Conserving habitats and ecosystem is the key to species conservation. Habitat is defined as the place where an organism lives and an ecosystem as the interaction or functioning between a community of organisms and their nonliving environment (Odum, 1963). Degradation of habitat and ecosystem leads to lowered population size and extirpation. Freshwaters and especially rivers and wetlands are amongst the most imperiled and worlds most severely impacted and have received many of the direct effects of human activities McAllister et al (2001). Humans mainly induce extinctions by causing habitat loss (Wilcove et al, 1998). The ecological changes brought about by river valley developmental programmes adversely affect both the migratory and non-migratory species of fishes. An analysis by Postel (1996) indicates that humans presently use 54% of the geographically and seasonally accessible runoff. Demands by the year 2025 may increase to more than 70% of accessible runoff. The existing and growing friction between countries over shared waterways shows that humans are already facing water shortages that are international in scope. Dams are a principal threat to freshwater diversity and that threat is largely mediated through loss of habitat frequently involving modifications to the natural flow regime and to blockage of migrations McAllister et al (2001). The 1996 IUCN Red List of threatened animals, list 617 freshwater fishes (including euryhaline species); about 6% of the known number of freshwater fishes. The red list has evaluated
only a fraction of freshwater fishes, therefore a conservative estimate gives 20% as extinct, endangered or vulnerable or more realistically 30-35% (Stiassny, 1996). The importance of all components of the ecosystems including primary producers, herbivores, carnivores, detritivores and recyclers and their ecological functions are necessary to be considered to conserve a habitat and hence a species.

While threats to charismatic terrestrial organisms such as mammals, birds and orchids, or to disappearing habitats such as rain forests, have attracted much attention, the same cannot be said of the many freshwater habitats that are under very serious threat, or of the very large number of aquatic organisms within them that face imminent extinction (Moyle and Leidy, 1992; Wilcove and Bean, 1994; Abramowitz, 1995). Detailed information on distribution, habitat, feeding habits, population size and reproduction is available for just a handful of species and these data are based on adults.

River habitat Survey (RHS) is a method that has been developed for assessing the physical character and quality of river habitats based on results from a standard field survey. The main types of channel modifications recorded during RHS survey are reinforcement, re-sectioning and regulation of flow by impounding structures. The RHS data collected in the field can be used to express the degree of modifications of the riverbed and banks (Environment Agency, 2002). Habitat quality can also be assessed using RHS, giving a broad measure of the diversity and naturalness of a stretch of river. It is determined by the presence and extent of features of known wildlife interest such as natural channel substrate, mid-channel islands, exposed tree roots etc.

It is generally known that freshwater ecosystem are economically more valuable that terrestrial ones. Diversity indices which measure the relative richness, evenness, rarity and abundance, require quantitative sampling and at present there are little or not enough data for aquatic ecosystem. Thus an attempt has been made to quantify and describe existing habitat of Iril River so as to enable in identifying restoration opportunities.
Material and Methods

A general inventory of the habitat and fish fauna of the entire Iril river was carried out. An accurate method of quantitative assessment of stream habitat and its use by fish is one of the approaches by stream fish ecologists (Boyce and Zuboy, 1988; Hankin and Reeves, 1988 and Everest et al 1991). All the methods for habitat inventory followed Armantrout (1992). For classification and identification of reach type riparian zone, fish cover, the methodology manual supplied by Annon (2000) was used. Types and number of reaches along the course of the river were identified. Satellite imagery, GPS position characteristics of the river in respect of reach type, cover and refuge, riparian zone, substrate, macro invertebrates and aquatic plants have been studied.

General Survey of the River course: Recognizable river segments representing different habitat were examined. Identification of reaches was based on the following:

1. Vegetation- Bamboo growth / forest cover
2. Physical characteristics of rock, soil type, bottom materials etc.
3. Species diversity

Satellite Imagery: satellite imagery path row and watershed code of the study site was determined using National Remote Sensing Satellite-IC (IRC-1C) reference map obtained from National Remote Sensing Agency (NRSA), Department of space, Government of India, Balanagar, Hyderabad.

Determination of stream order: Stream order of Iril river was determined using Survey of India (SOI) toposheets (scale: 1:50,000). The toposheets were examined in the Department of Earth Sciences, Manipur University.

GPS Position: Latitude and Longitude of the study site was noted in the field by using GPS (Garmin, Germany).

Altitude: Altitude of the study site was noted using an altimeter (Barigo, Germany).
Mapping of the river: The altitude, the entire length of the river, basin area and map of the river course are taken from the digitized map prepared from toposheet with the help of GSI software (Map Info). The entire river course is divided into upper, middle and lower segments depending upon the characteristics of the river segment and diversity of fishes. The upper and lower coordinates of the river are identified from the toposheets.

Stream order: The stream order was calculated from the toposheet on which the river course is located. Confluence of two first order stream gives a second order stream, and two second order stream gives a third order stream and so on.

Water current: The speed of water is measured by using a floater. A floater is made to drift down the stream in a definite time. The distance traveled in this definite time was calculated using a meter tape.

Reach selection: After surveying thoroughly the river stretch, the river stretch was divided into segments having some identical characteristic features. Again, within the river segment, a reach was selected which is the exact small replica of the river segment.

Determination of breadth of the bankful channel (Fig. 41): For determining breadth, Sextant's method as described by Punmia (1989) was followed. In this method a Sextant instrument is fixed in a suitable position (P₁) at a little distance (l₁) away from the bank. From P₁ an imaginary straight line was taken across the river and a reference position P₂ was chosen on the opposite bank of the river. The position of the Sextant is shifted to another position (P₃) through a known distance (x) from P₁ perpendicularly. Thus, a right angled triangle is made with three vertices, i.e. P₁, P₂, and P₃. From this right angled triangle, the length of the river (L) can be determined. This method is very useful for very big river, where measurement of river by rope is not possible.

Determination of gradient or the slope of the river bank (Fig. 42): A thread of known length (l₁) was stretched from the edge of the bank parallel to the ground by using water level. Then another thread (h₁) is stretched perpendicular to the previous thread, the distance of which is determined. A second l₂ is
stretched and \( h_2 \) determined and so on. By adding \( l_1, l_2, l_3 \ldots l_n \), we can determine ‘L’ and similarly value of ‘H’ is determined by adding \( h_1, h_2, \ldots h_n \). From this, the gradient of the river when full upto bank are measured.

Fig. Determination of Breadth (Fig. 41) and Slope (Fig. 42) of River Bank
Observation and Results

Iril river a principal tributary of the Imphal River drains the North Eastern part of Manipur. It originates from the Southeastern slope of the Hougdu Hill range at Lakhmei village, Ukhrul district at a height of about 2473 metre above sea level. The main portion (two third) of the river lies in the hilly areas and a small portion (one third) lies in the plain. After traveling a distance of about 90 km in the hills, it enters the Imphal valley at Saikul village. The river runs southward and joins Imphal river at Lilong which in turn flows southward into the Irrawaddy river. On emerging over the plain, the river loses much of its energy and the whole characters changes. It begins to flow in a zigzag course forming many meanders.

The entire Iril river course can be divided into three portions based on its rock and soil types they are:

1. Barail shale+ sandstone
2. Disang shale
3. Alluvium

Description of the area:

Name of the stream: Iril river
Watershed code: 3D2B1
Valley segment: Bedrock and Alluvial
Stream order: 6 (six)
SOI Topo sheet No.: 83 (K3, K4, K7, L1, H13, H14)
Satellite image Row path: 113/54 of IRS-IC-LISS (III)
Total number of reaches: 3 (three), one in upper, middle and lower

After a thorough survey, three sampling points were selected for the study: Upper segment (Phungdhar), middle segment (Morkot) and lower segment (Bamonkampu).
Habitat Inventory of Upper segment- Phungdhar

A reach of 100 metre length was selected for habitat inventory at Phungdhar, Ukhrul district. The sampling site is the border of Senapati and Ukhrul district.

GPS position. 94°15' E and 25°14'N

Altitude. 1824.23 metre above mean sea level

Reach type: The reach type is 'pool-riffle'. The soil has grey to reddish brown colour. The channel has fast water: Riffle (turbulent) and Run (non-turbulent) and slow water; convergence, lateral type (scour pool) and Debris, Landslide and backwater (Dammed pools). The average water current is at a speed of about 0.16 metre per second.

Bank stability: The northern bank is highly erodible and the southern bank is mainly the bedrock.

Water current: There is fluctuation of speed of water current. In the dammed pool area the speed decreases and increases below the pool.

Substrate: The river substrate consists of gravel, cobbles and boulders, cobbles dominating the substrate. Large boulders are embedded high. About 55% of sampling site is covered by thick layer of cobble, 20% by boulders, sand and clay particles form the rest. Cobbles harbour large number of macro-invertebrate and they provide spawning place to many fishes. The water is clear and due to the high light penetration, there is abundant algal growth on the rocks, constituting an important food resource for fishes and invertebrates which themselves form prey of other species.

Average width of the bankful channel: 32 metre(m).

Average width of the channel stream: 9.8m the average width of stream shows variation.

Average depth of the bankful channel: 25m

Average depth of the stream: 7.3m.

Average gradient of the bank: The northern bank has high gradient i.e. 0.53 and southern has low gradient i.e. 0.34 and gentle sloping.
Cover and refuge for fish: Big boulders and bedrocks mainly form the fish cover. Boulders are stable and provide large spaces which are an ideal hiding place for larger fishes. Fishes of *Garra gotyla*, *Bangana orientalis* and *Crossocheilus burmanicus* were found abundantly in these hiding places. The thick layer of cobbles dominates the substrates. This proves excellent hiding and feeding ground for smaller fishes such as *Schistura*, *Amblyceps*, *Glyptothorax*, *Devario* etc. On clearing these cobbles, one could easily find such small fishes.

Algal growth in the bottom also provides shade to fish. There are also bedrock band having many holes and undercut, drifted straws etc. overhanging vegetation on riverbank also proves as fish cover.

Riparian zone: It consists of shrub, herb and deciduous trees. The northern bank is dominated by tall grasses. Southern bank is dominated by trees and other vegetations. Human encroachment is not to be seen along the river stretch.

**Habitat inventory of Middle segment- Morkot.**

**Description of study site.** A reach of 100 m length was selected at Morkot village which is about 45 km North of Imphal. The sampling site is where the river enters the valley after running 90 km in the hills.

**GPS position.** 25°47.226' N and 94°02.802' E

**Altitude.** 8114.4 metres above sea level

**Reach type:** the reach type is Braided. The soil and rock type is Barail shale + Sandstone and Disang shale.

**Bank stability:** The river bank is erodible type i.e. non-erodible bank and erodible sandy bed.

**Water current:** The speed decreases from upstream and at Morkot it is about 0.4 m/sec. or 1.44 km/hr and forms many shallow step pools. Speed here is not affected by the Imphal barrage located at Samurou village.
Substrate: The substrate is gravel with a mixture of sand and clay. Cobble and gravels dominate the substrate. The cobbles provide spawning place of many fish species. The cobbles harbour large number of macro-invertebrates.

Average width of the bankful channel: The width of the bankful shows variation in the entire river system. The average width is less and is 48.9 m. this is because there is no horizontal expansion of water even during the rainy season. Bank is high due to which even during flood there is only increase in the water level and so no horizontal expansion occurs.

Average width of the channel stream: The width of the stream at study site is narrow. It is 12.5m.

Average depth of the bankful channel: The average depth is 11.22 m.

Average water depth: The water depth shows great variation. The depth is about 1.2 m in the deepest pool and a few inches shallow area but the average depth is only 0.7 m.

Average gradient of the river: The gradient of the Eastern bank is about 0.468 approximately whereas the Western bank is very steep.

Cover and refuges for fishes: The pool is the main fish cover and refuge for fishes. Pool contributes 40% of the cover component. The pools are deep and used as hiding, resting and feeding place. Some 6/7 big boulders are found under the overhanging bridge. They are very stable. Holes and instream vegetation constitutes about 20% of the cover component. There are some wood debris and a big log in the Northwestern side of the sampling reach. There is no free floating plant but there is a good luxurious growth of algae. Pool contributes the greatest amount i.e. 40% of the total cover component.

Riparian zone: The riparian vegetation is mostly Bamboo and trees. The shrubs and herbs are less in the riparian vegetation and trees are very abundant. The vegetation stage is found to be of shrub stage (< 10% tree cover). The bank is sloping. The riparian type is Mesoriparian. The texture is fine, unstable and contains much organic matter. Some parts of the riverbank stretch are human inhabited.
At Samurou village just above the Imphal barrage, there is a wetland area called, “Ngangou –pat” which means lake of white fishes. It is an important breeding, feeding and resting ground for some fishes. These wetlands are affected by human activities. Now they are inhabited by some small fishers. The dominant land use is plantation crop. There is sign of erosion in the river bank. The bank shape is sloping and texture is fines.

**Habitat Inventory of lower segment- Bamonkamu.**

After surveying for about 10 km in the downstream stretch, a sampling reach of 100 m length was selected at Bamonkamu which is about 15 km North of Imphal.

**GPS position.** 24° 58.856’ N and 93°58.856’E.

**Altitude** 94° E and 24° 42’ N

**Reach type:** The reach type is plane bed. The soil has grey to pale brown colour and contains moderate organic matter. The soil is alluvial type.

**Bank stability:** the river bank is erodible i.e. non-erodible bank and erodible sandy bed.

**Water current:** The speed of water current at the lower river segment depends on the Imphal barrage located at Samurou. When the barrage is closed this segment is like a long, damped pool. The barrage is mainly agro-irrigation purpose and when the barrage opens the water runs with a great speed. Half the segment is almost like a deep long damped pool.

