EVALUATION OF FISH SPECIES AS POTENTIAL INDICATOR SPECIES FOR MONITORING AQUATIC ECOSYSTEM: ASKOT LANDSCAPE, UTTARAKHAND

Phase – 1 Report

Biodiversity Conservation and Rural Livelihood Improvement Project (BCRLIP)

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Executive Summary

This is a Phase I Report under the project Biodiversity Conservation and Rural Livelihood Improvement (BCRLIP) for fish taxa in Askot landscape which has a unique assemblage of flora and fauna having a need for conservation. The mountain habitats are a source of livelihood in various different ways for the local people leading to create a severe pressure. So therefore an inventory of biodiversity is of prime importance for its conservation and sustainable development.

As preliminary information for the fish species is not adequate for this landscape so an inventory is performed in Gori sub watershed and lower reaches of the Kuti basin. A total of 12 fish species belonging to 2 order, 3 family and 9 genera were recorded from the Askot landscape. Information was also collected on different environmental and habitat variables with disturbances affecting the distribution and abundance. Different disturbances were noted in all the study streams. On the basis of the disturbance matrix prepared in all study sites with species presence and absence, species were narrowed down having the effects of disturbances. Two indicator species *Schizothorax richardsonii* and *Naziritor chelynoides* were identified following certain criterion which also includes the effect of disturbances. Further it is very important to use the indicators which tell the scientific understanding and management of water ecosystem. So it is very important to know the population structure of the indicator species in the next phase which will help in monitoring by simple monitoring protocol.

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Chapter 1

Introduction

1.1 BACKGROUND

Landscape as the name suggests is the visible features of an area of land. Landscape includes the physical and living elements like mountains, hills, rivers, lake, vegetation and different types of land use buildings and structures. Landscape involves terrestrial ecosystem and aquatic system together. Aquatic system is linked with the terrestrial in terms of water flow, substrate and in many other ways. Water is a much more effective agent in linking the different elements of landscape. Landscape ecology then involves the study of landscape patterns, the interactions among these elements of this pattern in relation to water system and how these patterns and interactions changes over time. It can also be explained as the interrelationship between the human society and living environments. It emphasises the importance of humans in landscapes and the relevance of landscape ecology to human land use in relation to aquatic system.

Water is an increasingly valuable resource to humans everywhere in each and every way. Rivers and streams are the main focus of human culture and activities. A lot of activities are carried out in these streams like for drinking water, bathing, and irrigation and for water turbines. Water is much more effective agent in linking landscape elements. Therefore, streams and water system can be considered as the functional part of the landscape by exchanging the organisms, energy and also for the transportation. The geographical dynamics and hydrological flow in river systems affects the spatial and temporal patterns of this system. The effect of these physical forces on the spatial dimensions of river ecology is immediate. Therefore, the stream chemistry and inputs of detritus and woody debris are affected by the composition and structure of the surrounding terrestrial landscape.

Rivers and streams are influenced by the landscape through which they flow and therefore the landscape that features river is called as riverscape (Hynes 1975, Vannote et al. 1980). In addition to this,

any changes in the terrestrial landscape leads to changes in the riverscape in terms of habitat which later on influence the biological diversity of streams. Freshwater fish population are consequently driven by a complex interaction between landscape and riverscape. The interactions between mobile fish species and their environment can be understood by investigating different habitats of the riverscape as fish ecology and their movements are the best way to indicate the state of the riverscape which finally depicts the changes in the landscape. This can be described as the deforestation in the terrestrial landscape reduces the woody debris in the streams affecting the channel morphology, decreasing invertebrate biomass which directly affects the fish diversity and densities (Wright and Flecker 2004).

Fishes in general provide a range of benefits including a means of livelihood and a source of protein supplement for many people. These resources also create a means of rejoice for the time along with the thrill of catching fishes. Especially young people those who are studying are very much interested in catching fish as a means of recreation and also for free proteinaceous food. Despite the apparent importance of fishes and other freshwater aquatic resources for large numbers of people, conservation and sustainability often fail to recognize their role. As a consequence, it seems that these resources and the benefits that they provide are increasingly overexploited and will decline in the near future. Harmful practices like bleaching powder etc. are practised for catching fish to save the effort and time for getting large amount of fishes without knowing its sustainability.

There is a paucity of information available on fishes in the Askot landscape with an indicative plan submitted by PEACE which states about 7 fish species are found in this landscape (PEACE, 2007). In the management plan of Pithoragarh (2011-2021) around 74 species were reported from the Kali River which is for the entire Pithoragarh district including the lower elevation also. However, there is no information available in the Askot landscape on the fish assemblage structure in different streams and their associated habitat.

An understanding of the health and condition of a stream habitat, species diversity and distribution are the key factors.

So the present study was intended to document baseline information on fish species and their associated habitat in Askot landscape; identify the human impacts on the stream community and also to identify the indicator species for monitoring aquatic ecosystem. In this background the following objectives were undertaken.

1.2 Objectives

1. To develop a baseline characterization for stream habitat and associated fish assemblage structure in Askot landscape.
2. To identify the human induce impact on stream ecosystem in selected streams of Askot landscape.
3. Identify suitable indicator fish species for monitoring the aquatic system.

Chapter 2

Study Area

The Askot Conservation Landscape is located in Eastern Kumaon of Western Himalaya, in the state of Uttarakhand. It lies between the coordinates 80° to 81° 5' E Longitude, and 29° 5' to 30° N Latitude encompassing an area of 4463 sq. km. There is a great altitudinal range within the landscape, from 560 m MSL at Jauljibi, to 7434 m at the summit of Nanda Devi East. The Major River systems of the Askot landscape consist of Gori in east, Kali in Southwest and Dhauli River in the central part of landscape. Gori River originates from two headwaters- the eastern branch having its rise in a glacier south of the Untadhura ridge and the western originating from a glacier near Milam and finally joins the Kali River at Jauljibi which is famous for its annual trade fair.

Kali is the largest river in Kumaon both in respect of volume of water as well as extent of the catchment area. There are two headwaters of the river Kali- the Kalapani, the eastern headwaters which is a collection of springs, and the KutiYangti, the western headwaters that rise in the snowfields of the Himadri on the southern slopes of the main Himalayan range. After their confluence at Gunji, the Kali flows in a southwesterly direction upto 120km where Gori River meets. One of the major tributary of Kali is Dhauli originating from Lissar Glacier and it joins Kali River at Tawaghat. All these river system comprises of freshwater ecosystem which provides a wide range of habitats like Run, Riffle, Pool, Cascade etc. In the present survey a total of 18 streams covering Gori, Kutiyangti and Dhauli rivers were sampled and the sampling locations is given in Figure 1 and summary of sites is given in Table 1.

Stream Order

A different approach to classification of streams types arises from the branching pattern of river channel in any of the drainage basins. These are categorized according to the order of streams which is defined as follows: first order streams are those having no tributaries, second order streams are formed by joining of two first order streams, third order streams are formed by the junction of two second order streams and so on (Fig. 2). On the

basis of this classification most of the streams found in the Askot landscape belongs to second and third order.

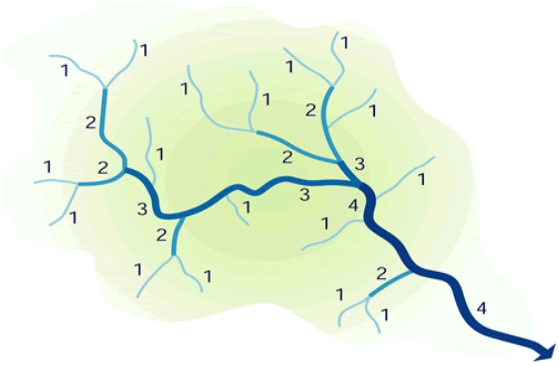

Figure 3. Diagram showing the classification of stream orders

Stream Characters: The physical characteristics of the stream are determined by the interaction between the range of factors including climate geology, topography, channel steepness and land use which directly control the hydrology of the water system. These processes interact with the multitude scale of the parameters in their own. The most obvious feature of the stream is lotic system which means flowing water. These streams are started from the headwaters which later fall down and meet the other downstream rivers. Various streams are shown in the map ahead.

