

Study of Biodiversity in Shivalik Ecosystem of Punjab

By

Neelima Jerath, Puja & J. Chadha (Editors)

A Project of PSCST in collaboration with

ZSI, BSI, IIRS & Punjabi University, Patiala

EXECUTIVE SUMMARY

Biological diversity, comprising the variability of genes, species and ecosystems, is essential for maintaining the basic processes on which life depends and is a key to sustainable development. It not only provides food, medicine and products of commercial and non-commercial use, but also maintains life by providing environmental services like, air and water quality, soil fertility, pest and disease control, waste disposal, etc. However, human activities which have adversely affected the environment, are leading to loss of the planet's biodiversity. The Convention on Biodiversity, of which India is a signatory, makes it mandatory for all nations to inventorise their biodiversity. In this context, the present project was initiated by PSCST in collaboration with the Zoological Survey of India, Dehra Dun and Solan, Botanical Survey of India, Dehra Dun and Punjabi University, Patiala to enlist flora and fauna of Punjab Shivaliks. The Indian Institute of Remote Sensing (NRSA), Dehra Dun was also requested to conduct broad biodiversity characterization studies in the area. Useful inputs were provided by the Department of Forests and Wildlife, Government of Punjab.

The Shivalik area of Punjab with a geographical spread of 9448.97 km², is the hill tract lying in the north-eastern part of the state, running from north-west to south-east along the Himachal Pradesh border. The area has been identified as one of the micro-endemic zones of the country, and is also one of the eight most degraded rain fed agro-ecosystems.

During the present project the participating agencies conducted surveys in the region to record available plant and animal species and broadly assess their

distribution with respect to their abundance/rarity of occurrence. The present document presents lists of major flora and fauna of the area, including information on their common/rare/threatened/endemic status, their diagnostic features, and general distribution within the Shivaliks. Data regarding the floral groups of Algae, Fungi and Bryophytes has been contributed by Botanical Survey of India, Dehra Dun. Information on Lichens has been provided by Dr.Kiran Rana on special request. Punjab State Council for Science and Technology carried out studies on Pteridophytes, Gymnosperms and Angiosperms. Similarly, data for the faunal groups Centipedes, Milipedes, Arachnida, Odonata, Ephemeroptera, Plecoptera, Isoptera, Pices, Reptiles and Mammals has been contributed by Zoological Survey of India, Dehra Dun. Data for the groups Nematoda, Crustacea, Lepidoptera (Butterflies), Diptera, Hemiptera, Dermoptera, Orthoptera, Mollusca, Amphibia and Aves has been contributed by Zoological Survey of India, Solan. Studies on Hymenopterans and Lepidoptera (Moths) have been conducted by Punjabi University, Patiala. The broad Biodiversity Characterization Studies at landscape level have been conducted by IIRS, Dehra Dun through Remote Sensing and GIS.

The number of species of plants and animals recorded from the area are summarized as below:

S.No	Plant/Animal group	No. of species	%age of species in India*	Agency
KINGDOM PLANTAE				
1.	Algae	104	1.6%	Botanical Survey of India, Dehra Dun
2.	Fungi	560	3.9%	Botanical Survey of India, Dehra Dun
3.	Lichens	21	1.1%	PSCST, Chandigarh
4.	Bryophytes	27	0.9%	Botanical Survey of India, Dehra Dun

