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ASSESSMENT OF AQUATIC RESOURCES OF ASKOT LANDSCAPE WITH REFERENCE TO HUMAN FOOTPRINTS

PHASE-2 REPORT



BIODIVERSITY CONSERVATION AND RURAL LIVELIHOOD IMPROVEMENT PROJECT (BCRLIP)



भारतीय वन्यजीव संस्थान
Wildlife Institute of India

MARCH, 2018

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**Assessment of Aquatic Resources of Askot
Landscape with Reference to the Human
Footprints**

Phase-- 2 Report

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Wildlife Institute of India**



March, 2018

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Contents

S.No.	Contents	Page No.
	Acknowledgements	
	Summary	
1	Introduction	1
1.1	Objectives	3
2	Study area	3
3	Methodology	
3.1	Assessment of Fish density	5
3.2	Assessment of people dependency on Fishery resource	5
3.3	Assessment of human disturbance along the aquatic habitat	7
3.4	Assessment of riparian quality along the river system	8
3.5	Assessing ecological status of Indicator fish species	10
4	Result & Discussion	
4.1	People dependency on Fish resource	12
4.2	Human disturbance	14
4.2(1)	Level of disturbance in the riparian forest	23
4.2(2)	Habitat requirement for Indicator species	25
5	Recommendations	30
	References	32
	Annexure	34

List of Figures

Figure No	Figure legend	Page No.
1	View of Askot landscape from the high altitude	4
2	Map showing Gori, Dhauli, Dharchula and Kuti sub-watershed in Askot landscape	4
3	The snow trout <i>Schizothorax richardsonii</i>	6
4	The black mahseer <i>Schizothorax richardsonii</i>	6
5	Map describing electrofishing activity in Askot landscape	17
6	Map describing bleaching activity in Askot landscape	17
7	Map describing water diversion activity in Askot landscape	18
8	Map describing dynamiting activity in Askot landscape	19
9	Map describing regulated water activity in Askot landscape	19
10	Map describing sand mining activity in Askot landscape	20
11	Map describing roads in Askot landscape	20
12	Map describing stream crossings activity in Askot landscape	21
13	Map describing waste discharge activity in Askot landscape	21
14	Map showing micro-watershed wise combination of all threats	22
15	Map indicating micro-watershed wise condition of riparian vegetation	25
16	Frequency distribution of different categories of Depth categories available in streams of Askot landscape	26
17	Frequency distribution of different categories of flow categories available in streams of Askot landscape	27
18	Frequency distribution of different categories of substrate categories available in streams of Askot landscape	27
19	Depth suitability curve of <i>Schizothorax richarsonii</i> and <i>Naziritor</i>	28

	<i>chelynoides</i>	
20	Flow suitability curve of <i>Schizothorax richarsonii</i> and <i>Naziritor chelynoides</i>	29
21	Substrate suitability curve of <i>Schizothorax richarsonii</i> and <i>Naziritor chelynoides</i>	29

List of Tables

Table No	Table legend	Page No.
1	Riparian vegetation index scores and corresponding river classes with description	10
2	Categories of substrate, depth and flow used for generating frequency distribution of habitat availability and use	12
3	Summary of fish harvest in different sites on the basis of questionnaire survey	13
4	Severity rank score for threats	15
5	Frequency score derived for different streams in Askot landscape	16
6	Riparian vegetation index derived for stream of Askot landscape	24

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Summary

The aim of the report is to give an overview regarding the areas in Askot landscape which are in need for conservation in terms of aquatic habitat. This study is a part of the project Biodiversity Conservation and Rural Livelihood Improvement (BCRLIP) in Askot landscape.

This report deals with the assessment of aquatic resources of Askot landscape with reference to human footprints available there. The focus is mainly on the assessment of fish density and people dependency on fishes along with the caused disturbances. People were highly dependent on stream Rautis which is located at lower altitude of the landscape. Several human disturbances were identified in the landscape which is electrofishing, bleaching, water diversion, dynamiting, regulated water, sand mining, roads, stream crossings and waste discharge. Riparian quality was assessed in the streams of Askot landscape and found out Dhauri coming under the category F which shows low quality because of changes in the habitat. This provides the health and ecological status of all streams. On the basis of indicator criteria two indicator species was narrowed down as *Schizothorax richardsonii* and *Naziritor chelynoides*. So habitat requirement for both the species was studied and found out different requirement for substrate as boulders for *Schizothorax* and sand, silt for *Naziritor*. Further monitoring protocol is made for managing the Askot landscape in terms of aquatic fauna.

1. Introduction

Freshwater habitats account for about 0.01% of the Earth's total surface but they play an important role in fundamental ecosystem functions and services, besides sustaining an overwhelming diversity of species (Vorosmarty et al. 2010; Carpenter et al. 2011). This tiny habitat is one of the most threatened ecosystems in the world, with high species extinction rates resulting from high human dependence on freshwater resources. Freshwater fishes are among the most diverse groups of vertebrates in the world, exhibiting extraordinary taxonomic diversity, endemism, and geographic scope in their distribution (Leveque et al. 2008). They exhibit great diversity and are responsible for several important functions. Besides being valuable food resources, sport and ornamental value, they are responsible for fundamental ecological processes and functions such as nutrient cycling, trophic dynamics, productivity, ecosystem engineering and ecosystems connection through migrations, among others. Major threats to fish diversity are numerous; examples of identified threats are overexploitation and flow modification, habitat loss and fragmentation, abstraction of water for human use, deleterious effects of agriculture, introduction of non-native species, climate change and pollution including eutrophication (Dudgeon et al. 2006). Overexploitation of fishery resource is increasing day by day. For example, illegal fishing such as using pesticides, electrofishing and dynamite are responsible for the collapse in fish stocks in the stream habitats. Coupled with this altered flow in the stream/ river habitat may disrupt both longitudinal and lateral connectivity of river habitat, which leads to loss of spawning and feeding grounds of fishes. Streams/ rivers of Askot landscape inhabits 12 species of fishes, in which the snow trout *Schizothorax richardsonii* and *Naziritor chelynoides* are being considered as indicator species of stream condition (Rajput et al. 2015). All the efforts taken by people to conserve fish fauna have not come up with any fruitful conclusion as not

sufficient information was available on habitat requirement of fishes. The diversity of fishes depends upon the characteristics of habitat features which include water temperature, stream bed composition like bedrock, boulder, clay, gravel, leaf litter etc., depth, flow of water and availability of fish cover like bedrock undercutting and vegetation cover where fish can hide. Habitat availability is very important feature for fish habitat selection (Yu and Peters 1997). Different fish species depends differently on the availability of appropriate depth, water velocity, substrate type and stream cover. Any effort to conserve the fishery resources, require complete knowledge on ecological status of important fishes.

In addition changes in the land use pattern and modification in the riparian habitat along the river triggers degradation in the aquatic habitat. Riparian vegetation connect a stream with its watershed and control within stream biological communities by influencing solar radiation and water temperature, regulating nutrient budgets, stabilizing stream banks and providing a source of organic energy (Schiemer and Zalewski 1992). When buffer strips are degraded or removed, a common result is a change in sediment loads within the stream channel, flooding and channel widening. Despite of providing many important goods and services to mankind, it is facing the destruction.

One of the major goal of the World Bank supported project on Biodiversity Conservation and Rural Livelihood Improvement Programme is long-term monitoring aquatic resource in the Askot landscape. Under the programme, during the phase-I: fish diversity associated with stream habitat, distribution and abundance of fishes with reference to various disturbance factors and indicator fish species were documented. In the phase-II: status of aquatic resources of Askot landscape with reference to human food print was documented. The followings are the specific objectives of the phase-II programme.

1.1. Objectives

1. To assess the level of human footprints and dependency on the aquatic resources in Askot landscape.
2. To study quality of Riverine habitats with respect to intensity of Human use.
3. To study the ecological status of economically important fish species with reference to changing landscape.

2. Study area

The study was conducted in Askot landscape of eastern Kumaon region (29°46'45" to 30°27'45" N latitude and 81°01'53" to 80°16'25" E longitude) in Western Himalaya, which lies in the state of Uttarakhand. It covers an area of 4463 km², with an altitudinal range between 560 and 7434 m situated in district Pithoragarh (Figure 1). The landscape is physiographically a mix of lower, mid and higher Himalaya spreads from sub-tropical to alpine altitude zones experiencing extreme cold winters and very hot summers. This forms the catchment of river Kali, which defines the international border between India and Nepal. This landscape covers four watersheds –Gori, Dhaul, Dharchula and Kuti. Gori valley is approximately 42% of the entire landscape. Kali is the largest river in respect of water volume and catchment area originating from two headwaters - Kalapani and Kutiyanngti. One of the major tributaries of Kali is Dhaul, which joins it at Tawaghat and later on river Kali confluence with Gori river at Jauljibi (Figure 2).

There are two hydro-power projects present in this landscape, one is functional known as Chirkila dam built on the river Kali at Tawaghat. It has a capacity of producing 150MW of energy and other one is located at Seraghat, currently it is not functional, got washed off in 2013 flash flood. The phase II study was conducted between March 2015 and October 2017.



Figure 1: View of Askot landscape from the high altitude.