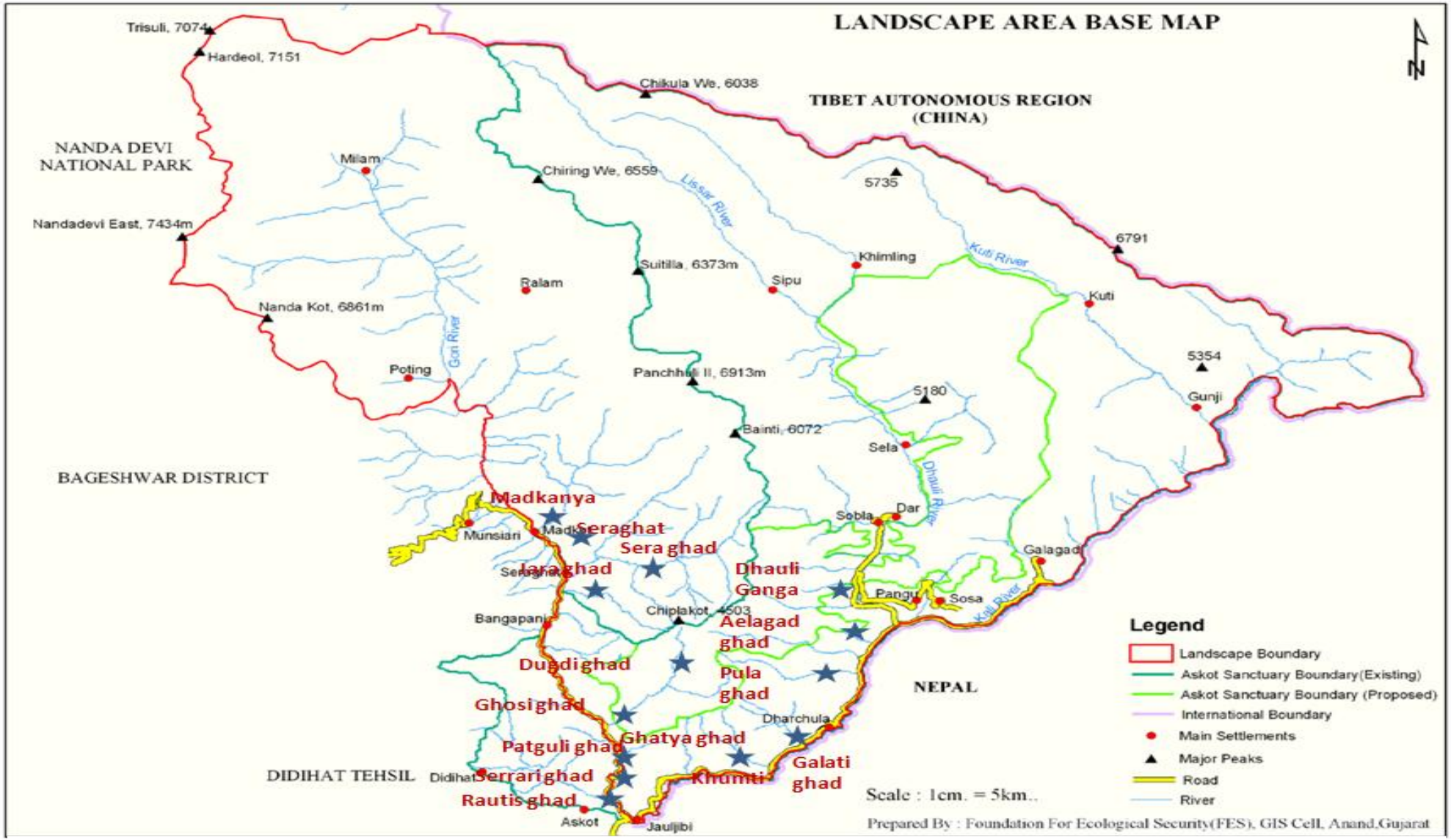

Figure 1. Map showing different sampling locations in Askot Landscape

Table 1. Summary of sampling sites in Askot landscape

S. No.	Site name	GPS Location		Altitude	Landuse Pattern
		Latitude	Longitude		
1.	Rautis	29°46´26.8´´	80°21´22.0´´	620cm	Left Bank-Bed Rock,boulders,Right Bank-Agricultural land
2.	Serrari	29°47´22.1´´	80°21´44.3´´	685cm	Left Bank-Forest area, Right Bank-100m ahead settlement
3.	Ghosi Downstream	29°51´09.6´´	80°21´16.7´´	815cm	Left Bank-Settlement,Right Bank-Commercial(Shops)
4.	Seraghat	30°01´16.2´´	80°20´06.2´´	877cm	Left Bank-Grassland ,Right Bank-Steep hilly mountain
5.	Shera	29°59´39.0´´	80°19´10.2´´	1119cm	Left Bank-Agricultural land,Right Bank-Barren land
6.	Madkanya	30°03´38.3´´	80°17´50.3´´	1261cm	Left Bank-Natural forest,Right Bank-Barren land
7.	Dugdi	29°52´53.3´´	80°19´51.0´´	948cm	Left Bank-Forest,Right Bank-Forest area
8.	Ghosi Upstream	29°53´58.0´´	80°24´26.4´´	1478cm	Left Bank-Forest,Right Bank-Agricultural & Settlement
9.	Chali	29°53´45.9´´	80°24´22.4´´	1450cm	Left Bank-Rocky montain,Right Bank-Forest
10.	Aneri	29°53´41.9´´	80°24´11.8´´	1414cm	Left Bank-Settlement, Right Bank-Natural forest
11.	Patguli	29°50´08.2´´	80°21´35.2´´	740cm	Left Bank-Road & above settlement,Right Bank-Agricultural land
12.	Ghatya	29°48´23.6´´	80°25´16.6´´	828cm	Left Bank-Settlement area,Right Bank-Settlement
13.	Khumti	29°48´59.7´´	80°28´24.8´´	1128cm	Left Bank-Civil forest, Right Bank-Rocky mountain
14.	Chari	29°52´17.6´´	80°20´14.9´´	948cm	Left Bank-Van Panchayat forest,Right Bank- Forest area
15.	Bheri	29°52´45.1´´	80°18´51.2´´	907cm	Left Bank- Forest area,Right Bank- Forest area
16	Galati	29°50´56.7´´	80°30´21.3´´	693cm	Left Bank-Rocky Steep mountain,Right Bank-Nursery of forest div.
17.	Aelagad	29°55´35.9´´	80°33´51.0´´	1157cm	Left Bank-Steep mountain,Right Bank-Civil forest
18.	Dhauli	29°58´23.5´´	80°35´51.5´´	1186cm	Left Bank-Rocky Steep mountain,Right Bank-Agricultural land

Chapter 3

Methodology

3.1 FISH SAMPLING

Fish sampling was done in all study streams of Kali and Gori rivers based on the methods of Johnson et al. (2012). Sampling was done in different habitats like run, riffle and pool from January 2013 to June 2014 covering three seasons such as Intermediate, Summer and Post-monsoon. Sampling was performed streams falls under 2nd and 3rd order categories. At each site 100 m section of the stream was selected for fish sampling. Fish sampling was performed using different nets such as cast net, monofilamentous gill net (Fig. 2) of varying sizes (16 to 30mm); drag net, scoop net and also using fishing hooks. After collection fishes were photographed, length and weight measurements were taken using measuring board and top pan balance. After the measurement fishes were released back into the streams. Specimens of few unidentified fish species were preserved in 10% formalin for species conformation. Fish species were conformed based on Jayaram (2010), current valid taxonomic names as given in Catalog of Fishes, California Academy of Sciences were followed (Eschmeyer, 2014).

[a]

[b]

Figure 2. Fish sampling in stream habitat using different fishing gears (a- gill net operation; b- cast net operation).

3.2 Habitat Inventory

At each study stream the major habitat characteristics such as channel morphology, habitat structure (depth, flow and substrate categories) and water quality parameters were quantified based

on Pusey et al. (1993) and Johnson et al. (2012). At each study site (100m reach) different types of habitat such as pool, riffle, cascade and run were identified. Length of each habitat and width of the channel at different interval was recorded. Across the channel at every 2m interval depth, flow and substrate categories were recorded. Depth was measured using depth rod, velocity was recorded using pygmy water flow meter and substrate types were quantified visually. In addition to that, the following six stream variables were recorded: Stream order, Altitude, GPS Co-ordinate, Water temperature (°C), Stream characters, Riparian type and cover (%).

- **Stream Order:** It is the way to define the size of streams. The smallest tributary is referred to as first order stream and no other stream feeds them. Two such first orders join to form 2nd order streams and so on. First to third order streams are called headwater streams and fourth to sixth are called as medium sized stream (Strahler, 1952).
- **Altitude:** Altitude is defined as the vertical distance of a level measured from mean sea level. Altitude is the surrogate variable for temperature and gradient. It has a great influence on the distribution fishes.
- **GPS Co-ordinate:** It provides the geo-location and time information anywhere on the Earth.
- **Temperature:** Water and air temperature were recorded with thermometer in degree Celsius at every sampling site. Temperature impacts both the chemical and biological characteristics of water, which in turn influences the distribution of aquatic organism.
- **Stream characters:** Stream character comprises of the substrate identification. Substrate composition ranges from silt/clay sized particles to boulders and bed rock elements. It is visually estimated on the basis of six size classes-Bedrock, boulder, cobbles, gravel, silt, leaf litter which indicates the habitat of fishes. It also includes the flow of water and can be classified on the basis of four parameters-fast flowing, moderate, slow and zero (Pusey et al. 1993).