**Substrate:** The substrate is sandy. There are no leaf debris unlike that in middle segment.

**Average width of the bankful channel:** The average width of the bankful is 63.8 m. the river in this segment have very low banks. Therefore during flood, there is horizontal expansion in bankful channel.

**Average width of the channel stream:** The width of the stream here is broad. It is 23.8 m.
Average depth of the bankful channel: the average depth is 11.2 m.

Average water depth: the water depth in this region is almost constant. Its average depth is 2.78 m.

Average gradient of bank: The gradient of the eastern bank at segment study site is 0.33 approximately and at western side it is about 0.624.

Cover and refuges for fishes: water is not transparent. Its depth and turbidity is the main cover and refuges. Half of the total length of the segment is about 2.78m deep and rather appears a long, deep, damp pool. There are luxuriant algal growth, free floating emergent and submerged aquatic plants, holes, undercuts and some overhanging vegetation. The stream shade portion is much about 10% of the habitat area.

Another important cover is the submerged intricate roots of Bamboo grooves. Due to the insatability of the bank, it frequently erodes with its bamboo and tree vegetation. The roots thus brought down to the river beds provide an important shelter, resting and feeding ground of fishes.

Riparian zone: The riparian zone is about 70 m from the water (channel width is 20-100 m). Shrubs and herbs which are mainly seasonal dominate the vegetation herbs cover the entire river bed with clumps of shrub bushes, representing about 50% of the river bed. Bamboo constitutes about 30-40% of perennial vegetation. They are cultivated along the fertile river bank in some places. This increases perennial vegetation and stream shade. Tree vegetation is deciduous type and is of small size. Common trees are Banyan and pine; however pine is not original vegetation. Human activities promote change of vegetation.

Near the study site, a wetland of about 2 sq. km area joins Iril river by a first order stream. This wetland is a resting ground, feeding and probably breeding ground for some fishes. This wetland is now being used for paddy cultivation. During monsoon time, often gravid females and males of Lepidocephalichthys berdmorei, Mystus bleekeri, and even young ones of Wallago attu are caught. This shows the importance of this wetland area as breeding and resting ground. However, nowadays these wetland areas are affected by human activities and are no ore an ideal feeding or resting ground of fishes.
The conservation of fish has been given little attention in India. Some species have become rare while others have disappeared. These could be due to overfishing, high population pressure along the river banks, entry of other castes into fishery, use of improper and illegal fishing gears and methods, heavy floods and siltation, habitat degradation, erosion, impact of barrages etc. Some of these factors have actually disturbed or damaged the fish habitats, especially spawning and nursery grounds and cause mass killing. Conversion of forested lands on steep slopes into agricultural lands and road construction in the mountain regions have resulted in heavy soil erosion during the monsoon season. Soil erosion affects the river ecology, resulting in the loss of breeding and nursery grounds of the riverine fish species. Fishes are indirectly affected when their food organisms are destroyed. Silt and increased turbidity above natural levels can interfere with primary production (Arthington and Welcomme, 1995). Mechanical injury or blocking of gills from silt or other suspended material has also affected the river fish fauna. Hence global attention is now being given to maintenance of biodiversity, most notably through the Convention on Biological diversity (http://www.biodiv.org/).

The cover provided by the vegetation, the nutrient inputs associated with inflow from the streams and the abundance of invertebrates combine to make critical spawning, nursery, and rearing habitat. Stable sand gravel, cobble and woody debris also provides some benefit for spawning, but are primarily nursery and rearing areas for a variety of fish. However, their value in this capacity is somewhat diminished without the cover and diversity of food provided by vegetation and inflows from the streams. The presence of woody debris enhances the quality of any substrate type as nursery and rearing habitat for fish.

Substrate cover types can include cobbles, large rocks, boulders, and large woody debris. These cover types provide feeding and cover habitat for fish and macroinvertebrates. Water turbulence cover is typically provided by riffles in the
river, which visually obstruct views into the water from above. Piscivorous birds are unable to forage in these areas because they can’t see the fish through the turbulence (Barnard and Steven, 1999).

The first order stream that connects Iril river and the wetlands in Bamonkampu along with the vegetation, probably serves as a nutrient supply and hence the region as critical spawning habitat. However nowadays these wetland areas are affected by human activities and are no more an ideal feeding or resting ground of fishes. Catching of gravid females of *Lepidocephalichthys berdmorei*, *Mystus bleekeri*, *Wallago attu* and *Pangio pangia* here during monsoon, may have caused the decline of these fishes (report from fisherman and personal experience).