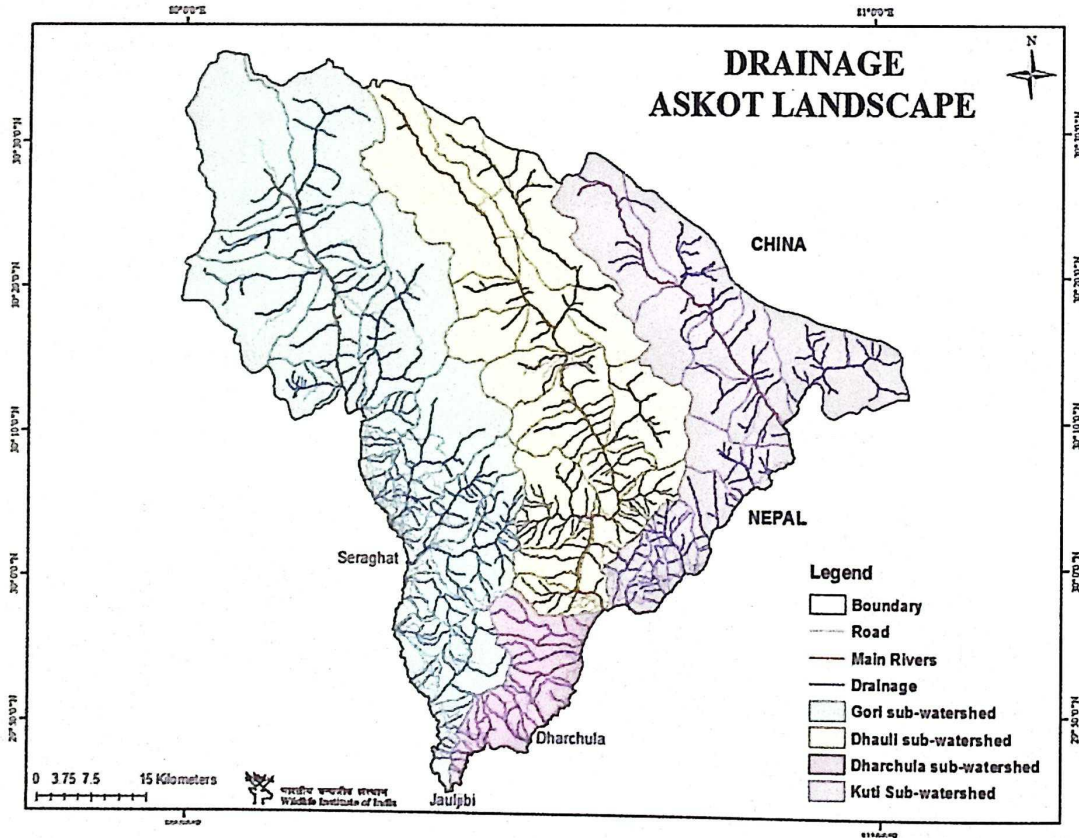


Figure 2: Map showing Gori, Dhauli, Dharchula and Kuti sub-watershed in Askot landscape.

3. Methodology

3.1. Assessment of Fish density

As the snow trout (*Schizothorax richardsonii* – Figure 3) and the black mahseer (*Naziritor chelynoides* – Figure 4) are dominant fish species in the rivers of Askot landscape, their population abundance and people dependency were evaluated. Total 10 streams were selected for this assessment and all sites were surveyed in three seasons; intermediate (January to March), summer (April to June) and post monsoon (October to November). These sites, 100m reach length, was selected to include all the variability of each particular stream. At all the study sites in different habitats like run and pool, length and breadth was calculated to know the area of the habitat. At each section from different points number of fish was counted several times for accuracy to cover the entire habitat. In addition to cast net sampling was performed to riffle, pool and run habitat. At each cast number of species and species wise biomass was calculated. Based on the cast net area and number of effective cast species density and biomass for *Schizothorax richardsonii* and *Naziritor chelynoides* were established.

3.2. Assessment of people dependency on Fishery resource

People dependency on fishes in streams of Askot landscape was performed by questionnaire survey method. This questionnaire survey involves the sampling technique which is used to nominate another potential person for the complete information. This sampling method is known as snow ball sampling which is based on referrals (Glain et al., 2001; Panagopoulou et al., 2017). The questionnaire was divided into many parts for different people like fisherman,

pisciculturist, fish seller shops, hotels and villagers. Questionnaire includes the questions like general information about the person, their fishing habits, fishing methods they use, income

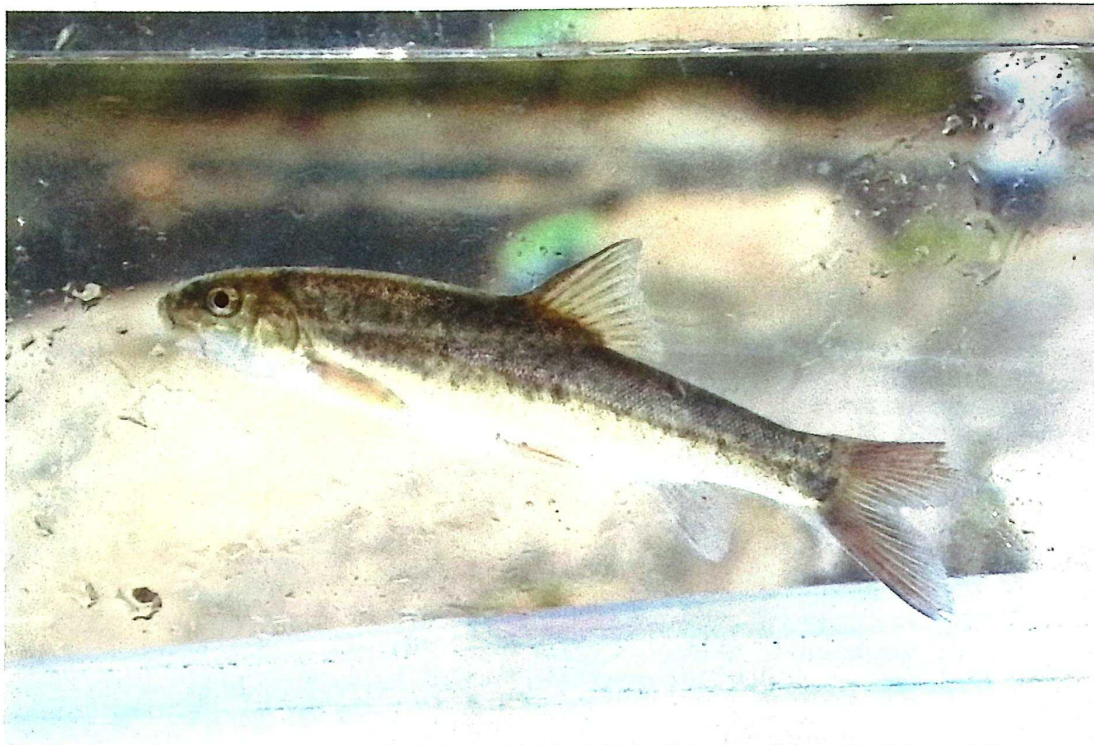


Figure 3: The snow trout *Schizothorax richardsonii* (Photo: J.A. Johnson).



Figure 4: The black mahseer *Schizothorax richardsonii* (Photo: J.A. Johnson).

generated by selling fish, problems faced in pisciculture, species preferred by local people etc.(Appendix). Around 10% of people from fish catching group were interviewed from the village in 2014-2016 which make 136 interviews. Villages near to stream were covered. Respondents were found by nominating other people from the first one from hard to access groups.

3.3. Assessment of human disturbance along the aquatic habitat

In the phase-I study, there are twelve different types of human disturbance along the water resources were identified (electrofishing, bathing, washing, sewage effluents, bleaching, dynamite, gill netting, water diversion, water mill, sand mining, dam, agriculture). Out of 12 disturbances, the disturbance such as chemical bleaching, electrofishing, dynamiting, water diversion, sand mining, water regulation, road construction, stream crossing and waste disposal were considered for assessing intensity of human food prints on aquatic resources. The main purpose of this assessment is to evaluate the risk of human impacts to stream system. Two aspects of risk assessment were integrated into the methodology- frequency and severity of risk (Paukert et al., 2011). Each threat was measured in terms of frequency and severity at each site. Severity values were measured on the basis of already published ecological impacts. Frequency scores were given on the basis of total frequency counts of certain disturbance in each site. Severity ranks was given from low=1, medium=2 and high=3. And then frequency scores were multiplied by severity scores to get threat value for each disturbance. This index measures the threat prevalence. This facilitates a comparison of each threat across different sites. A composite index of ecological risk was calculated by summation for each disturbance to get an overall value for each stream sites. Based on the composite index of risk score, risk maps were prepared for Askot landscape.

3.4. Assessment of Riparian quality along the river system

Human food prints along the aquatic habitat can be easily visible along the riparian corridor, because most of the human activities such as agriculture along the rivers, cattle grazing, tree lopping for fodders and modification in the river banks. It is well-established fact that condition of riparian vegetation along the riparian explains the quality and health of river ecosystem. In the present study, the condition of riparian vegetation quality was conducted in tributaries of Gori, Kali and Dhauli rivers between 2015 and 2017. Sampling and field observations were done in 18 streams covering all three drainages. The condition of riparian vegetation quality was measured in the form of Riparian vegetation index (RVI), which was outlined by Kemper (2002). The index is based on four components of riparian habitat – percentage of riparian cover, structural intactness of riparian species, percentage of exotic weeds and terrestrial species and their level of disturbance. The index value was generated for each stream based on the riparian quality in 1km stretch. At each sampling stretch, every 250m, 5m radius circular plot were laid and different components were recorded.

- Extent of vegetation cover (EVC) is determined by calculating the average score of EVC1 and EVC2. EVC1 is a direct assessment of the percentage of vegetation cover of all vegetation, natural or not, in a circular plot on the basis of six slots. A certain score value is given on the basis of percentage cover. EVC2 depicts the percentage of disturbance and score value given as 0 for no disturbance, 1 for very low disturbance, 2 for low, 4 for medium, 6 for high and 10 for very high disturbance. Thus the total EVC is calculated as follows: $EVC = [(EVC1 + EVC2)]$
- Structural intactness is calculated for tree species (SI1), shrubs (SI2) and grasses (SI3). Score value is given on the basis of sparse as 0, scattered as 1, clumped as 2 and continuous as 3. SI is calculated by following formula:

$$SI = [((SI1 + SI2 + SI3)/3 \times 0.33)]$$

- Percentage cover of indigenous riparian species (PCIRS) expresses the extent of exotic species, terrestrial species and reed beds. The increase of terrestrial species and reed bed invasion is a persistent problem in streams as flow has been influenced, which are exposed to nutrient loads. PCIRS is calculated by subtracting the score value of exotic, terrestrial and reed species from the EVC score.

$$PCIRS = [(EVC/2) - ((exotic \times 0.7) + (terrestrial \times 0.1) + (reed \times 0.2))]$$

- Recruitment index of riparian species (RIRS) is a measure of indigenous riparian species present at the site relative to the recruitment of exotic species and spread of grass. The maximum score which can be given is 5.

