
10
North of Nallah
Nallah
8
Gharpa
9
11
12
Salgi-Chargha
7
Salgi- Chargha
6
Gharpa
5
Hilog
4
1
UHL River
3
Siram
2
Road Towards Mandi
Mayal
13
1 Drinking water
2 Power Station
3 Lecture Halls, Labs, etc
4 Computer & Internet centers
5 Student's activity center
6 Admin-cum-Academics
7 Oxidation ponds & Solid Wastes
8 International activity & GH
9 Girls' hostel, school & services
10 Communication center
11-13 Residence & Boy's hostel

Executive Summary

The Indian Institute of Technology Mandi is slated to be built on a 531 acre Campus within an ecologically pristine Himalayan watershed at Kamandh in Mandi District (Himachal Pradesh). IIT Mandi, over the next decade, is likely to develop infrastructure for providing quality education to around 1000 students. Including the faculty and the support staff, the Campus will have a resident population of 3000 or more people, mostly from outside the region. A sudden increase in the population density that is at present less than 500/km^2 except in the most crowded towns of the district may have an extraordinary impact on the landscape, both within and beyond the boundaries of the Campus.

In an effort to minimize the ecological impact caused by the sudden and rapid transformation of the landscape, Professor Timothy A Gonsalves, the Director of IIT Mandi, called for the drafting of an Ecological Management Plan (EMP) that will guide sustainable development of the Campus. In March 2010, a team of ecologists and a senior forest conservator, led by Care Earth Trust, visited the Campus and carried out a field study that spanned a period of 17 days.

The March 2010 field study not only focused on the Campus, but also the surrounding villages and natural areas bordering Mandi town, Kullu and all the way up to the sacred Parashar Lake. The main findings of the field study and the strategy to be adopted while developing infrastructure on the Campus are summarized in the EMP.

IIT Mandi is a part of the extensive West Himalaya Biogeographic Province that falls within the Palearctic realm. Climate is temperate with three distinct seasons; winter (November-March), summer (April-June) and rainy season (July-September). It is warm during April-October when the maximum temperature tends to exceed 30^{o}C, becoming hotter locally. Winters are freezing when snow descends to around 1200m ASL. Rainfall, as recorded at the Pandoh dam site (Mandi district) during the years 1982-1993, is known to vary from 358mm to 1954mm, the average being 1224mm.

The Campus falls within one of the upland watersheds of the river Beas. A minor tributary called the *Kataula ki Khad* (nallah) flows through the Campus and drains into the river Uhl, a right bank tributary of the river Beas. These are perinneal and free of industrial and urban pollution.

The major forest types are Himalayan Subtropical Pine, dominated by Chir Pine (*Pinus roxburghii*) and Lower Western Himalayan Temperate (deciduous & broadleaved) dominated by species of Oak (*Quercus* spp) and Rhododendron. Long history of logging, fire, agriculture and livestock grazing has degraded and fragmented the once extensive forests. The fragmented vegetation of the Campus and its surrounding hills are in the form of a heterogeneous mosaic of Chir Pine forests, broadleaved deciduous forests, scrub, cultivation and pasture.

During the March 2010 study more than 200 species of plants were identified on the Campus. These include rare species such as *Myrica esculenta, Tulipa stellata*, *Notholirion thomsonianum* and *Sauruaia napaulensis*. Variations in altitude and aspect have created distinct vegetation zones and unique habitats. The mosaic of terrestrial and aquatic habitats has also contributed to the remarkable biodiversity of the Campus.

The transition from winter to summer during March was best suited for observing birds. 115 species of birds were observed on the Campus of which half were new records for the Mandi district. Endangered birds like the Himalayan Griffon Vulture, the Khaleej Pheasant and the House Sparrow were quite common. The avifauna of the Campus is rich in small, sedentary birds such as babblers and laughing thrushes that (being poor dispersers) may be very sensitive to habitat transformation. Riparian birds like redstarts, dipper and the forktail were also common.

Butterflies were quite frequently seen although not as diverse as birds. 31 species observed included Peacock, Windmill, Admiral, Tortoiseshell, etc. As with birds, half the species observed on the Campus have not been previously reported from the Mandi district.

Presence of two species of Snow Trout (locally called *Sal*) is remarkable. Snow Trout can serve as bioindicators for the long-term monitoring of the riparian health. The season was not the best for

amphibians and reptiles that there was hardly any species seen within the Campus. Villagers however reported the presence of the Central Asian Cobra and at least one species of viper. A few lizards were also seen outside the boundaries.

Mammals, in general, were not quite visible. The Rhesus Macaque, however, was quite common. Other than the primate, the Indian Jackal and the Grey Mongoose were seen. Based on secondary signs the presence of Leopard and Wild Pig was inferred. Information provided by the local foresters suggests that there can be other species of mammals like Civets, Porcupine, Otter, etc.

It is evident that Campus falls within a Himalayan zone that has not been previously explored for its biodiversity wealth and a study that spans the different seasons will certainly add many more species of plants and animals to the existing list.

The Kataula-Kamandh landscape with its many hamlets is a natural extension of the town of Mandi (which is also known as Chota Kashi) in that the inhabitants accord immense reverence to religion. This is evidenced by the presence of a large number of shrines and temples dedicated to Devi (Goddess Durga), Siva and Vishnu. There are also a number of sacred habitats named after sages such as Parashar, Markandeya, Ved Vyas, Vashisth, Manu, etc.

The landscape is home to Hindus and Muslims and despite the staunch caste and religious identities there are no conflicts between the groups. This in many ways typifies the social structure of the landscape – wherein the lines of rights, roles and responsibilities are clearly drawn and regulated by customary rules and governing structures.

While Kataula can be designated as a village in terms of structure and population, Kamandh, Salgi, Garpa etc are essentially hamlets. IIT Mandi falls within the Panchayat of Kamandh (reserved constituency for women) headed by a rather dynamic Pradhan and Up-Pradhan. The Gram Sabha is a strong entity, and keeping in with tradition, nominations are strictly based on the stature earned by the individual within the landscape. It is also a point of interest that many of the forest guards are also women.

Interestingly, the landscape is typified by a number of abandoned hamlets, although the names continued to be used (eg Mayal, Chargha). Land use is planned with the river as the focus; with dedicated places of grazing, agriculture and worship (locally known as Malkiyal, Kadiyather, Charag, etc). Domicile was historically defined by land ownership – people preferred to stay close to the lands – hence the scattered distribution of households.

Major endogamous groups of the landscape include the Gaddis (pastoralists who tend goats and sheep), Gujjars (pastoralists who keep cows), Lavene (who tend to horses and mules), Lohars (iron smiths), Duwains (goldsmiths), Charchas (undertakers), Kumhars (potters), Rajputs, the broad class of Scheduled Castes and Brahmans (of various Gothras). Muslims form a minority and are engaged in trade and agriculture.

Literacy rates within the landscape are extremely low; with rather high drop out rates amongst girls. Lack of access to higher education and paucity of infrastructure and personnel in the local school are cited as the primary reason for poor literacy rates.

Livelihood options are of the primary sector, dominated by agriculture and cattle rearing. Other preferred options include the armed services (there are a number of retired personnel of the armed services in the landscape) and transport. Trade is limited to small shops selling basic grocery and clothes – the nearest major market is Chandigarh from where goods are procured on a pre-arranged basis.

Historically, sugarcane was a major crop of the landscape. In fact the name Kamandh means sugarcane. At present, wheat is the major crop around the Campus although there are others like garlic, radish, carrot, pulses, pea, etc cultivated. While apple is not locally cultivated, there are apple nurseries around Kataula.

Cultivated land, closest to the Campus, are most extensive in and around Salgi and Siram villages. Cultivation bordering the nallah is irrigated through a simple network of canals. Higher up on the

slopes, the cultivation is rain-fed. Lands within Hilog and Salgi have been converted to pasture and agro-forestry, largely for tree-fodder, during the past 50 years.

The Ecological Management Plan (EMP) has been outlined keeping in view the biodiversity wealth of the Campus and surrounding landscapes, the fragility of mountain ecosystems, its people, their livelihoods and the academic vision of IIT Mandi. Acknowledging that there is deficiency in information on the flora and fauna of the Campus and the ecosystem processes that sustain the biodiversity, the EMP provides a road map to development of the IIT Mandi, taking adequate precautions such that the long-term ecological, social and academic goals are not compromised. The EMP is elaborated within the framework of the proposed objectives that have been consolidated as under.

Land use and infrastructure development on the Campus (both short-term and long-term) should be guided by ecosystem principles that govern fragile mountain and riparian ecosystems. The following are the 4 main guiding principles to be adopted while planning the land use and infrastructure development:

1. As far as possible restrict the buildings to the flat areas that have already been used by the Animal Husbandry Department
2. As far as possible do not disturb the vegetation on the slopes, ridges and riparian gorges
3. Neither the nallah nor the river Uhl should be burdened with the task of waste water disposal
4. The Campus cannot be managed as an island insulated from the rest of the landscape.

The location and clustering of buildings are proposed adopting the four guiding principles. Locating the Administration Building and the associated infrastructure at Gharpa (south) is strategically ideal as it oversees the rest of the Campus, especially the lecture halls and laboratories within the Hilog flat areas. The International Center (including the Guest Houses) is also being proposed at Gharpa (north). This is a scenic location from where it is easy to have a good view of the valley. Moreover, it will be compatible with the overall serene ambience of the Temple.

The hostels and other residential facilities have been located closer to the villages at Salgi (north) and Mayal. These areas are farther away from the forests thereby reducing the chances of

invasion by wild animals, although the ultimate factor that has determined the choice of locations for infrastructure development is the discharge of waste water and management of solid wastes.

A centralized oxidation pond and solid waste management facility is proposed in the Salgi-Chargha (west) flat lands. This facility has to be used very judiciously. Right from the time of construction, solid wastes have to be segregated and all organic wastes should be composted. And as composting will attract wild animals, it is best that the facility is created and maintained as close to the forests as possible such that the movement of animals (especially Wild Pig and the Rhesus Macaque) into the residential areas is restricted.

Decentralized collection and treatment of waste water will certainly reduce the burden on the nallah and river. The proposed infrastructure has been segregated and clustered such that there is a waste water collection and treatment facility for each building complex. With the exception of the proposed waste water collection and treatment facility at Siram-Hilog blocks that will contain inorganic (laboratory & workshop wastes) and medical was tes, all others will only generate organically enriched (largely domestic) sewage that can be locally treated using soak pits and natural filters.

The topography will help in the use of gravitational flow to a large extent and the filtration technique adopted should take advantage of this. It is proposed that the filtered domestic sewage is used for restoring the vegetation (and also preventing forest fires during summer) on the slopes through a network of sprinklers. Surplus treated domestic sewage can be provided for irrigation of crops in the adjoining villages during summer (example around Salgi-Mayal). The location of the hostels and residential quarters is chosen considering this.

Waste water containing irorganic pollutants should be treated more carefully to detoxify it, eliminating the oil, diesel, etc before sending it into the oxidation ponds. There must be a provision by which all the waste water collection and treatment units are also linked to the oxidation ponds. This is necessary as local irrigation will not be viable during the rains.

Treated water from the oxidation ponds can be discharged into the river only during the rainy season (July to September) when the flow of water is at its peak. The nallah is shallow. The summer flow is considerably less (as inferred during March 2010) suggesting that during the height of summer, the water may not reach the river Uhl. Any discharge of sewage into the *nallah*, especially during summer, will cause substrate pollution due to sedimentation, thereby permanently ruining the ecology of the *nallah* and the river.

The suggested lay out will also enable securing the boundary of the Campus against unwarranted human intrusion. The perimeter of the Campus is quite long due to its shape and orientation. Further, the topography, the presence of the *nallah* and at least one highway (Katuala-Mandi road) do not permit construction of a wall all around the Campus. The boundaries of the Campus can at best be marked and secured with a fence.

The suggested lay out does permit securing the buildings and other infrastructure blockwise. Major blocks proposed are Gharpa (Administration, Guest House, etc), Hilog (Lecture Halls, etc) and Salgi-Chargha-Mayal (Utilities, Residential). Whereas each block can have a gate, IIT Mandi as such cannot function from within a walled or insulated Campus.

Thoroughfare through the Campus cannot be entirely stopped as the Kataula-Mandi road runs across. While this road is outside the boundary in most parts of the Campus, it cuts through the areas between Salgi (north) and Mayal and between Hilog and Gharpa. The dirt road opposite the proposed Communication Center that runs through Salgi-Charga (east) and the metal-capped road from Kamandh to Navalai (through Hilog) are within the boundaries of the Campus. These roads are important links to some of the villages around the Campus.

Checkposts at strategic points can regulate unwarranted human intrusions. The existing roads can serve as the arterial roads. Newer roads can be minimized, restricting them to stairways along the slopes, foot overbridges across the *nallah* and if necessary cable cars (for emergencies and restricted use) to the guest houses.

The most critical habitat within the Campus is the *nallah* and the riparian vegetation that sustains it. The riparian vegetation overhangs the *nallah* (also in some parts the river Uhl) and is habitat to a range of native herbs, shrubs, palms, grasses and ferns. Native species such as the Ivy (*Hedera helix*), climbing fig (*Ficus foveolata*), wild pepper (*Piper brachystachyum*) and the aroid *Scindaspus officinalis* are species that not only have attractive evergreen foliage but also roots and stems that bind soil and rocks together. This vegetation plays a very crucial role in preventing soil erosion and protecting the gorges against landslides.

The scrub on the slopes is critical too. This vegetation is comprised of native plants that provide the spring and autumn colors to the landscape. The rich diversity of birds on the Campus may be attributed to this vegetation. Broadleaved deciduous vegetation is found along the slopes in parts of Salgi bordering Chargha. This type of vegetation is the most extensive in Chargha. The

characteristic species is the emergent wild silk cotton *Bombax ceiba*. The silk cotton provides nectar to many species of birds.

Chir Pine (*Pinus roxburghii*) and deodar (*Cedrus deodara*) are largely planted and can be seen on the hills bordering Hilog and down the slopes of Gharpa. These forests are known to sustain also confined to the vegetation.

The critical habitats are integrated and as the entire landscape is subject to variations in micro-climate, due to the complex topography and aspect, ecological management should be holistic. Summer fires are frequent. Although these fires are human-induced, certain plants like Chir Pine (the fallen dry needles) and *Lantana camara* are more prone to burning and can aggravate the fire.

Accidental fire can be avoided by adopting stringent steps. Wherever there is a Chir Pine forest patch, no smoking signs should be displayed. Burning of solid wastes should be strictly carried out within designated incinerators. Outdoor camping and bonfires in these habitats should not be allowed. Chir Pine forests should be bordered by a live fire-line of plants such as *Euphorbia royleana, Agave* sp, *Prinsepia utilis, Berberis* sp, etc. Regular sprinkling of waste water during summer will complement the regeneration of vegetation while keeping fires at bay. In addition to these, there must be routine collection and removal of fallen pine needles.

It is recommended that no plant species other than that identified and listed in the EMP be planted on the Campus. Conventional 'landscaping' can be detrimental and should not be resorted to. Alternately, natural avenues, hedges and meadows can be created and maintained using native bamboo, palms and other flowering plants.

The natural vegetation on the Campus is quite attractive and diverse and can also be effectively used on slopes to prevent soil erosion and landslides. Scientifically guided restoration and management of the vegetation will result in the Campus being one of the finest places for observing and studying a diverse assemblage of West Himalayan biodiversity.

According to the information provided by the Forest Range Office at Kataula there are 17,568 trees within the forest lands that have been ear-marked for the IIT Campus. Some of these trees may have to be felled while the infrastructure is developed. It is recommended that the trees that are to be felled are marked and inventorized with the help of the local foresters.

A blockwise inventory of trees to be felled should be created and made available to the Forest Department before the construction works are started. Trees that are felled should duly be handed over to the Forest Department and not used for purposes of construction or fuel without prior approval.

Infrastructure development on the Campus should be closely monitored by an Ecological Monitoring Committee (EMC). The EMC headed by an official of the Himachal Forest Department should be in place even during the inception stage so that the recommendations provided in the EMP are implemented.

There is a sizeable population of the Rhesus Macaque (*Macaca mulatta*). Rhesus Macaques are known invaders and unless there is a clear policy of not disposing food and household wastes in the open, and a strict regulation on voluntary feeding by animal lovers, there will be a lot of conflict between the residents and the mammal. The Rhesus Macaque will invade the Campus even as the construction begins and unless supervised and regulated, the resident labor force will invariably feed these animals.

A system has to be put in place to regulate the invasion by the Macaque and other wild animals like the Wild Pig and an occasional Leopard. Home gardens will attract the Wild Pig thereby necessitating the erection of fences. Leopards are attracted by the presence of domestic dogs. Free-ranging dogs on the Campus are a sure cause for trouble. Residents should adhere to a strict code of conduct by not feeding and maintaining free-ranging dogs.

Free-ranging cats can be quite destructive on small birds, especially those that nest close to the ground or on the ground. There are many species of babblers that nest low in scrub and the Peafowl, Jungle Fowl, Black Francolin and Khaleej Pheasant, lay and brood eggs on the ground. Cats when let loose take a heavy toll of the chicks of ground nesting birds.

Dealing with wild animals that invade the Campus is not easy. A Wildlife Rescue and Rehabilitation Center (WRRC) must be set up on the Campus. The WRRC should have the services of a full-time veterinary doctor and the support of the Forest Department. The WRRC should prescribe guidelines on the maintenance of mammalian pets on the Campus and the residents should strictly

adhere to the guidelines. The Estate Officer (preferably one with experience in forest and wildlife management) should oversee the WRRC.