- **Riparian type and cover:** These include the vegetation community along the stream bank. Aquatic organisms are highly dependent on the riparian vegetation as major food resource (fallen leaves; woody debris, fruits, flowers, insects from plants etc.) to stream communities. The shade of the plants also provides habitat to fishes. The area of canopy was estimated in terms of percentage using densiometer.
- **Land use pattern:** Land use pattern incorporates the usage of land alongside the streams as it affects the water quality of the stream. The basis of classification of land use pattern is as follows- Barren land, agricultural land, settlement area, Industrial area etc.
- **Human Dependency:** Human dependency includes the usage of fishes by people. Human dependency is seen in terms of the number of people engaged in fishing, income generated by the people out of fishing, preferred fish species, methods of fishing etc.

3.3 Measurement of water quality

In the present study six water quality parameters such as pH, Conductivity, Dissolved Oxygen, Turbidity and Water temperature were recorded in each of the study streams based on the follows procedures:

pH: The pH of water is a measure of how acidic or basic it is on a scale of 0 to 14, with 7 being neutral. The pH reading below 4.5 indicates that there is strong mineral acidity, which is typically harmful to fish and difficult (expensive) to neutralize.

Conductivity: Conductance of water is mainly based on the amount of dissolved salts (anion and cations). Freshwater fishes thrive over a wide range of conductivity, but distribution of stream fishes are influenced by conductivity of water. Conductivity of water was recorded using electrical conductivity meter.

DO: Dissolved oxygen is the amount of oxygen diffuses into the water from the air especially where the surface is turbulent. Water also obtained oxygen form photosynthesis of aquatic plant community.

Turbidity: Turbidity is a measureof water clarity how much the material suspended in water decreases the passage of light through the water. Suspended materials include soil particles (clay, silt, and sand), algae, plankton, microbes, and other substances. More turbidity means less productivity which affects the fish populations.

Water temperature- Water temperature is the most important factor for distribution of fishes. All fish species have a preferred temperature range.

Figure 3. The researcher is recording different water quality parameters in streams of Askot Landscape

3.4 Identification of human disturbances

Human community depends on the aquatic resources for many purposes, which includes water for drinking, bathing, washing, fishing, irrigation etc. These interventions are ultimately affect the structure and function of the aquatic habitat. In the present study the major human-made activities along the aquatic habitat were recorded based on the direct observation at study site as well as by questionnaire survey.

To know the disturbance level in each of the stream, score values were generated as 1 for low, 3 for medium and 5 for high disturbance. With the help of these score values cluster analysis were performed using XLSTAT software. Cluster analysis is a major technique for classifying the information on the basis of same attributes that make them similar.

3.5 Human dependency

Human dependency on fishery resources in streams of Askot Landscape was evaluated based on the preliminary socio-economic survey along the Gori River valley. This survey involved formal interviews with fisherman, aquaculturist, fish seller and hotels/ restaurants located within the vicinity of study streams. A total of 70 people were interviewed. Basically, snowball sampling technique was adopted for this survey, it is a non probability sampling technique which is used to conduct the survey and asking

people to nominate others having the same traits. About 10% of the people in a village/ study area were interviewed from March 2014 to June 2014 for human dependency survey.

3.6 Selection of indicator species

Fish serves as excellent indicators of biological integrity due to the continuous exposure of them to the water system. Slight change in aquatic habitat due to the disturbances like habitat alteration, pollution, chemical fertilisers, fishes display a variety of responses. Therefore, fishes are considered as good indicators and can become a part of any monitoring program for biological conservation as they can warns early sign of changes. For identification of indicator species certain criteria (Table 2) were followed from the research article on “Faunal indicator taxa selection for monitoring ecosystem health” by Hilty and Merenlender (2000). The followings are the baseline criteria and attributes for selection of indicator fish species used for selection of indicator species for monitoring aquatic habitat in Askot Landscape.

Table 2: Criteria adopted for selecting indicator fish species

Baseline Information	Attributes
Clear taxonomy	Taxonomic status clear
Biology and life history studied	>30 primary literature articles
Tolerance levels known	Tolerance levels studied
Locational Information	
Distribution	Not migratory
Limited Mobility	Home range size small
Early warning and functional over range of stress	Small body size
Trends detectable	Low or medium trophic level
Specialist	Food/habitat specialist
Easy to find and measure	Easy to find
Other	
Taxa representing multiple agendas	Species at risk
	Economically valuable

Also followed the research paper "A holistic approach to ecosystem health assessment using fish population characteristics" by Munkittrick and Dixon (1989) in which the response of the fish population to the disturbances was identified on the basis of species response.

3.7 Data Analysis

Fish Assemblage structure is very essential as seasonal patterns make it necessary to sample repeatedly and understand all of the fishes in a particular area covering all seasons. Information was obtained from the streams of Askot landscape like Shannon index, evenness index and species richness index to understand the assemblage structure. The calculation of these indices were followed the methods of Johnson et al. (2012). The Shannon index of diversity was calculated using the formula**,** $H' = -\sum pi \ln (Pi)$. In which, $Pi=ni/N$; ni - is the number of individuals and $N=\Sigma ni$. Evenness index was calculated using formula $J'=H'/\ln S$, where S - is number of individuals of all species and H' - is Shannon index. Species richness index is calculated using the equation, $R=S-1/\ln N$, where S - is number of species; N - is total number of individuals. These indices were used to compare the species diversity, richness and evenness index in the streams of Askot landscape. For the habitat characterization each category of depth, flow and substrate was recorded in all seasons. Mean values of depth, flow and substrate was compared in different seasons using the graph depicting the effects of seasons on stream habitat. To know the relationship among the indicator species distribution and disturbances with streams Canonical Correspondence Analysis (CCA) was performed. This is a direct gradient ordination technique to relate species distribution in the multivariate space described by disturbances. CCA was performed using the XLSTAT software. The biplot is an ordination diagram in which sites are represented by blue points and disturbances with red points.

Chapter 4

Results and Discussion

4.1 BASELINE INFORMATION

4.1.1 Fish Assemblage structure and distribution pattern

A total of 12 fish species belonging to 2 order, 3 family and 9 genera were recorded from the Askot landscape. Among the recorded species, the snow trout *Schizothorax richardsonii* was recorded in most of the study streams. Very rare and highly specialized cat fish *Parachiloglanis hodgarti* was recorded from four streams along the Gori and Kali River basin. Cyprinids were the dominant members of the assemblage structure in the study area. During the winter season fish assemblage structure across the sampled streams comparatively low and maximum numbers of species were recorded in Patguli Ghad and Khumti Ghad, where 4 species of fishes were recorded. This is probably due to low water temperature which may not be suitable for warm water species. Low fish diversity in Askot landscape could be because of low water temperature, low order and snow melt waters in streams. The detailed information on each study stream and associated species recorded from Askot landscape is given in Table 3.

The Shannon index, evenness index and species richness index are given in the graph (Fig. 4) for all the study sites with a comparison among the different seasons which are calculated using the different formulas.

Table 3. List of fish species recorded in streams of Askot Landscape between 2013 and 2014 (Numbers in the upper row are site information: 1-Rautis, 2-Serrari, 3-Ghosi, 4-Seraghat, 5-Shera, 6-Madkanya, 7-Dugdi, 8-Ghosi Up, 9-Chali, 10-Aneri, 11-Patguli, 12-Ghatya, 13-Khumti, 14-Chari, 15-Bheri, 16-Galati, 17-Aelagad, 18-Dhauli).