Using all the above components (Kemper 2002), RVI score was calculated from the following formula:

$$RVI = [(EVC) + ((SI \times PCIRS) + (RIRS))]$$

Where, EVC is extent of vegetation cover

SI is structural intactness

PCIRS is percentage cover of indigenous riparian species

RIRS is recruitment of indigenous species

The index score varies between 0 and 20. Based on the index value, streams were assessed from A to E level as given in Table 1.

Based on RVI indices, the riparian quality was classified into High (Class A & B), Medium (Class C & D) and Low (Class E & F) quality of riparian vegetation.

Table 1: Riparian vegetation index scores and corresponding river classes with description

RVI Score	Class	Description
19-20	A	Natural, Unmodified
17-18	B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
13-16	C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.
9-12	D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
5-8	E	The loss of natural habitat, biota and basic ecosystem functions are extensive.
0-4	F	Modifications have reached a critical level and the system has been completely modified with almost complete loss of natural habitat and biota. In the worst case the basic ecosystem functions have been changed.

3.5. Assessing ecological status of Indicator fish species

As part of phase-I study two indicator fish species were chosen on the basis of indicator criteria and also on the basis of disturbances found in streams which depict the presence and absence of species. These indicator fish species, were identified based on the indicating different disturbance level in Askot streams, they are: *Schizothorax richardsonii* and *Naziritor chelynoides*. Before setting long-term monitoring protocol, ecological requirement of indicator fish species is essential. Hence, in the phase-II, this objective was covered and the study was conducted in tributaries of Gori and Kali river basin during 2015-2017. As all the stream water in the Askot landscape is clear underwater observation was made in the selected habitat. Habitat use by indicator fish species was evaluated in selected habitat like

pool and run based on underwater observation using aquascope and underwater mask. Transects were laid in the habitat on the basis of its size. At each observation, depth, flow and substrate near the fish were recorded using depth measuring rod, hand held flow meter and visual observation respectively (Hued and Bistoni 2006, Johnson et al., 2017). Followed by habitat availability (flow, depth, substrate) were measured at every 1×1 m grid in the same habitat. All measured variables were organized into six categories (Table 2). The frequency for each variable was calculated for all different classes between used and available resources. Then the preference was evaluated for each class interval of depth, flow and substrate from relative frequencies of utilization and availability by following formula (Johnson et al., 2017):

$$P_i = U_i/A_i,$$

Where, P_i is the relative preference value for a specific interval of the measured variable

U_i is the proportion of utilization of a specific interval of measured variable

A_i is the proportion of availability of a specific interval of measured variable while sampling in stream.

The obtained ratio was normalized to a preference scale of 0 to 1 using the formula:

$$P_n = P_i/\text{Max } P,$$

Where, P_n is the normalized index of preference of the variable at each interval and $\text{Max } P$ is the maximum index of preference for the range of the variable P_i .

Finally habitat suitability curve was generated for *Schizothorax richardsonii* and *Naziritor chelynooides* by plotting the species preference values against the variable interval.

Table 2: Categories of substrate, depth and flow used for generating frequency distribution of habitat availability and use (based on Hued & Bistoni 2006).

Category	Substrate size(cm)	Depth (cm)	Flow (m/sec)
1	Leaf litter	<16	0<0.093
2	Sand & silt	16<28	0.093<0.279
3	Gravel	28<39	0.279<0.465
4	Cobble	39<51	0.465<0.650
5	Boulder	51<62	0.650<0.836
6	Bedrock	>62	0.836<1.022

4. Results and Discussion

4.1. People dependency on Fish resource

Stream and river fishes are the source of natural protein for people living in the Askot landscape. During the survey it was found that there is no specific community involved fishing as profession, but different community people are involved in fishing. Local people are dependent on fish most for food and few people earn little bit income by supplying fish to fish sellers and local hotels. Generally, local youth and young children go for recreational fishing in the evening or during holidays and they mainly use gill nets and other traditional traps. Socioeconomic profiling of villages around Gori and Kali river revealed that very few people depending on stream/ river fish for their consumption (Table 3).

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Table3: Summary of fish harvest in different sites on the basis of questionnaire survey.

Site	Catch(per year)	Total no. of people	Total harvest(kg)
Rautis	38.56	14	539
Ghosi	40	9	360
Jari	23.54	16	376.6
Rachi	31	10	310
Seraghat	9.16	15	137
Mandakini	15	10	110
Khet	7	12	84
Ghatya	15	15	225

All the respondents were male with age group varying from 12- 45 years. The area for catching fish depends upon the easy accessibility and on the basis of their experience of getting more fish. All people who were fishing for more than 5 years (n = 40) reported changes in the catch. Nearly all stated that their catch had decreased from before not in amount but also fish size got reduced.

From the above table, among the fish catching people (n=102) the harvest is found highest in stream rautis. This might be due to lower elevation of rautis with warm temperature. In this stream, diversity of fish was also recorded more in comparison to other streams because of less gradient and tributary effect. In the streams, mandakini and khet fish catch is very less as it is at high altitude with low water temperature and gradient is also high making it difficult for species diversity. High gradient streams and high elevation reduces the number of fishes in upper areas (Smith et al., 2010).

Many young participants admitted for using dynamite and electrocution for catching fish as they don't have to put more effort for catching fish. In less time, more number of fishes was caught. As fishing is the side business for many people in Askot, they were very much interested in Pisciculture which can enhance their livelihood. On interviewing pisciculturist (n=15) from Askot, 28% of them earned in first year and remaining 72% of them got failed. Only 11% of them earned during second year. However, in a nutshell 89% of fish farming got failed in Askot landscape due to various reasons. Lack of funds is the main cause for failure as fish tank should be covered for preventing birds and snakes entry for which people don't have enough money. Proper training should be given for addressing various issues involved during fish farming like fish disease, type of food for fish. There is shortage of water in summer season which is very necessary in fish farming. On the basis of above insights it can be said that more emphasis should be given on investment, capacity building and institutional strengthening for expansion in fish farming which is very important to generate the livelihood among the people of Askot.

4.2.Human disturbance

To assess the ecological risk of human activities on aquatic system a protocol is followed giving the score values to threats. Two methods were used to get the final score value-severity score on the basis of published literature and frequency score is given on the basis of intensity of threats found in field. These severity scores were given on the basis of regional impacts over ecological functions like water quality, habitat quality, biotic interactions, flow regime and energy sources (Table 4). From all the above identified threats from Askot, regulated water i.e. dam has high effects over ecological functions and therefore score value came out maximum (Table 4).

Table4: Severity rank score for threats (low =1, moderate =2 and high =3).

Severity Ranks	Water quality	Habitat quality	Biotic interactions	Flow regime	Energy Sources	Total severity
Electrofishing	0	0	3	0	1	4
Bleaching	3	1	2	0	2	8
Water diversion	0	3	0	3	1	7
Dynamiting	1	2	2	1	2	8
Regulated water	3	3	3	3	3	15
Sand mining	1	3	1	1	1	7
Roads	2	2	0	1	2	7
Stream crossings	2	2	1	1	1	7
Waste discharge	3	2	1	0	2	8

These scores were given on the basis of published literature. Dam affects the aquatic community severely by altering fish habitat (Johnson et al., 2008). Dams hinder the fish movement affecting their spawning behavior. Electrofishing has lowest score value as it only affects the biotic interactions and energy source. Other functions are not affected. Regular electrofishing can reduce the population density of fish. Therefore it is not a severe threat. Frequency scores were given on the basis of the number of sightings of each threat at the site (Table5). Threats were given a score zero if the threat is not present at that site. Score was given 1 when presence is minimum, 2 when presence is moderate and 3 when presence is maximum.

Table5:Frequency score (0 - not present, 1 – minimum, 2 – moderate, 3 - maximum) derived for different streams in Askot landscape (S1-Bheri, S2-Madkanya, S3-Seraghat, S4-Sera, S5-Jara, S6-Dugdi, S7- Ghosi, S8-Rautis, S9-Ghatya, S10- Khumti, S11- Galati, S12-Aelagad, S13-Khet, S14-Dhauri).

Threats	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14
Electrofishing	0	0	1	1	0	0	1	1	2	0	1	1	1	2
Bleaching	1	0	1	0	1	1	0	1	0	0	2	0	0	1
Water diversion	0	0	0	1	1	1	0	1	1	2	1	0	0	0
Dynamiting	2	0	0	1	1	0	3	2	1	1	0	0	0	1
Regulated water	0	0	2	0	0	0	0	0	0	0	0	0	0	2
Sand mining	1	0	3	1	2	1	1	2	2	2	2	1	1	2
Roads	0	0	2	0	1	0	1	2	1	2	2	0	0	2
Stream crossings	0	0	1	1	0	0	1	1	1	1	1	0	1	0
Waste discharge	0	1	0	0	0	0	1	1	0	0	0	0	0	0

Using both the score values i.e. frequency and severity scores, a threat value were generated for Askot landscape. Frequency scores were multiplied by severity score to get threat value for each stressor and then added all threats value to calculate an overall threat value for each watershed.

Maps were generated using threat value for each stressor reflecting the specific risk pattern for individual threat in Askot landscape. Map for electrofishing shows lower risk in Askot due to absence of this threat in many watersheds (Figure 5). Frequency is also not that higher in streams. For bleaching, map depicts the absence of this threat in many areas (Figure 6). It is found low in the lower areas except one i.e. Galati where it is found moderate.

