Shekhar, S., and Singh, D. 2013. Environmental flow for Monsoon Rivers in India: the Yamuna River as a case study [online]. Submitted on 12 June 2013 to the Cornell University. Available from: http://arxiv.org/ftp/arxiv/papers/1306/1306.2709.pdf [Accessed 4 November 2013].
83. Souchon, Y., & Keith, P. (2001). Freshwater fish habitat: science, management, and conservation in France. Aquatic Ecosystem Health & Management, *4*(4), 401-412.
84. Stalnaker, C. B., & Arnett, J. L. (1976). *Methodologies for the determination of stream resource-flow requirements: an assessment* (No. 76/03). US Fish and Wildlife Service.

85. State of India's Rivers for India Rivers Week, 2016
86. Stevović, S., & Nestorović, Ž. (2016). Impact of environment GIS modeling on sustainable water systems management. *Procedia engineering*, *162*, 293-300.
87. Sundaray, P. (2013). Environmental Flow (Doctoral dissertation).
88. Tan, G., Yi, R., Chang, J., Shu, C., Yin, Z., Han, S., ... & Lyu, Y. (2018). A new method for calculating ecological flow: Distribution flow method. *AIP Advances*, *8*(4), 045118.
89. Tare, V., Gurjar, S. K., Mohanta, H., Kapoor, V., Modi, A., Mathur, R. P., & Sinha, R. (2017). Eco-geomorphological approach for environmental flows assessment in monsoon-driven highland rivers: A case study of Upper Ganga, India. *Journal of Hydrology: Regional Studies*, *13*, 110-121.
90. Tharme, R. E. (1996). Review of international methodologies for the quantification of the instream flow requirements of rivers. Water Law Review: final report for policy development, South African Department of Water Affairs and Forestry. Freshwater Research Unit: University of Cape Town: Pretoria.
91. Tharme, R. E. (2003). A global perspective on environmental flow assessment: emerging trends in the development and application of environmental flow methodologies for rivers. *River research and applications*, *19*(5-6), 397-441.
92. Thorn, P., & Conallin, J. C. (2006). RHYHABSIM as a stream management tool: Case study in the River Kornerup Catchment, Denmark. *The Journal of Transdisciplinary Environmental Studies*, *5*(1-2), 1-17.
93. Todo, K., & Sato, K. (2002). Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a system for Community action in the field of water policy. *ENVIRONMENTAL RESEARCH QUARTERLY*, 66-106.
94. Van Wyk, E., Breen, C. M., Roux, D. J., Rogers, K. H., Sherwill, T., & van Wilgen, B. W. (2006). The Ecological Reserve: towards a common understanding for river management in South Africa. *Water SA*, *32*(3), 403-409.
95. Verma, R. K., Murthy, S., & Tiwary, R. K. (2015). Assessment of environmental flows for various sub-watersheds of Damodar river basin using different hydrological methods. *Journal Waste Resources*, *5*(182), 2.
96. Volchek, A., Kirvel, I., & Sheshko, N. (2018). E-flowassessment for the Yaselda River in its Selets reservoir section. Ecohydrology & Hydrobiology.
97. WWF (Worldwide Fund for Nature), 2012. Summary report. Assessment of environment flows for Upper Ganga basin. New Delhi: WWF-India.

98. WWF (Worldwide Fund for Nature), 2013. Environmental flows for Kumbha 2013. Triveni Sangham. Allahabad: WWF-India.
99. Yasi, M., & Ashori, M. (2017). Environmental flow contributions from in-basin rivers and dams for saving Urmia lake. Iranian Journal of Science and Technology, Transactions of Civil Engineering, 41(1), 55-64.
100. Yue, S., Li, H., Cheng, B., & Gao, Z. (2018). The Value of Environmental Base Flow in Water-Scarce Basins: A Case Study of Wei River Basin, Northwest China. *Water*, *10*(7), 848.
101. http://cwcb.state.co.us
102. http://news.sina.com.cn/o/2011-03-04/060022049983.shtml.
103. http://sifn.bse.vt.edu
104. http://wipo.int/portal/index.html.en
105. http://www.bafu.admin.ch
106. http://www.legifrance.gouv.fr
107. http://www.regulation.gov.uk/ukpga/1963/38/contents
108. http://www.swfwmd.state.fl.us