Fish Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Schizothorax richardsonii	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Barilius bendelisis	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Barilius vagra	-*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Naziritor chelynoides	+	+	-	-	-*	-	-	-	-	-	+	+	+	+	+	+	-	-
Garra gotyla	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tor putitora	-*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nemacheilus montanus	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-*	-	-
Nemacheilus rupecola	-	-	-	-	-	-	-	+	-	-	-	-*	-	+	-	-	-	-
Nemacheilus multifasciatus	-	-	-*	-	-	-	+	+	-	-	+	-	-	+	-	-	-	-
Parachiloglanis hodgarti	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-*	-	-
Glyptothorax	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Pseudoecheneis sulcatus	-**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

*found in summer season

** found in post monsoon season

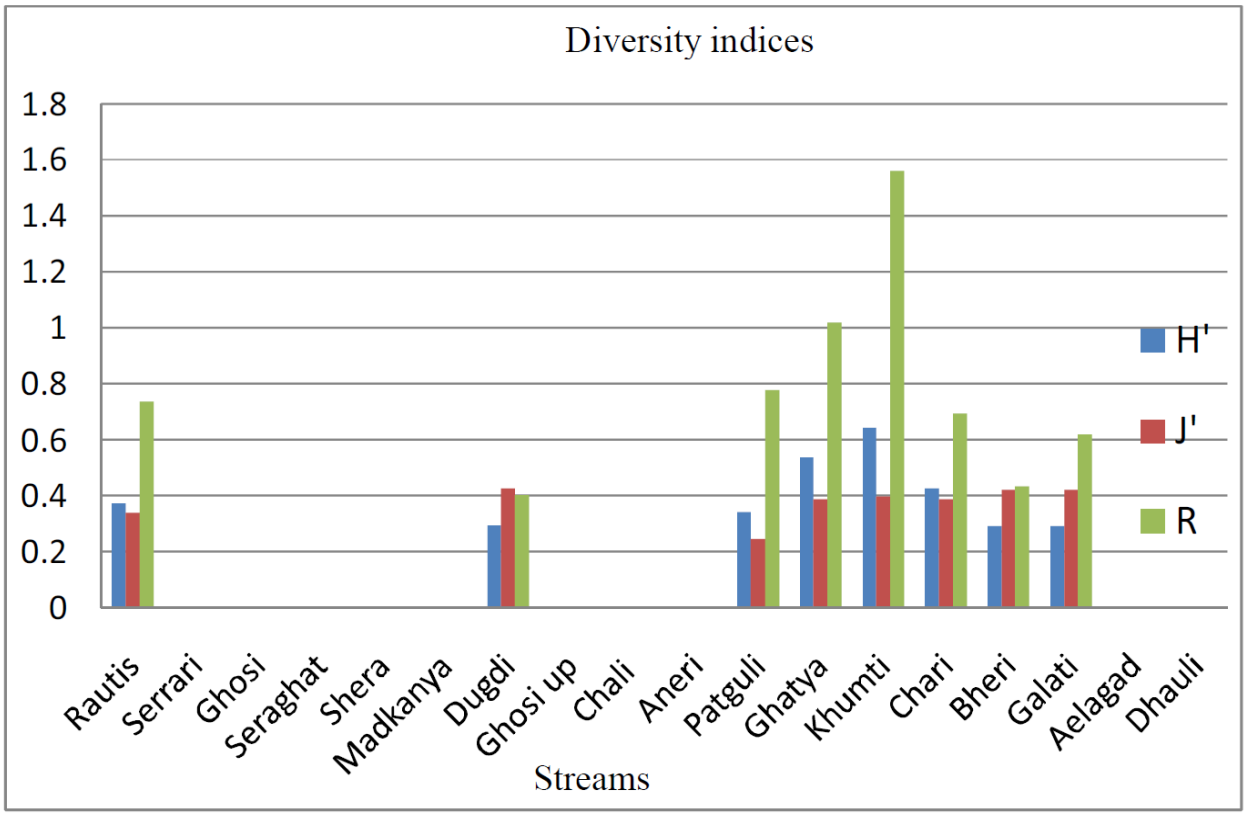

Figure 4. Fish diversity recorded in streams of Askot landscape (H' - Shannon index; J' - evenness index ; R - species richness index).

The result of diversity analysis indicates that many streams scored zero diversity index, because they has only fish species i.e. *Schizothorax richardsonii*. High value of Shannon diversity index (H') was recorded in Khumti stream with high species richness, whereas evenness was low when compared to other streams. The reason for high diversity is mainly due to the geo-position of the habitat as it is situated in the low elevation area with warm temperature zone in comparison to other streams. The low evenness encountered in this stream is mainly because of low abundance of species like *Parachiloglanis hodgarti*. Some of the major fishes recorded from Askot landscape are given in Figure 5 (a) & (b).

4.1.2 Habitat Variables

The habitat variables show great variability among the different seasons (intermediate, summer and post-monsoon seasons). During summer high flow was registered in Rautis and Madkanya streams (Fig. 6). Similarly, mean depth of the channel also greater in summer season. This is mainly because of melting of the ice during summer, which resulted in more volume of water in streams of Askot landscape (Fig. 7).

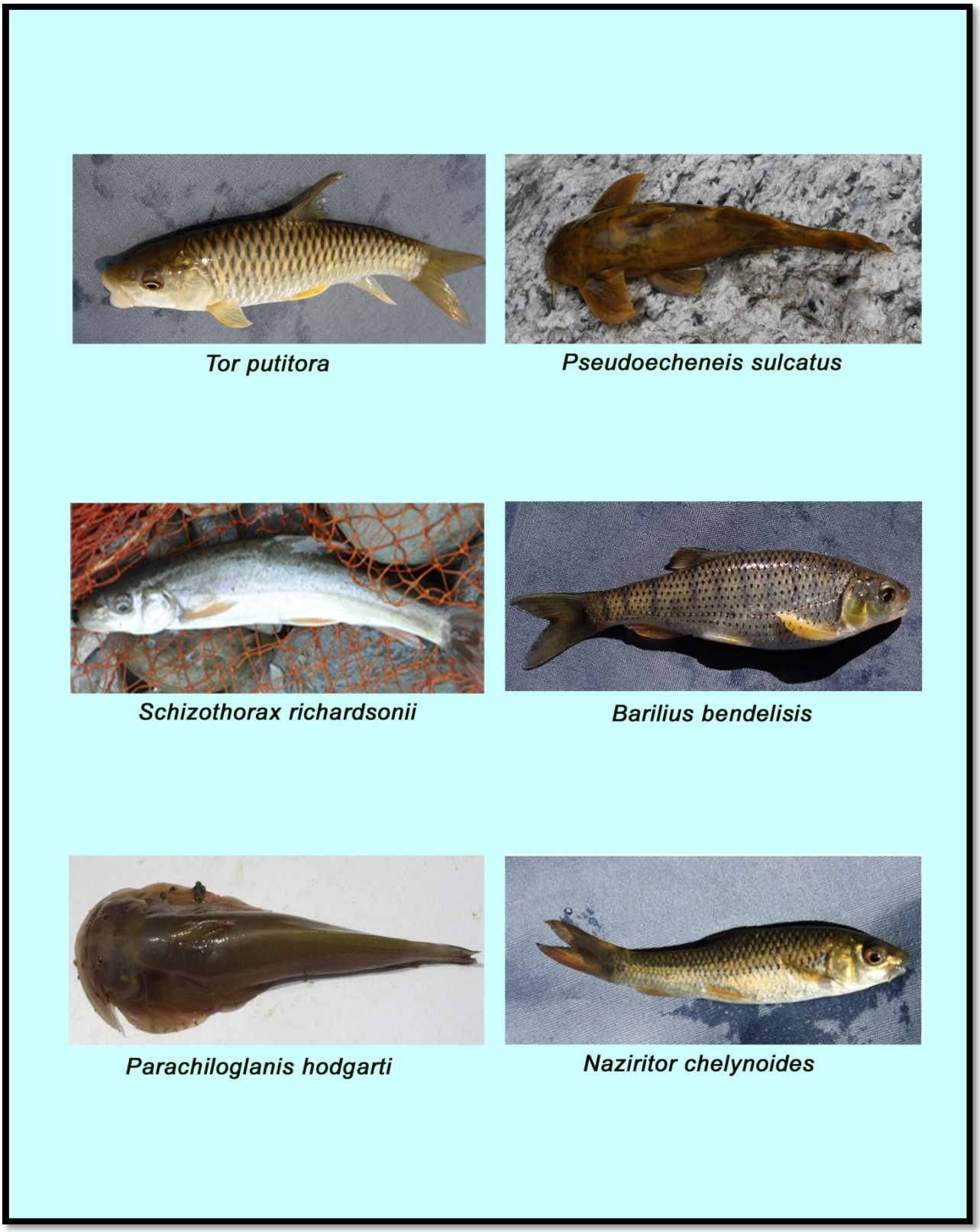

Figure 5(a). Fish species recorded from Askot landscape.