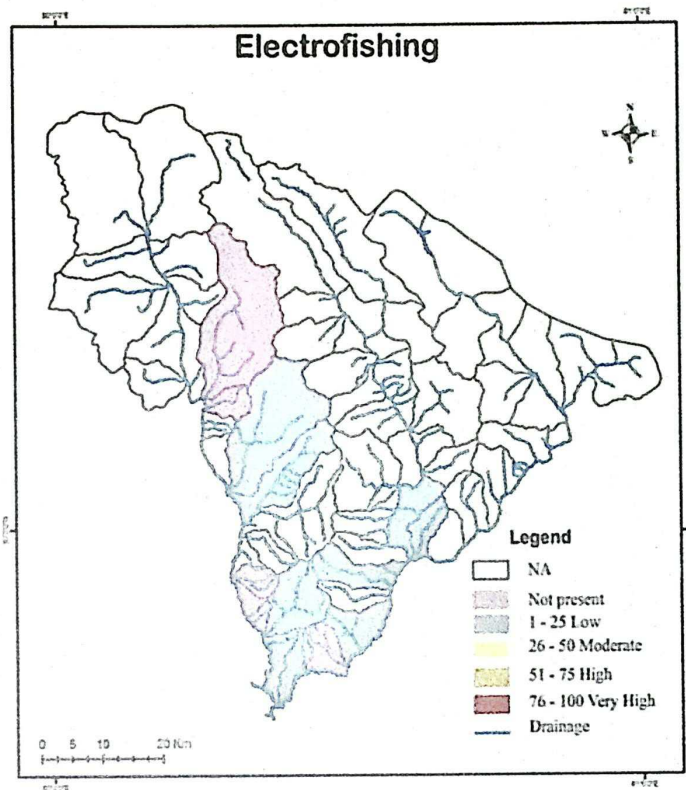


Figure 5: Map describing electrofishing activity in Askot landscape

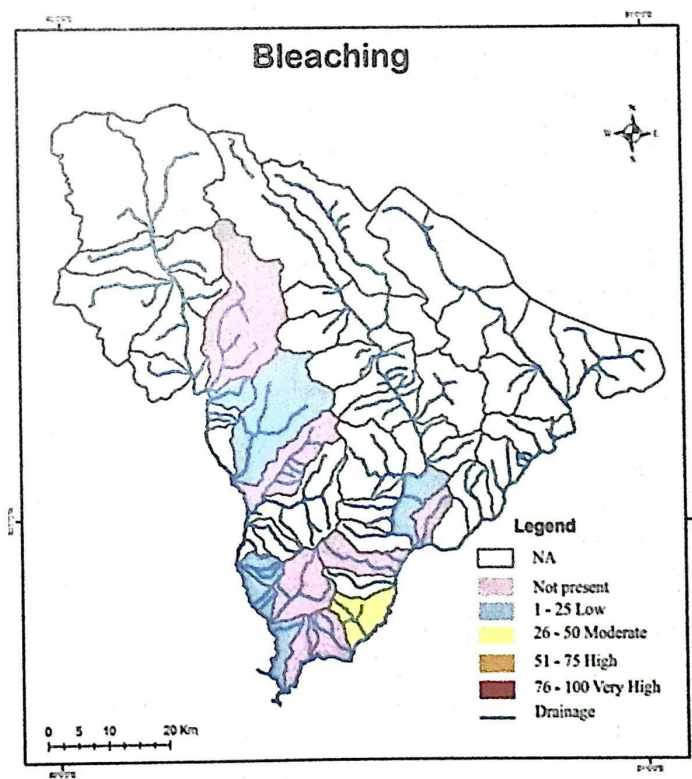


Figure 6: Map describing bleaching activity in Askot landscape

The severity value is not that high for water diversion but due to frequency score value at one area it is having moderate risk (Figure 7). From map of dynamite, it can be said that dynamiting is at high risk in ghosi and moderate in other watersheds (Figure 8). Streams near to the roads are easily accessible for dynamiting. Regulated water is having very high risk in the landscape as two areas have dams with high severity value (Figure 9). Sand mining is present in almost all the watersheds except at higher altitude (Figure 10). At lower elevation areas, it is at moderately risk. At many streams, roads are far off posing no risk to it (Figure 11). Streams having major areas of stream connected with roads come under moderate risk. Stream crossings are the fords or pathway that allows people and livestock to cross a stream. These stream crossing destroys the aquatic habitat, damage stream beds and channels. In some of the areas, it is not present in such a way that causes harm to habitat. In lower stretches these stream crossings are present but at low risk (Figure 12). From waste disposal map, it is visible that waste facilities entry point is at low risk (Figure 13).