Most habitable parts earmarked have been under human possession and use for over 50 years. The presence of livestock on the Campus during the past 50 years, if not more (traditional grazing by the local shepherds), has led to the proliferation of parasitic ticks and mites. Human response to tick and mite bites is quite varied. Some develop rashes, allergic reactions and fever. It is not easy to eradicate these organisms. Since mites inhabit grass, pastures and meadows, it is safer to avoid these habitats (including creation of lawns).

There is no simple formula or rule of thumb to estimate ecological carrying capacity of a landscape given the human population size. What is critical to the IIT-Mandi Campus is its ability to absorb the initial shock due to transformation of land for creating infrastructure and the long-term capacity to handle the solid and liquid wastes that the system generates.

What would be a safe approach is limiting the intake of students, at least during the first 10 years. For instance, if there are 250 students that come in during the first year, at the end of four years, there could be around a 1000. One thousand students plus, 2000 faculty, staff and their dependents, would limit the resident population to 3000.

Carrying capacity of the Campus (and the landscape) will be evaluated by its ability to absorb, recycle and reuse the waste water and solid wastes. Himachal is a 'no-plastic-bag' state and it is quite strictly adhered to even in remote villages like Kataula. Plastic and non-degradable material that is brought in during the construction phase should all be safely taken out and disposed.

A system that guarantees the safe handling and disposal of all no-degradable construction (and other) wastes should be in place right from the beginning. Wood, cardboard and other degradable material can be disposed with the help of the local people (who may welcome these as fuel).

The numerous stone buildings abandoned by the Animal Husbandry Department will generate a lot of debris and muck when broken down. Unless there are plans of reusing the stones for the new buildings, they would be best used to secure the erosion-prone banks of the nallah and river (as is commonly done in and around the Campus) or to stabilize the slopes that overhang the riparian gorges and in demarcating the boundaries.

Stones can also be reused to create (in the traditional manner without cementing) to build compost pits and incinerators. Using stones to stabilize the steep slopes may be very crucial, at least during the early years, in preventing soil erosion and landslips as the plant growth will be slow and may

not provide the service immediately. Debris or muck, on no account, should be pushed into the *nallah* or river.

Treated wastewater (from the oxidation ponds) can be discharged into the river only during the three rainy months (July-September). The ability to reuse the waste water without sending it into the *nallah* or river during the other nine months of the year is the yardstick that measures the carrying capacity of the Campus for it is this that will ultimately limit the number of residents that can be sustained without having an adverse impact on the riparian ecosystem.

It is recommended that water samples are collected from upstream and downstream at preset locations in both the *nallah* and river and tested and recorded as a benchmark before any work begins on the Campus.

Composted organic wastes and the sludge that comes out of the water treatment units can be used to fertilize the forests and restoration areas. Surplus compost and sludge can also be supplied locally to the farmers. As there is a diverse earthworm fauna known from the district, using the same in vermicomposting must be explored.

It was rather clear that much of the local population perceives IIT to be yet another college. Also emerging rather clearly was the divide amongst men and women in their overall perception and response to the new initiative. While the women were rather categoric about issues connected to the *nallah* and River Uhl, as well as access to grazing lands; the men were concerned about issues such as the influx of migrant labour, erosion of their traditional rights and customary regulations, availability of employment etc. On the other hand, other stakeholders such as officials of Government Departments while lauding the initiative were rather categoric on the need to ensure sustained protection to the socio-ecology of the landscape.

Women from the neighboring villages can be involved in the sustainable management of the raising nurseries for forest restoration and slope stabilization, composting (including the pine needles) and soild waste management, rainwater harvesting, weed management (especially *Bhang*), removal of grass during summer, managing livestock grazing and transit, regulating fishing in the *nallah* and river and related services.

IIT Mandi should reach out and work with state government departments concerned with landscape development and ecology. The Parashar Lake is the nearest picnic destination for the residents of IIT Mandi. The road to the Lake is lined with some of the best forests that can be seen in the landscape. The proposed Center for Integrated Mountain Development should work with the Forest Department and local people in creating a sustainable model of eco-tourism in and around the Lake.

Introduction

Institutional campuses have served as repositories of biodiversity throughout the world and as such they are gaining a lot of significance in global efforts to save the biosphere. There are many classical examples of plants and animals that were once believed to have gone extinct, discovered centuries later within institutional campuses. A good example is the campus of Indian Institute of Technology-Madras in Chennai where recent studies have shown the presence of plants like *Garcinia spicata* that the rest of the city had lost in recent times and others like *Typhonium trilobatum*, an entirely new record for the state of Tamil Nadu (Daniels *et al,* 2008).

Well managed campuses located in biodiversity rich landscapes serve as refuges and attract plants and animals that lose their natural habitats due to urbanization. While it is good to see birds and other animals sharing the campus with its human inhabitants, harmonious co-existence is not something that automatically evolves. Human-animal conflicts are common and if they have to be kept under control, there should be foresight and in biodiversity rich institutional campuses a practical ecological management plan should be at hand (Care Earth, 2006; Daniels and Arivazhagan, 2008).

Whereas *post facto* ecological management plans (EMP) are available (example Care Earth, 2006), the initiative by Indian Institute of Technology-Mandi to first evolve an EMP and plan the campus infrastructure guided by the EMP, is laudable. The proposed EMP is meant to provide guidelines on sustaining the ecology of the campus and the landscape that surrounds it.

The main objectives of the proposed EMP are the following.

- To create a baseline ecological map that will guide all decision-making on land use and infrastructure development
- To identify critical habitats and the ecosystem processes which naturally sustain them
- To identify the potential re-colonizers of the landscape specifically the ones that might prove invasive in the long-term
- To assess the potential of natural regeneration of vegetation and the direction in which it will move without human interference
- To assess the drainage pattern and identify threats, if any, to the downstream riparian ecosystem
- To document the ecological history of the landscape such that future socio-ecological impacts of the campus can be understood and mitigated

Mountains

Mountains are very special places. For many they are sacred; to most they bring an uplifting of the spirit and refreshment; to a few, they bring fear. They are the home of many different peoples in every continent. They occur in all biogeographical regions of the world, where, because of their history, isolation, and great variability of habitat, they are treasuries of high biodiversity and rich in endemic species. They contain a great variety of climates and of geological and physiographic features. They provide magnificent scenery and the qualities of remoteness and wilderness – a solace and a challenge to those who visit them. And they are the gathering grounds of much of the world's water. In fact, they are of untold value to those who live in them, those who visit them, and enjoy or study them, and those in the valleys and plains who count upon a dependable yield of high quality water, other products (wood, minerals, game, food, etc.) and recreational opportunity from them.

Hamilton and McMillan (2004)

According to Hamilton and McMillan (2004) mountains are 'steep-sided, three-dimensional earth features that are conspicuous in the landscape, have more than one altitudinal vegetation zone, and are regarded as mountains by local people'. Due to their steepness and extreme weather conditions and instability of soils mountains are not ideal for commercial agriculture. Some may however support subsistence farming, grazing and agro-forestry. Many are remote and inaccessible that they are far from markets and provision services such as education and health.

In many countries, the lowland urban centers have viewed mountains as supply areas, to be used or exploited for wood, water, wildlife, minerals, or recreational opportunity including mass tourism. Also, since they frequently form international borders, they are important for defense. The people who live there are often proud and independent, and considered unruly and backward by lowlanders. But their (mountains') very remoteness and difficulty of access often means they are the last bastions of wild, pristine nature and unfettered evolutionary processes. This makes them rich treasuries of native biological diversity. It also means that they possess some of the last remaining large wilderness areas, for those who crave or need solitude and as much absence of human disturbance as possible (Hamilton and McMillan, 2004).

Hamilton and McMillan (2004) have listed a number of reasons for conserving mountains. These reasons, although focused on wildlife protected area management, are relevant to the management of the upcoming IIT Mandi Campus and are therefore listed below (with minor changes).

- Mountains are often associated with “sacred” aspects of nature. There may be pilgrimage to holy hills or taboo places of fear that present unusual management situations
- Mountains have mystique for scholars, visitors and the general public. This has plus and minus effects
- Traditional indigenous groups with threatened cultures often occupy or use the areas
- They add greatly to the interest, can contribute much and represent a clear case for cultural diversity conservation. Cultural diversity may be more threatened than biodiversity
- Mountains are headwaters of valuable surface water resources
- Special care is needed to safeguard water quality for all downstream sites. The few remaining economically feasible water storage reservoirs for water and power are in mountain valleys
- Mountain biota, under climate stresses at the best of times, is particularly vulnerable to climate change from increasing greenhouse gases, as well as from exogenous air pollution. They offer great possibilities for global climate change and air quality research and monitoring
- Mountains are a last refuge for many rare plants and animals eliminated from more transformed lowlands. They are vital to biological diversity conservation
- These are dynamic landscapes of relatively rapid change. Volcanism, uplift, erosion, glacial outbursts, seismic activity, avalanches and torrents all contribute to significant rapid alterations in topography, vegetation and land use. These are high-energy environments where some control over human alternations is often needed
- There is a concentration of high scenic value, attractions for tourists and recreational use. Management is needed to maintain these values
- The concentration of humans in confined landscapes demands a proactive policy and management approach to avoid overcrowding and degradation (rubbish, sanitation, erosion, etc.) and call for positive control to avoid site degradation and require that equipment, materials and refuse brought in be taken out.

Himachal Pradesh: Geography and Wildlife

Himachal Pradesh (Himachal) is a mountainous Himalayan state (30^{o} 22’N-33^{o} 12’N; 75^{o} 45E-79^{o} 04’E) with a rugged and steep topography. It has a geographical spread of 55,673km^2. The altitude varies from around 450m to 6500m ASL. The state is well-drained and the major rivers that flow through it are Chenab, Ravi, Beas, Sutlej and Yamuna. All these rivers are snow-fed and perennial. Reservoirs cover an area of 41,796ha; the largest being the Bakra Nangal (Gobind Sagar) and Pong with a water spread of 16, 867ha and 24,629ha (at full level) respectively (Katiha *et al*, 2009). The state accounts for 17% of the northwest Himalayan region with a forest cover of 10,770km^2 and a human population density of 109/km^2 (Prasad *et al*, 2004; Vijayan *et al*, 2004). As per the Botanical Survey of India the major forests types of Himachal include Subtropical Pine Forest, Montane Wet Temperate Forest and Subalpine and Alpine Forest. Around 11% of the state has

been brought under the system of wildlife protected areas (Satyakumar and Shivakumar, 2007; pages 117-119).

Elsewhere, the state has been described as a mosaic of vegetation types that are typical of the Himalayan eco-region. The broad categories of vegetation are Montane Grasslands and Shrublands that are representative of the Tibetan Plateau and Northwestern Himalayan Alpine Shrub and Meadows and Temperate Broadleaf Forests such as Western Himalayan Broadleaf Forests. There are also sub-alpine and subtropical conifer forests; Western Himalayan Sub-alpine Conifer Forests and Himalayan Subtropical Conifer Forests (Wikremanayake *et al*, 1998).

Himachal is divided into 5 distinct provinces as per the Wildlife Institute of India's biogeographic classification of India (Prasad et al, 2004): the Trans-Himalaya-Ladakh Mountains (Biogeographic Province 1A), Trans-Himalaya Tibetan Plateau (Biogeographic Province 1B), Himalaya-Northwest Himalaya (Biogeographic Province 2A), Himalaya-West Himalaya (Biogeographic Province 2B) and Semi-arid Punjab Plains (Biogeographic Province 4A).

The state is known for its diverse high-altitude Himalayan flora and fauna. The region comprising the hills of Jammu-Kashmir, Himachal and Uttar Pradesh is home to 450 species of endemic flowering plants (Rawat, 1997; Wikremanayake *et al*, 1998).

Amongst birds, pheasants are ecologically important (being ground birds, large in body size, attractive in plumage and relished as food). Six species including the Himalayan Monal (*Lophophorus impejanus*), Kalij (*Lophura leucomelana*), Cheer (*Catreus wallichii*), Koklass (*Pucrasia macrolopha*), Western Tragopan (*Tragopan melenocephalus*), Red Jungle Fowl (*Gallus gallus*) and Indian Peafowl (*Pavo cristatus*) are known from the State (Sathyakumar and Shivakumar, 2007; p117).

While there are many species of pheasants and other birds of ecological significance, the state as a whole falls within the Himalayan zone that has, relatively speaking the lowest diversity of birds. According to Wikremanayake *et al* (1998) the number of species of birds known within the state varies from as low as 84 to a maximum of 485 locally. This figure is considered as 'low' only when compared with the central and eastern Himalayas where species richness of birds falls in the range of 609-682.

The northwest and western Himalayan regions, that cradle Himachal, are well-known for the diversity of highly elusive, rare and endangered mammals such as the Musk Deer and Snow Leopard. Much less is known of the smaller mammals, especially the carnivores including

mongooses, weasels, civets and martens. The important species representing this group of carnivorous mammals known from the region are Beech or Stone Marten (*Martes foina*), Yellow-throated Marten (*Martes flavigula*), Himalayan Stoat or Ermine (*Mustela erminea*), Pale Weasel (*Mustela altaica*), Yellow-bellied Weasel (*Mustela kathiah*), Siberian Weasel (*Mustela sibrica*) and the Himalayan Masked Civet (*Paguma larvata*) (Hussain, 1999).

Ecological Significance of Mandi District

Mandi district has a geographical extent of 3950km^2. The elevation varies from 750m ASL or less (as around Mandi town) to 4038.5m ASL at the Nargu Peak. The human population is 901,344 with a density of 228km^2. One per cent (3951ha) of the district is designated as forest (www.himachalpr.gov.in).

As with most parts of Himachal, the district falls within the Palearctic biogeographical realm largely experiencing temperate climate. According to Sharma (undated) the district has three distinct seasons; winter (November-March), summer (April-June) and rainy season (July-September). It is warm during April-October when the maximum temperature tends to exceed 30^{o}C, becoming hot locally with a recorded maximum of 41^{o}C.

Winters are freezing when snow descends to around 1200m ASL. Snow descends lower occasionally as during the years 1961, 1973 and 1991, Mandi town had experienced snowfall in winter (Sharma, undated). Rainfall, as recorded at the Pandoh dam site during the years 1982-1993, varied from 358mm to 1954mm, the average being 1224mm placing the district within the moist climatic regime (Sharma, undated).

Mandi district is also known for its rock salt deposits, iron ore, limestone and clay and slate (Sharma, undated). The major forests types are Subtropical Pine and Montane Wet Temperate. Judging by the vegetation type in adjoining hills of the state, the specific type of vegetation could be treated as Himalayan Subtropical Pine, dominated by Chir Pine (*Pinus roxburghii*) and Lower Western Himalayan Temperate, dominated by species of Oak (*Quercus* spp) (Jayapal and Ramesh, 2009). Specifically, the HP Forest Department has described the forests as moist temperate and at lower elevations, dry, tropical and subtropical forests (Sharma, undated). Twenty-four subcategories of vegetation have been listed for the Mandi and Joginder Nagar forests divisions (Table 1).

Table 1: Vegetation types of Mandi and Joginder Nagar forest divisions (Sharma, undated)

Northern dry mixed deciduous forest
Upper or Himalayan Chir Pine forest
Himalayan subtropical scrub
Subtropical Euphorbia scrub
Olea cuspidata scrub forest
Lower western Himalayan temperate forest and *Ban* oak forest
Moru oak forest
Oak scrub
Moist Deodar forest
Western mixed coniferous forest
Spruce-Deodar forest
Predominantly spruce forest
Spruce-silver fir forest
Pure silver fir forest
Moist temperate deciduous forest
Low level blue pine forest
Kharsu oak forest
West Himalayan upper oak & fir forest
Montane bamboo brakes
Himalayan temperate pastures
Himalayan temperate secondary scrub
West Himalayan sub-alpine fir forest
West Himalayan sub-alpine birch and fir forest
Birch-*Rhododendron* scrub forest

The district falls within the Himalaya-Northwest Himalaya biogeographic province (2A) (Prasad et al, 2004). Three of the 34 (or more) wildlife protected areas declared in Himachal Pradesh fall within the district; Bandi Wildlife Sanctuary, Nargu Wildlife Sanctuary and Shikari Devi Wildlife Sanctuary. Together they cover an area of 390km^2 (10% of the district) (Mathur, 2000).

Mandi district lies within one of the important biodiversity conservation landscapes of the Himalayas. The Himalayan landscape described as Govind Pashu-Kedarnath-Pin Valley Complex, a designated endemic bird area as per the International Council for Bird Preservation assessment, cradles the district and its surrounding areas (Wikremanayake *et al*, 1998).

However, the District has not been fully explored for its biodiversity wealth. There is lack of information on plants and even the most obvious animals. For instance, the only list of plants

available as a benchmark is that provided for the Mandi and Joginder Nagar forest divisions in the Working Plan. The list provided in Sharma (undated) includes around 385 species of plants.

Similarly, for animals the only baseline information on species that are known from the district is that provided by the Zoological Survey of India (Director, 2005). This list, while apparently comprehensive for the State as a whole is rather rudimentary for the Mandi district. The list includes 132 species of birds, 21 species of fishes, 11 species of amphibians and no reptiles. There is no specific list of mammals for the district although at least 107 species are known from the State of Himachal (Director, 2005). Further, while Zoological Survey of India has listed 288 species of butterflies for the State, only 34 are listed from Mandi district (Director, 2005).