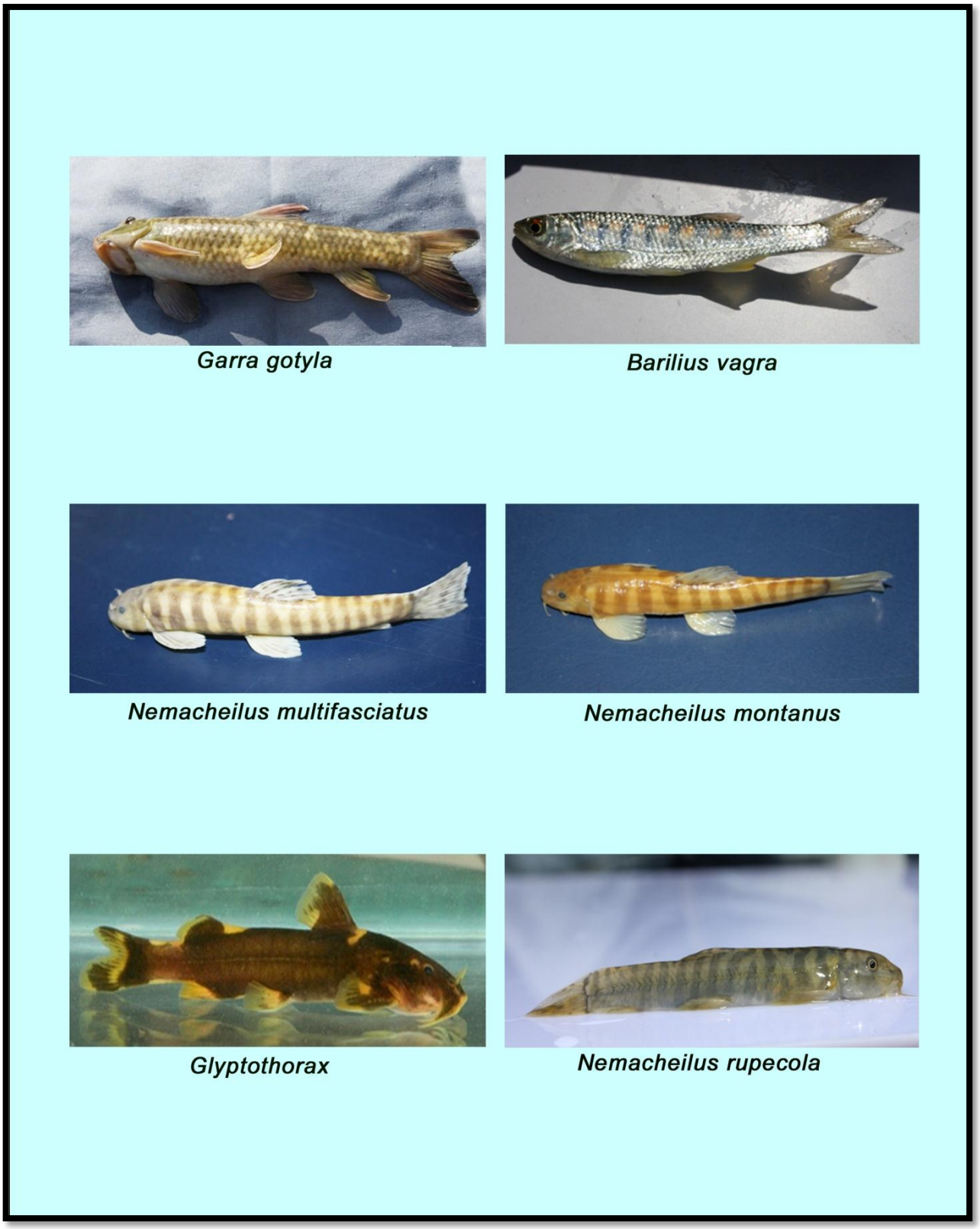

Figure 5(b). Fish species recorded from Askot landscape

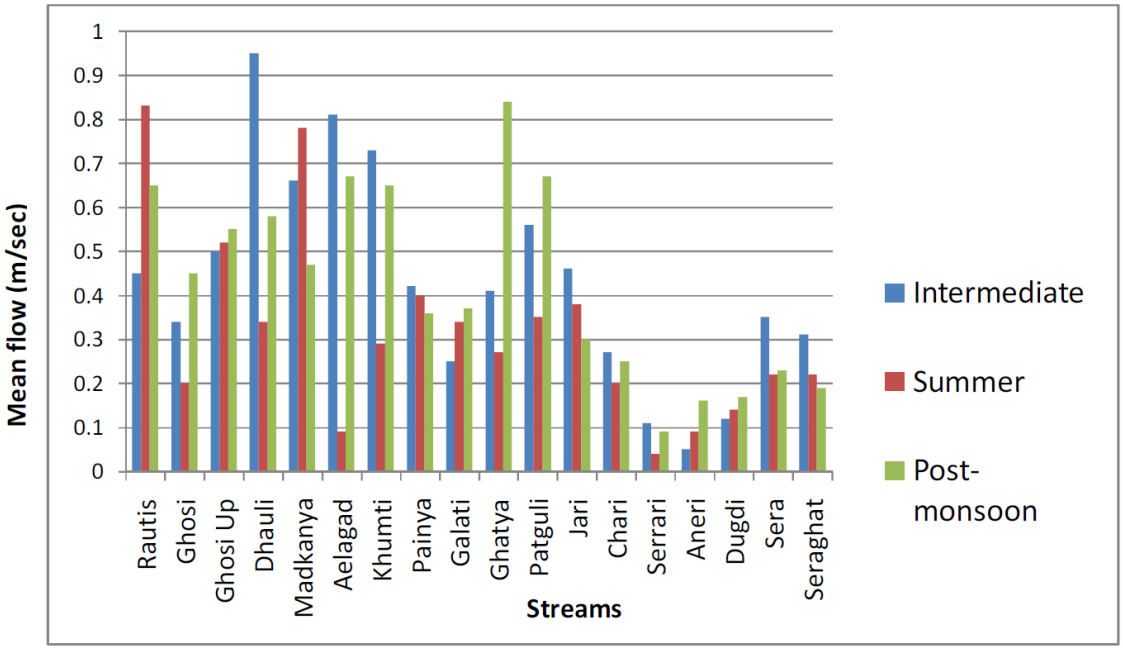

Figure 6. Showing the variation of flow across three seasons in streams of Askot landscape.

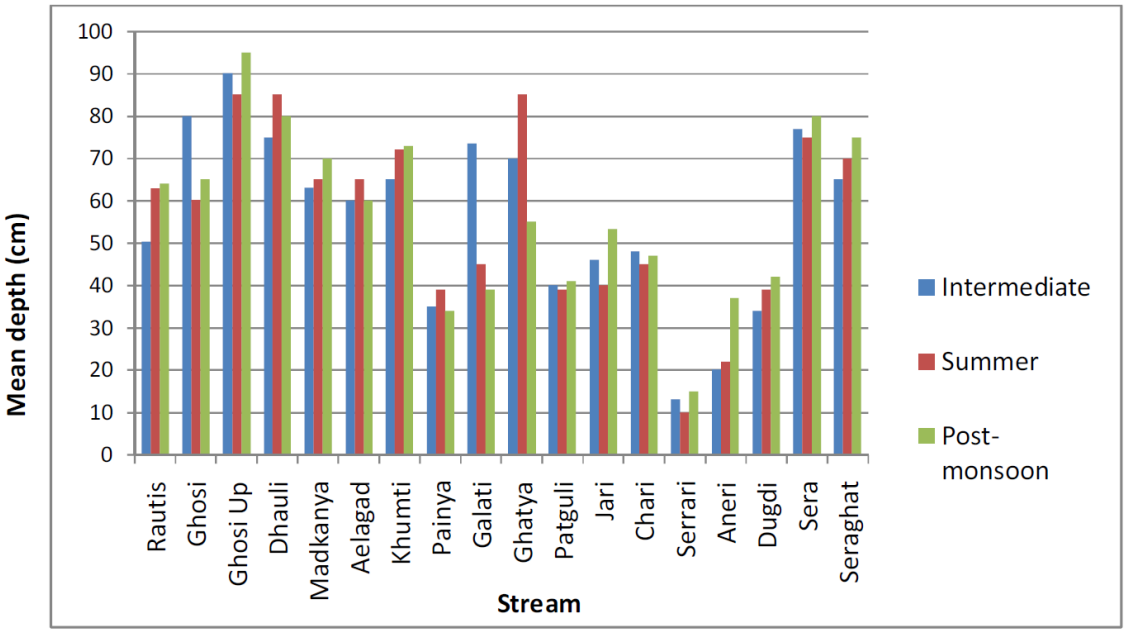

Figure 7. Showing the variation of depth across three seasons in streams of Askot landscape.

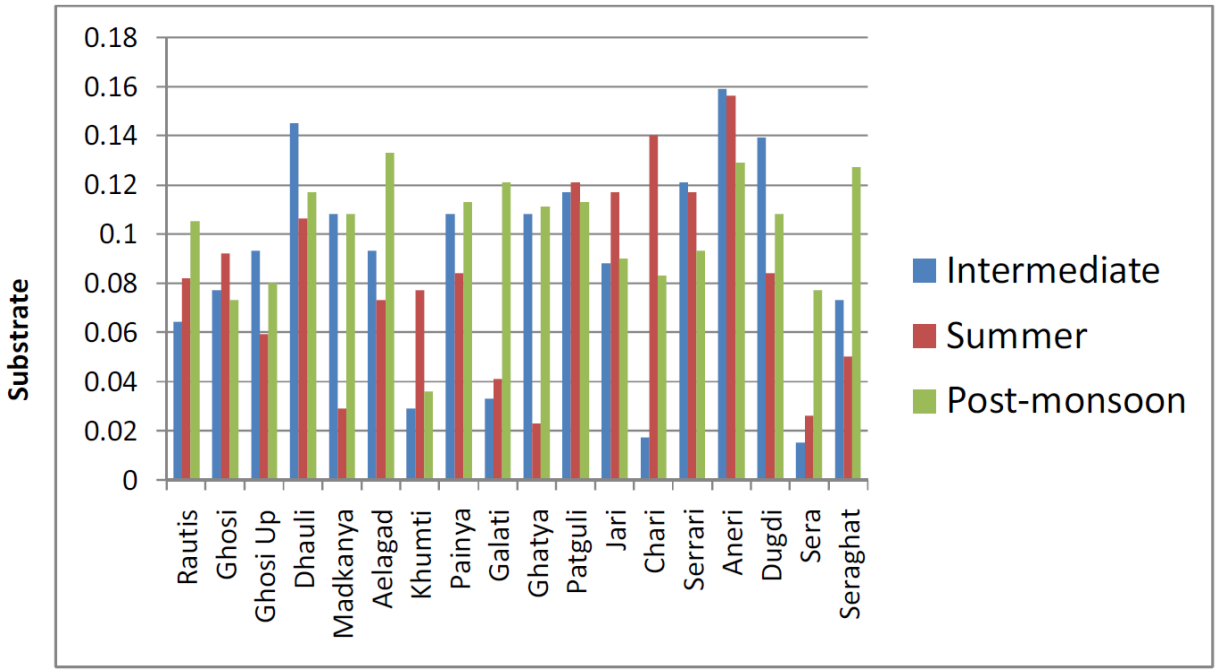

Figure 8. Comparison of substrate in different seasons of intermediate, summer and post-monsoon.

Substrate depends upon the depth of the water as depth increases in the summer season the substrate got reduced and when depth got reduced in the winter season the substrate get increased (Fig. 8).

4.2 Identification of human stresses

Twelve different kinds of human made impact were observed along the study streams. Among which some of the activities like bathing and washing cannot be considered as disturbance because fast flowing streams they may not create any harm to the stream community. Hence, those minor disturbances were excluded for further analysis (Table 4).

Score values were assigned to all the disturbances recorded in the landscape on the basis of questionnaire survey (Table 5). Based on the score matrix, it is found that the stream Serrari has no disturbance as the stream is of very small size and far off from the human habitation, whereas Rautis, Ghosi and Jari had more intense disturbance like dynamiting, bleaching and water diversion. The cluster analysis formed of all the disturbances are grouped into four clusters that are less disturbed, water diversion, sand mining and regulated water. The streams which come under particular cluster have that disturbance in majority (Fig. 9).

Table 4. List of total disturbances recorded in the streams of Askot landscape and considered disturbances for the freshwater.

12 Disturbances	Considered disturbances
Seawage	Electrofishing
Washing	Bleaching
Bathing	Water diversion
Electrofishing	Dynamite
Bleaching	Regulated water (Dam)
Dynamite	Sand mining
Gill net	
Water diversion	
Water mill	
Sand mining	
Dam	
Agriculture	

Table 5: Different disturbance level were observed across streams of Askot landscape with score values (1=less disturbance, 3=medium & 5=high disturbance).

Sites	Electrofishing	Bleaching	Dynamite	Water diversion	Sand mining	Dam
Rautis	1	3	5	3	1	0
Ghosi	1	3	5	3	1	0
Ghosi up	1	1	3	1	0	0
Dhauli	1	5	3	1	0	5
Madkanya	1	1	1	1	1	0
Aelagad	3	1	1	1	0	0
Khumti	3	1	3	3	1	0
Painya	1	1	1	5	5	0
Galati	1	5	1	1	3	0
Ghatya	3	3	3	3	3	0
Patguli	0	3	3	5	1	0
Jari	1	3	5	3	1	0
Chari	0	1	3	3	1	0
Serrari	0	0	0	0	0	0
Aneri	1	1	0	3	1	0
Dugdi	1	1	3	3	1	0
Sera	1	3	5	1	1	0

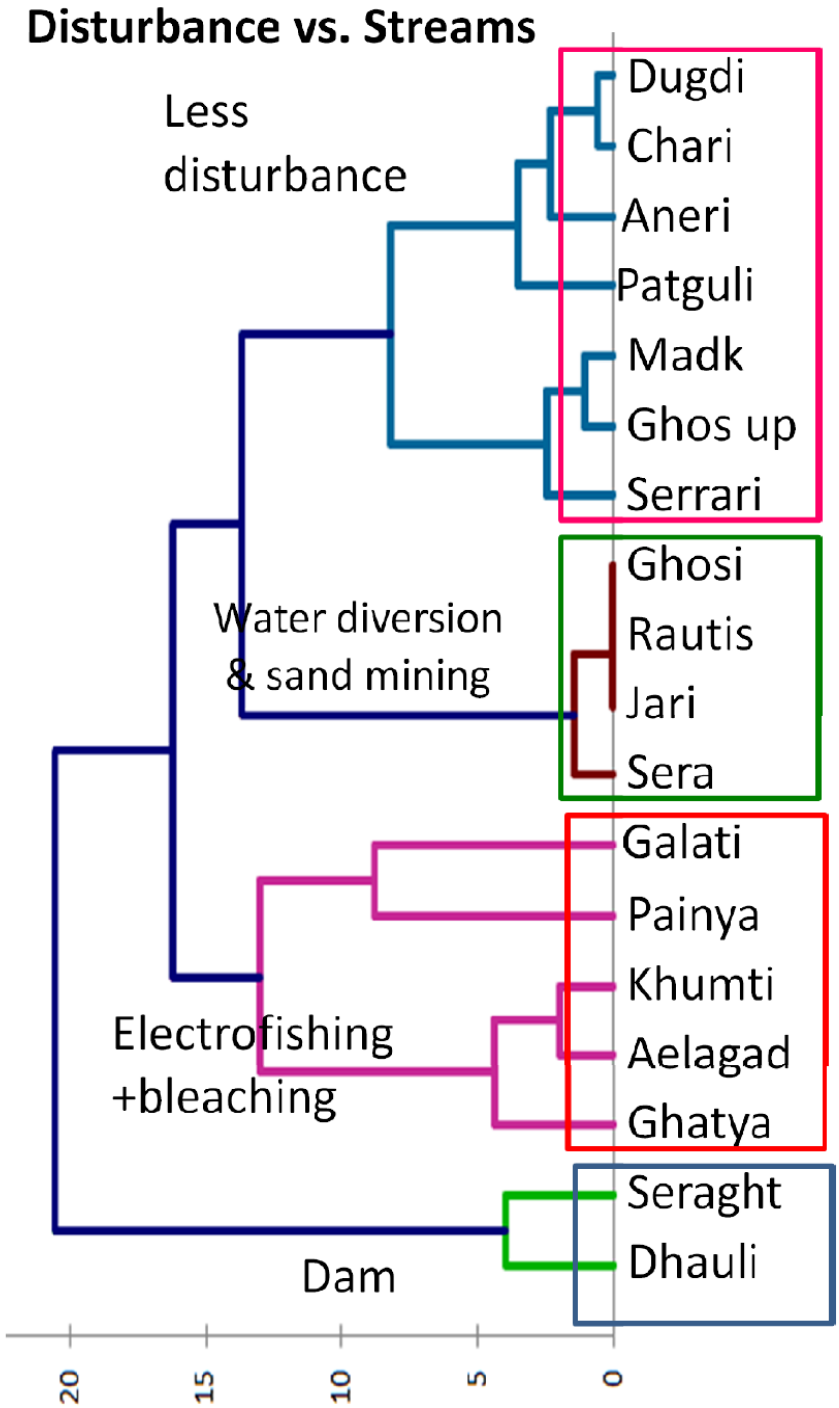

Figure 9. Dendrogram produced based on the site disturbance score matrix.

These disturbances like water diversion, sand mining, regulated water destroys the natural habitat available for fishes leading to destruction of feeding and feeding habitat of fishes, which in turn affect the distribution and abundance of fishes. Some of the images depicting major disturbances/ destructive fishing practices in streams of Askot landscape are given in Fig. 10.

4.3 Identification of Indicator species

For identification of indicator fish species for monitoring the stream habitat, all the fish species recorded from the study area were matched with the indicator criteria mentioned in the methods. Based on the criteria analysis, it is found that the species *Schizothorax richardsonii* and *Naziritor chelynoides* are matching with all the indicator criteria.

Water diversion

Water mill

Sand Mining

Figure 10. Pictures showing human-made alteration made in streams of Askot landscape.

Since this two species have considerable information on biology and taxanomy and they have wide distribution record across the landscape and local people are well aware about these species. Further, it is found that these species have limited mobility within the stream habitat and both the species are specialized in terms of food and habitat as *Schizothorax* is herbivore fish which prefers fast flowing streams and *Naziritor* is an omnivorous fish preferring clear pool habitat. Both the species are locally preferred as food fish by local community.

The cluster analysis showed the different clusters of high disturbances found in the streams. Then the CCA is performed between disturbances and two indicator species to know the effect of the disturbances on the fish species (Fig.11). It is found that *Schizothorax* is distributed in almost all the disturbed areas and *Naziritor* is associated with less disturbed streams when compared to *Schizothorax*. Stream serrari is quite far off in the cluster which shows least disturbance, which inhabits both *Naziritor* and *Schizothorax*.

Table 6: Indicator species criteria with Askote landscape indicator species attributes

Characteristics	Attributes	*Schizothorax* sp.	*Naziritor* sp.
Baseline Information			
Clear taxonomy	Taxonomic status clear	Yes	Yes
Biology & life history studied	>30 primary literature articles	Available	Available
Tolerance levels known	Tolerance levels studied	Not known	Not known
Locational Information			
Cosmopolitan distribution	Non migratory	Yes	Yes
Limited mobility	Home range size small	Yes	Yes
Niche & Life history characteristics			
Early warning	Small body size	Yes	Yes
Trends detectable	Low or medium trophic level	Yes	Yes
Specialist	Food/habitat specialist	Specialized	Specialized
Easy to find & measure	Easy to find	Yes	Yes
Other			
Taxa representing multiple agendas	Species at risk	Vulnerable	Vulnerable
	Economically valuable	Yes	Yes

As *Schizothorax* is found in all the disturbed areas so it is quite a tolerant species whereas *Naziritor* is sensitive avoiding the disturbances. So in this way both the fish species are considered the two indicator species. However, the population structure of these species with reference to level of disturbance is not known. Hence it is necessary to investigate the density and abundance of different life history traits of these species for further validating indicator species.

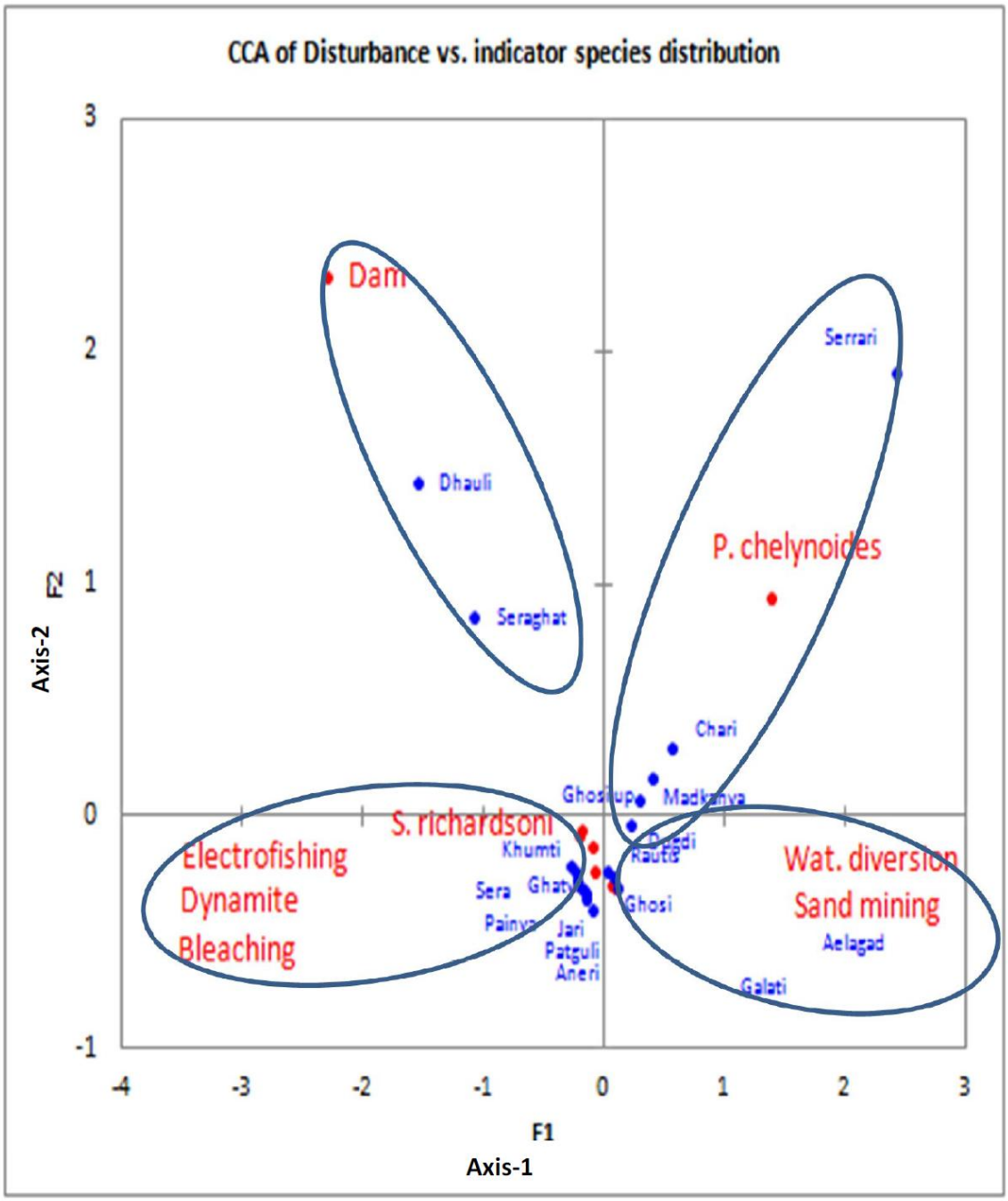

Figure 11. Canonical Correspondence Analysis (CCA) plot depicting eighteen sites disturbance scores along with fish distribution.

4.4.1 Dependency of local people on fishes

Fish resources in this landscape play an important role in providing food and income to the local people. One of the aims of this study is to identify how much fishery resource is utilized by local community from the streams of Askot landscape. Based on the questionnaire survey, it is found that the dependency of people on fishes is mainly for sport and not for earning as such. Mostly the young generation people catch fishes for fun, recreation and a small amount of money.

4.4.1 Fish Catching Methods in Askot Landscape

In order to manage fisheries in running waters different gears have been used in different seasons. At different times different gears are used for catching more amounts of fishes. Because of catching fish more in less time people also evolve some destructive methods of catching fish. So in this way methods of catching fish can be classified into 3 ways-

Conventional methods: Local people use various conventional methods to catch fishes mainly for their domestic consumption. Some of these methods are ecofriendly but many of them are destructive, too. These methods are applied according to the behaviour, abundance in different seasons, and habitat uses of fish. The intensity of adopting these methods varies with seasons, locations, and species. Most of the methods given below are practiced in small and medium sized streams.

1. **Goda:** At the onset of the monsoon season fish species tend to migrate to small streams from the main river for spawning and while returning back only one point of drainage is kept openand at that point a structure is placed of conical shape made of bamboo sticks, shrubs, wires and stones called *'goda'* so that fishes got trapped into it. As the movement of fish is active during nights so fishes are collected in the morning. The *'Goda'* is placed at high gradient riffle and cascade areas (Fig. 12).

Figure 12 (a). '*Goda'* structure

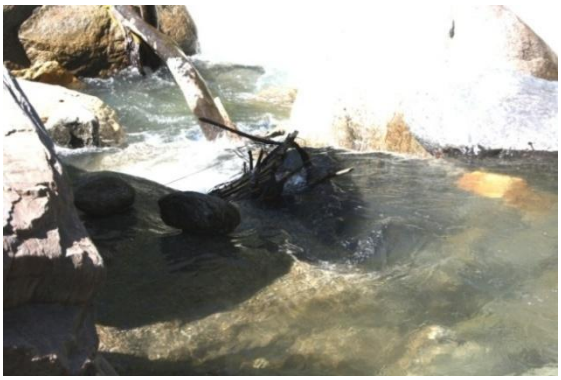

Figure 12 (b). Both the pictures (a & b) are showing the *'Goda'* structure installed in stream channel to catch fish.

1. **Hammering:** Fishes used to reside under the boulders and bed rocks as the safest point. People use to hit the boulders with a hammer by which the fishes got injured and can be easily caught (Fig. 13).

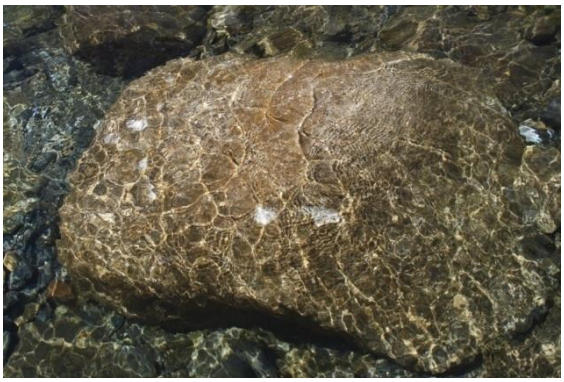

Figure 13. Picture showing the hammer signs on the boulder.

2. **Water diversion:** Water is diverted where two openings are there in the streams. So one stream is blocked using the sacks, stones, silt, plants and water is diverted to the next opening. Then the fishes are easily collected from the blocked part of stream. This is practised in small streams which require 2 to 3 persons (Fig.14).

Figure 14. Water diversion done to catch fish when other channel becomes dry.

3. **Herbal poisoning:** This practice is common in some of the streams. In this method leafs of *Agave*, stem of *Syzygium*, *Sapium* and *Madhuka*sps. are crushed and added into the slow moving pool areas (Fig. 15). This crushed herbal part makes the fishes unconscious and they come to the surface of water which can be easily collected.

Figure 15. Fish collection using herbal poisoning method.

4. **Hand picking:** In small streams people used to catch fish by their hands under the boulders where fish hides.

Commercial methods: Local people use these methods for commercial fishing. These methods are usually confined near the fish markets especially Baram and Jauljibi area. Although, most of the people try to over exploit the fishing resources, these methods will not pose any threat to the fishes if practiced with limitations.

1. **Hooks:** This method is usually used in pre monsoon, monsoon and post monsoon period when the water is more turbid. It is used in river where the depth is high. Nylon rope is tied with 3-4 hooks at different lengths with a bait as earthworm, wheat flour, flour mixed with turmeric powder. It is kept inside the water up to fish are caught (Fig. 16 & 17).

Figure 16. Hook is placed to catch fish

Figure 17. Fish catch using hooks

1. **Suraka:** Nylon rope is there in which at regular intervals noose are there of 10 cm diameter depending upon the fish size to be caught is tied vertically in the stream. Fish got trapped in these nooses which is kept at riffle areas or in fast moving water. It is laid in the evening and fishes are collected in the morning (Fig. 18).

Figure 18. Suraka net showing the noose.

3.Cast netting: It is a commonly used gear to catch fishes in good amount. For which much effort is needed as after several attempts, one can catch fish that too with perfect netting. Cast net are mostly used at less depth areas with heavy sinkers attached at the lower end of the net so that without taking much time net get settle at the bottom and trapping the fishes into it (Fig. 19).

Figure 19. Cast net operation

4.Gill netting: This net is locally called as *'ballvalajaal'* because of the floaters used in it. It is made of nylon thread with different mesh size depending upon the size of fish. At the top thermocol or plastic floats is tied which acts as floaters indicating the presence of the net in the river and at the lower end stones are used as sinkers by which the net lay straight in the middle of the water channel. It is tied vertically across the stream (Fig. 20).

Figure 20. Gill net is placed in the river

Destructive methods: With the advancement in technology and population increase, efforts are made to over exploit the aquatic resources that will yield more fishes in less time and with a little effort. In the process, various destructive techniques are introduced for the fishing activities. The destructive methods are the killers of the entire aquatic organism including the entire life stages of fishes. These include the use of dynamite, pesticides, electric current and other chemicals. These methods are generally adopted by floating population such as road contract workers, labours and vehicle drivers.

1. **Dynamite:** It is one of the easier ways to catch a large amount of fish in less time. People use to choose deep pools for exploding which they used to take from road construction group working in these areas. After the explosion fish become unconscious and people dive inside the pools and catch all of them (Fig. 21).

Figure 21. Fish catch as a result of dynamiting.

2. **Bleaching powder:** This chemical is freely available among the people, because they use this chemical for cleaning water tanks, but people are using it to catch fishes. On adding this powder fish dies and come up to the water levels which are collected. Small fingerlings also die. It is used in slow running waters.

3. **Electrofishing**: This is one of the modern methods, which is practised by many people. A method in which the electric current is passed in the water system to catch fish making them unconscious. All the fishes come up to the water surface. It is practised in shallow pool areas. Sometime people used to carry battery with them for the power source but many times they took the power from the nearby houses of the stream indicating the local people involvement.

4.4.2 Socio-economic profile of Local people

Socioeconomic information was collected using the questionnaires survey. The questionnaire focused on obtaining general information, resources available, income level and sources. Different parts of the questionnaire are described below:

1. **Fisherman:** The fishermen are the youngest group having age from 15 years to 30 years. Mostly school going children are there who catch fishes using the gill nets. There is no fisherman by profession in this

landscape. On an average people catch fish in summer and post-monsoon with 2 to 3kg. Basically, there catch is of *Naziritor, Schizothorax* and *Glyptothorax* in monsoon. Mostly gill nets are used to catch fish. Near Jauljibi and Baram people used to sell fishes, but above Baram the catch is not so high but sometime they sell. Around Rs. 4000 to 5000/ month. are earned by selling fishes in the market.

2. **Pisicultarist:** Not many people are practising fish rearing in this landscape as the demand for fishes is there but threats are there from snakes, birds and proper seeds are also not available to them. On an average 3 to 5 Kg of fishes are produced yearly at 3 times. Continuous water supply is required which is not available at many places. Fishes are also stolen from the tank by other resident people. Many people want to continue fish farming but they don't have proper guidance to do it.

3. **Fish seller:** These are the shops which sell fishes coming from Haldwani every third day. These shops are located in Dharchula because local fishes are not available here in more amounts. So to fulfil the needs of local people fishes are ordered from Haldwani after every third day. About 10 Kg of fish brought here to sold after every third day.

4. **Hotels:** There are small *'dhabas'* which are present at the stoppage point of the vehicles which are in Jauljibi, Baram, Dharchula and Bangapani. Hotels present in Jauljibi and Baram have good business because of fishes as the availability of fishes in these areas is more because of the lower elevation and confluence of river Gori and Kali. In the post-monsoon season fish catch got increased increasing their business. In this season *Glyptothorax* are in good demand by the people because of good amount of flesh and are sold at Rs. 10 per piece.

5. **Villagers:** Most of the villagers prefer eating *Schizothorax* because

of small scales on the body and greater availability in the landscape as it is the most available fish species.

6. **Harvest of Fishes:** The questionnaire survey leads to the catch done by the people along each of the streams. From table 7 it can be said that as the altitude increases (Sites name is in the increasing order of the altitude) the harvest of fishes keep on decreasing.

Because the temperature of water goes on decreasing as the altitude increases making the number of fish species less. In stream Rautis the fish catch is high with different number of fish species as the altitude is low making the water temperature warmer than other streams. Due to the tributary effect and less gradient this stream is having more number of species and individuals too.

Table 7: Summary of fish harvest in different sites on the basis of questionnaire survey.

Site	Catch (1 person per year)	Total no. of people harvest fish from streams	Total harvest (per year in kg)
Rautis	38.56kg	14	539kg
Ghosi	40kg	9	360kg
Jari	23.54kg	16	376.64kg
Rachi	31kg	10	310kg
Motighat	9.16kg	15	137.4kg
Mandakini	15kg	10	150kg

Chapter 5

Outcomes

The followings are the outcomes of the two years study:

- Fish species distribution and their associated habitat in streams of Askot Landscape were generated.

- The major human disturbances along the study streams were identified.

- Based on the distribution of species along the various gradient disturbances two indicator fish species namely *Schizothorax richardsonii* and *Naziritor chelynoides* were identified for monitoring stream ecosystem.
- Dependency of local people on fishery resources and different types of fishing practices adopted by people of the landscape were brought out.

5.1 RECOMMENDATIONS

Askot landscape fish fauna needs high conservation practices because of the increasing use of destructive fishing which includes explosives, bleaching powder, illegal electrofishing, plants toxin for fish like *Agave, Sapium, Glochidion*. These practices lead to destruction of young ones even at fry stage also exterminate the specialized cat fishes like *Parachiloglanis hodgarti*. Another harmful act of people is sand mining for which they divert the water channel and would make pits to excavate the sand by which the natural habitats of fishes get ruined declining the fish populations. Hence, it is necessary to sensitize the people regarding effect of destructive fishing and other activities on fish community.

Since the people of Askot landscape are heavily depend on stream fishes for their livelihood and protein need, culture based fisheries activities should be emphasized in this region through Fishery Institutions, this will minimize the pressure on the natural water resources of the Askot landscape.

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EVALUATION OF FISH SPECIES AS POTENTIAL INDICATOR SPECIES FOR MONITORING AQUATIC ECOSYSTEM: ASKOT LANDSCAPE, UTTARAKHAND

Phase – 1 Report

Biodiversity Conservation and Rural Livelihood Improvement Project (BCRLIP)

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Wildlife Institute of India

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