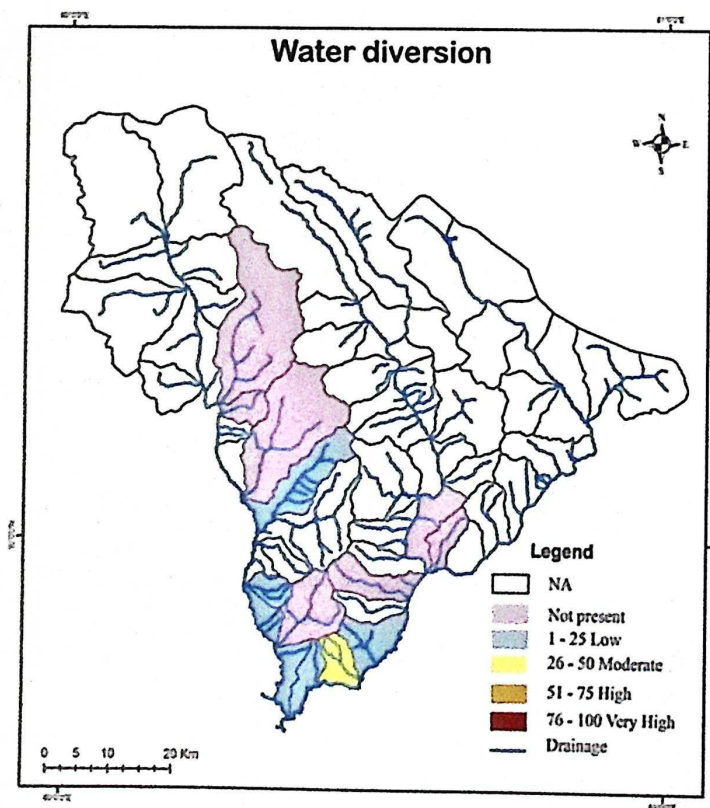


Figure 7: Map describing water diversion activity in Askot landscape

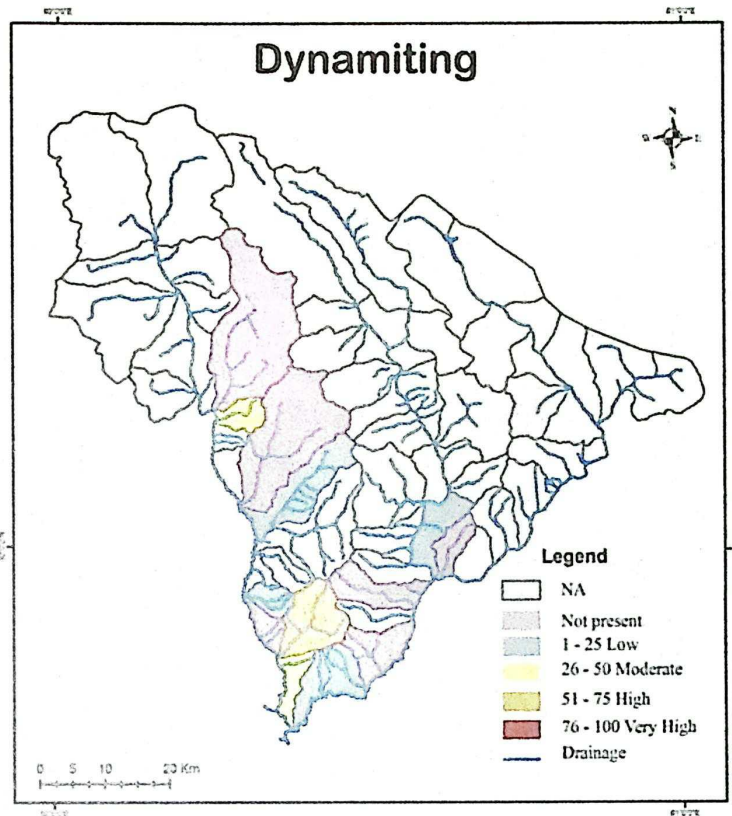


Figure 8: Map describing dynamiting activity in Askot landscape

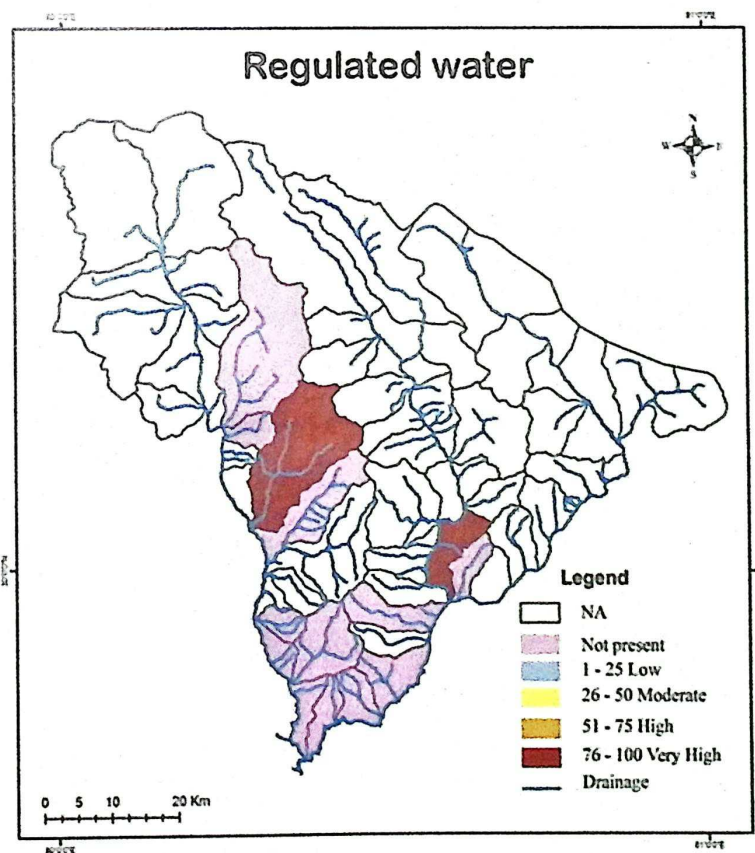


Figure 9: Map describing regulated water activity in Askot landscape

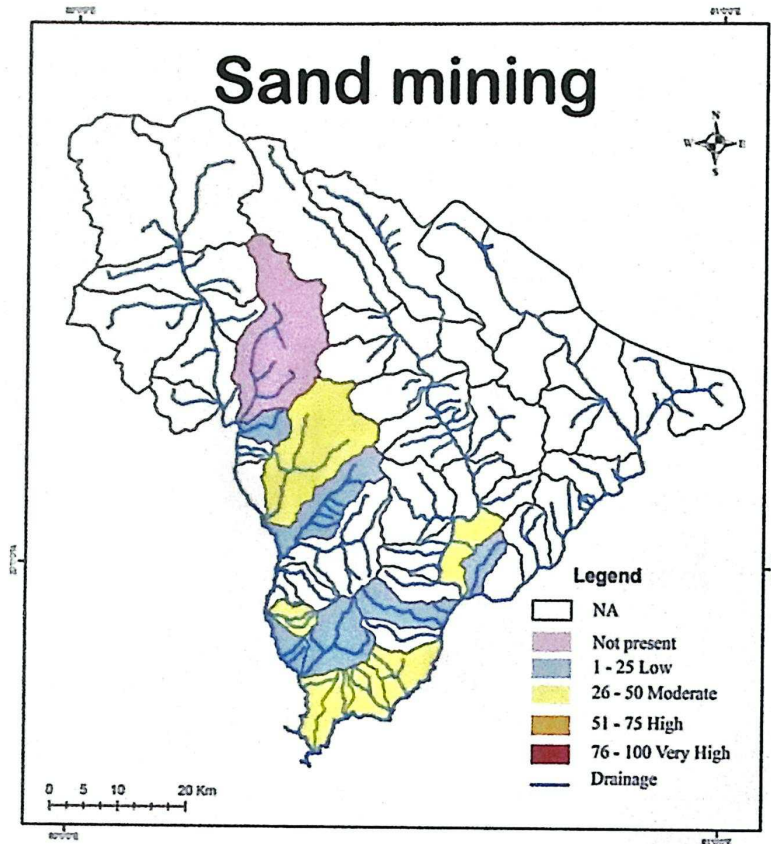


Figure 10: Map describing sand mining activity in Askot landscape

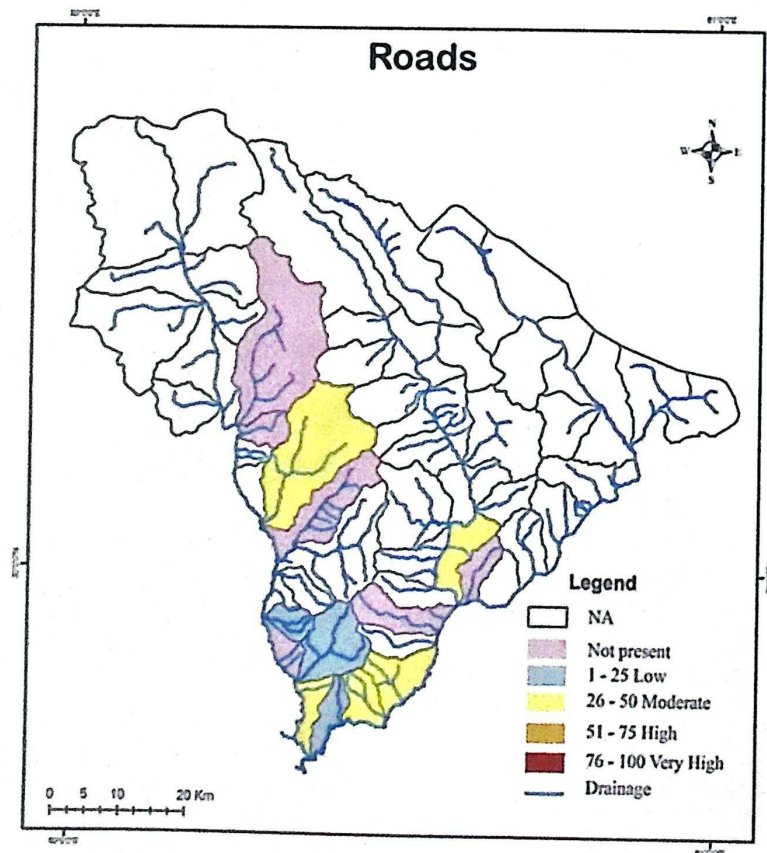


Figure 11: Map describing roads in Askot landscape

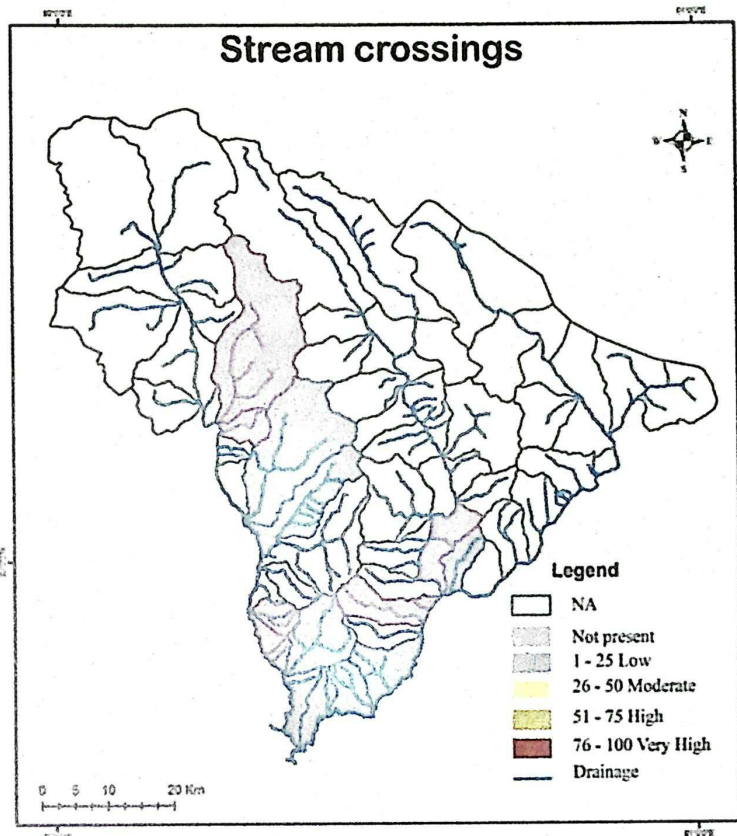
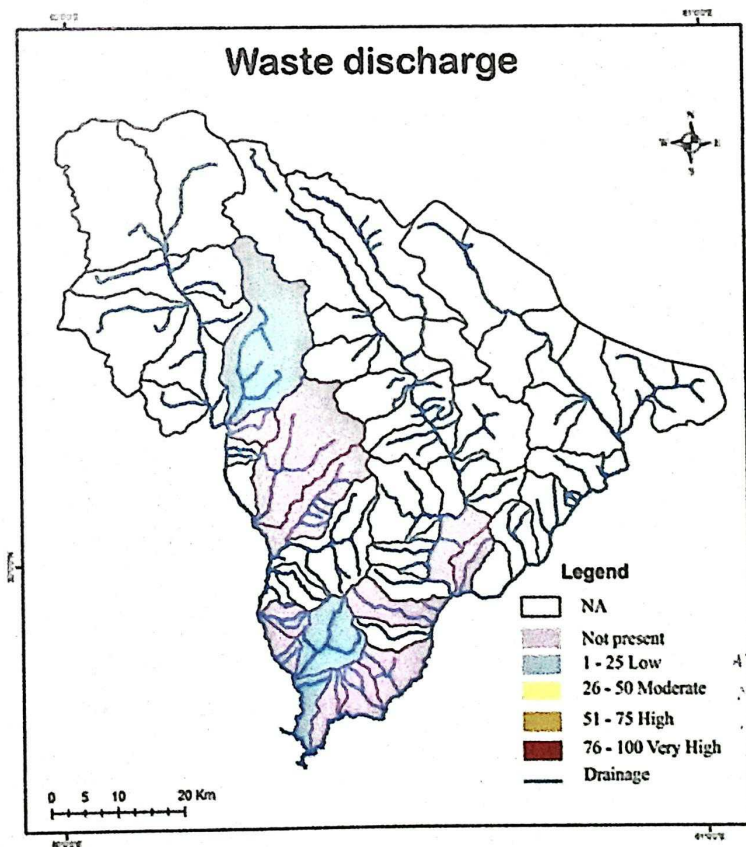


Figure 12: Map describing stream crossings activity in Askot landscape



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Figure 13: Map describing waste discharge activity in Askot landscape