The Mandi district is also an important watershed that sustains Beas, a major tributary of the River Indus. Tirthan, Hansa, Bakhli, Jiuni, Suketi, Panddi, Son and Bather that flow from the north join the Beas within the Mandi district (Moza and Mishra, 2009). These are the left bank tributaries. Bajuara and Uhl are amongst the right bank tributaries that feed river Beas (Sharma, undated). According to river ecologists the district covers two Himalayan riparian zones; Lesser Himalayan Riparian Zone (1000-2000mASL) and Siwalik Riparian Zone (<1000m ASL) (Sehgal, 1999).

The River Beas

River Beas is the only tributary of the River Indus that is confined to India. The 460km (470km according to some sources eg Sehgal, 1999) long river originates from two sources, Beas Kund (4060mASL) and a cavern Beas Rishi adjacent the Rohtang Pass at an elevation of 4350mASL. The two streams meet at Palchan village, 10km north of Manali to form the river Beas (Moza and Mishra, 2009).

Beas is a perennial river and has drainage of 25,900km^2. However, the rate of water discharge varies with the seasons being the highest in July-September wherein 67% of the water is discharged and lowest in January-March when the discharge is just 8% of the annual volume. The seasonal fluctuation in the discharge of water and drying out of streams, leaving only isolated pools is vital to the ecology of the river (Sehgal, 1999).

The water quality parameters of the river Beas are: 23.3^{o}C, transparency 29.5cm, dissolved oxygen 6.7mg/l, pH 6.8, total alkalinity 71.5mg/l, conductance 208 µmhos, total dissolved solids 103mg/l, total hardness 89mg/l, chloride 20.7mg/l, silicate 2.0mg/l and phosphate 0.290mg/l (Pathak and Tyagi, 2009).

The ecology of the river is better studied within the limits of Punjab, starting from Talwara till the Harike Lake (about 165km stretch of the river). The primary productivity estimated during 2002-05 ranges between 177.09 mg C/m^3/hr and 207.03 mg C/m^3/hr. The average standing crop of plankton varied between 80 and 270µ/l, 80-95% being phytoplankton. *Eunotia, Cyclotella, Staurnies, Naviucla, Diatoma, Frustulia, Microcystis* and *Spirulina* were the common phytoplankton observed during 2002-05. Rotifers (*Brachionus, Filina*), Copepods (*Cyclopsis, Diaptomus, Nauplii*) and protozoans were the predominant zooplankton observed (Moza and Mishra, 2009).

Around 100 genera of aquatic invertebrates have been recorded in river Beas. Sixty per cent of the invertebrate genera are of insects, while 25% are mollusks (snails and allies). The river is home to 53 species of fish, important being the Snow Trout (*Schizothorax richardsonii*)* and Golden Masheer (*Tor putitora*) both popular game fish (Moza and Mishra, 2009).

Seasonal migration of fish has been reported along the river Beas. The Snow Trout, for instance, migrates upstream towards the higher reaches during summer when the water downstream becomes warmer. This species breeds in the upper reaches of the river during July-August when the water temperatures are between 16.5 and 18.5^{o}C. The Snow Trout is adapted to fast flowing and turbulent waters (0.9-1.8m/sec), lower temperature (monthly mean of 17.3^{o}C) and high concentrations of dissolved oxygen (10.1mg/l). The Masheer, also a migratory fish, is a species of warmer and less turbulent water; temperature 22.1^{o}C, dissolved oxygen 8.0mg/l and velocity 0.5-0.7m/sec (Sehgal, 1999).

The first reservoir across the river Beas, namely Pandoh is in the Mandi district from where water is diverted to the river Sutlej through the Beas-Sutlej Link Canal (Moza and Mishra, 2009). The reservoir is at an altitude of 987mASL. The water temperature varies between 10.5 and 16.5^{o}C (Raina and Petr, 1999). Cold water steam fishes including the Snow Trout and the Golden Masheer inhabit the reservoir. Other species known from the waters are carps (*Labeo dero* and *Labeo dyocheilus*)* (Raina and Petr, 1999).

*Note: Snow Trout is known as *Asela* or *Rasela*, *Labeo* spp as *Unera* and *Barilius* spp as *Dhaur* or *Jabua* in Kumaun Himalayas (Sunder Singh, Undated); *Labeo dero* as *Chhali* and *Labeo dyocheilus* as *Torki*, *Schizothorax* spp as *Swati, Keerni, Baltastani*, *Barilius* spp as *Chilwa* in Urdu (Mirza and Alam, 1994)

Kataula Forest Range

The proposed IIT Mandi will be located within the Kataula forest range. The Katuala forest range is a part of the Mandi forest division and as with the rest of the division has had a long history of forest exploitation. According to Sharma (undated) the forests have been worked for timber starting 1880. Much of the natural Deodar, Chir Pine and Ban oak have been depleted in the past 200 years. Remnant vegetation that provides habitat for the 3 species is scarce and most of what has been left (especially of Chir Pine) within the range is planted.

The forests, at present, within the Kataula range represent 5 of the 24 vegetation types known from Mandi-Joginder Nagar forests divisions (see Table 1). The vegetation is secondary (degraded) although it has not entirely lost its original character. As with the rest of the landscape altitude and aspect have played a major role in determining the distribution, extent and quality of each vegetation type (Table 2).

Table 2: Major vegetation types of Kataula Range

Type of vegetation	Associated plants	Topographic distribution
Northern dry mixed deciduous forest	*Acacia catechu, Bombax ceiba, Erythrina variegate, Lannea coromandelica, Bauhinia variegata, Ougenia sp, Kydia calycina, Emblica officinalis, Albizzia spp, Mallotus philippinensis, Murraya koenijii, Adhathoda vasica, Woodfordia fruticosa, Indigofera pulchella, Euphorbia royleana, Rubus spp*	Less than 1200m ASL; south, southeast and east-facing aspects that are lit by the morning sun
Upper Himalayan Chir Pine forest	*Pinus roxburghii, Quercus spp, Rhododendron arboreum, Berberis sp, Rubus spp, Prinsepia utilis, Pedicularis carnosa, Heteropogon contortus, Agrostis alba, Plectranthus strictus*	600-2200m ASL; north, northwest and west-facing aspects that receive sunlight only in the afternoon and evenings
Subtropical *Euphorbia* scrub	*Euphorbia royleana, Bombax ceiba, Ficus spp*	Rocky slopes that are lit by the morning sun; more associated with the northern dry mixed deciduous forest
Predominantly spruce forest	*Picea sp, Cedrus deodara, Juglans regia, Acer spp, Aesculus indica, Quercus spp*	Scarce & locally along the slopes overhanging the *nallah*; restricted to slopes that receive only evening sunlight
Montane bamboo brakes	*Arundinaria falcata, Arundinaria spathiflora*	No specific information

IIT Campus

IIT Mandi is to be located at Kamandh. The word Kamandh means 'sugarcane' a crop that was once extensively cultivated in the landscape. The Campus is shaped like an unfinished boomerang with an east-west spread of around 3km and a north-south reach of a little more than 2km (Figure 1). The northeastern limit of the Campus lies closer to the Kataula village at a distance of 3-4km (by road) from the Forest Rest House. At this end the Campus is at an elevation of 1000-1200m ASL from where it gently slopes downwards till about 950m ASL at the valley (southwestern end) through which the river Uhl flows. River Uhl is one of the right back tributaries of the River Beas (Sharma, undated).

The entire Campus that covers 531 acres (212ha or 2.12km^2) has an undulating topography with the *Kautala ki khad* (nallah) running east-west like a backbone. The nallah flows through a gentle gradient. Boulders characterize the course of the nallah keeping it narrow in most parts. Wherever the nallah meanders the course is wider and in some parts of its course, where it flows through gorges, it is narrow.

Downstream the nallah joins the river Uhl, a major tributary of river Beas, close to the historic wooden bridge, forest nursery and check post at Kamandh. The river Uhl flows from north to south and is as boulder-strewn as the nallah, although where it meanders, there are deep pools and sandy beaches. South of Kamandh, the north-south boundary of the Campus is defined by the river Uhl (the same may be treated as the western limit of the Campus).

In cross section, the Campus is rather narrow, accommodating the valleys of the nallah and river Uhl that locally assume the topography of gorges, spreading out into rather flat or gently sloped table lands (around 1000-1100m ASL) and all along the periphery bounded by hills that rise rather steeply to around 1300m ASL. In other words, it may be described that the Campus has all the topographic features of a small watershed.

Present Study: Duration and Approach

An ecological study was undertaken in March 2010. The field study that was led by Care Earth Trust was spread over 17 days (March 10-27, 2010) and involved a team of ecologists and foresters (see Project Team for details). The study adopted the following approach:

- Compile available information on ecology and biodiversity of the landscape from various sources such as the Wildlife Institute of India, Dehra Dun (Jayapal and Ramesh, 2009; Jishtu *et al*, 2007; Rawat, 1997 & 2007), Indian Council of Agricultural Research (Das *et al*, 2007; Katiha *et al*, 2009; Moza and Mishra, 2009; Pathak and Tyagi, 2009) and Zoological Survey of India (Director, 2005).
- Visit the various habitats in and around the Campus and assess the biodiversity and the apparent ecological processes that govern them.
- Map the topography and current land use of the Campus and surrounding landscape.
- Visit the neighboring villages and conduct interactive meetings to document peoples' views and concerns about the establishment and long-term impacts of an educational institution.
- Meet with officials of the Forest Department to understand the history of the forests and their views on sustainable management and ecological restoration of the vegetation within the Campus and surrounding areas.
- Review the proposed land use and infrastructure development (eg IIT Roorkee, 2009; Vaidya & Associates and Space Matrix, 2009) for their ecological appropriateness.

History of land use

Agrarian and pastoral villages including Kamandh, Siram, Salgi, Hilog, Gharpa, Khara and Kani have had a historical influence on the Campus. Other than these villages, Chargha and Mayal are localities that are marked in the revenue map, although at present there is no human habitation here. According to the local residents, the villages Salgi, Hilog and Gharpa were handed over to the Animal Husbandry Department (HP) by the government around 50 years ago. These areas that are largely flat have since been used for intensive grazing and agro-forestry. There are also many buildings, including cattle-sheds, built by the Animal Husbandry Department strewn across these flat table lands that have been abandoned recently. Whereas Salgi and Hilog are mostly confined to the table lands that lie south of the nallah and east of the river Uhl, Gharpa is on the north, overhanging the river Uhl and the nallah, and at a higher elevation (around 1100m ASL).

The Gharpa table land presently accommodates a temple within the northern part of it (31.78001^{o}N; 76.98728^{o}E) and (what appeared like) the administrative buildings of the Animal Husbandry Department in the south (31.77712^{o}N; 76.98463^{o}E). The two fragments of table land are divided by a ridge, yet connected by foot paths; the longer one (cemented) that passes the

temple descends down to the school and primary health centre, close to the new bridge (31.77643°N; 76.98982°E). The Gharpa table land has had a motorable access from the Kataula-Kamandh road (to the right as one approaches the historic wooden bridge; 31.77626°N; 76.98489°E). Opposite this point there is yet another motorable road that runs downhill and through the nallah providing access to the Hilog flat areas previously used by the Animal Husbandry Department.

Major roads that are of immediate relevance include the Kataula-Kamandh link road and the Kamandh-Mandi road (steep road uphill) that are used rather intensively for public transport (buses ply frequently on these roads). One less intensively used *kutcha* road from the historic wooden bridge (also known as the old Mandi road) links the Siram village with Kamandh and Kataula. Near the school and primary health centre at Kamandh a metal (tar-capped) road deviates and runs south after crossing the new bridge, and through the Animal Husbandry flat areas through Hilog (touching the site where the IIT Mandi foundation stone has been erected; 31.77565°N; 76.98742°E). This road links the Navalai village to Kamandh. Further, there is a wide, dirt road that runs across the nallah through a new concrete bridge (31.78324°N; 76.99926°E; old iron bridge lies abandoned adjacent this bridge) starting from Salgi and uphill beyond Mayal. There is a traditional watermill (still in use) right below this bridge.

Socio-ecology of the Landscape

The Kataula-Kamandh landscape with its many hamlets is a natural extension of the town of Mandi (which is also known as the Chota Kashi) in that the inhabitants accord immense reverence to religion. This is evidenced by the presence of a large number of shrines and temples dedicated to Devi, Siva and Vishnu. There are also a number of sacred habitats named after sages such as Parashar, Markandeya, Ved Vyas, Vashisth, Manu, etc.

The landscape is home to Hindus and Muslims and despite the staunch caste and religious identities there are no conflicts between the groups. This is many ways typifies the social structure of the landscape – wherein the lines of rights, roles and responsibilities are clearly drawn and regulated by customary rules and governing structures. The absence of any external organization (such as community based organizations or non governmental organizations) for engagement in community mobilization or development is an issue of interest – and is an opportunity for IIT Mandi to engage itself in programmes beyond regular academics.

While Kataula can be designated as a village in terms of structure and population, Kamandh, Salgi, Garpa etc are essentially hamlets. IIT Mandi falls within the Panchayat of Kamandh (reserved constituency for women) headed by a rather dynamic Pradhan and Up-Pradhan. The Gram Sabha is a strong entity, and keeping in with tradition, nominations are strictly based on the stature earned by the individual within the landscape. It is also a point of interest that many of the forest guards are also women.

Interestingly, the landscape is typified by a number of abandoned hamlets, although the names continued to be used. The rather dynamic nature of the hamlets is due to large scale internal displacement facilitated not only by the establishment of the Animal Husbandary Unit during 1958-62, but also because of the nomadic nature of some of the tribal groups who practice slash and burn agriculture or are pastoralists who moved animals across to further north. There has also been a large scale inflow of Rajputs (Thakurs) from the lower reaches of the region about 40-45 years ago in search of livelihoods (lands and timber felling).

Land use is planned with the river as the focus; with dedicated places of grazing, agriculture and worship (locally known as Malkiyal, Kadiyather, Charag, etc). Domicile was historically defined by land ownership – people preferred to stay close to the lands – hence scattered distribution of households.

Major endogamous groups of the landscape include the Gaddis (pastoralists who tend goats and sheep), Gujjars (pastoralists who keep cows), Lavene (who tend to horses and mules), Lohars (ironsmiths), Duwains (Goldsmiths), Charchas (undertakers), Kumhars (potters), Rajputs, the broad class of Scheduled Castes and Brahmans (of various Gothras). Muslims form a minority and are engaged in trade and agriculture.

Literacy rates within the landscape are extremely low; with rather high drop out rates amongst girls. Lack of access to higher education and paucity of infrastructure and personnel in the local school are cited as the primary reason for poor literacy rates. Livelihood options are of the primary sector, dominated by agriculture and cattle rearing. Other preferred options include the armed services (there are a number of retired personnel of the armed services in the landscape) and transport. Trade is limited to small shops selling basic grocery and clothes – the nearest major market is Chandigarh from where goods are procured on a pre-arranged basis.

Agriculture is dominated by the cultivation of wheat, maize, minor millets and vegetables through a system that can be broadly described as intermediate between subsistence and commericial – wherein the cereals are predominantly consumptive or in parts used for barter, while the vegetables and spcies are sold in the nearby markets. The reasons for the abandonment of sugar cane (cash crop) could not be probed during the current study and may well be a point of interest since not many landscapes have rejected commercial crops for food crops notably cereals. While apple is not locally cultivated, there are apple nurseries around Kataula.

Land within Hilog has been traditionally used as pasture and for agro-forestry, largely for tree-fodder. Cultivated land, closest to the Campus, are those within Salgi and Siram villages. Cultivation bordering the nallah is irrigated through a simple network of canals that are fabricated using boulders and slates in the lower reaches of the landscape, or rainfed along the slopes and higher reaches. The last few years have witnessed the use of sprinklers in some of the hamlets. Keeping in the overall view of many of the hill dwelling communities of India, home gardens are not exclusive entities but are seen as a natural extension of the habitations with many plants being a common property resource. The tradition and practice of pastoralism is rather well entrenched and there are about 3800-4000 cattle in the landscape.

Flora

Background information, specifically on the diversity of plants in and around the Campus, is scarce and limited to reports and publications that focused on similar terrain within the Western Himalayas; example Jayapal and Ramesh, 2009; Jishtu *et al*, 2007; Rawat, 1997 & 2007; Sharma, undated; Collett and Hemsley, 1980; Dhaliwal and Sharma, 1999; Polunin and Stainton, 2006. Around 200 species of plants were observed in and around the IIT Campus during the brief field studies in March 2010. The complete list of plants is provided in Appendix 4.

Based on the the March 2010 field investigation and the plants identified it may be said that the vegetation on the Campus is a mosaic of three broad types amongst those listed in Table 2, viz., northern dry mixed deciduous forests, upper or Himalayan Chir Pine forests and subtropical *Euphorbia* scrub (Champion and Seth, 1968). Of these the mixed deciduous forests and *Euphorbia* scrub are predominant covering most of the Campus designated as forest.