Freshwaters and especially rivers and wetlands are amongst the worlds most severely impacted and have received many of the direct effects of human activities. In the construction of reservoirs, the clearing of vegetation, movement of earth and rock, the presence of humans and machinery, bringing in construction materials, use of explosives, noise and reducing or cutting off river flow and increasing turbidity, will affect biodiversity (IUCN). According to Mc Cartney et al (1999), reservoirs tend to serve as sediment traps since river velocities and carrying capacity for particles decrease in reservoirs. Sedimentation can degrade habitat both in the reservoir and below the dam, as well as reduce storage capacity.

Although the benefits of dams can be substantial, their negative impacts, including significant biodiversity loss, are common. Analysis by the World Commission on Dams (WCD, 2000) has shown that the environmental, hydrological and economic arguments used to support dam construction are often flawed. There are a number of different migratory patterns of river-dwelling species. The blockade of fish movements upstream can have a very significant and negative impact on fish biodiversity or according to IUCN water quality, flow and seasonality of flow are not normally disrupted in the upstream area above the reservoir so impacts are generally less than for the reservoir and downstream
areas. However, the dam and the reservoir affect migratory movements of species into and out of this upstream area. Flow modification (channelization, diversion) and flood control have a significant impact as they reduce or adversely affect the spawning grounds and the possibility of lateral migrations. Threats may have cumulative effects: the reduced run-off resulting from reservoir construction may no longer be enough to flush concentrated urban, agricultural and industrial pollution, leading to extensive anoxic zones (Kottelat and Whitten, 1996). The importance of all components of the ecosystem including primary producers, herbivores, carnivores, detritivores and recyclers and their ecological functions (Mosquin, 1994) should be considered in the design of the dams. Information from the local fishermen downstream of Iril river obtained that fish catch have declined greatly. This may be due to the barrage at Samurou. The fishermen in the Phungdhar village in Ukhrul district reveal that they get a fair catch.

The communities of large rivers are threatened by deforestation which results in increased temperature and siltation and degradation of nursery grounds for fry during floods, pollution, and overfishing and flood control. Along the course of the lower segment and middle segment of the river at Bamonkampu, Keibi and Saikul villages the banks of the river are used for cultivation of vegetables by cutting down the trees, shrubs etc.

Habitat loss is the principal factor that fragments natural populations and increases their risk of extinction but this often acts in synergy with other pressures such as alien species and unsustainable harvesting (Eder, 1996; NBSAP, 2000; NIES, 1997). If a habitat is severely degraded or destroyed, then much of the associated biodiversity will be lost. Although introductions of exotic species by individual are forbidden in most countries, they do occur, witness the numerous cases of feral populations of aquarium fishes (Kottelat et al, 1993) whose impact has not yet been assessed in Asia (Kottelat and Whitten, 1996). The impacts of the introduced fish Ctenopharyngodon idella, Cyprinus carpio have been already discussed in chapter II. Ideally, governments should control these activities and conduct an eradication of all exotics introduced in the ponds.

In response to deteriorating biodiversity, many countries are party to international agreements. All except Afghanistan, Brunei Darussalam and
Thailand are party to the Convention on Biological Diversity (CBD). The CBD specifies a framework of measures at the national level for the conservation of biodiversity and many countries have prepared National Biodiversity Strategy and Action Plans and submitted National Reports. Most countries are party to CITES (Convention on International Trade in Endangered Species of Wild Flora and Fauna) and the Ramsar Convention on Wetlands. Protected areas have been set up in different countries but they tend to be geographically limited and disconnected. The proportion of protected area to total area in most countries is lower than the 10 per cent norm recommended by IUCN (http://www.roap.unep.org/region/geo/Biodiversity.pdf). The fish sanctuaries and public awareness of the importance of fish species and their conservation will be critical for the proper conservation and management of the fishery resources. In Nepal, the Nepal environmental Policy and Action Plan (NEPAP) has been prepared and launched. Conservation of fishery resources is part and parcel of the broad NEPAP. Promulgation of Aquatic Animal Protection regulations: Aquatic Animal Protection Act (AAPA) was passed in 1961, in 1999 the Government promulgated AAPA regulations. Such regulations on fish conservatyion have not been passed in the state till date. The importance of maintaining a balance between economic development and environmental conservation must be made to aware among the people. Biodiversity as such has many kinds of values and potential benefits for humans and world as a whole. Before it is diminished, it is necessary that we consider the Precautionary Principle and take action to conserve it before components of it are permanently lost, even when evidence for loss is not as strong as might be desired.