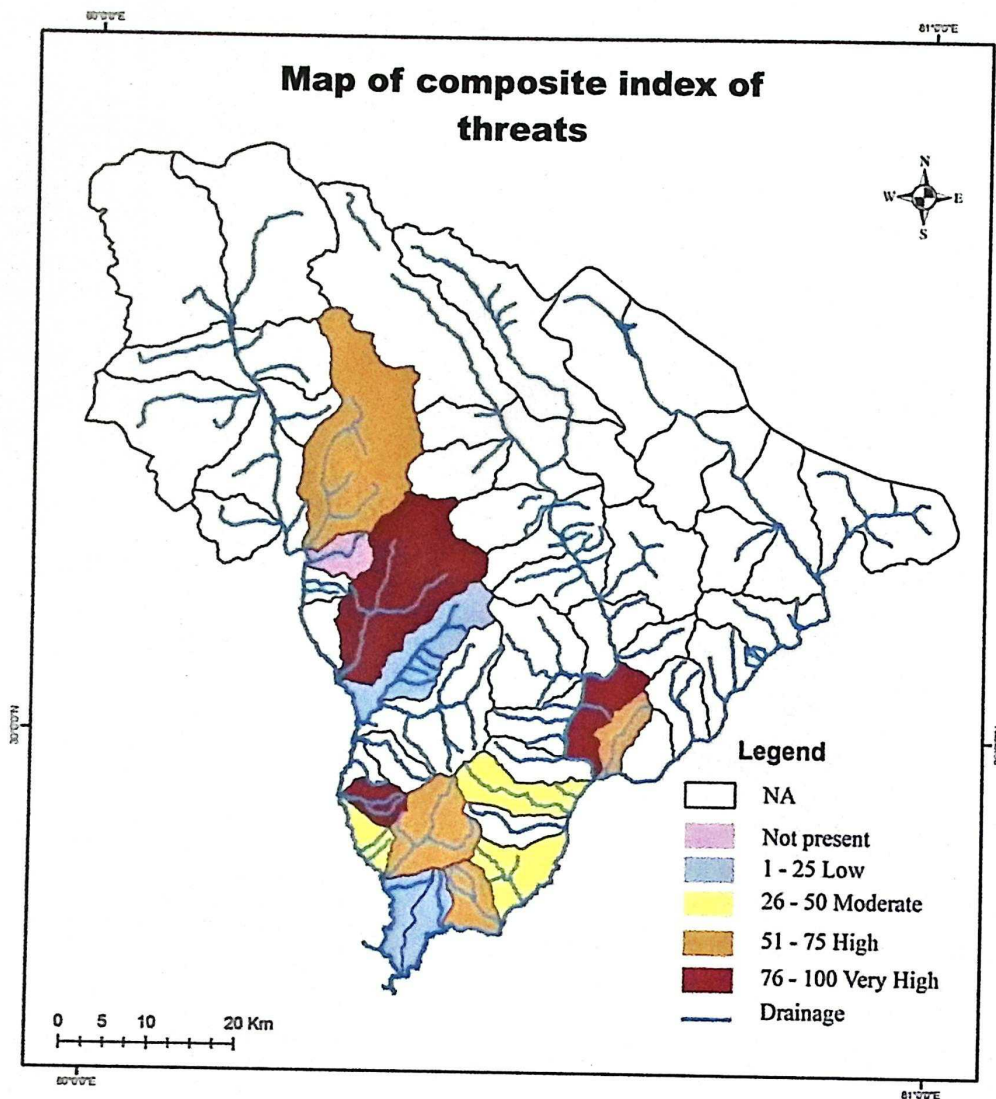


Figure14: Map showing micro-watershed wise combination of all threats

Values were summed up over all threats and a composite map is obtained of ecological risk to understand the aquatic system health (Figure 14). High risk areas may be identified due to high frequencies of threat. Therefore, the threat with high severity but low frequency contribute less risk like waste discharge have second highest severity found but due to less frequency it came out to be at low risk for health of system. Streams at lower altitudes were at high composite risk for aquatic health. Threat scores were typically highest in watersheds located in downstream areas. As the people aggregation is higher at lower altitude increasing the pressure on water system making it ecological risky. However, according to many studies

in Himalayan waters an increase in elevation leads to decrease in fish. So, at lower elevation fish density is more increasing the dependency of people by unconventional methods of catching fish. Seraghat and Dhauli come under very high risk due to the presence of dam having high severity value affecting the water quality and habitat for stream community. All the ecological threat indices were most sensitive to inclusion of stressors describing regulated water, sand mining and roads making it clear that these threats play the great role in defining watershed risk.

This study demonstrates that ecological risk index is a useful tool for evaluating risk for better management of landscape.

1) Level of disturbance in the Riparian forest

Riparian vegetation is the strip of vegetation connecting the terrestrial and aquatic system together. A slight change in the riparian vegetation can lead to change the shore stability. Riparian vegetation index tells about the extent of vegetation cover, structural intactness, percentage cover of indigenous riparian species and recruitment of indigenous riparian species. The riparian vegetation index score varies between 0 and 20 points. Based on this index value, the conditions of streams were assessed from A to F.

RVI score generated for Askot landscape revealed that the RVI score fall between 4 and 9 (Table 6). Based on RVI score, the site Dhauli was rated as Class F (4.6) of low quality and less disturbed stream Khet was observed in class D (9.3) of medium quality. Sub-watershed wise condition of RVI score was displayed in Figure 15. There is no stream that comes under high category showing loss of natural vegetation. This loss is caused due to human interventions for making road, lopping and by natural cause i.e. flood. Dhauli came under category F due to flood and also because of continuous road construction at the either side of river, destroying most of the riparian vegetation. Riparian disturbance affects the water

quality, channel morphology and the biological properties of streams. Stream khet faced fewer disturbances because of less lopping due to less people dependency.

Table 6: Riparian vegetation index derived for stream of Askot landscape

Sites	RVI
Bhadeli	6.5
Madkanya	5.2
Seraghat	6.4
Sera	8.8
Jara	8.9
Dugdi	6.1
Ghosi	5.3
Rautis	7.6
Ghatya	5.6
Khumti	5.3
Galati	8.1
Aelagad	5
Khet	9.1
Dhauri	4.6

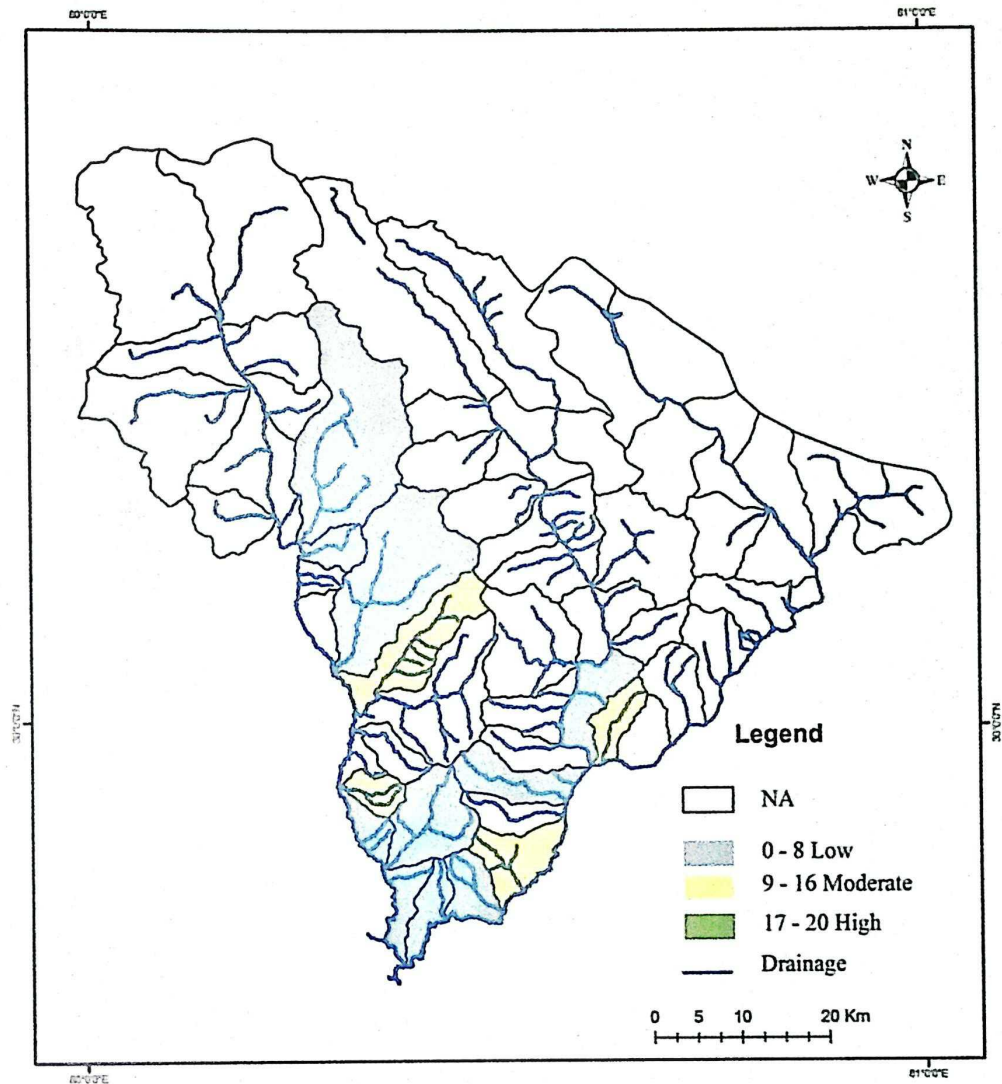


Figure 15. Map indicating sub-watershed wise condition of riparian vegetation

2) Habitat requirement for Indicator fish species

The indicator species *Schizothorax richardsonii* (Figure 14) is widely distributed in streams of Askot landscape starting from 600 m altitude to 1500 m altitude, whereas the *Naziritor chelynoides* (Figure 15) are localized only in streams at lower elevation (altitude ranges from 600 to 800 m). Both the species are specialized in terms of food and habitat use: *Schizothorax* is herbivore preferring fast flowing riffle habitat and *Naziritor* is a detritivore preferring clear pool habitat. As these are commonly used as food fish by locals, people are well aware of these species. Hence these species are considered as right candidate species for ecosystem monitoring.

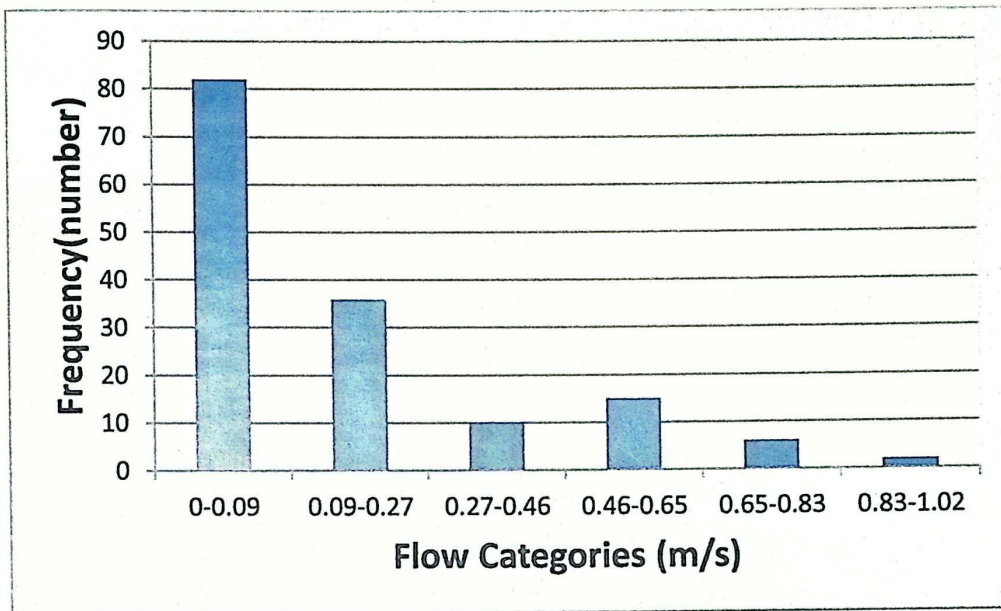


Figure 17. Frequency distribution of different categories of flow categories available in streams of Askot landscape