Chir Pine (*Pinus roxburghii*) is associated with *Rhododendron arboreum*, *Phoenix sylvestris*, *Myrica esculanta* and *Engelhardia spicata*. The common shrub species forming understory of the Chir forest include *Rhus cotinus, Berberis lycium, Berberis asiatica, Reinwardtia indica* and *Prinsepia utilis.* The ground vegetation is represented by a variety of herbaceous species such as *Gentiana capitata, Geranium wallichianum, Gerbera gossypina, Artemisia vestita, Eupatorium adenophorum, Galium aparine, Stellaria media, Taraxacum officinale, Campanula argyrotricha, Aechmanthera pedata, Bergenia ciliata, Sauromatum pedatum, Leucas lanata, Micromeria biflora*, *Scutellaria angulosa*, *Ajuga parviflora*, *Ageratum conyzoides*, *Senecio nudicaulis*, *Notholirion thomsonianum* and *Tulipa stellata.* Common grasses associated with Chir forest are *Arundinella nepalensis*, Themeda anathera, *Oplismens burmanii*, *Eulaliopsis binata, Thysanolaena maxima, Apluda mutica, Cynodon dactylon, Arundinaria falcata* (Nargal) and *Pennisetum orientale*.

Chargha is the only part of the Campus where there is a dense natural stand of the Chir Pine (*Pinus roxburghii*). As with the rest of the landscape, aspect plays a major role in determining the distribution of vegetation in that the natural Chir forests are confined to the slopes. Here there are occasional trees of *Rhododendron arboreum* (example the southern slopes facing Salgi). Chir Pine trees over the rest of the Campus are largely planted. They are young, as inferred by the slender boles.

Myrica esculenta is a very valuable medicinal plant and its fruits are cherished by the local people and also eaten by a variety of frugivorous birds and other animals. *Tulipa stellata* (Wild Tulip) and *Notholirion thomsonianum* (Lily) are small interesting herbaceous flowering plants growing exclusively in the Chir forests. These species are of high conservation significance.

A major chunk of vegetation in the Campus is represented by scrub which seems to be a result of degradation of the dry mixed broadleaved deciduous forests and subtropical scrub due to over-grazing, timber and fuelwood collection during the past several decades. This vegetation type can be seen mainly around Hilog and Gharpa. Besides a number of shrub species, a few tree species can be seen scattered here and there e.g., *Albizia julibrissin*, *Bauhinia variegata, Bombax ceiba, Celtis tetrandra, Emblica officinalis, Ficus palmata, Ficus roxburghii, Ficus semicordata, Glochidion velutinum, Grewia optiva, Juglans regia, Mallotus philippensis, Machilus odoratissima, Morus alba,* and *Myrica esculenta.* The shrub species of the this habitat are *Adhatoda zeylanica, Agave americana, Barleria cristata, Berberis asiatica, Berberis lycium, Boehmeria platyphylla, Buddleja paniculata, Pogostemon benghalense, Caryopteris odorata, Colebrookea oppositifolia,*

Debregeasia hypoleuca, Dendrocalamus strictus, Deutzia corymbosa, Ficus foveolata, Idigofera pulchella, Inula cappa, *Kirganellia virosa*, *Maesa indica, Murraya koengii, Myrsine africana*, *Plumbago zeylanica, Prinsepia utilis, Cyathula tomentosa, Hypericum elodeoides, Rabdosia rugosa, Reinwardtia indica, Rosa moschata*, *Solanum verbascifolium, Solanum indicum, Solanum torvum, Urtica dioca, Vitex negundo, Zanthoxylum armatum* and *Lantana camara.*

Steeper slopes, relatively free from anthropogenic pressures, harbor quite a few species representing sub-tropical scrub and dry mixed broad leaf forests e.g., *Ougenia oogeinensis, Pistacia integerrima, Pyrus pashia, Rhamnus triqueter, Sapindus mukorossi, Saurauia napaulensis, Syzygium cumini, Terminalia belerica, Toona ciliata, Ulmus wallichiana, Zizyphus mauritiana, Sapium insigne, Sterculia villosa* and *Bridelia retusa*. The steep sides of the gorges along the nallah (*Kataula ki Khad*) near Kamandh have a profuse growth of broom grass (*Thysanolaena maxima*).

Kataula ki Khad, a small tributary of Uhl river that forms lower boundary of the Campus is characterized by steep ravines and gorges. The vegetation is unique and marked by the presence of typical riparian species such as *Salix alba, Machilus odoratissima* and *Syzygium cumini.* Other species along the river courses are *Acorus calamus, Ageratum conyzoides, Ajuga parviflora, Anagalis arvensis, Eupatorium adenophorum, Mantha longifolia, Mazus surculosus, Nasturtium officinale, Nepeta hindostana, Oxalis corniculata, Kirganellia virosa, Ranunculus sceleratus, Rumex nepalensis, Rumex hastatus, Rungia pectinata, Solanum indicum, Solanum nigrum, Stellaria media, Veronica anagallis-aquatica* and *Veronica persica.*

The riparian and rocky slopes also harbor a number of climbers and shrub species such as *Ampelocissus latifolia, Cayratia divaricata, Asparagus adscendens, Bauhinia vahlii, Cissampelos pareira, Dioscorea belophylla*, *Helinus lanceolatus, Clematis barbellata, Ipomea* sp., *Piper brachystachyum, Pueraria tuberosa, Rubus ellipticus, Rubus niveus, Rubus paniculatus, Smilax aspera* and *Trachelospermum axillare.*

The fallow fields (abandoned since the past 5-10 years) have scattered trees largely planted for fodder or ornamental purposes. Common trees along the field borders and building premises are *Albizia julibrissin, Bauhinia variegata, Callistemon lanceolatus, Cassia fistula, Cedrus deodara, Celtis tetrandra, Dalbergia sissoo, Grevillea robusta, Grewia optiva, Melia azedarach, Jacaranda mimosifolia, Leucaena leucocephala, Populus cilita, Prunus armeniaca, Pyrus pashia, Quercus leucotrichophora, Thuja compacta, Ulmus wallichiana, Lagerstroemia indica*, and *Eucalyptus* sp. In

addition, a few native species can be seen scattered along the edges of fallow fields such as *Ficus palmata, Ficus religiosa, Ficus roxburghii, Bombax ceiba, Erythrina suberosa, Mallotus philippensis, Mangifera indica, Morus alba, Oroxylum indicum, Pistacia integerrima Salix alba, Punica granatum, Syzygium cumini, Terminalia bellerica* and *Toona ciliata.*

The other shrubs and herbaceous species in fallow lands and along the roadsides are *Opuntia dillenii, Agave wightii, Berberis asiatica, Berberis lycium, Boehmeria platyphylla, Buddleja paniculata, Cannabis sativa, Pogostemon benghalense, Carissa opaca, Caryopteris odorata, Colebrookea oppositifolia, Dendrocalamus strictus, Deutzia corymbosa, Lepidagathis cuspidata, Maesa indica, Murraya koengii, Plumbago zeylanica, Prinsepia utilis, Rabdosia rugosa, Reinwardtia indica, Rosa moschata*, *Solanum indicum, Solanum torvum, Urtica dioca, Zanthoxylum armatum*, *Lantana camara, Asparagus adscendens, Cissampelos pareira, Rubus ellipticus, Rubus niveus, Rubus paniculatus, Smilex aspera, Artemisia nilagirica, Acorus calamu Aechmanthera pedata, Aerua scandens, Ageratum conyzoides, Ajuga parviflora, Anagalis arvensis, Bidens pilosa, Bidens wallichii, Vicia hirsuta, Cynoglossum zeylanicum, Cannabis sativa, Dicliptera bupleuroides, Duchesnia indica, Erigeron canadensis, Eupatorium adenophorum, Euphorbia hirta, Evolvulus alsinoides, Galium aparine, Geranium ocellatum, Geranium wallichianum, Lepidagathis incurva, Leucas lanata, Mantha longifolia, Mazus surculosus, Micromeria biflora, Nasturtium officinale, Nepeta hindostana, Oxalis corniculata, Ranunculus sceleratus, Rumex nepalensis, Rumex hastatus, Rungia pectinata, Sauromatum pedatum, Scutellaria angulosa, Solanum indicum, Solanum nigrum, Stellaria media, Strobilanthus glutinosus, Taraxacum officinale, Trifolium repens, Vernonia cinerea, Veronica anagallis-aquatica Veronica persica, Xanthium strumarium* and *Youngia japonica.* A few grasses along the edges of the forests are *Arundinella nepalensis*, *Oplismenus burmanii*, *Eulaliopsis binata, Thysanolaena maxima, Apluda mutica, Cynodon dactylon* and *Pennistum orientale*.
Albizia julibrissin, Celtis tetrandra, Pistacia integerrima and *Grewia optiva* are important fodder species favored by the local communities for agro-forestry. *Zanthoxylum armatum, Asparagus adscendens, Pueraria tuberosa, Acorus calamus, Scindapsus officinalis, Plumbago zeylanica* and *Hydrocotyle asiatica* are some important medicinal plants found in this landscape.

Common invasive species of plants like *Lantana camara* (*Choti podari*), *Parthenium hysterophorus, Eupatorium adenophorum, Cassia tora and Cassia occidentalis* are frequent on the Campus. *Choti*

podari is used locally as a hedge plant. *Parthenium* is abundant throughout the grazed areas, especially within the Hilog and Gharpa flat spaces. These plants are unusually tall here reaching heights of close to 2m.

Other than these there are a few species of undesirable plants such as *Cannabis sativa* (Bhang), *Papaver somnifera* (Opium Poppy) and *Nicotiana tabaccum* (Tobacco). *Bhang* naturally occurs in the Western Himalayas and is also nurtured by the people locally and is quite prolific on the Campus. The opium poppy is cultivated around Kullu, especially close to Bajuara. Apparently, although not at the same scale, the poppy is also locally cultivated around the Campus. Isolated plants were observed in the Siram village. Tobacco grows as a roadside plant and sparse weed in the cultivated areas.

Fauna

Available information on the fauna is limited covering selected groups of animals and generally for Mandi district (Director, 2005). Supplementary information was obtained from Jayapal and Ramesh (2009). It was evident during the present study that the Campus (Kataula Range in general) falls in a Himalayan zone that has not been previously explored for its fauna. For instance, the study that began with a list of 132 species of birds for the entire Mandi district (Director, 2005) extended it by another 54 species (see Appendix 2 D). Similarly, the list of 34 species of butterflies for Mandi district has since increased to 48, despite the fact that March is not the best season for observing these insects (see Appendix 2 A). These additions are remarkable as butterflies and birds are the two most easily observed groups of animals in any habitat and if there had been any previous study in the landscape at least the common ones would have been listed.

One hundred and fifteen species of birds were observed during the two weeks and many of these including Laughing Thrushes, Yuhina, Blue Magpie, Great Barbet, etc are typical Himalayan birds. The Khaleej (a pheasant), Red Jungle Fowl and Black Francolin are ground birds that are vulnerable to habitat loss and transformation. The rich diversity of birds on the Campus may be attributed to the mosaic of habitats including the cultivated areas; in fact smaller species like the Whiskered Yuhina, Black-chinned Babbler, Scaly Breasted Wren Babbler, etc were encountered only along cultivation. These birds have a preference for scrub and thickets. The nallah is another important habitat for Himalayan birds that are associated with streams. Whistling Thrush, Brown Dipper, Crested Kingfisher, Forktail and Redstarts are generally tied to the nallah.

The Campus attracts a fairly sizeable population of vultures. Three species including the Himalayan Griffon (the largest of Indian vultures), the Red-headed Vulture and the Egyptian Vulture were observed during the study. The Griffon is particularly common and has probably benefited by the animal carcasses that are disposed in the open ever since the area was managed by the Animal Husbandry Department. Indian vultures are ranked amongst the world's endangered birds.

Two species of sparrows, the House Sparrow and the Cinnamon Tree Sparrow are common. The House Sparrow is particularly abundant in the villages that border the Campus. At a time when the world is lamenting the decline of the House Sparrow, IIT Mandi could be one of the long-term conservation areas for the Sparrow and can be an ideal study area for validating the numerous theories that biologists have proposed in recent times to argue why the species has disappeared from most urban areas.

The nallah and the river Uhl are also important habitats for native Himalayan fish. Masheer (*Tor putitora*) were quite numerous in the nallah. There were also smaller fish like the Baril (*Barilius* spp). What is most interesting however is the occurrence of Snow Trouts. Two species *Schizothorax richardsonii* (locally known as *Sal*) and *Schizothoraichthys labiatus* were observed in the nallah during March 2010. *Sal* is known for its large size, and listed amongst Indian sport fishes (Daniels, 2002). Adults may grow to 2 feet (60cm) in length. Both species of Snow Trout are much relished as food by the local people and are an important source of livelihood. Small restaurants at Kamandh regularly sell 'fish pakoda' made using *Sal.*

Snow Trout are not previously recorded anywhere from Mandi district; the latter *Schizothoraichthys labiatus* not reported earlier from Himachal (Director, 2005). The Snow Trout migrates upstream towards the higher reaches during summer when the water downstream becomes warmer. This species is known to breed in the upper reaches of the river during July-August when the water temperatures are between 16.5 and 18.5^{o}C. It is adapted to fast flowing and turbulent waters (0.9-1.8m/sec), lower temperature (monthly mean of 17.3^{o}C) and high concentrations of dissolved oxygen (10.1mg/l) (Sehgal, 1999).

Local people also reported the presence of a large species of *Channa* (could be *Channa striatus* or *Channa marulius*). A large individual that was caught near Siram village from the river Uhl apparent weighed 14 lbs (c. 6.5kg). According to the villagers introduced European trout (*Salmo* spp)

migrate downstream during winter when there is heavy snow in the mountains. Other species of fish that might be found in the river and nallah are listed in Appendix 2 B.

March marks the transition from winter to summer. It is certainly not the best time to observe reptiles and amphibians. While 11 species of amphibians are known from Mandi district (see Appendix 2 C), the only species that was active during the study is *Euphlyctis cyanophlyctis*. This aquatic frog commonly known as the Indian Skipper is one of the most adaptive and widespread of Indian animals (Daniels, 2005). Other than the Skipper, the Common Indian Toad (*Bufo melanostictus*) was observed during the study. Unfortunately, the Toad was found only as a road kill.

The only reptile that was seen during the study on Campus was a Checkered Keel-back Water Snake (*Xenochrophis piscator*). Someone had killed this! Other than the Water Snake, the villagers reported the *Dhaman* (Rat Snake *Ptyas mucosus*) and a viper (*Saptad*) and Cobra. Cobras are apparently common during the rainy season and from what the people described it is the Central Asian Cobra (*Naja oxiana*); locally called '*Spade*'. The Central Asian Cobra, also known as the 'Black' Cobra, is known from Himachal as are vipers such as the Saw-scaled Viper (*Echis carinatus*), Russells Viper (*Daboia russellii*) and Himalayan Pit Viper (*Gloydius himalayanus*). The Pit Viper is known to inhabit conifer forests around 1500m ASL and rocky terrain close to glaciers (4877m ASL) and may occur in the hills that border the Campus (Whitaker and Captain, 2008).

March may be the season when the lizards re-emerge after winter hibernation. Lizards were just beginning to come out during the study period. One Garden Lizard (*Calotes versicolor*), two individuals of the Spotted House Gecko (*Hemidactylus brooki*), one Ground Skink (*Scincella/Asymblepharus* sp) and a few individuals of the Kashmir Agama (*Laudakia tuberculata*) were observed during the study. However, none of these were seen on the Campus. The Agama was seen on the road from Kataula to Parashar Lake. The others were all within the Kataula village. Undoubtedly, all these species would occur on the Campus too.

Very little information is available on the mammals found in Kataula and the IIT Mandi Campus. The Indian Jackal (*Canis aureus*) was once sighted close to the Campus and heard at nights at Kataula. Fresh scat and pug marks on the Campus confirmed the presence of the Leopard (*Panthera pardus*). The presence of the Leopard was also confirmed by the local people. A local forester described a small wild cat that he once observed fishing in the river. When shown pictures of the species (Prater, 1980) he pointed to the Fishing Cat (*Felis viverrina*). However, since the list

of mammals provided by Zoological Survey of India (Director, 2005) for Himachal, and that, by Jayapal and Ramesh (2009) for Rupi-Bhaba Wildlife Sanctuary (Kinnaur District) do not include this species of wild cat its occurrence in Kataula has to be treated with caution.

Small bats were observed during the study. One species of Pipistrelle (*Pipistrellus* sp) was seen flying over cultivation at dusk. The abandoned Animal Husbandry Department's buildings showed signs of the presence of one or more species of fruit bats. It is likely that the Short-nosed Fruit Bat (*Cynopterus sphinx*) and the Fulvous Fruit Bat (*Rousettus leschenaultia*) occur on the Campus. The local forester reported the presence of the Flying Fox (*Pteropus giganteus*) in and around Kataula.

During the study, the Grey Mongoose (*Herpestes edwardsii*) was observed on the Campus. A sizeable population of the Rhesus Macaque (*Macaca mulatta*) was observed regularly. One road kill of the House Rat (*Rattus rattus*) was the only sign of the presence of rodents on the Campus. The local forester however reported the occurrence of the Northern Palm Squirrel (*Funambulus pennanti*). He also mentioned that he had seen the Indian Porcupine (*Hystrix indica*) in and around Kataula.

There were signs of the presence of the Wild Pig (*Sus scrofa*) in many parts of the Campus and the villagers also confirmed its presence in the landscape. Other than these the local residents reported the Indian Hare (*Lepus nigricollis*), Otter (*Lutra* sp) and Civets. The specific identity of these animals has to be confirmed.