5.	Pteridophytes	30	2.7%	PSCST, Chandigarh & BSI, Dehra Dun, IIRS, Dehra Dun
6.	Gymnosperms	1	0.01%	PSCST, Chandigarh, IIRS, Dehra Dun
7.	Angiosperms	526	3.1%	PSCST, Chandigarh, IIRS, Dehra Dun
KINGDOM ANIMALIA				
1.	Phylum: Nematelminthes	34		Zoological Survey of India, Solan
2	Phylum: Annelida		1.3%	
i	Class: Oligochaeta	18		Zoological Survey of India, Solan
ii	Class: Hirudinaria	5		Zoological Survey of India, Solan
3.	Phylum: Arthropoda	819	1.34%	
i	Class Arachnida	30		Zoological Survey of India, Solan
ii	Class Crustacea	12		Zoological Survey of India, Solan
iii	Class: Insecta			
a	Order: Chilopoda	5		Zoological Survey of India, Dehra Dun
b.	Order: Orthoptera	77		Zoological Survey of India, Dehra Dun
c.	Order: Isoptera	6		Zoological Survey of India, Dehra Dun
d.	Order: Odonata	41		Zoological Survey of India, Dehra Dun
e.	Order: Thysanoptera	40		Zoological Survey of India, Solan
f	Order: Hemiptera	45		Zoological Survey of India, Solan
g.	Order: Homoptera	39		Zoological Survey of India, Solan
h.	Order: Dermaptera	8		Zoological Survey of India, Solan
i	Order: Coleoptera	63		Zoological Survey of India, Solan
j	Order: Lepidoptera			
j-i	Moths	135		Punjabi University, Patiala
j-ii	Butterflies	89		Zoological Survey of India, Solan
k.	Order: Diptera	31		Zoological Survey of India, Solan
l.	Order: Hymenoptera	198		Punjabi University, Patiala

4.	Phylum: Mollusca	31	0.6%	Zoological Survey of India, Solan
5	Phylum : Vertebrata			
i.	Class: Pisces	55	2.2%	Zoological Survey of India, Dehra Dun
ii	Class: Amphibia	9	0.1%	Zoological Survey of India, Solan
iii	Class: Reptilia	20	4.1%	Zoological Survey of India, Dehra Dun
iv	Class: Aves	396	32.2 %	Zoological Survey of India, Solan
v	Class: Mammalia	19	5.1%	Zoological Survey of India, Dehra Dun

* Calculated from MoEF, 1998

Microbial flora and fauna was not studied under the project. Further, no studies were conducted on Phyla Coelenterata, Platyhelminthes, Porifera and Echinodermata as the species are either marine (hence, not found in Punjab) or are parasitic. Within large Phyla certain orders have also been missed out either due to non-availability of specimens or due to inaccessibility to experts for conducting these studies.

For the present study, a district was taken as a geographical unit. The area was divided into specific zones identified by experts from Department of Forests & Wildlife, Govt. of Punjab. The importance of these areas from the biodiversity rich/poor angle was validated through Remote Sensing and GIS data through Biodiversity Characterization techniques and species inventorization was conducted using stratified random sampling. During the project ZSI carried out 35 surveys spending a total of 330 days in the field covering different localities of the area (Survey areas marked in map no.1) and Punjabi University carried out 15 surveys spending about 50 days in the field. Similarly, PSCST carried out nine surveys spending about 40 days in the field area and BSI carried out 3 surveys in the region spending about 45 days in the field.

As per the present study the recorded forest area of the Shivalik hills of Punjab is 1599.42 km² constituting 16.93% of the total geographical area (as per the Department of Forests and Wildlife, Government of Punjab). The non-forest area such as agricultural, grasslands, water bodies, canals, settlements,

riverbeds and barren land together contribute 7849.55 km² constituting 83.07% of the total geographical area.

Four major forest types have been recorded. These are Dry Deciduous, Moist Deciduous (including Khair-Sissoo and Dry Bamboo Brakes), Dry Deciduous Scrub (including Euphorbia) and Chir Pine forests. Out of these the Dry Deciduous forest areas showed maximum biodiversity (high Importance Value Index and high Shannon-Wiener Index) whereas Chir pine forests showed minimum diversity. The Scrub forests have been found to show maximum degree of fragmentation, an indicator of high anthropogenic activity. *Lantana* and *Parthenium* are major exotics occurring in the area, which need immediate management.

The floral studies highlight that a considerable number of cryptogams exist in the area, the number of fungi being especially high. Out of these three species of Algae (*Spirogyra jassiensis* (Teodoresco) Czurda, *Zygnema carterae* Czurda, *Z. mucigenum* Randhawa), two species of Fungi (*Orbilbia sarraziana*, *Calvatia coelata*) and five species of Pteridophyta (*Actiniopteris radiata* (Swartz) Link., *Pteris cretica* Linn., *A. lunulatum* Burm., *Ceratopteris thalictroides* (Linn.) Brong., *Asplenium dalhousiae* Hook.) are found to occur very rarely in the area. Further, though earlier studies have recorded only 448 species of both macro and micro fungi from the state of Punjab, during the present study 560 species were recorded from the Shivalik area alone. Further, 21 species of Lichens have also been reported to occur in the study area. Out of these 12 species are crustose, seven species are foliose and one species each is of fruticose and squamulose type. However, further studies need to be conducted on Lichens in the area. Similarly, there appeared to be no record of mosses and only 10 species of liverworts were known from Punjab earlier. However, the present study records nine species of mosses and 17 species of liverworts. The present study also reports five new records of Pteridophytes from Punjab out of which one species (*Adiantum lunulatum* Burm.) occurs very rarely. Another important observation has been the presence of a single species of Gymnosperm (*Pinus*

roxburghii Sarg.) in the study area, though earlier studies report presence of 21 species of Gymnosperms from Punjab (out of which some were from cultivated areas).

Amongst the Angiosperms, c 355 herbs, c 70 trees, 70 shrubs or undershrubs, 19 climbers and 21 twiners were recorded from the study area. Families like Poaceae, Papilionaceae, Asteraceae and Cyperaceae are the dominant families. Out of a total number of 562 angiospermic species of plants recorded from the study area, two species (*Hibiscus hoshiarpurensis* Paul & Nayar and *Argyrolobium album* Bhattacharyya) are found endemic to Punjab-Shivaliks, 11 species are new reports from Punjab, 44 species are found to occur very rarely (only 1-2 specimens were observed from the study area) and about 145 species occur rarely (occasionally seen). The area also harbours 28 wetland plants and 214 plants of economic importance out of which 132 are medicinal plants. Some of the economically important plants are: *Acacia catechu* (Linn.f.) Willd., *Bombax ceiba* Linn., *Cassia fistula* Linn., *Pinus roxburghii* Sarg. and *Euphorbia royleana* Boiss.. Some of the important medicinal plants are: *Adhatoda zeylanica* Medik., *Bacopa monnieri* (Linn.) Wettst., *Azadirachta indica* Juss., *Ricinus communis* Linn. and *Abrus precatorius* Linn.

The Total Importance Value (TIV) for major angiospermic species was also calculated based on known uses and analysed using GIS by IIRS considering 10 important parameters. The TIV of different vegetation types based on 214 economically important plants and 132 medicinal plants recorded by IIRS, Dehra Dun alone, was recorded as under:

Forest Type	TIV (% age)
Dry Deciduous (DD)	10.53
Moist Deciduous (MD)	10.46
Deciduous Scrub forest (DS)	9.75
Chir-pine forest (PN)	8.01

An overview of percent utilizable species within each forest type has also been recorded by IIRS, Dehra Dun and is presented below:

Uses	Forest types				
	DD	MD	DS	PN	Total
Food	11.15	12.7	10.05	0	33.9
Fuel	0.79	2.36	2.21	0	5.36
Fodder	9.09	6.94	9.06	8.56	33.61
Fiber	9.8	7.91	9.31	0	27.02
Timber	10.2	2.6	9.55	0	22.35
Medicinal	31.66	32.1	31.61	20.78	116.15
Oil	5.02	0.65	6.37	0	12.04
Gums/ Resin	3.5	0.86	3.18	0	7.54
Tannin	5.18	1.3	6.61	0	13.09
Others	9.83	8.45	8.09	2.35	28.72

As the fauna of an area depends upon its flora, as expected, the area is also found to be quite rich in faunal diversity especially bird fauna (two important wetlands exist in the area out of which Ropar wetland is a Ramsar site). A total of 396 species of birds have been recorded from Shivaliks.

Results indicate that five species of Lepidoptera, 44 species of fish, 18 species of reptiles, 156 species of birds and 19 species of mammals are listed under different categories of conservation status of IUCN, CITES, CAMP and IW (P) Act.

Further, two Annelid species (*Perionyx bainii* and *P. simlaensis*) have been found to be endemic to North-Western Himalayas including Punjab Shivaliks and three species (*Amyntas alexandri* Beddard, *Perionyx excavatus* Perrier and *Perionyx sansibaricus* Michaelsen) have been found to have good vermicomposting potential. Furthermore, all the five leeches recorded from the area are new records for Punjab.

One species each of the Orders Homoptera, Thysanoptera and Lepidoptera (*Vesiculaphis punjabi*, *Heliothrips siwalik*, *Campsocotena robinsoni*, respectively) are new additions to science. Two genera of Coccid insects (Order Hemiptera) *Humococcus* Ferris and *Drepanococcus* William & Watson, are reported for the first time in the Indian Literature. Similarly, one species each of Orders Thysanoptera and Lepidoptera, Class Insecta (*Moundinothrips robustus* Bhatti and *Ethmia praeclara* Meyrick respectively) have been reported for the first time from India. Another species of Order Hymenoptera, Class Insecta i.e. *Vespa himalyana* Smith is found to occur very rarely and seems to be

endangered in the area as only one specimen of the same could be collected during the entire project (from Dunera, district Gurdaspur).

The study has also recorded four Endangered (En) species (*Ompok pabda* Ham.-Buch., *Tor putitora* Ham.-Buch., *Eutropiichthys vacha* Ham.-Buch. and *Botia lohachata* Chaudhuri), 12 Vulnerable (Vu) species, 24 Lower Risk near threatened (LRnt) species and three Lower Risk least concern (LRlc) species of Fish. Further, two species of Reptiles, which are globally threatened under IUCN-LR/nt category (*Kachuga smithi* Gray and *Python molurus* Linn.) and two vulnerable species of lizards (*Varanus bengalensis* Linn. , *Varanus flavescens* Gray) as per CAMP have been reported. Furthermore, one species of snake *Python molurus* Linn. , three species of turtles (*Kachuga tecta* Gray, *Lissemys punctata punctata* Lacepede and *Trionyx gangeticus* Cuvier) are under Sch. I of IW (P) Act.

Four species of birds have been found to be Globally threatened as per IUCN-LR/nt category (*Anhinga melanogaster* Pennant, *Aythya nyroca* Guldenstadt, *Circus macrourus* Gmelin, *Mycteria leucocephala* Pennant). Further, of the total species recorded from Punjab Shivaliks two species have been found to be under App.1 of CITES (*Falco jugger* Gray, *Falco peregrinus* Tunstall) and 156 species under Wild Life Protection Act.

Only 19 mammalian species could be recorded from the area which include four globally threatened species as per IUCN (*Semnopithecus entellus* (Dufresne), *Macaca mulatta* (Zimmermann), *Lutra lutra* (Linn.) and *Manis crassicaudata* Gray), three species belonging to Sch. 1, three species under Sch. II , four species under Sch. III, six species under Sch.IV and two species under Sch.V of Indian Wildlife Protection Act.

The list of globally threatened vertebrate fauna of Punjab-Shivaliks is as below:

Table: 1 Globally Threatened Vertebrate Fauna of Punjab Shiwalik

S.No	Common Name	Zoological Name	IUCN
Reptiles			
1	Brown River Turtle	<i>Kachuga smithi</i> (Gray)	LR/nt
2	Indian Rock Python	<i>Python molurus</i> (Linnaeus)	LR/nt
Birds			
1	Oriental Darter	<i>Anhinga melanogaster</i> Pennant	LR/nt
2	Ferruginous Pochard	<i>Aythya nyroca</i> (Guldenstadt)	LR/nt
3	Pallied Harrier	<i>Circus macrourus</i> (Gmelin,.)	LR/nt
4	Painted Stork	<i>Mycteria leucocephala</i> (Pennant)	LR/nt

Mammals			
1	Common Langur	<i>Semnopithecus entellus</i> (Dufresne)	LR/nt
2	Common Otter	<i>Lutra lutra</i> (Linn.)	Vu
3	Indian Pangolin	<i>Manis Crassiaudata</i> Gray	LR/nt
4	Rhesus Monkey	Macaca mulatta (Zimmermann)	LR/nt

Vu: Vulnerable, **LRnt:** Lower risk near threatened, **LRlc:** Lower risk least concern

The project highlights that the Shivalik area is quite rich in biodiversity. Based on the diversity of species of plants and animals collected from the region, the following areas have been identified as biodiversity rich pockets in the Punjab Shivaliks:

- Guru Gobind Singh Nature Reserve, Anandpur Sahib (Ropar)
- Sadavarat Forest Ropar & Ropar Wetland (Ropar)
- Kahanpur Khuhi Forest (Ropar)
- Dholbaha-Kukanet Forest (Hoshiarpur)
- Nara Forest (Hoshiarpur)
- Chohal Forest (Hoshiarpur)
- Takhni-Rehmapur Wildlife Sanctuary (Hoshiarpur)
- Talwara Forest (Hoshiarpur)
- Manguwal Forest (Hoshiarpur)
- Dhar & Dunera Forest (Gurdaspur)

A view of some of the important localities is presented in Plate 1.1 & 1.2.

However, certain areas in the region show poor diversity due to erosion and land degradation. These are (Plate 1.3):

- Certain areas of Jaijjon (Hoshiarpur)
- Rel Majra (Nawanshahr),
- Certain areas of Ropar Shivaliks (near Mirzapur and Ropar city).

- Certain areas in Talwara block (Hoshiarpur)

Conservation measures need to be taken up in these areas.

The study, though exhaustive, is by no means all-inclusive. Data needs to be generated on those taxa, which could not be covered, as well as, on phytosociology and detailed ecological distribution of important elements of flora and fauna. However, it can serve as a useful baseline document.

RECOMMENDATIONS

The present study indicates that the Shivalik area is biologically rich. This is the only major forested area of the state, which, otherwise has 84% land under agriculture. Since it harbours several species of economic and medicinal value, special efforts need to be initiated by the State Govt. to conserve this important natural resource of the state.

However, the study also points out that the biodiversity of Punjab Shivaliks is under threat due to various developmental activities. The irony is that some parts of the districts harbouring important flora and fauna in Shivaliks have been identified as 'backward blocks' in Punjab with a thrust to industrial and urban development.

Satellite data provides qualitative information on the land cover and land use pattern of the region. It has been found that disturbance caused due to human activities is a significant contributor to loss of biodiversity.

The major threats to the biodiversity of the area are:

1. **Promotion of urbanization and industrialization:-** Increase in population and promotion of urbanization and industrialization in and around Shivalik area is a major cause of concern. Several large and medium industries in Ropar, Hoshiarpur and Gurdaspur districts (e.g. DCM Engineering Products, Max India Ltd., United Paper Mills, Rishabh Paper Mills and Ranbaxy Industries in district Ropar; Mukerian Paper Mills, Mahavir Spinning Mills, Hawkins India Ltd. and ABC Paper Mill in

- district Hoshiarpur and Cooperative Sugar Mill and Distillery and about 40 stone crushers in district Gurdaspur) not only release effluents into adjoining water bodies and land, as well as emissions in the air, but have also led to increase in human activity in the area, thus adversely effecting biodiversity. Similarly, growing towns & cities and establishment of new housing colonies have encroached upon areas forested earlier and caused resource stress in the region.
2. **Road Construction:** Construction of roads in Shivalik region has resulted in fragmentation of the forest habitat especially for smaller fauna.
 3. **Invasion of exotic species:**
 - (i) Introduction of exotic species of fishes like Common carp and Silver carp in ponds, rivers and reservoirs has adversely affected the native species of fishes by competing with them for food and space.
 - (ii) Promotion of exotic species for plantations i.e. Poplar and Eucalyptus has resulted in neglect of native species like *Acacia*, *Dalbergia*, *Eugenia*, etc. Further, such type of monoculture does not provide any habitational refuge to wild fauna thus affecting their diversity.
 - iii) Invasion of Lantana in the area has led to it being spread as an obnoxious weed which competes with the natural vegetation and has covered vast tracts in the Scrub forest area. However, the species is allowed to grow by the forest department on dry slopes & poor soils where other species cannot survive.
 - iv) Similarly, *Eichhornia* species, an exotic weed, has inundated and degraded the water bodies.
 4. **Soil Erosion:** Water erosion of top soil is a major threat to natural vegetation in the area. The problem can be attributed to seasonal choes which wash away the fragile fertile top soil and illegal quarrying in certain areas causing loss of habitat for important flora and fauna. Excessive biotic interference is also a contributing factor though specific data are lacking.

5. **Overexploitation of medicinally and economically important flora and fauna:** Overexploitation of species like *Acacia*, *Cassia*, *Dalbergia*, etc. for Gum, Catechu, fuel and fire wood and timber by local population has led to degradation of the natural forests and hence, loss of biodiversity. Specific data on regenerative capacity of these species needs to be generated to regulate their harvesting and ensure sustainability. Further, since the area is rich in medicinal and economically important plants, illegal harvesting by locals has been reported leading to decrease in their population and diversity. However, specific data is lacking.
6. **Illegal Hunting and Poaching:** Illegal hunting and poaching activity has also been reported from the Shivaliks in local newspapers. The regions where such activities were reported to occur are Mirzapur, Kahanpur Khuhi, Dhar, Guru Gobind Singh Nature Reserve, Anandpur Sahib, River Sutlej, Ropar, River Beas, Talwara and Sadavrat forest, Ropar for Wild Boar, Jungle Fowl, Porcupine, Turtles and Peafowl. Specific data, however, need to be generated.
7. **Change in Traditional Agricultural Practices:** The area is traditionally suitable for rainfed agriculture. Introduction of HYVs and use of farm chemicals in form of fertilizers and pesticides has led to loss of domesticated biodiversity as well as impact on wild fauna causing pesticide poisoning. This can result in loss of their reproductive capacity.
8. **Man-Animal conflict:** Human animal conflict has also been reported (especially due to wild boar and certain bird species) in the area. This issue needs to be addressed at policy level.
9. **Nomadic activity of Gujjars and Gaddis:** Gujjar and Gaddi tribes have been regularly migrating to the Shivalik area during the rabi harvesting and the winter season respectively, sharing pasture land and forest resources with the locals. Traditionally their rights on common property resources have been recognized. However, over the years

commercialization of agriculture and encroachment of shamlat lands has lead to deterioration in community conserved lands and exploitation of forest resources resulting in biodiversity degeneration.

An analysis of remote sensing and GIS data along with phytogeographical analysis indicates very high disturbance in the fringes of the Shivaliks especially in the Dry Deciduous and Dry Deciduous Scrub Forest area. This is a matter of great concern for biodiversity conservation. Since the Shivalik hills are faced with increasing anthropogenic activities and forest landscape is invaded by humans in the name of development, specific actions need to be initiated at the government and community level to conserve this ecologically rich area. Some actions which have been initiated by the Deptt. of Forests & Wildlife, GOP are:

- Establishment of Protected Area Network in the form of Takhni Rehmanpur Wildlife Sanctuary, Hoshiarpur and Guru Gobind Singh Nature Reserve, Ropar.
- World Bank aided project on Integrated Watershed Development for Water and Soil Conservation.
- Punjab Afforestation project by Japan Bank for International Cooperation (JBIC)
- Preparation of Forest working plans and actions for control of excessive harvesting of minor forest produce and illegal hunting and poaching, etc.
- Preparation of proposals under State Biodiversity Strategy & Action Plan.

However, these efforts are clearly not enough.

The present study recommends:

1. (a) Bio-rich areas identified under the present project may be brought under Protected Area Network (wherever such PANs do not exist already) as these are restricted to certain fragmented pockets. The Moist

deciduous forests type was found to record highest biological richness followed by dry deciduous forest. Hence, these areas need to be specifically targeted. Major areas requiring protection are:

- Guru Gobind Singh Nature Reserve, Anandpur Sahib (Ropar)
- Sadavrat Forest Ropar and Ropar Wetland (Ropar)
- Kahanpur Khuhi Forest (Ropar)
- Dholbaha-Kukanet Forest (Hoshiarpur)
- Nara Forest (Hoshiarpur)
- Chohal Forest (Hoshiarpur)
- Takhni-Rehmapur Wildlife Sanctuary (Hoshiarpur)
- Talwara Forest (Hoshiarpur)
- Manguwal Forest (Hoshiarpur)
- Dhar and Dunera Forests (Gurdaspur)

(b) Important wetlands (like Ropar wetland, which is a Ramsar site and Dholbaha, wetland) and other water bodies in the area be scientifically conserved and managed. Some efforts have been initiated in this direction by PSCST with assistance from Ministry of Environment & Forests, Govt. of India. which need to be further strengthened.

(c) The Shivaliks have been declared as an IBA (Important Bird Area) site by Bombay Natural History Society in view of the large bird population recorded from the area. Specific projects with international funding could be taken up for conservation of rare, endemic and threatened bird species.

(d) Specific actions to restore biodiversity in degraded areas like Jaijion (Hoshiarpur), Rel Majra (Nawanshahr), Ropar Shivaliks near Mirzapur and Ropar city and certain areas in Talwara block (Hoshiarpur) need to be initiated.

2. A total ecosystem conservation concept needs to be adopted for conservation of the Shivalik area. An effective naturalization plan for the region needs to be devised based on principles for maintaining natural

- diversity. To enrich low diversity areas, efforts should be made to restore native communities by complementing natural species rather than planting as many different kinds of trees as possible without looking into the natural vegetation and the needs of the natural fauna of a site. Further, introduction of exotic species in the area be banned by the forest department and promotion of plantation of both, slow and fast growing native species of herbs, shrubs and trees be promoted. NGOs adopting plantation activities be adequately trained/advised.
3. It is imperative that ecosystems and species are used sustainably for human welfare. Biodiversity Management, therefore, needs to strike an optimal balance between conserving the diversity of nature, as well as, promoting sustainable utilization. Adequate financial, infrastructural and institutional capacities need to be developed to achieve this objective.
 4. Involvement of local communities (especially women) in forest and wildlife protection through awareness, participatory planning and equitable sharing of responsibility and benefits needs to be promoted. Excluding local populations (who have lived in harmony with nature since ages) from protected areas can lead to illegal activities which can cause further degradation of the environment. Conservation plans which minimize restrictions on local populations and allow traditional practices to continue need to be adopted to ensure their long term success. Capacity building programmes for local communities may be taken up.
 5. Efforts be made to preserve as many large natural communities as possible in single tracts as large areas sustain more species than smaller areas. Where there is no opportunity to preserve, increase or create large patches of natural communities, the number of small patches be increased. This will help sustain regional diversity.
 6. Wherever, possible, fragmentation of large patches of natural vegetation be avoided. Even a narrow access road through a forest can act as a barrier to movement of small organisms and can affect their habitats.

7. Ecotones between natural communities support a variety of species from both communities. Hence, these should be allowed to develop naturally between adjacent communities.
8. Conversion of Shivalik forest areas to other uses be banned and industrial activity restricted. Wherever industry already exists, it may be ensured that pollution control norms are religiously met.
9. Preparation of People's Biodiversity Registers be taken up to document traditional knowledge systems.
10. Interpretation and environment education centers for public awareness (especially for students) be set up in PANs and important biodiversity sites.
11. The area harbours several commercially important species. However, their economic valuation needs to be taken up to understand the full economic potential of the area. This study can help to promote bio prospecting of these species also. However, IPR concerns related to biodiversity need to be adequately understood and addressed. Mechanisms be established for regulation of bioprospecting and access to genetic resources of the area, commercial use of local biodiversity by business houses, and ensuring their equitable benefit sharing with locals.
12. Where population of wild animals has risen considerably (e.g. wild boar in district Ropar) and is adversely affecting life of local communities, policy for reduction of human-animal conflict needs to be designed and implemented by the forest department.
13. Strict legal measures to control illegal harvesting, hunting and poaching activities need to be taken up especially in protected areas. Also, migratory cattle population needs to be regulated through issuance of transit permits, stay permits
and movement permits in biorich areas.

14. Regular monitoring and updation of species specific data through R & D activities needs to be taken up. Ethno biological information also needs to be generated.
15. Biodiversity conservation criteria be included in all developmental projects in/around Shivaliks and pre & post project EIAs be conducted. Also, training of staff of Development Deptts. on biodiversity conservation issues and regular in-service and pre-service training of forest deptt personnel be promoted.
16. The State may put in place necessary infrastructure for biodiversity conservation and implement the recommendation of the State Biodiversity Strategy and Action Plan.

The present study is fairly exhaustive as far as Broad Biodiversity Characterization and inventorization of species is concerned. It can serve as a baseline databank for future studies. Nevertheless, it has several gaps, like, certain groups of flora and fauna have not been covered nor any large scale phytosociological distribution studies conducted. However, the project is one of the first attempts to study the biodiversity of this important ecosystem of Punjab in an integrated and holistic manner.

It is hoped that the present document will act as a base for several future studies in the area and will help to initiate an integrated conservation program in Punjab Shivaliks.