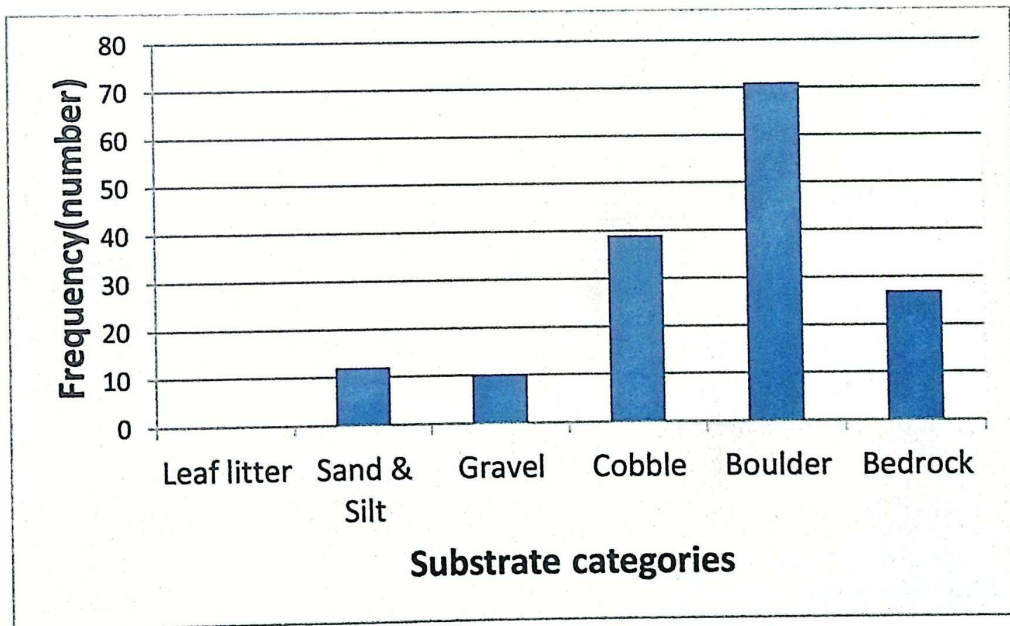


Figure 18. Frequency distribution of different categories of substrate categories available in streams of Askot landscape

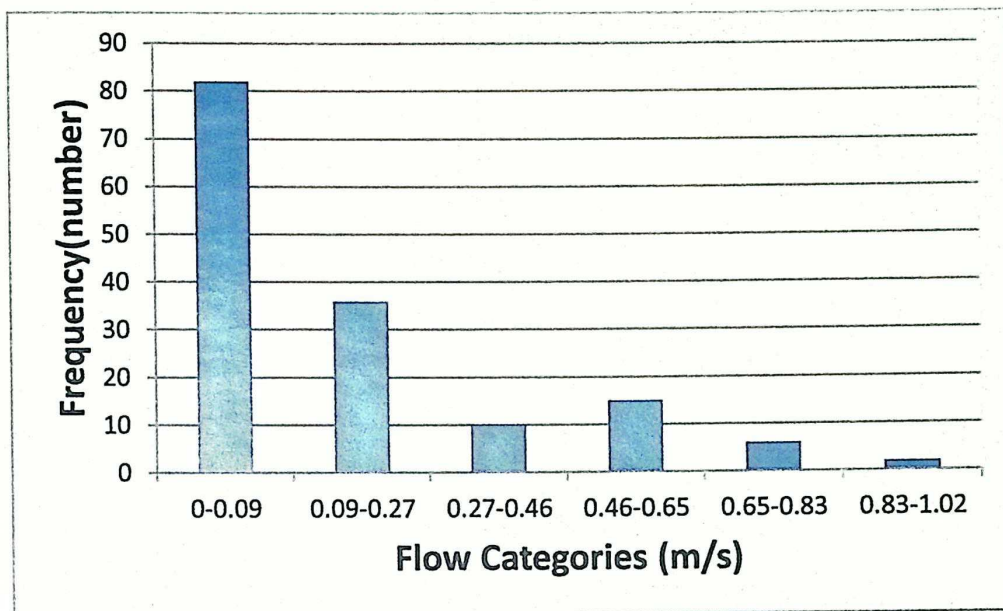


Figure 17. Frequency distribution of different categories of flow categories available in streams of Askot landscape

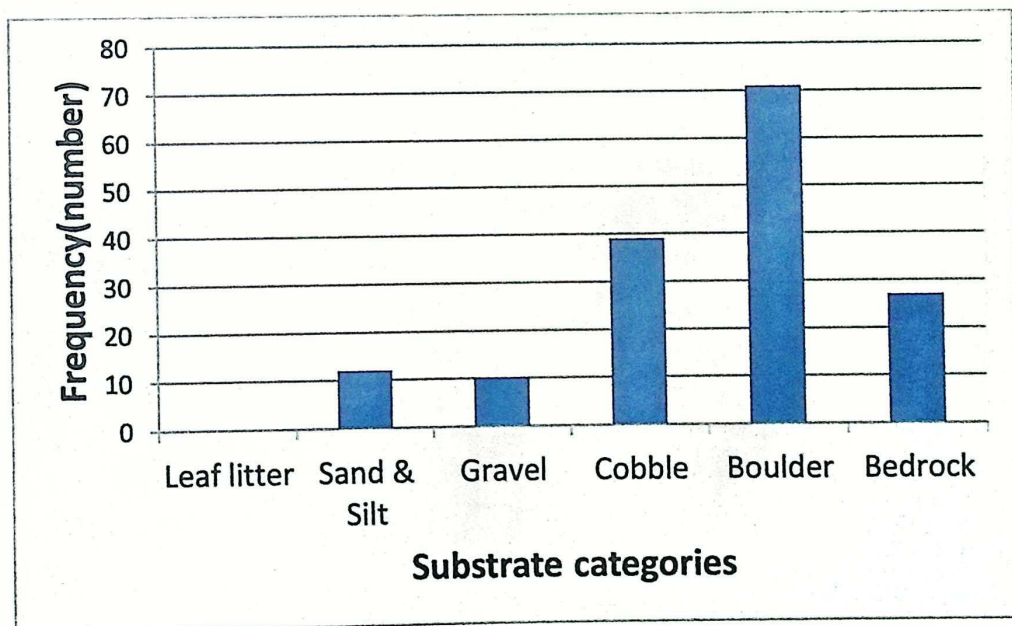


Figure 18. Frequency distribution of different categories of substrate categories available in streams of Askot landscape

2.1. Habitat use by *Schizothorax richardsonii*

Based on the habitat availability and species preference, habitat suitability curve was prepared. The result of suitability curve it is observed that *Schizothorax* used depth ranges from 39<51cm (Figure 18); flow ranges from 0.27<0.46 m/s (Figure 19) and it is exclusively preferred boulder substrate (Figure 20).

2.2. Habitat use by *Naziritor chelynoides*

The habitat suitability curve of *Naziritor chelynoides* indicated that they use little deeper habitat (51<62cm) than the *Schizothorax*(Figure 19); they preferred flow ranges between 0.27 and 0.46 m/sec (Figure 20) and they are highly associated with sand and silt substratum (Figure 21).

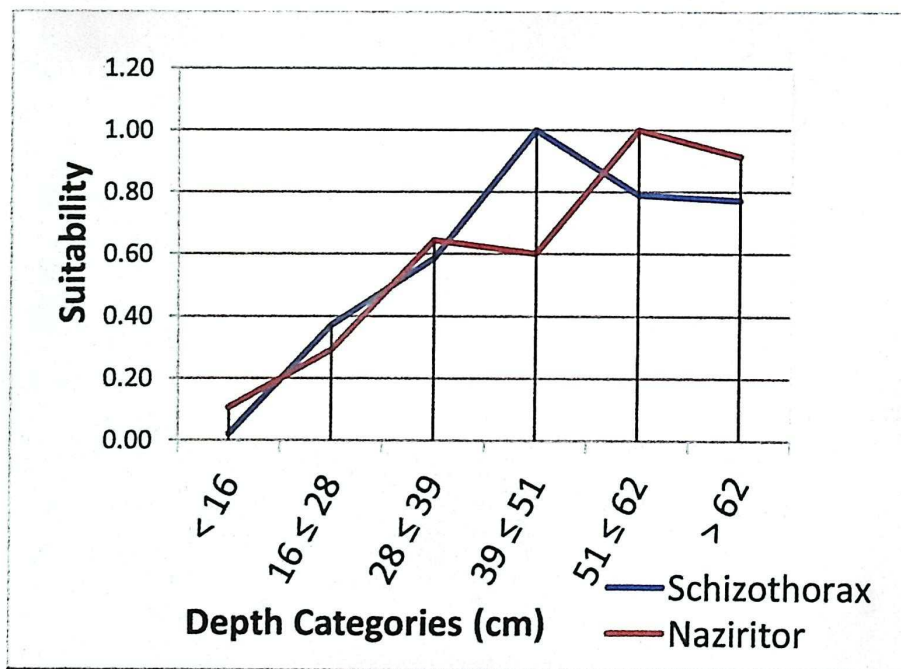


Figure19. Depth suitability curve of *Schizothorax richarsonii* and *Naziritor chelynoides*