Land Use and Infrastructure Development

Land use an infrastructure development on the 531 acre Campus should be guided by ecosystem principles (see Hamilton and McMillan, 2004) and the fragility of the mountain and riparian ecosystems that sustain the landscape and its people. Throughout the landscape, including the surrounding areas (such as Kullu, Mandi and Parashar Lake that were visited during the March 2010 study) altitude, slope and aspect play a major role in creating diverse micro-environmental regimes. It is evident that the forest types, despite the degraded nature, are still limited by the topography to the extent that there is a marked difference between the slopes that receive sunlight during the morning and the slopes that enjoy morning shade. This pattern is apparently very consistent and will have a major bearing on the Campus' ecology and micro-climate. Topography playing a major role in the phenology of plants and animals was evident during the study; for

instance, while the wild rose (*Rosa* spp) in and around Mandi town was profusely blooming, there was not even one plant within the Campus that had flowers during March 2010. The wild rose is seen on Campus and in the villages.

Local residents reported that there have been snowfall in winter in Kamandh and other villages and it is likely that areas of the Campus that are around 1200m ASL are likely to experience snow and frost during winter. Lowered winter temperature can drive wild animals closer to the residential areas leading to conflicts. Although there have not been recent reports of earth quakes in and around the Campus, landslides are frequent. Local residents attribute this to the loss of vegetation and frequent widening of roads, especially the newly laid Kamandh-Mandi road.

Table 3: Proposed land use and distribution of infrastructure on Campus

Number on Map	Facility/infrastructure*	Plinth area*		Suggested location (Block)
		Sq m	Acres	
1	Drinking water pumping/purification station	-	-	Hilog
2	Main power station	-	-	Siram
3	Lecture hall complex	16,000	4.0	Siram
	Laboratory complex	32,000	8.0	
	Central laboratory facility	6,000	1.5	
	Health center	6,000	1.5	
	WRRC & veterinary facility	-	-	
	Automobile workshop	-	-	
	Wastewater collection and treatment - 1	-	-	
4	Computer center & internet center	6,000	1.5	Hilog
5	Student's activity center & cafeteria	8,000	2.0	Hilog
6	Academic-cum-administration building	16,000	4.0	Gharpa (south)
	Central library	10,000	2.5	
	Conference-cum-auditorium	10,000	2.5	
	Technology incubation center	10,000	2.5	
	Continuing education center	6,000	1.5	
	Faculty offices building	12,000	3.0	
	Wastewater collection and treatment - 2	-	-	
7	Oxidation ponds and Solid waste management	-	-	Salgi-Chargha (west)
8	International activity center	8,000	2.0	Gharpa (north)
	Guest houses including international GH	10,000	2.5	
	Community center	4,000	1.0	
	Placement cell	4,000	1.0	
	Wastewater collection and treatment – 3	-	-	

Number on Map	Facility/infrastructure	Plinth area		Suggested location (Block)
		Sq m	Acres	
9	Campus school	10,000	2.5	Salgi-Chargha (east)
	Indoor sports	4,000	1.0	
	Commercial center including bank, etc	Not provided	Not provided	
	Recreation center for students, faculty and staff	4,000	1.0	
	Girls' hostel	4,000	1.0	
	Outdoor games/stadium	-	-	
	Wastewater collection and treatment – 4	-	-	
10	Communication center	4000	1.0	North of nallah (north Salgi)
	Wastewater collection and treatment – 5	-	-	
11-13	Faculty housing	50,000	12.5	Mayal
	Staff housing	40,000	10.0	
	Boy's hostel	6,000	1.5	
	Wastewater collection and treatment – 6	-	-	

*Note: Infrastructure and the required plinth area are based on the Project Report Prepared by IIT Roorkee (2009) with a few additional facilities as deemed necessary

The Campus falling within an important watershed of the river Beas has to be planned and managed with utmost care so that the riparian ecology is not disturbed. The following are the 4 main guiding principles adopted while outlining the EMP:

1. As far as possible restrict the buildings to the flat areas that have already been used by the Animal Husbandry Department
2. As far as possible do not disturb the vegetation on the slopes, ridges and riparian gorges
3. Neither the nallah nor the river Uhl should be burdened with the task of waste water disposal
4. The Campus cannot be managed as an island insulated from the rest of the landscape.

Table 3 provides the details of land use and infrastructure development based on the assessment of the ecological vulnerability of the Campus and surrounding villages. Suitable areas (Figure 2), designated as blocks (A-L), their extent and location as provided in the land use report prepared by Vaidya & Associates and Space Matrix (2009) were reassessed during the study and the map

redrawn (Figure 3). The required infrastructure and the proposed plinth area of each facility have been taken from the project report by IIT Roorkee (2009).

The location and clustering of buildings are proposed adopting the four guiding principles. Locating the Administration Building and the associated infrastructure at Gharpa (south) is strategically ideal as it oversees the rest of the Campus, especially the lecture halls and laboratories within the Hilog flat areas. The International Center (including the Guest Houses) is also being proposed at Gharpa (north). This is a scenic location from where it is easy to have a good view of the valley. Moreover, it will be compatible with the overall serene ambience of the Temple.

The hostels and other residential facilities have been located closer to the villages. These areas are farther away from the forests thereby reducing the chances of invasion by wild animals, although the ultimate factor that has determined the choice of locations for infrastructure development is the discharge of waste water and management of solid wastes. A centralized oxidation pond and solid waste management facility is proposed in Salgi-Chargha (west). This facility has to be used very judiciously. Right from the time of construction, solid wastes have to be segregated and all organic wastes should be composted. And as composting will attract wild animals, it is best that the facility is created and maintained as close to the forests as possible such that the movement of animals (especially Wild Pig and the Rhesus Macaque) into the residential areas is restricted.

Decentralized collection and treatment of waste water will certainly reduce the burden on the nallah and river. The proposed infrastructure has been segregated and clustered such that there is a waste water collection and treatment facility for each building complex. With the exception of the proposed waste water collection and treatment facility – 1, that will contain inorganic (laboratory & workshop wastes) and medical wastes, all others will only generate organically enriched (largely domestic) sewage that can be locally treated using soak pits and natural filters. The topography will help in the use of gravitational flow to a large extent and the filtration technique adopted should take advantage of this. It is proposed that the filtered domestic sewage is used for restoring the vegetation (and also preventing forest fires during summer) on the slopes through a network of sprinklers. Surplus treated domestic sewage can be provided for irrigation of crops in the adjoining villages during summer (example around Mayal). The location of the hostels and residential quarters is chosen considering this.

Waste water from the facility – 1, should be treated more carefully to detoxify it, eliminating the oil, diesel, etc before sending it into the oxidation ponds. There must be a provision by which all the waste water collection and treatment units are also linked to the oxidation ponds. This is necessary as local irrigation will not viable during the rains. Treated water from the oxidation ponds can be discharged into the river only during the rainy season (July to September) when the flow of water is at its peak. The nallah is shallow. The summer flow is considerably less (as inferred during March 2010) suggesting that during the height of summer, the water does not reach the river Uhl. Any discharge of sewage into the nallah, especially during summer, will cause substrate pollution due to sedimentation, thereby permanently ruining the ecology of the nallah and the river.

The suggested lay out will also enable securing the boundary of the Campus against unwarranted human intrusion. The perimeter of the Campus is quite long due to its shape and orientation. Further, the topography, the presence of the nallah and at least one highway (Katuala-Mandi road) do not permit construction of a wall all around the Campus. The boundaries of the Campus can at best be marked and secured with a fence. The suggested lay out does permit securing the buildings and other infrastructure blockwise. For instance, the Administration Building and the Guest House Complex at Gharpa can be secured as a single block. This block can be approached from the Kataula-Mandi road via the kutcha road already available (31.77624^{o}N; 76.98585^{o}E).

The second major chunk of land that can be secured as one includes the Hilog-Siram blocks (Animal Husbandry Department area). This unit has an unused motorable access from the Kataula-Mandi road (opposite the road to Gharpa). However, to make more usable, a bridge will have to built, where it crosses the nallah. The Hilog block can also be accessed by vehicles (including heavy vehicles that transport building material and other equipment) through the metal-capped road that connects Kamandh with Navalai village.

The third block will be within Salgi-Charga (east). This block has a wide access (dirt road) from the Kataula-Mandi road almost at the beginning of the Campus. The block at Mayal can be a part of Salgi-Charga (east) or it may be maintained as another smaller block. The segment north of the road/nallah (north Salgi) where the Communication Center has been proposed is to be managed a small walled block as it is right next to the road and isolated from the rest of the Campus.

Thoroughfare through the Campus cannot be entirely stopped as the Kataula-Mandi road runs across. While this road is outside the boundary in most parts of the Campus, it cuts through the north Salgi block and divides the Gharpa blocks from the Hilog block. The dirt road opposite the

proposed Communication Center that runs through Salgi-Charga (east) and the metal-capped road from Kamandh to Navalai (through Hilog), are within the boundaries of the Campus. These roads are important links to some of the villages around the Campus and therefore public use cannot be entirely stopped.

Whereas each block can have a gate, the Campus as such cannot function within a walled or insulated area. Checkposts at strategic points can regulate unwarranted human intrusions. The existing roads can serve as the arterial roads. Newer roads can be minimized, restricting them to stairways along the slopes, foot overbridges across the nallah and if necessary cable cars (for emergencies and restricted use) to the guest houses.

Sustaining Critical Habitats and Biodiversity

The most critical habitat within the Campus is the nallah and the riparian vegetation that sustains it (see Wikramanayake *et al*, 1998). The riparian vegetation overhangs the nallah (also in some parts the river Uhl) and is habitat to a range of native herbs, shrubs, palms, grasses and ferns. Native species such as the Ivy (*Hedera helix*), climbing fig (*Ficus foveolata*), wild pepper (*Piper brachystachyum*) and the aroid *Scindaspus officinalis* are species that not only have attractive evergreen foliage but also roots and stems that bind soil and rocks together. Along with these there are many species of grasses and ferns creating on the faces of the gorges lush evergreen vegetation, much like the ones in tropical rainforests. There are also palms (*Phoenix* spp) that adorn the gorges. This vegetation plays a very crucial role in preventing soil erosion and protecting the gorges against landslides. The habitat attracts numerous birds such as babblers and laughing thrushes.

The scrub on the slopes is critical too. This vegetation is comprised of native plants that provide the spring and autumn colors to the landscape. The rich diversity of birds on the Campus may be attributed to this vegetation. Broadleaved deciduous vegetation is found along the slopes in parts of Salgi bordering Chargha. This type of vegetation is the most extensive in Chargha. The characteristic species is the emergent wild silk cotton *Bombax ceiba*. The silk cotton provides nectar to many species of birds.

Chir Pine (*Pinus roxburghii*) and deodar (*Cedrus deodara*) are largely planted and can be seen on the hills bordering Hilog and down the slopes of Gharpa. These forests are known to sustain

ground birds especially pheasants and jungle fowl. The Khaleej Pheasant and Red Jungle Fowl are common here.

The critical habitats are integrated and as the entire landscape is subject to variations in micro-climate due to the complex topography and aspect, management should be holistic. Summer fires are frequent and during the March 2010 study fire was observed in and around the Campus on 2-3 occasions. Although these fires are human-induced, certain plants like Chir Pine and *Lantana camara* are more prone to burning and can aggravate the fire.

Accidental fire can be avoided by adopting stringent steps. Wherever there is a Chir Pine forest patch, no smoking signs should be displayed. Burning of solid wastes should be strictly carried out within designated incinerators. Outdoor camping and bonfires in these habitats should not be allowed. Chir Pine forests should be bordered by a live fire-line of plants such as *Euphorbia royleana, Agave* sp, *Prinsepia utilis, Berberis* sp, etc (see Appendix 3). Regular sprinkling of waste water during summer will complement the regeneration of vegetation by keeping fires at bay. In addition, the fallen pine needles should be periodically removed and composted. They can also be used in making fuel brickets, an activity that can benefit the local women.

Ecological Restoration and Dealing with Invasive Species

Ecological restoration is not by any means an easy exercise. Critical habitats will regenerate rather quickly when the grazing and fire are controlled and the soil moisture is conserved. Further, irrigation using sprinklers will at least initially lead to rapid regeneration of vegetation, especially of herbs, grasses and shrubs. Species of plants and animals that are opportunists will take advantage of the newly created niches and proliferate proving to be invasive. One invasive alien species of plant *Lantana camara* is quite a difficult plant to deal with as its fruits are dispersed by birds. Extensive growth of *Lantana camara* will interfere with the regeneration of other native species. Further, it is prone to fire in summer. This species can be identified and controlled.

Another species of plant, although native to the landscape, that has proven invasive on the Campus is *Cannabis sativa* (*Bhang*). This plant is also locally cultivated. It is likely to proliferate further when the Campus becomes more moist and hospitable. *Bhang* has to identified and systematically eradicated. The job may be entrusted with the local women who can be organized into ‘self help groups for sustainable Campus management’.

It is recommended that no plant species other than that identified and listed in Appendix 3 be planted on the Campus. Conventional 'landscaping' can be detrimental and should not be entertained. Alternately, natural avenues, hedges and meadows can be created and maintained using native grasses and the plants listed in Appendix 3. The natural vegetation on the Campus is quite attractive and diverse capable of producing the spring and autumn flushes. It is best that the natural vegetation is restored wherever there is a need for an avenue, hedge or woodlot. Natural vegetation can also be effectively used on slopes to prevent soil erosion and landslides.

According to the information provided by the Forest Range Office at Kataula there are 17,568 trees within the forest lands that have been ear-marked for the IIT Campus. Some of these trees may have to be felled while the infrastructure is developed. It is suggested that the trees that are to be felled are marked and identified with the help of the local foresters. A blockwise inventory of trees to be felled should be created and made available to the Forest Department before the construction works are started. Trees that are felled should duly be handed over to the Forest Department and not be used for purposes of construction or fuel without prior approval.

There is a sizeable population of the Rhesus Macaque (*Macaca mulatta*). Rhesus Macaques are known invaders and unless there is a clear policy of not disposing food and household wastes in the open, and a strict regulation on voluntary feeding by animal lovers, there will be a lot of conflict between the residents and the mammal. Local residents are facing problems to the Macaque (and also Wild Pig) as they raid crops. If these animals proliferate on the Campus due to protection and surplus food, they will lead to conflicts between the neighbors and the residents of the Campus. The Rhesus Macaque will invade the Campus even as the construction begins and the resident labor force will invariably feed these animals. A system has to be put in place to regulate the invasion by the Macaque and strictly monitored.

The topography of the Campus does not permit creation of a walled or insulated space. Wild animals like the Wild Pig and even the Leopard are likely to invade the Campus. Home gardens, especially when vegetables are grown, will attract the Wild Pig and also the Hare. While fencing the gardens might keep the animals out, it is better to avoid home gardens that attract wild animals so that conflicts are minimized. Leopards are also attracted by the presence of domestic dogs. Bhotia sheep dogs are common and are adorable pets. Free-ranging dogs on the Campus, however, are a sure cause for trouble. Residents should adhere to a strict code of conduct by not feeding and maintaining free-ranging dogs (and cats).

Free-ranging cats can be quite destructive on small birds, especially those that nest close to the ground or on the ground. There are many species of babblers that nest low in scrub and the Peafowl, Jungle Fowl, Black Francolin and Khaleej Pheasant, on the ground. Cats when let loose take a heavy toll of the chicks of ground nesting birds.

Invasions by wild animals were foreseen during the March 2010 study and independently by the Forest Department. During discussions, the Conservator of Forests (Mandi) suggested that a Wildlife Rescue and Rehabilitation Center (WRRC) be set up on the Campus. The WRRC should have the services of a full-time veterinary doctor and the support of the local Forest Department. The WRRC should prescribe guidelines on the maintenance of mammalian pets on the Campus and the residents should strictly adhere to the guidelines. The WRRC and its functioning may be overseen by the Estate Officer who should ideally be one with experience in managing forests and wildlife.

The presence of livestock on the Campus for over 50 years, if not more due to grazing by the local shepherds, has led to the proliferation of parasitic ticks and mites. Whereas ticks are visible the mites are too small and can only be felt by the itch (sometimes rashes) that they cause on the human skin. Members of the field team that the developed the EMP experienced the mites. Obviously these mites are more numerous than what is normally found in natural forests.

Human response to tick and mite bites is quite varied. Some develop rashes, allergic reactions and fever. And as these tiny organisms are not seen with the naked eye, few really attribute the itching and trauma to mites. A list of parasitic mites known from Mandi district is provided in the Appendix (1B). Knowledge of the species will help in seeking the right treatment without undue stress and trauma. It is not easy to eradicate these organisms. Since mites inhabit grass, pastures and meadows, it is safer to avoid these habitats.

Carrying Capacity of the Landscape

According to the WWF-UNDP report by Wikramanayake *et al* (1998) the Himalayan region is characterized by generally rising human population growth rates in the last half century. In many areas, the human population has apparently doubled in the last 50 years. The landscape where the IIT Mandi is coming up is within an eco-region wherein the human population does not currently exceed 500/km^2 on average (Wikramanayake *et al*, 1998). Considering that the Mandi district has

an average human population density of around 200/km^2, a sudden influx of people, locally, can really shock the landscape. Can the landscape cope with the shock?

There is no simple formula or rule of thumb to estimate ecological carrying capacity of a landscape given the human population size. What is critical to the IIT-Mandi Campus is its ability to absorb the initial shock due to transformation of land for creating infrastructure and the long-term capacity to handle the solid and liquid wastes that the system generates. What would be a safe approach is limiting the intake of students, at least during the first 10 years. For instance, if there are 250 students that come in during the first year, at the end of four years, there could be around a 1000. One thousand students plus, 2000 faculty, staff and their dependents, would limit the resident population to 3000.

A resident human population size of 3000 is one and a half times higher than the current population of the entire Kamandh Panchayat. Given the extent of the Campus this would imply there are 1200-1500 people/km^2; a density that is 3 times higher than the eco-regional average (Wikramanayake *et al*, 1998). If it is possible that the student intake (and hence the support human population) is kept low during the first ten years, it might work well as the landscape will be able to cope with the impact (as there will also be simultaneous efforts to restore the critical habitats).

After 10 years, the ecological impact can be evaluated and the resilience of the landscape, its critical habitats and biodiversity reassessed. While the resident population of the Campus may remain at around 3000, the same cannot be said of the adjoining villages. There are at least 3 villages where the rush to provide basic services (amenities) will lead to large-scale human immigration. From the overall pattern of livelihoods inferred during the study, it is foreseen that Kataula, Silog and Kamandh will experience rapid transformation due to the influx of markets and service providers (example transport, restaurants, petrol bunks, etc). Population rise, locally, in these villages will have a major impact on the landscape's carrying capacity further jeopardizing the ecology and resilience of the IIT Mandi Campus.

Most habitable areas earmarked for IIT Mandi have been under human possession and use for over 50 years. Since it was first transferred to the Animal Husbandry Department around 1960, the land has been subjected to intensive grazing, fire and pressures of institutional infrastructure development. Apparently there was no system of waste management and (as inferred from the numerous bones strewn all over) dead animals were just dumped in the open, amongst scrub and forests. The fact that there is a resident population of vultures would only substantiate this

inference. Further, waste water from the Animal Husbandry Department and the adjoining villages (including Kataula) have for long gone into the *nallah* and river. But, the volume being very small, has not had any visible impact.

That the land use around the *nallah* and river Uhl has not had deplorable ecological impact on the riparian habitats was made evident by the abundance of fish. Snow Trout and Masheer were quite abundant (with signs of breeding) and local people enjoy the bounty. In fact, one of the concerns of the local residents was that the IIT Campus should not in any means transform the ecology of the *nallah* and river such that it affects their livelihoods and food security. The riparian habitats are also home to many species of Himalayan birds like Redstarts, Brown Dipper, Forktail and Crested Kingfisher. These species of birds were quite commonly seen during the study (see Appendix 2D).

Carrying capacity of the landscape that cradles the Campus will be evaluated by its ability to absorb, recycle and reuse the waste water and solid wastes. Himachal is a 'no-plastic-bag' state and it is quite strictly adhered to even in remote villages like Kataula. Plastic and non-degradable material that is brought in during the construction phase should all be safely disposed. A system that guarantees the safe handling and disposal of all non-degradable construction (and other) wastes should be in place right from the beginning. Wood, cardboard and other degradable material can be disposed with the help of the local people (who may welcome these as fuel).

The numerous stone buildings abandoned by the Animal Husbandry Department will generate a lot of debris and muck when broken down. Unless there are plans of reusing the stones for the new buildings, they would be best used to secure the erosion-prone banks of the nallah and river (as is commonly done in and around the Campus) or to stabilize the slopes that overhang the riparian gorges and in demarcating the boundary. They can also be used to create (in the traditional manner without cementing) to build compost pits and incinerators. Using stones to stabilize the steep slopes may be very crucial, at least during the early years, in preventing soil erosion and landslips as the plant growth will be slow and may not provide the service immediately. Debris or muck, on no account, should be pushed into the nallah or river.

Treated wastewater (from the oxidation ponds) can be discharged into the river only during the three rainy months (July-September). The ability to reuse the waste water without sending it into the nallah or stream during the other nine months of the year is the yardstick that measures the carrying capacity of the Campus for it is this that will ultimately limit the number of residents that can be sustained without having an adverse impact on the riparian ecosystem. The lay out of the

Campus proposed in Table 3 takes this into consideration and provides a protocol for maximizing the reuse of waste water. The network of collection and treatment units (including the soak pits, gravitational sedimentation) and the oxidation ponds should guarantee that the waste water is not directly discharged into the riparian habitat.

It is recommended that water samples are collected from upstream and downstream at preset locations in both the nallah and river and tested and recorded as a benchmark before any work begins on the Campus. While the EMP has provided available information on water quality for the river Beas, specific information on the nallah and river Uhl are lacking. Water quality should be continuously monitored during construction and after the Campus becomes functional.

Composted organic wastes and the sludge that comes out of the water treatment units can be used to fertilize the forests and restoration areas. A number of species of earthworms are known from Mandi district (see Appendix 1A). Earthworms can be identified and used as monitors of soil health in and around the Campus. Surplus compost and sludge can also be supplied locally to the farmers. This activity can be entrusted with local women organized into self-help groups after appropriate training.

Evolving a Locally Compatible Socio-Ecological System

The district of Mandi in Himachal Pradesh is perceived to be backward not only in terms of conventional development indicators such as literacy, employment and food security, but also because of the absence of any well known institution. This is perceived as the major driver for selecting Mandi for the establishment of yet another IIT. Of the various areas surveyed within the district, Kataula-Kamandh landscape has been found to be the most suitable for the following reasons:

1. Minimal diversion of forest land
2. Nearly 500 acres of land with the Animal Husbandry Department made available
3. Existence of large segments of (habitable) flat land within the proposed site
4. Proximity (and connectivity) to the district headquarters, Mandi
5. Availability of natural resources notably water.

As stated in the earlier sections of the report, the landscape has not only been devoid of large scale development initiatives by the State, but is also devoid of any community based organization or non-governmental organizations that can articulate the demands of the local population. The

current initiative of consulting the local population to develop the Environmental Management Plan was therefore viewed with bewilderment by many of the local inhabitants, notably women. It was also rather clear that much of the local population perceives IIT to be yet another college. Also emerging rather clearly was the divide amongst men and women in their overall perception and response to the new initiative. While the women were rather categoric about issues connected to the nallah and River Uhl, as well as access to grazing lands; the men were concerned about issues such as the influx of migrant labour (and their inherent tendency to abuse the nallh and river), erosion of their traditional rights and customary regulations, availability of employment, etc. On the other hand, other stakeholders such as officials of Government Departments while lauding the initiative were rather categoric on the need to ensure sustained protection to the socio-ecology of the landscape.

The following section consolidates the responses of the inhabitants of the landscape:

1. The land that has been earmarked for IIT Mandi by relocating/vacating the Animal Husbandary Facility was originally agricultural lands owned by 75-78 farmers of Kamandh Panchayat. These lands were acquired during 1958-62 at the rate of Rs.100/Bhiga (800 sqm) with the assurance that the Animal Husbandary facility would not only provide local employment but also strongly support their pastoral tradition and livelihood.
2. While regular employment was not provided by the Department, daily wage opportunites were made available in programmes dealing with fodder collection, processing, cleaning, etc.
3. The presence of the Department is not perceived negatively primarily because it functioned on an unrestricted access mode and the activities were easily understood by the local population. The institution was perceived to be engaged in activities that are of local relevance and benefit. The fact that the staff of this facility were largely drawn from within the State further strengthened the acceptance.
4. From this scenario, the following issues emerge: There is no understanding about the nature and scope of an IIT; and it is thus rather important to engage in awareness building initiatives. The institution needs to invest effort on making itself relevant to the local population. The rather nascent aspirations that the local population harbour in being able to send the children to a good school needs to be furthered by not only ensuring access to good schooling, but also by devoting time and effort to elevate capabilities. Apart from

ensuring that the local population is given the opportunity to enroll their children in the school that IIT would establish, it would also be beneficial to make available the services of resource persons to the local middle school. Similarly, the local anganwadis (kindergartens) would also benefit with expertise on preschool pedagogic training and capacity building.

5. The second issue of concern is the current absence of a veterinary facility. Emerging rather strongly from the pastoralists is the fact that the lands were given to a facility that would provide support to local livelihoods and not for an institution that works on computers. The possibility of extending the scope of the Wildlife Rescue and Rehabilitation Centre to function as a referral veterinary centre needs to be considered.
6. The issue of continued access is a point of contention to the local populations: for instance villages such as Seel Khanni reach the local markets through the proposed Campus on a foot path. Providing a road would not be acceptable since this would increase the distance, but also be difficult for the headloaders and school children. For villagers of Khara, Neeri, Khanni and Sukada, the traditional access is through the proposed Campus and this needs to be reconciled through mutual consultation.
7. Continued access to the grazing lands is yet another strong demand that emerged notably from women.
8. There are three culturally significant components within the campus: the temple (Gharpa which has the shrine of Markandeya rishi) and the access to the cremation grounds on the banks of the river. While the temple may provide an opportunity to the Campus to be included as an element of interest and relevance; the issue of the cremation ground needs to be worked out in detail. The third component is the water mill – the *charka* is considered symbolic and seen as being the primary reason for the palatable nature of the *rotis*. The possibility of expanding the use of this mill could be considered.
9. The landscape has a strong history of illicit felling of trees, and it is feared that the new campus may further this menace. Apart from declaring a complete ban on the use of local wood for construction and fuel, it would be ideal if the campus mainstreams a policy of being wood free. The possibility of having green buildings would serve to further conservation efforts in the region.

10. An Ecological Monitoring Cell (EMC) should be set up such that infrastructure development is monitored right from its inception. The EMC should be headed by an official from the Himachal Forest Department on deputation for a specified period of time.
11. In this context, it is also rather important to sensitise the students and staff on the ecological merit of the landscape. That the services provided by the ecosystem needs to be respected and conserved needs to be made part of the student orientation programme. For instance, seemingly harmless acts as throwing garbage or a cigarette butt can wreck havoc in terms of increased human animal conflict or forest fires. It would be considerable help if the entire Campus is declared smoke free.
12. The Animal Husbandary facility had about 30 people on its payroll, although effectively only 15-20 personnel would be present on any given day. This did not significantly enhance the human foot print of the landscape. Even at its lowest strength, say about 3000, IIT's population would be approximately one and half times the size of the current population of 2100 in the entire Kamandh Panchayat.
13. While the requirements of such a population is perceived as quantum increase in local trade opportunities, the women and the elderly population is concerned about the demand on local natural resources.
14. Also of concern is the impact that the inhabitants would cause on the culture of the local population. It was rather categorically stated that no 'untoward' behaviour would be tolerated and this includes speeding on motorbikes, eve teasing, etc.
15. The Panchayat was also clear in that opportunities related to labour (as in construction and allied activities), security, maintenance, etc, should accord priority to the local inhabitants. The possibility of reserving certain posts to the locals needs to be explored.
16. In the event labour needs to be brought from other places, the contractors should provide identification cards and domicile facilities to the labourers. This is to address the fear of theft or robbery. It is rather distressing to note that in the absence of any protection to the campus currently, trees are being felled from within the campus rather rapidly. Likewise, LPG or Kerosene stoves need to be provided so that the migrant labour does not engage in felling of trees. The migrant labour should not also be allowed to soil (especially defecate) and abuse the river and nallah.

17. Similarly, in the event of allowing trade units such as grocery shops, tailors, photocopying facilites to be established within the campus, or engaging transport services, local inhabitants could be given priority.
18. Quality medical care is a major requirement of the landscape, and a referral based system could be made available to local inhabitants.
19. 23 Kms from the landscape is the rather scenic village of Parasher at an altitude of 2730m ASL. While the approach to Parasher is dotted with well preserved mature forests representing native conifers and broad leaved deciduous forests, the village has an ancient three pagoda temple and a lake. This place is of immense cultural and ecological significance and the negative impact on this sacred land is the greatest concern of all the stakeholders. That this revered land would become a picinic spot through laying new metalled roads and emergence of trade units is a fear that local inhabitants strongly articulated.
20. Evolving a strategy and action plan for long-term sustainable management of the Campus cannot be successful without the involvement and support of the local residents. Women are dynamic and would come in as major human resources when trained and utilized. Such a scenario offers immense opportunity to the proposed Centre for Integrated Mountain Development of IIT Mandi to engage in initiatives that could effectively combine cultural, social and ecological concerns for responsible management of the Campus and the natural habitats within the vast West Himalayan landscape.

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Appendix 1

Species useful in monitoring the ecological health of IIT Mandi Campus

A: Earthworms

Family	Scientific Name
Moniligastridae	*Drawida japonica*
	Drawida nepalensis
Lumbricidae	*Allolobophora parva*
	Aporrectodea caliginosa
	Aporrectodea rosea
	Dendrobaena octaedra
	Dendrodrilus rubidus
	Octolasion tyrtaeum
Ocnerodrilidae	*Ocnerodrilus occidentalis*
Octochaetidae	*Eutyphoeus incommodus*
	Eutyphoeus waltoni
	Lennogaster chittagongensis
	Lennogaster pusillus
	Lennogaster yeicus
	Octochaetona beatrix
Megascolecidae	*Amynthas alexandri*
	Amynthas cortices
	Metaphire anomala
	Metaphire birmanica
	Metaphire houlleti
	Metaphire posthuma
	Perionyx bainii
	Perionyx barotensis
	Perionyx excavatus

Source: Zoological Survey of India, Director (2005)

B: Parasitic Mites

Laelapidae	*Laelaps jugalis*
	Laelaps nuttalli
	Echinolaelaps echidninus
Macronyssidae	*Ornithonyssus bacoti*
	Ornithonyssus bursa
	Ornithonyssus sylviarum
	Pellomyssus passeri
Dermanyssidae	*Liponyssoides sanguineus*
Rhinonyssidae	*Tynaminyssus sp*
Spinturnyssidae	*Ancystropus taprobanicus*
	Ancystropus zeleborii
	Meristaspis lateralis

Source: Zoological Survey of India, Director (2005)

Appendix 2: Checklist of selected species of animals known from the Mandi District also observed on the IIT Mandi Campus during the March 2010 study

A: Butterflies

Family	Common English Name	Scientific Name	Zoological Survey of India (Director, 2005) for Mandi District	Observed on IIT Campus in March 2010
Papilionidae	Common Windmill	*Atrophaneura philoxenus*	+	+
	Common Bluebottle	*Graphium sarpedon*	+	+
	Spot Swordtail	*Graphium nomius*		+
	Common Rose	*Pachliopta aristolochiae*		+
	Common Lime Butterfly	*Papilio demoleus*	+	+
	Spangle	*Papilio protenor*	+	
	Common Peacock	*Papilio polyctor*	+	+
	Common Mormon	*Papilio polytes*	+	+
Pieridae	Common Emigrant	*Catopsilia crocale*	+	+
	Pale Colored Yellow	*Colias erate*	+	+
	Common Jezebel	*Delias eucharis*	+	+
	Spotless Grass Yellow	*Eurema laeta*	+	
	Grass Yellow	*Eurema hecabe*	+	+
	Brimstone	*Gonepteryx rhamni*	+	
Nymphalidae	Plain Tiger	*Danaus chrysippus*	+	+
	Striped Tiger	*Danaus genutia*	+	+
	Common Crow	*Euploea core*	+	+
	Glassy Tiger	*Parantica aglea*	+	+
	Chestnut Tiger	*Parantica sita*	+	
	Tawny Coster	*Acrea violae*		+

Family	Common English Name	Scientific Name	Zoological Survey of India (Director, 2005) for Mandi District	Observed on IIT Campus in March 2010
	Narrow-banded Satyr	*Aulocera brahminus*	+	
	Common Tree Brown	*Lethe rohria*	+	+
	Dark Evening Brown	*Melanitis phedima*	+	
	Large Three-ring	*Ypthima nareda*	+	
	Himalayan Five-ring	*Ypthima sakra*	+	
	Common Sergeant	*Athyma perius*	+	+
	Great Egg Fly	*Hypolimnas bolina*	+	
	Chocolate Pansy	*Precis iphita*	+	+
	Lemon Pansy	*Precis lemonias*		+
	Yellow Pansy	*Precis hierta*		+
	Peacock Pansy	*Pecis almanac*		+
	Commander	*Limenitis procis*		+
	Common Leopard	*Phalantha phalantha*		+
	Baronet	*Euthalia nais*		+
	Orange Oak-leaf	*Kallima inachus*	+	
	Indian Tortoiseshell	*Aglais kaschmirensis*		+
	Common Nawab	*Polyura athamas*	+	
	Indian Red Admiral	*Vanessa indica*	+	
	Blue Admiral	*Kaniska canace*		+
	Common Sailer	*Neptis hylas*		+
	Indian Lascar	*Neptis hordonia*		+

Family	Common English Name	Scientific Name	Zoological Survey of India (Director, 2005) for Mandi District	Observed on IIT Campus in March 2010
Lycaenidae	Angled Sunbeam	*Curetis acuta*	+	
	Dull Oak Blue	*Narathura centaurus*	+	
	Eros Blue	*Polyommatus eros*	+	+
	Common Flash	*Rapala nissa*	+	
	Himalayan Red Flash	*Rapala selira*	+	
	Common Pierrot	*Castalius rosimom*		+
	Common Shot Silver-line	*Spindasis ictis*	+	
Total = 48			**34**	**31**

B: Fishes

Family	Scientific Name	Zoological Survey of India (Director, 2005) for Mandi District	Observed on IIT Campus in March 2010
Notopteridae	*Notopterus notopterus*	+	
	Chitala chitala	+	
Cyprinidae	*Barilius barila*	+	To be confirmed
	Barilius bendelisis	+	To be confirmed
	Crossocheilus latus	+	
	Garra gotyla	+	
	Garra lamta	+	
	Labeo dero	+	
	Labeo dyocheilus	+	
	Labeo pangusia	+	
	Labeo rohita	+	
	Puntius conchonius	+	
	Puntius sarana	+	
	Puntius sophore	+	
	Puntius ticto	+	
	Tor putitora	+	+
	Schizothoraicthys labiatus		+
	Schizothorax richardsonii		+
Cobitidae	*Noemacheilus botia*	+	
	Noemacheilus corica	+	
	Noemacheilus montanus	+	
Amblycipitidae	*Amblyceps mangois*	+	
Sisoridae	*Glyptothorax conirostrae*	+	
Channidae	*Channa spp*		Reported by local people
Salmonidae	*Salmo spp*		Reported by local people

C: Amphibians

Family	Scientific Name	Zoological Survey of India (Director, 2005) for Mandi District	Observed on IIT Campus in March 2010
Ranidae	*Euphlyctis cyanophlyctis*	+	+
	Fejervarya limnocharis	+	
	Hoplobatrachus tigerinus	+	
	Sphaerotheca breviceps	+	
	Paa minica	+	
	Paa liebigii	+	
	Paa vicinia	+	
	Amolops afghanus	+	
Bufonidae	*Bufo melanostictus*	+	+
	Bufo stomaticus	+	
	Bufo himalayanus	+	

D: Birds

Common English Name	Scientific Name	Zoological Survey of India (Director, 2005) for Mandi District	Observed on IIT Campus in March 2010
Snow Partridge	*Lerwa lerwa*	+	
Black Francolin	***Francolinus francolinus***		**+**
Blue-breasted Quail	*Coturnix chinensis*	+	
Hill Partridge	*Arborophila torqueola*	+	
Western Tragopan	*Tragopan melanocephalus*	+	
Koklass Pheasant	*Pucrasia macrolopha*	+	
Himalayan Monal	*Lophophorus impejanus*	+	
Red Junglefowl	***Gallus gallus***		**+**
Kaleej Pheasant	***Lophura leucomelanos***	**+**	**+**
Cheer Pheasant	*Catreus wallichii*	+	
Indian Peafowl	*Pavo cristatus*	+	+
Great Slaty Woodpecker	*Mulleripicus pulverulentus*	+	
Eurasian Wryneck	*Jynx torquilla*	+	
Speckled Piculet	*Picumnus innominatus*	+	
Grey-capped Pygmy Woodpecker	***Dendrocopus canicapillus***	**+**	**+**
Fulvous Breasted Woodpecker	***Dendrocopus macei***		**+**
Brown-fronted Woodpecker	*Dendrocopus auriceps*	+	
Yellow-crowned woodpecker	*Dendrocopus mahrattensis*	+	
Rufous-bellied Woodpecker	*Dendrocopus hyperythrus*	+	
Lesser Yellow-naped Woodpecker	*Picus chlorolophus*	+	+
Scaly-bellied Woodpecker	*Picus squamatus*	+	
Grey-headed Woodpecker	***Picus canus***	**+**	**+**
Great Barbet	***Megalaima virens***	**+**	**+**

Common English Name	**Scientific Name**	**Zoological Survey of India (Director, 2005) for Mandi District**	**Observed on IIT Campus in March 2010**
Brown-headed Barbet	*Megalaima zeylanica*	+	
Lineated Barbet	*Megalaima lineata*		+
Blue-throated Barbet	***Megalaima asiatica***	**+**	**+**
Coppersmith Barbet	*Megalaima haemacephala*	+	
Common Hoopoe	*Upupa epops*	+	+
Small Blue Kingfisher	*Alcedo atthis*	+	+
White-throated Kingfisher	*Halcyon smyrnensis*	+	+
Crested Kingfisher	***Megaceryle lugubris***		**+**
Little Green Bee-eater	*Merops orientalis*	+	
European Bee-eater	*Merops apiaster*	+	
Common Hawk Cuckoo	***Cuculus varius***	**+**	**+**
Oriental Cuckoo	*Cuculus saturatus*	+	
Asian Koel	*Eudynamys scolopacea*		+
Sirkeer Malkoha	*Phaenicophaeus leschenaultii*	+	+
Alexandrine Parakeet	***Psittacula eupatria***		**+**
Slaty-headed Parakeet	***Psittacula himalayana***	**+**	**+**
Plum-headed Parakeet	***Psittacula cyanocephala***		**+**
House Swift	*Apus affinis*	+	+
Fork-tailed Swift	*Apus pacificus*	+	
Alpine Swift	*Tachymarptis melba*	+	
Eurasian Eagle Owl	*Bubo bubo*	+	
Tawny Wood Owl	*Strix aluco*	+	
Brown Wood Owl	*Strix leptogrammica*	+	

Common English Name	Scientific Name	Zoological Survey of India (Director, 2005) for Mandi District	Observed on IIT Campus in March 2010
Asian Barred Owlet	***Glaucidium cuculoides***	**+**	**+**
Large-tailed Nightjar	*Caprimulgus macrurus*		+
Blue Rock Pigeon	***Columba livia***	**+**	**+**
Snow Pigeon	*Columba leuconota**		
Oriental Turtle Dove	*Streptopelia orientalis*	+	
Spotted Dove	***Streptopelia chinensis***	**+**	**+**
Eurasian Collared Dove	*Streptopelia decaocto*	+	
Red-wattled Lapwing	*Vanellus indicus*	+	
Black-shouldered Kite	*Elanus caeruleus*	+	
Black Kite	***Milvus migrans***	**+**	**+**
Egyptian Vulture	*Neophron percnopterus*	+	+
White-backed Vulture	*Gyps bengalensis*	+	
Long-billed Vulture	*Gyps indicus*	+	
Himalayan Griffon	***Gyps himalayensis***	**+**	**+**
Red-headed Vulture	*Sarcogyps calvus*	+	+
Crested Serpent Eagle	*Spilornis cheela*	+	+
Hen Harrier	*Circus cyaneus*	+	
Indian Shikra	*Accipiter badius*	+	+
Eurasian Sparrow-hawk	*Accipiter nisus*	+	+
Northern Goshawk	*Accipiter gentilis*		+
Upland Buzzard	*Buteo hemilasius*	+	
Steppe Eagle	*Aquila nipalensis*		+
Booted Eagle	*Hieraaetus pennatus*	+	

Common English Name	**Scientific Name**	**Zoological Survey of India (Director, 2005) for Mandi District**	**Observed on IIT Campus in March 2010**
Common Kestrel	*Falco tinnunculus*	+	+
Peregrine Falcon	*Falco perigrinus*	+	
Little Egret	*Egretta garzetta*	+	
Bay-backed Shrike	*Lanius vittatus*	+	
Long-tailed Shrike	***Lanius schach***		**+**
Eurasian Jay	*Garrulus glandarius*	+	
Black-headed Jay	*Garrulus lanceolatus*	+	
Yellow-billed Blue Magpie	***Urocissa flavirostris***	**+**	**+**
Rufous Tree Pie	*Dendrocitta vagabunda*	+	
Grey Tree Pie	***Dendrocitta formosae***	**+**	**+**
Black-billed Magpie	*Pica pica*	+	
House Crow	*Corvus splendens*	+	+
Large-billed Crow	***Corvus macrorhynchos***	**+**	**+**
			+
Black-headed Cuckoo-Shrike	*Coracina melaschistos*	+	
Long-tailed Minivet	*Pericrocrotus ethologus*	+	+
White-throated Fantail	***Rhipidura albicollis***	**+**	**+**
Black Drongo	*Dicrurus macrocercus*	+	
Ashy Drongo	***Dicrurus leucophaeus***		**+**
Spangled Drongo	***Dicrurus hottentottus***		**+**
Asian Paradise Flycatcher	*Terpsiphone paradise*		+
Common Wood-shrike	*Tephrodornis pondicerianus*		+

Common English Name	Scientific Name	Zoological Survey of India (Director, 2005) for Mandi District	Observed on IIT Campus in March 2010
Brown Dipper	***Cinclus pallasii***		**+**
Chestnut-bellied Rock Thrush	*Monticola rufiventris*		+
Blue Whistling Thrush	***Myiophonus caeruleus***	**+**	**+**
Pied Thrush	*Zoothera wardii*	+	
Tickell's Thrush	*Turdus unicolor*	+	
White-collared Blackbird	*Turdus albocinctus*	+	
Asian Brown Flycatcher	*Muscicapa daurica*	+	
Rusty-tailed Flycatcher	*Muscicapa ruficauda*	+	
Ultramarine Flycatcher	*Ficedula supercilliaris*	+	
Slaty-blue Flycatcher	*Ficedula tricolor*		+
Verditer Flycatcher	***Eumyias thalassina***		**+**
Rufous-bellied Niltava	*Niltava sundara*		+
Grey-headed Canary Flycatcher	*Culicicapa ceylonensis*	+	
White-tailed Rubythroat	*Luscinia calliope*		+
Orange-flanked Bush Robin	*Tarsiger cyanurus*		+
Oriental Magpie Robin	***Copsychus saularis***	**+**	**+**
Indian Robin	*Saxicoloides fulicata*	+	+
Rufous-backed Redstart	*Phoenicurus erythronotus*	+	
White-winged Redstart	*Phoenicurus erythrogaster*	+	
White-capped Water Redstart	***Chaimarrornis leucocephalus***	**+**	**+**
Plumbeous Water Redstart	***Phoenicurus fuliginosus***	**+**	**+**

Common English Name	Scientific Name	Zoological Survey of India (Director, 2005) for Mandi District	Observed on IIT Campus in March 2010
Spotted Forktail	***Enicurus maculatus***	**+**	**+**
Common Stonechat	*Saxicola torquata*		+
Pied Bushchat	***Saxicola caprata***	**+**	**+**
Grey Bushchat	*Saxicola ferrea*	+	+
Spot-winged Starling	*Saroglossa spiloptera*	+	
Chestnut-tailed Starling	***Sturnus malabaricus***		**+**
Indian Myna	***Acridotheres tristis***	**+**	**+**
Jungle Myna	*Acridotheres fuscus*	+	+
White-tailed Nuthatch	*Sitta himalayensis*	+	
Wall Creeper	***Tichodroma muraria***		**+**
Bar-tailed Tree Creeper	*Certhia himalayana*	+	
Great Tit	***Parus major***	**+**	**+**
Green-backed Tit	*Parus monticolus*	+	+
Black-lored Tit	***Parus xanthogenys***		**+**
Black-throated Tit	*Aegithalos concinnus*	+	
Euarsian Crag Martin	*Hirundo rupestris*	+	
Wire-tailed Swallow	*Hirundo smithii*	+	
Red-rumped Swallow	***Hirundo daurica***	**+**	**+**
Himalayan Bulbul	***Pycnonotus leucogenys***	**+**	**+**
Red-vented Bulbul	***Pycnonotus cafer***	**+**	**+**
Himalayan Black Bulbul	***Hypsipetes leucocephalus***	**+**	**+**
Striated Prinia	*Prinia crinigera*	+	+
Grey-breasted Prinia	***Prinia hodgsonii***		**+**

Common English Name	Scientific Name	Zoological Survey of India (Director, 2005) for Mandi District	Observed on IIT Campus in March 2010
Oriental White-eye	***Zosterops palpebrosus***	**+**	**+**
Chestnut-headed Tesia	*Tesia castaneocoronata*	+	
Grey-sided Bush Warbler	*Cettia brunnifrons*		+
Lesser Whitethroat	*Sylvia curruca*		+
Tailorbird	***Orthotomus sutorius***	**+**	**+**
Tickell's Leaf Warbler	*Phylloscopus affinis*		+
Common Chiffchaff	*Phylloscopus collybita*	+	
Greenish Warbler	*Phylloscopus trochiloides*	+	+
Large-billed Leaf Warbler	*Phylloscopus magnirostris*		+
Blyth's Leaf Warbler	*Phylloscopus reguloides*		+
Grey-headed Warbler	***Seicercus xanthoschistos***	**+**	**+**
White-throated Laughing Thrush	*Garrulax albogularis*	+	
White-crested Laughing Thrush	*Garrulax leucolophus*	+	
Striated Laughing Thrush	*Garrulax striatus*	+	
Streaked Laughing Thrush	*Garrulax lineatus*	+	+
Chestnut-crowned Laughing Thrush	***Garrulax erythrocephalus***		**+**
Scaly-breasted Wren Babbler	*Pnoepyga albiventer*		+
White-browed Scimitar Babbler	*Pomatorhinus schisticeps*	+	
Rusty-cheeked Scimitar Babbler	*Pomatorhinus erythrogenys*	+	
Black-chinned Babbler	***Stachyris pyrrhops***		**+**
Tawny-bellied Babbler	*Dumetia hyperythra*	+	
Yellow-eyed Babbler	*Chrysomma sinense*	+	

Common English Name	**Scientific Name**	**Zoological Survey of India (Director, 2005) for Mandi District**	**Observed on IIT Campus in March 2010**
Jungle Babbler	***Turdoides striatus***	**+**	**+**
White-browed Shrike Babbler	*Pteruthius flaviscapis*		+
Chestnut-tailed Minla	*Minla strigula*	+	
Whiskered Yuhina	*Yuhina flavicollis*		+
Rufous Sibia	*Heterophasia capistrata*	+	+
Oriental Skylark	*Alauda gulgula*	+	
Pale-billed Flowerpecker	*Dicaeum erythrorynchus*		+
Fire-breasted Flowerpecker	*Dicaeum ignipectus*		+
Purple Sunbird	***Nectarinia asiatica***		**+**
Crimson Sunbird	***Aethpoyga siparaja***	**+**	**+**
House Sparrow	***Passer domesticus***	**+**	**+**
Cinnamon Tree Sparrow	***Passer rutilans***	**+**	**+**
White Wagtail	***Motacilla alba***		**+**
White-browed Wagtail	*Motacilla maderaspatensis*	+	
Yellow Wagtail	*Motacilla flava*		+
Grey Wagtail	*Motacilla cinerea*		+
Tree Pipit	*Anthus trivialis*	+	+
Olive-backed Pipit	*Anthus hodgsoni*		+
Rosy Pipit	*Anthus roseatus*		+
Rufous-breasted Accentor	*Prunella strophiata*		+
Scaly-breasted Munia	*Lonchura punctulata*		+
Yellow-breasted Greenfinch	*Carduelis spinoides*	+	+
European Goldfinch	*Carduelis carduelis*		+

Common English Name	Scientific Name	Zoological Survey of India (Director, 2005) for Mandi District	Observed on IIT Campus in March 2010
Common Rosefinch	*Carpodacus roseus*		+
Pink-browed Rosefinch	*Carpodacus rodochrous*		+
Crested Bunting	*Melophus lathami*	+	+
Rock Bunting	*Emberiza cia*		+
White-capped Bunting	*Emberiza stewarti*	+	
Chestnut-eared Bunting	*Emberiza fucata*		+
Total	**186**	**132**	**115**

Note: Species commonly seen on IIT Mandi Campus are highlighted in Bold; names and sequence are after Grimmett et al, 1999;
*seen only in Parashar Lake

Appendix 3: List of Plants recommended for planting on the Campus

Scientific Name	Local Name	Suitability		
		Avenues & Hedges	Slope stabilizing	Restoration
Morus alba	*Chimmu/Sahatut*		+	
Phoenix spp	*Kajri*	+	+	+
Ficus roxburghii	*Tremal*		+	+
Celtis tetrandra	*Khirok/Khadak*	+		+
Mallotus philippinensis	*Kambal/Kamal*		+	+
*Quercus leucotrichophora**	*Ban/Banj*	+	+	+
Salix spp	*Beun, Majnu*	+		
Euphorbia royleana	*Thor*		+	+
Ougenia oogeinensis	*?*	+	+	+
*Rhododendron arboreum**	*Burah, Baras, Parag*	+	+	+
Phyllanthus emblica	*Amla*		+	+
*Cedrus deodara**	*Kelo, Diar*	+	+	+
Woodfordia fruticosa	*Dawa*		+	+
Arundinaria spp	*Ringal, Gadi, Nirgal*		+	+
Prunus spp	*Chuli, Paja, Jammu*	+		+
Pyrus spp	*Bumfal, Segal, Kainth*	+		+
Artimesia spp	*Drubha, Seski, Buer*	+		
Hedera helix	*Grumru*	+	+	
Rosa spp	*Kujas*	+		
Jasminum spp	*Banmalti, Dure*	+		
Prinsepia utilis	*Bakhal*	+	+	+
Rubus spp	*Kala akha*	+	+	+

Scientific Name	Local Name	Suitability		
		Avenues & Hedges	Slope stabilizing	Restoration
Berberis spp	*Kasmal, Chutrum*	+	+	+
Acer spp	*Mandru, Mandor, Perange, Chirndru*	+		
Populus spp	*Chiluna, Pahari Pipal*	+		
Toona ciliata	*Tun, Tooni*	+		+
Bombax ceiba	*Semal*	+		+
Agave spp	*Rambas*	+	+	
Adathoda zeylanica	*Bisuti*			
Bauhinia spp	*Kachrar, Karal*	+	+	+
Sapium insigne	*Dhudala*		+	

*****species better suited to the north, northwest and west facing slopes that do not receive sunlight in the mornings

Appendix 4: List of plants identified on the IIT Mandi Campus in March 2010

S. No.	Species	Local name	Habit	Habitat	Occurrence	Uses
1.	*Acorus calamus*	Bach-Ber	H	Riparian	R	Medicinal
2.	*Adhatoda zeylanica*	Basuti	S	Scrub Forest	C	Medicinal
3.	*Adiantum veneris*	-	H	Riparian	C	Ornamental
4.	*Aechmanthera pedata*	-	H	Open Slope	C	-
5.	*Aerua scandens*	-	US	Open Slope	O	-
6.	*Agave americana*	Rambas	S	Open Slope	C	-
7.	*Agave wightii*	Rambas	S	Fallow field	C	-
8.	*Ageratum conyzoides*	-	H	Riparian, Fallow field	C	-
9.	*Ajuga parviflora*	Darpatre	H	Riparian, Pine forest	C	-
10.	*Albizia julibrissin*	Siras	T	Scrub forest	C	Fodder
11.	*Ampelocissus latifolia*	-	C	Scrub forest	C	-
12.	*Anagallis arvensis*	-	H	Fallow field	C	-
13.	*Apluda mutica*	-	G	Scrub forest/ Pine forest	C	Fodder
14.	*Artemisia nilagirica*	-	H	Fallow field	C	-
15.	*Artemisia vestita*	-	H	Scrub forest	C	-
16.	*Arundinaria falcata*	Nargal	R	Riparian area	O	Fodder, Fiber
17.	*Arundinaria spathiflora*	Ringal	G	Pine forest	O	Fodder
18.	*Arundinella nepalensi*	-	G	Scrub forest/ Pine forest	C	Fodder
19.	*Asparagus adscendens*	Sabsi-muli	C	Scrub forest	C	-
20.	*Asplenium dalhonsiae*	-	H	Scrub forest	C	-

S. No.	Species	Local name	Habit	Habitat	Occurrence	Uses
21.	*Barleria cristata*	-	S	Scrub forest	C	-
22.	*Bauhinia vahlli*	Taur	C	Scrub forest	O	Fodder
23.	*Bauhinia variegata*	Kachnar	T	Scrub forest	O	Fodder, Vegetable & Ornamental plantation
24.	*Berberis lycium*	Kashmal	S	Scrub forest	C	Medicinal
25.	*Berberis asiatica*	Kashmal	S	Scrub forest	C	Medicinal
26.	*Bergenia ciliata*	-	H	Scrub Forest, Pine forest	C	-
27.	*Bidens pilosa*	-	H	Riparian, Fallow fields	C	-
28.	*Bidens wallichii*	-	H	Riparian, Fallow fields	C	-
29.	*Boehmeria platyphylla*	Siar	S	Riparian	O	-
30.	*Boenninghausenia albiflora*	Pessumar	H	Scrub forest	C	-
31.	*Bombax ceiba*	Semal	T	Scrub forest	C	-
32.	*Bridelia retusa*	-	T	Riparian	O	-
33.	*Buddleja paniculata*	-	S	Scrub forest	O	-
34.	*Callistemon lanceolatus*	Bottle brush	T	Planted	P	Ornamental plantation
35.	*Campanula argyrotricha*	-	H	Scrub forest	C	-
36.	*Cannabis sativa*	Bhang	H	Scrub forest	C	Narcotic
37.	*Carissa opaca*	-	S	Scrub forest	C	-
38.	*Caryopteris odorata*	Rumri	S	Scrub forest	C	-
39.	*Cassia fistula*	Amaltash	T	Planted	P	-

S. No.	Species	Local name	Habit	Habitat	Occurrence	Uses
40.	*Cassia occidentalis*	Chingari	S	Fallow fields	C	-
41.	*Cassia tora*	-	H	Fallow fields	C	-
42.	*Cayratia divaricata*	-	C	Scrub forest	C	-
43.	*Cedrus deodara*	Devdar	T	Planted	P	-
44.	*Celtis tetrandra*	Khadak	T	Scrub forest	C	-
45.	*Cheilanthes bicolor*	-	H	Scrub forest	C	-
46.	*Circium* sp.	-	H	Scrub forest	O	-
47.	*Cissampelos pareira*	-	C	Scrub forest	C	-
48.	*Clematis barbellata*	-	C	Scrub forest	O	-
49.	*Cocculus laurifolius*	-	T	Scrub forest	O	-
50.	*Colebrookea oppositifolia*	Banse	S	Scrub forest	C	-
51.	*Cryptolepis buchanani*	Khurnmble	C	Scrub forest	C	-
52.	*Cyathocline purpurea*	-	H	Riparian	C	-
53.	*Cyathula tomentosa*	-	S	Scrub forest	O	-
54.	*Cynodon dactylon*	-	G	Fellow field	C	Fodder
55.	*Cynoglossum zeylanicum*	-	H	Scrub forest	C	-
56.	*Dalbergia sissoo*	Shisham	T	Planted	P	Timber
57.	*Debregeasia hypoleuca*	-	ST	Scrub forest	C	-
58.	*Dendrocalamus strictus*	Bans	G	Planted	P	-

S. No.	Species	Local name	Habit	Habitat	Occurrence	Uses
59.	*Deutzia corymbosa*	Chururu	S	Scrub forest	O	-
60.	*Dicliptera bupleuroides*	-	H	Scrub forest, Pine forest	C	-
61.	*Dioscorea belophylla*	Shingali Migali	C	Scrub forest	O	-
62.	*Duchesnea indica*	-	H	Riparian	C	-
63.	*Emblica officinalis*	Aamla	T	Scrub forest	O	Medicinal
64.	*Engelhardia spicata*	Samba	T	Scrub forest	C	-
65.	*Erigeron canadensis*	-	H	Riparian	C	-
66.	*Erythrina suberosa*	Pariara	T	Scrub forest	O	-
67.	*Eucalyptus* sp.	Safeda	T	Planted	C	Pulp Wood
68.	*Eulaliopsis binata*	-	G	Pine forest	C	Fodder
69.	*Eupatorium adenophorum*	-	S	All habitat	C (Invasive)	-
70.	*Euphorbia hirta*	-	H	Riparian	O	-
71.	*Euphorbia prostrata*	-	H	Fallow fields	C	-
72.	*Euphorbia royleana*	-	S	Scrub forest	C	-
73.	*Evolvulus alsinoides*	-	H	Fallow fields	C	Medicinal
74.	*Ficus foveolata*	-	C	Riparian, Scrub forest	C	-
75.	*Ficus palmata*	Faguda/Fegra	T	Scrub forest	C	Fodder
76.	*Ficus religiosa*	Pipal	T	Planted	P	Religious
77.	*Ficus roxburghii*	-	T	Scrub forest	C	Fodder
78.	*Ficus semicordata*	-	T	Scrub forest	C	Fodder
79.	*Flacourtia indica*	Kangu	T	Scrub forest	C	-

S. No.	Species	Local name	Habit	Habitat	Occurrence	Uses
80.	*Galium aparine*	-	H	Fallow fields	C	-
81.	*Gentiana argentea*	-	H	Pine forest	C	-
82.	*Gentiana capitata*	-	H	Pine forest	C	-
83.	*Geranium ocellatum*	-	H	Scrub forest	C	-
84.	*Geranium wallichianum*	-	H	Scrub forest	C	-
85.	*Gerbera gossypina*	-	H	Pine forest	C	-
86.	*Girardinia diversifolia*	Bichhubutti	US	Riparian	O	-
87.	*Glochidion velutinum*	Kaledar	T	Scrub forest	C	-
88.	*Grevillea robusta*	-	T	Planted	P	Ornamental plantation
89.	*Grewia optiva*	Bichul	T	Scrub forest	C	Fodder
90.	*Hedera helix*	-	C	Fallow fields	C	-
91.	*Helinus lanceolatus*	-	C	Scrub forest	O	-
92.	*Hydrocotyle asiatica*	Brahmi		Riparian	C	Medicinal
93.	*Hypericum elodeoides*	-	S	Scrub forest	O	-
94.	*Hypodematium crenatum*	-	H	Scrub forest	C	-
95.	*Idigofera pulchella*	-	S	Scrub forest	O	-
96.	*Inula cappa*	-	S	Scrub forest	O	-
97.	*Ipomea carnea*	Besharm-buti	C	Riparian	O	-
98.	*Ipomoea* sp.	-	C	Fallow fields	O	-
99.	*Jacaranda mimosifolia*	-	T	Planted	P	Ornamental plantation

S. No.	Species	Local name	Habit	Habitat	Occurrence	Uses
100.	*Jasmin officinal*	Banmalti	C	Riparian	O	-
101.	*Juglans regia*	-	T	Scrub forest	O	-
102.	*Kirganellia virosa*	-	S	Riparian	C	-
103.	*Lagerstroemia indica*	-	T	Planted	P	Ornamental plantation
104.	*Lantana camara*	Chhoti-Padari	S	Scrub forest	C (Invasive)	-
105.	*Lepidagathis cuspidata*	-	S	Scrub forest	C	-
106.	*Lepidagathis incurva*	-	H	Fallow fields, Scrub forest	C	-
107.	*Leucaena leucocephala*	Subabul	T	Planted	P	Fuel & Timber
108.	*Leucas lanata*	-	H	Pine forest	C	-
109.	*Leucasfegia innersa*	-	H	Scrub forest	C	-
110.	*Machilus odoratissima*	Charga	T	Scrub forest	O	Fodder
111.	*Maesa indica*	-	S	Scrub forest	O	-
112.	*Mallotus philippinensis*	Kamal	T	Scrub forest	C	-
113.	*Mangifera indica*	Aam	T	Planted	P	Fruit
114.	*Mantha longifolia*	Podin	H	Riparian	C	-
115.	*Mazus surculosus*	-	H	Riparian	C	-
116.	*Melia azedarach*	Darek	T	Planted	P	Avenue plantation
117.	*Micromeria biflora*	-	H	Pine forest	C	-
118.	*Morus alba*	Sahatut	T	Scrub forest	C	Fruit & Fodder
119.	*Murraya koengii*	Kadi-patta	S	Scrub forest	C	-
120.	*Myrica esculenta*	Kaphal	T	Pine forest	O	Fruit
121.	*Myrsine africana*	-	S/ST	Scrub forest	O	-

S. No.	Species	Local name	Habit	Habitat	Occurrence	Uses
122.	*Nasturtium officinale*	-	H	Riparian	C	-
123.	*Nepeta hindostana*	-	H	Scrub forest	C	-
124.	*Notholirion thomsonianum*	-	H	Pine forest	C	-
125.	*Oplismens burmannii*	-	G	Fellow field	C	Fodder
126.	*Opuntia dillenii*	-	S	Fallow fields	O	-
127.	*Oroxylum indicum*	Tarlu/Arlu	T	Planted	P	Plantation
128.	*Ougenia oogeinensis*	-	T	Scrub forest	C	-
129.	*Oxalis corniculata*	-	H	Fallow fields	C	-
130.	*Parthenium hysterophorus*	-	H	Fallow fields	C (Invasive)	-
131.	*Pennistum orientale*	-	G	Scrub forest/ Pine forest	C	Fodder
132.	*Phoebe lanceolata*	-	T	Scrub forest	O	-
133.	*Phoenix humilis*	-	S	Scrub forest	C	-
134.	*Phoenix sylvestris*	-	T	Scrub forest/ Pine forest	C	-
135.	*Pinus roxburghii*	Chir	T	Pine forest	C	Fuel & Timber
136.	*Piper brachystachyum*	-	C	Riparian	R	-
137.	*Pistacia integerrima*	Kakada	T	Riparian/ Slopes top	C	Fodder
138.	*Plumbago zeylanica*	-	S	Scrub forest	O	Medicinal
139.	*Pogostemon benghalense*	-	S	Scrub forest	C	-

S. No.	Species	Local name	Habit	Habitat	Occurrence	Uses
140.	*Polygonum capitata*	Nalora		Riparian	C	-
141.	*Polystichum sqnarrosum*	-	H	Scrub forest	C	-
142.	*Populus ciliata*	Poplar	T	Planted	P	Fodder & Pulp wood
143.	*Prinsepia utilis*	Bhekhal	S	Scrub forest	C	-
144.	*Prunella vulgaris*	-	H	Scrub forest	C	-
145.	*Prunus armeniaca*	Chuli	T	Planted	C	Fruit
146.	*Pteris cretica*	-	H	Scrub forest	C	-
147.	*Pueraria tuberosa*	-	C	Scrub forest	O	Medicinal
148.	*Punica granatum*	Daru	S	Planted	O	Fruit
149.	*Pyrus pashia*	Kaith/Shegal	T	Scrub forest	C	Fruit, Fodder
150.	*Quercus leucotrichophora*	Banj/Ban	T	Planted	P	Fodder
151.	*Rabdosia rugosa*	-	S	Scrub forest	C	-
152.	*Ranunculus sceleratus*	-	H	Riparian	C	-
153.	*Reinwardtia indica*	-	S	Scrub forest	C	-
154.	*Rhamnus triqueter*	-	T	Scrub forest	O	-
155.	*Rhododendron arboreum*	Burans	T	Pine forest	O	-
156.	*Rhus cotinus*	-	T	Pine forest	O	-
157.	*Rhynchostylis retusa*	-	H	Epipyte in *Bombax ceiba*	R	-
158.	*Rosa moschata*	Kujas	S/C	Scrub forest	O	-
159.	*Rubus ellipticus*	Aanchhu	S/C	Scrub forest	C	-

S. No.	Species	Local name	Habit	Habitat	Occurrence	Uses
160.	*Rubus niveus*	-	S/C	Scrub forest	O	-
161.	*Rubus paniculatus*	Kala-Akha	S/C	Scrub forest	O	-
162.	*Rumex hastatus*	Malori	H	Riparian	C	-
163.	*Rumex nepalensis*	Malori	H	Fallow fields	C	-
164.	*Rungia pectinata*	-	H	Fallow fields	C	-
165.	*Salix alba*	Biyus	T	Riparian	C	-
166.	*Sapindus mukorossi*	Ritha	T	Planted	R	Plantation
167.	*Sapium insigne*	Dudhala	T	Riparian/ Slopes	C	-
168.	*Saurauia napaulensis*	-	T	Scrub forest	R	-
169.	*Sauromatum pedatum*	-	H	Scrub forest	O	-
170.	*Schefflera venulosa*	-	S	Scrub forest	C	-
171.	*Scindaspus officinalis*	-	C	Riparian/Slopes	O	Medicinal
172.	*Scutellaria angulosa*	-	H	Scrub forest	C	-
173.	*Scutellaria* sp.	-	H	Fallow fields	C	-
174.	*Senecio nudicaulis*	-	H	Pine forest	C	-
175.	*Smilax aspera*	-	C	Scrub forest	O	-
176.	*Solanum indicum/ Solanum nigrum*	-	H	Scrub forest	C	-
177.	*Solanum torvum*	-	S	Riparian	C	-
178.	*Solanum verbascifolium*	-	S	Scrub forest	O	-
179.	*Stellaria media*	-	H	Fallow fields	C	-
180.	*Sterculia villosa*	-	H	Scrub forest	C	-

S. No.	Species	Local name	Habit	Habitat	Occurrence	Uses
181.	*Strobilanthus glutinosus*	-	US	Scrub forest	O	-
182.	*Syzygium cumini*	Jamun	T	Riparian/ Slopes	O	Fruit,
183.	*Taraxacum officinale*	-	H	Fallow fields	C	-
184.	*Tegetes* sp.	-	H	Scrub forest	O	-
185.	*Terminalia belerica*	Baheda	T	Scrub forest	P	Medicinal & plantation
186.	*Thalictrum foliolosum*	-	H	Scrub forest	C	-
187.	*Thuja compacta*	More Pankhi	T	Scrub forest	P	Ornamental plantation
188.	*Thysanolaena maxima*	-	G	Riparian	C	Fodder
189.	*Toona ciliata*	Toon	T	Scrub forest	O	-
190.	*Trachelospermum axillare*	-	C	Scrub forest	O	-
191.	*Trifolium pratense*	-	H	Fallow fields	C	-
192.	*Trifolium repens*	-	H	Fallow fields	C	-
193.	*Tulipa stellata*	-	H	Open Pine	C	-
194.	*Ulmus wallichiana*	Kosh	T	Planted	P	-
195.	*Urtica dioica*	Kugas	H	Riparian Slopes	C	-
196.	*Vernonia cinerea*	-	H	Fallow fields	C	-
197.	*Veronica anagallis-aquatica*	-	H	Riparian	C	-
198.	*Veronica persica*	-	H	Fallow fields, Riparian	C	-
199.	*Vicia hirsuta*	-	H	Fallow fields	C	-

S. No.	Species	Local name	Habit	Habitat	Occurrence	Uses
200.	*Viola* sp.	Banafsha		Pine forest	C	-
201.	*Vitex negundo*	Bahna	S	Riparian	O	Medicinal
202.	*Woodfordia fruticosa*	Dawa	S	Scrub forest	O	Medicinal
203.	*Xanthium strumarium*	-	H	Fallow fields	C	-
204.	*Youngia japonica*	-	H	Fallow fields & Scrub forest	C	-
205.	*Zanthoxylum armatum*	Tirmira	S	Scrub forest	C	Medicinal
206.	*Zeuxine strateumatica*	-	H	Riparian	O	-
207.	*Zizyphus mauritiana*	Ber	T	Scrub forest	O	Fruit

Habit: H Herb; US Under shrub; S Shrub; ST Small tree; T Tree; R Reed; G Grass; C Climber/twiner
Occurrence: C Common; P Planted; O Occasional; R Rare