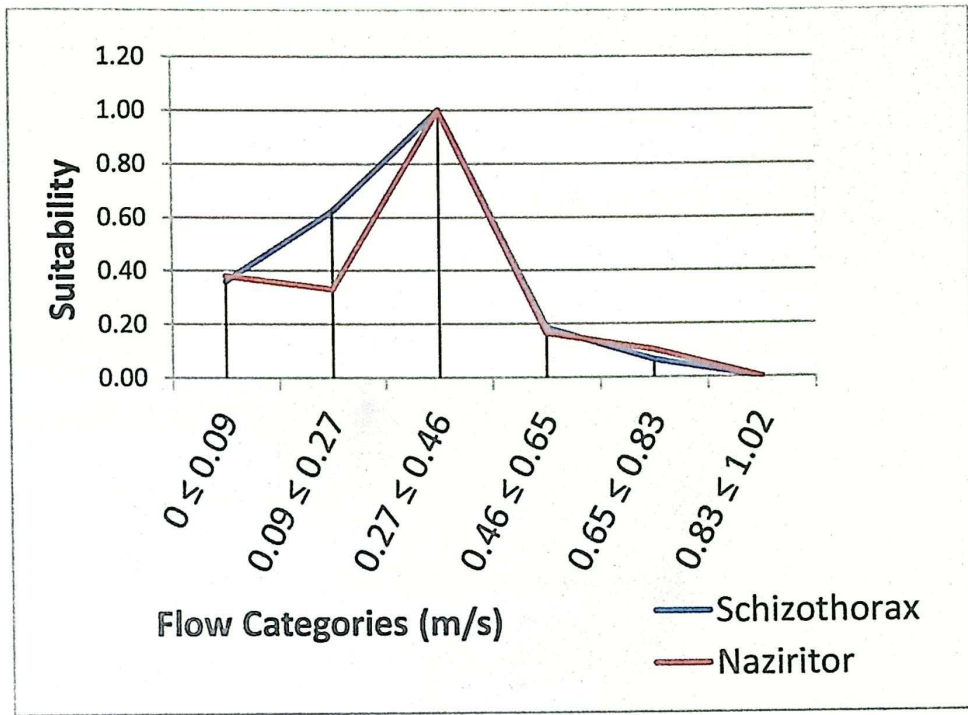


Figure 20. Flow suitability curve of *Schizothorax richarsonii* and *Naziritor chelynoides*

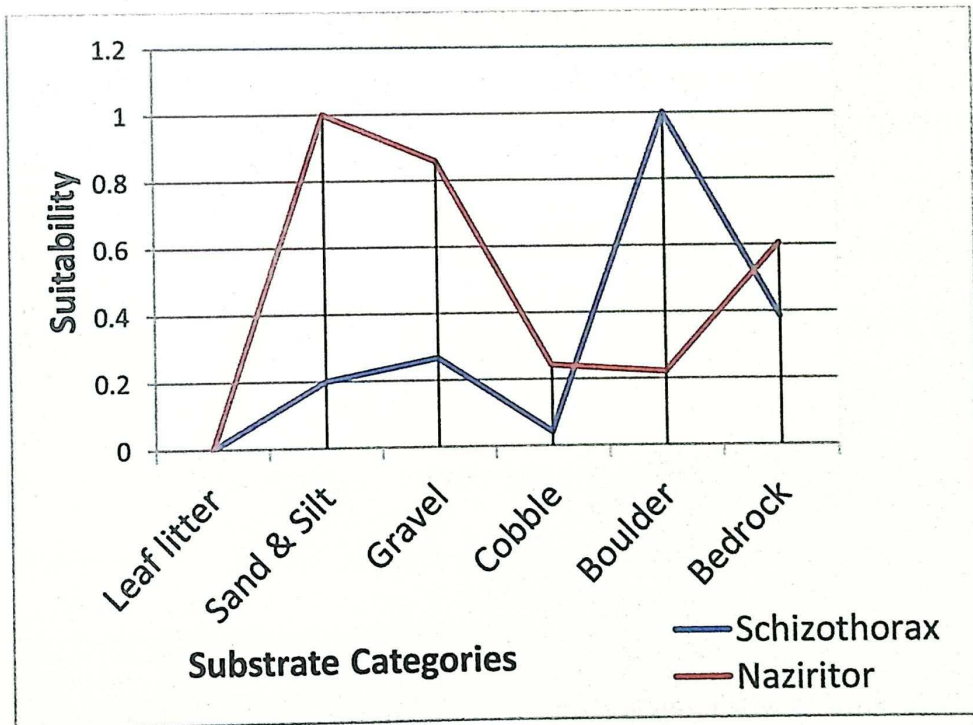


Figure 21. Substrate suitability curve of *Schizothorax richarsonii* and *Naziritor chelynoides*

The present study inferred that both the fish species show co-existence in the same habitats (pool and riffles), but they are segregated each other in terms of space usage. For example snow trout and black mahseer both occur in pool habitat, but they are specially segregated by resource. Snow trout lives in shallow habitat with moderate to fast flowing habitat, whereas black mahseer uses deeper habitat with moderately flowing habitat. Similarly, snow trout exclusively uses boulder substrates, because it provides foraging ground as well as refuge area. In the case of black mahseer prefer sandy habitat, where it explores the decayed organic matter as food. Information generated through this study can help in understanding the ecological status of indicator fish species. This information also provides necessary information for long-term monitoring of indicator species with reference to the changing landscape.

5. Recommendations

Askot landscape is a unique landscape in terms of its biodiversity and natural resource values. Due to lack of formal education and remoteness, people in this landscape are not much aware the value of its uniqueness and services provided by the natural resources. As a result the landscape is under tremendous pressure and threats especially the aquatic habitat and its resource. It needs immediate conservation interventions because of the overexploitation, aquatic habitat modification and harmful ways of fishing. Through this small study, we are proposing the following recommendation for long-term monitoring and conservation of aquatic resources of Askot landscape.

1. Local people especially youth are using destructive ways of fishing without having any conscience about the future circumstances. The common destructive practice used for fishing in the streams is: electrocution, dynamiting and chemical bleaching. In

order to stop such practices, frequent sensitization should be organized in the schools and colleges of this area so that youth will understand the consequences of harmful fishing.

2. Similarly, stream habitats in Askot landscape are under tremendous modification by local people, without understanding the consequence of ecosystem function and community process. The important alternations observed are: sand mining and small scale water diversion, which lead to reduction in food availability and water availability. Local district authorizes to empower the local Biodiversity Management Committee to monitor such condition and arrange adequate awareness program for local community
3. In the present study we have generated current status of riparian vegetation in different streams of Askot landscape. This information may be considered as baseline data for restoration of riparian forests along the river habitat by planting native riparian species. This will definitely improve the quality and condition of river habitat in due course of time.
4. Monitoring of the threatened fish species is required by the local people to experience the belongingness of them towards this landscape. Alternate livelihood such as aquaculture training should be provided to the local people for the enhancement of their earnings.

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13. Why:

14. How do you catch fish: gill net[] cast net[] by dynamite explosion[] using bleaching powder (*calcium hypochlorite*) [] electrocution[] water diversion[] poisoning through plants[] using balchi (hook)[] surka[] teep []

15. Where do you get the necessary equipments from:

Methods	Gill net	Cast net	dynamite	Bleaching powder	Battery/wires	plants	Balchi	Surka	Teep
Buy/get from									
Quantity (year)									
Price (per net)									
species									

16. Describe the technique and science of the method:

17. Why do you fish : to sell [] to eat [] both []

18. If sell why: if good catch [] better money[] market demand[]

19. Why eat: if meager [] for fun[] to eat along with drinks []

20. If you sell then

a) Which fishes are in demand:

b) Where/whom do you sell: to the middleman [] directly to the market[] in village itself []

c) If market then where:

c) If middle man then who is he:

d) How much does he pay you:

season						
Fish						
Rate (for fisherman)						
Market rate						

e) If market then where:

f) How do you take it to the market: two wheeler[] public means of transport[] on foot[]

21. What was your average earning by selling fish last year:

Maximum			Minimum		
Season	Earning	Quantity	Season	Earning	Quantity
Intermediate			Intermediate		
Summer			Summer		
Post-monsoon			Post-monsoon		

22. What is the effect of flash flood on the fish catch:
23. Do you think there are some other reasons for getting less fish like dam construction or any other:
24. Do you think provisions for pisciculture will enhance your income: yes[] no[]
 - a) If yes why/ how:
 - b) If no why:
25. Do you know anyone who is engaged in pisciculture:

Piscicultarist

Family information:

Land Holding:

Cattles:

Vocational avenues: Agriculture-
Labour-
Fishing-

Gross Annual Income including fishing

1. Since when do you practice fish farming:
2. How big is your tank:
3. How did you fund it:
4. How much did you get:
5. How much did it cost:
6. Why did you think of pisciculture:
7. From where do you get fingerlings:

Species						
Quantity						
Price						

8. How do you get it:
9. How much fish is produced:
10. What do you do with it: sell [] eat[] both[] sold earlier now eat[]
11. If you sell how much did you earn:
12. What are the threats to fishes:
13. How do you take care of the fishes:
14. What all problems do you face in fish farming:

Fish seller

1. Since when do you sell fish:
2. From where do you get fish: local fish [] plain area fish []

Local fish	Fish from plain area
Areas:	

3. From where do you buy plain area fish:
4. How much you buy plain area fish:

Seasons	Amount (per day)	Income	Local fish amount
---------	------------------	--------	-------------------

Intermediate season			
Summer season			
Post monsoon season			

5. How do you go to buy fish: by foot [] by vehicle [] somebody gives you []
6. If by vehicle then how much is the cost of going and buying fish:
7. How consistent is your supply:
8. What are the rates:

Seasons	Rate of local fish (per kg)		Rate of fish from plain areas (per kg)		Species of fish
	Buy at	sell at	Buy at	Sell at	
Intermediate					
Summer					
Post monsoon					

9. Who are your customers:
10. Is there any season when your sales are higher:
11. Do you store fish: yes [] no []
12. If yes then how and why
13. What is the cost of storage for fish:

Hotel

1. How much fish do you purchase everyday in different seasons :

Seasons	Amount	No. of persons involved
Intermediate		
Summer		
Post monsoon		

2. From whom at what rate:

Seasons	Rate (/kg)
Intermediate	
Summer	
Post monsoon	

3. Do you sell everything everyday: yes [] no []
4. Do you prepare all fish: yes [] no []
5. If no: to whom do you sell:
6. Which fish do people mostly prefer:
7. What are your rates of selling them:
8. Is there any particular season when sales or demand is high and low:
9. On an average how many fish eating customers of the total do you get per day:
10. How do you think your business will be affected if you do not sell fish:

Villagers

1. Do you eat fish: yes [] no []
2. If yes then do you catch fish: yes [] no []
3. If no then from where do you get fish:
4. If you catch then by what means:
5. At what rate do you buy fish:
6. How often do you buy fish in a month:
7. What species do you like most:
8. Which fishes do you get:
9. Which fish you get abundantly: