

BIODIVERSITY: LIVING WEALTH OF NEPAL

(Presidential Address)

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Introduction

At the very outset, I would like to quote the great poet, playwright and philosopher Bala Krishna Sama, whose wise and most expressive words always ring into my ears whenever I think of geography, environment and biodiversity of Nepal. In one of his famous earlier plays "Mukunda Indira", he describes Nepal in an excellent manner through Bhavadev, one of his main characters of the play who has been entrusted by his friend to bring his son, Mukunda, back home from Calcutta. I would like to recite here only a few lines from his memorable speech:

टिका कमल हीराको त्यो सुन्दर हिमालय सौन्दर्यसार संसार भरको लहराउदै
गौरीशंकरको पाउ लेखी आफ्नो ललाटमा, उघारी हरियो घुम्टो त्यो जंगल पहाडको ।
हास्रो नेपाल यो सानो संसारकै हो कि लोकको कल्पवृक्ष यही नै हो यहाँ पाइन्छ जे पनि
यही मधेसको धूप यहीं ठण्डी हिमालको मृतसंजीवनी देखि साधारण वुटी तक
यहीं छन् उर्वरा भूमि नदी नाला अनेक छन् गैडा बाघ यहीं हुन्छन् कस्तुरी चमरी पनि ।

He looks towards the snowy mountains in the north and starts describing the glorious grandeur of Nepal by reminding us how the lovely Himalaya which is as if sculptured out of the wonderful piece of the dazzling diamond emanating the unparalleled and most profound beauty in the world in all its essence with the special marks of the most venerable feet of *Gaurishanker* (Lord Shiva and Parvati) on its very high forehead, and uncovering, in the most charming manner, the emerald green veil of the rich forest of the mountains and hills; thus this Nepal of ours is a small world in itself or the *Kalpabriksha*, the everlasting and inexhaustible store house of all the necessary items in unimaginable varieties since it contains everything that can be desired. Within its borders lie the places like Madhes or terai with its scorching heat, in contrast with other spots like those of the Himalayas with its biting cold and grow such nontimber forest products ranging from the life restoring "*mrutasanjibani*" herbs to ordinary plants of medicinal value. Herein are to be found several rivers and streams along with the wide expanse of fertile cultivable land and among the wild animals there roam the famous one horned rhinoceros and the much admired striped tiger in the lower plains to the long haired yaks and much coveted musk deer in the alpine pastures in the higher parts of the lofty mountains. Thus the poet has introduced himself to us as a great admirer of our natural heritage and keen stock taker of the biological diversities found in Nepal.

Today I hasten to take this opportunity in paying homage to this great luminary of Nepal on the occasion of his birth centenary.

Similarly another great poet, contemporary to Bala Krishna is Laxmi Prasad Devkota, who has ventured to describe the so called tiny kingdom of Nepal as "beautiful, peaceful and spacious." Yes, it is beautiful, no doubt. No visitor from any part of the world can go back home without admiring the superb beauty of the snowy peaks of the high Himalayas, such as Mt. Everest, Kinchinjunga, Gaurishanker, Machhapuchchhre, Dhawalagiri, Manslu and Himalchuli. Even within the limited space around Dingboche, situated by the bank of the river Inja Khola not very far from the base camp of Mt. Everest there are a host of beautiful and lofty mountain peaks which exhibit the most beautiful panorama of excellent splendour which is beyond description so that the visitors are stunned at the splendid sight and forget the world for the time being, and when they come back to their sense they congratulate themselves for deciding to visit this country if they are from abroad and they feel themselves very fortunate for having born and bred up on the soils of this magnificent mountainous motherland if they

are from within the country. It is not only the lofty peaks that have made this country so beautiful. The different lakes which are to be found at various places in Nepal such as Gokyo of Solukhumbu, Panchpokhari of Sindhupalchok, Rara of Mugu, Phoksundo of Dolpo, Phewa, Begnas and Rupa of Kaski have all significantly contributed in their own ways to the magnificent splendour of the scenic speciality of Nepal since they not only show their own marvelous charm but also reflect on their translucent bosom of blue water the excellent beauty of the shapely peaks of the Himalayas. Furthermore, the rivers with their magnificent waterfalls, such as the famous Rupshe Chhahara, by the side of the deep gorge of the antecedent river Kaligandaki renowned as the "deepest canyon on earth," which when striking against the hard rocks of different hues on their way give rise to beautiful white foams and wonderful droplets that create a small rainbow in a multicoloured spectrum when they reflect the sunlight through them. The forests, where they are intact, add yet another bit of attraction along with the several birds of different colours and charm on the one hand and very rare sights of charming antelopes roaming around undisturbed.

Yes, Nepal is peaceful too. It was on the basis of this peaceful characteristic of this country that we were encouraged to declare this country of ours a "zone of peace" following the clarion call of our late King. The proposal was endorsed by several nations of the world. I must, however, admit that these days the country is passing through a difficult time of unrest and it is less peaceful unfortunately. But we do hope that this is a temporary event and normalcy will be restored soon and the country will gain back its own peace and serenity as before.

Last but not the least the celebrated poet says that Nepal is quite big and spacious. When we very often hear such statements as "Nepal is a small Kingdom" such a sentence of the poet sounds absurd and unbelievable. As a matter of fact quantitatively speaking too Nepal is not very small. There are several countries in this wide world that are smaller than this "tiny" kingdom. Switzerland, Bangladesh and Srilanka are smaller than Nepal, what to speak of Maldives, Fiji and Monaco. It looks small since it is sandwiched between the two very big neighbours in the north and the south, China and India respectively, whose relatively gigantic size is in most perceptible contrast with our country. Next and more pertinent and justifiable reason for calling Nepal "spacious" is also the fact that it contains a very rich variety of everything within its territorial space that can be thought of, such as, physical features, highest number of the highest peaks of the world, awe inspiring range of altitudes, soil types, climatic characteristics, natural vegetation, immense floral varieties both endemic and exotic, numerous varieties of birds and mammals, reptiles and amphibians, agricultural plants and products, as well several ethnic groups of population each speaking its own language. Nepal contains an area of land not more than 0.03 percent the world but it contains proportionately huge share of various species of plants and animals of the world. What more proof do we have to produce to declare it to be a rich repository of most diverse types of ecosystem, species and genetic varieties, which together constitute what we call today the main components of biological diversity or simply speaking 'biodiversity'? It is because of the great variety of ecosystems that we have a great variety of habitats for a great variety of wild animals. Egypt and Greece, scholars were trying to figure out the nature of the world in which they lived. They looked for answers to their curiosities in the heavens or the earth and in Vedas, Puranas and Scriptures and philosophy. And they debated endlessly over the various so called "truths" they hold. But unfortunately, after the fall of ancient civilizations, scientific curiosities steadily declined, so that between 200 and 1200 AD there were virtually no scientific advances at all. Although the great Greek Eratosthenes had precisely calculated the circumference of the earth to be very close to 25000 miles, the figure believed to be correct today, more than 200 years before the birth of Christ, Columbus in 1492 had trouble in convincing anyone except a few Moorish astronomers that the earth is round but, on the other hand, he had himself very erroneously believed the words of Toscanelli who wrote to him in 1474:

“.....you must not be surprised that I call the region in which spices are found “western”, although they are usually called “eastern” and there is not a great space to be traversed over unknown waters.”

Under the spell of the letter of Toscanelli, however, he was very much convinced that he would reach India if he sailed west across the Atlantic in about a month from Canary Islands off the coast of the West Africa. But when he sailed in 1494 he reached the area around what we call today the West Indies rather than the real Indian coastal area. However, with the death of Galileo in 1642, new revolutionary ideas were born particularly in physical sciences and until the eighteenth century science was largely limited to topics dealing with the inanimate subjects such as mathematics, astronomy and physics. Living things could not even be imagined as topics worthy of imagination for religious reasons and the then scientists believed that all the objects, animate or inanimate, were created by God in their present forms. However Buffon was bold enough to propose that in addition to the “created” creatures there were also ‘lesser families’ conceived by Nature and produced by Time.” Later came Erasmus Darwin, the grandfather of the famous Charles Darwin who was not only a physician but a naturalist who wrote about zoological and botanical subjects often in rhymes. In his versified ramblings, among many interesting ideas, he had stated the importance of competition in the formation of species, the effect of environment on changes in species and the heritability of these changes. Later Lamarck of France boldly suggested that not only one species had given rise to another but that human beings themselves had arisen from other species. He also observed that the fossils of animals found in older layers of rock seemed to be simpler than those in more recently deposited rock. This difference suggested to him that older ones have gradually given rise to the more recent ones. Although he could not impress the general public so much he did create some lively discussions among people of intellectual circles.

Charles Darwin and Diversity of Life

The intellectual climate of England was far more conservative than that in France when Charles Darwin was born. So Darwin was moving slowly with the people and hoped to join the parade of scientists and clergy as they marched along to produce a better world in their own ways. However, there were some scientists with unbiased and independent mind. Charles Lyell, the celebrated physical geographer was one of them. He set forth many of his ideas in his book “Principles of Geology”. He was only a few years older than Darwin and just before Darwin set out for his most famous journey on board the ship *Beagle* in 1831 the book on geology was just published. In his book Lyell rejected the religionists’ view that the earth had been created in the year 4004 B.C. and revealed that it was much older. Since the earth was older than what the then people thought he suggested that the earth’s most dramatic features had not appeared suddenly but were resulted from slow and steady process which occurred over an exceedingly long period of time.

During the voyage on board the *Beagle* Darwin visited Galpagos, a chain of Islands, situated about 650 Km off the coast of Ecuador. It was in these remarkable islands that Darwin got interested in biodiversity and although he was not very happy in the beginning he later encountered a very strange but fascinating assortment of animals. “A world in itself,” he wrote, “with inhabitants such as one found nowhere else. There are lizards, 3 feet long, grazing on seaweed beneath the turbulent sea. They are imps of darkness, black as the porous rocks over which they crawl.” So although he spent most of his time in “botanising” over the islands, he was very much struck not only by the strange animals found there but also by their landbound cousins further inland. He also collected various kinds of birds many of which, he knew, were undescribed species. Darwin, however, regretted that he had been collecting and storing all the birds species from the islands together on the boat. One day while he was looking at a few of the finches he noticed that two of them from different islands differed in

the size and shape of their bills. He was further explained by the acting British Governor that he could tell from which island any of the turtles came by looking at the size and shape of their carapace or shell and length of their extremities. Darwin wondered if each island was somehow giving rise and providing shelter to its own forms of creatures and, from that day on, he started separating his collection from each island, thus laying rather unconsciously the foundation of what was later to be called the concept of biodiversity. When Darwin had his finch collections examined by British specialists it was decided that there were at least thirteen species, differing primarily in the size and shape of their beaks. It was surmised that these birds must have come originally from the South American mainland, since the volcanic islands of the Galpagos would have been formed later than the continent. Darwin was very much encouraged, so although the expedition was supposed to last for two years only it took five years for Darwin to reach England since he was not tired of climbing each hill most enthusiastically equipped with his hammer which he used joyously ringing against the rocks, in the spirit of a typical geographer who, on his outings looks around at everything with wide eyes, alert ears and concentrated mind realizing the fact that every event has to be looked into thoroughly with an integrated approach and a holistic vision. Back in England he was influenced by what he read in the famous essay of Reverend Thomas Malthus (1766-1834), published in 1798, which pointed out that population tended to increase in a geometrical progression, and that if humans continued to reproduce at the same rate they would eventually inevitably outstrip their food supply and create a teeming world full of "misery and vice". Malthus essay set Darwin to thinking. He calculated that even a pair of elephants who are notoriously known as slow breeders, could produce 19 million progeny in only 750 years, yet it seemed that through the years, the number of elephants on the earth stayed about the same. Something was obviously interfering their output. But the question was: "Was that "something" exerting an equal effects on all elephants or did individuals differ in their ability to reproduce. Were some less successful at leaving offspring?" To cut the narration short, Darwin finally came up with the famous idea of natural selection. It is certainly rather strange, or is it rather a miraculous transformation, that Charles Darwin whose academic prowess had been thoroughly unremarkable so much so that at one point his father, a huge commanding man, a noted physician of great will and principle, had told his son, "You care for nothing but shooting dogs and rat catching and you will be a disgrace to yourself and to all your family." What a stark and utter under-estimate of the father of his great son who was destined to be such a famous pioneer in the world of Science.

Problem of Understanding the Meaning of Life

In spite of the fact that Charles Darwin wondered about biodiversity in the form of varieties of life living in different parts of the Galpagos archipaelago, and people have shown such a tremendous interest in the life cycle of various animals living on earth today, the best steps taken by the scientists in making an attempt in defining life seem to have a way of grinning back at general people and making us feel a bit unsure of ourselves - furrowed brows, cleared spectacles, cleared throats and all the other trappings of great knowledge do not diminish the simple reality that no one knows what life is. We have, no doubt, been able to list some of the special qualities associated with life, but as a matter of fact we must honestly admit that we have not been able to precisely define life. What we have done so far is that we have only characterized it, pointing at some of its common traits. However, there are two schools of thought on the nature of life. They are the schools of mechanism and vitalism. Mechanism implies that physical entities, including living organisms, must follow the same chemical and physical laws while vitalism implies that life is more than its molecular interaction. Thus the former school of thought reduces the wondrous qualities of life to the simple interaction of minute molecules; the latter school of thought, on the other hand, is based on the premise that living beings are more than the result of molecular interaction and that life inherently pos-

sesses some undefinable and unmeasurable quality which is very well known as an essence that some have called the "life force". Thus the real meaning of life is yet to be scientifically understood. The problem has perhaps best been expressed by Albert Szent-Gyorgi who wrote:

"In my hunt for the secret of life, I started research in histology. Unsatisfied by the information that cellular morphology could give me about life, I turned to physiology. Finding physiology too complex I took to pharmacology. Still finding the situation too complicated I turned to bacteriology. But bacteria were even too complex. So I descended to the molecular level, studying chemistry. After twenty years hard work, I was led to conclude that to understand life we have to descend to the electronic level, and have no life at all. Evidently on the way I lost life, it had to run out between my fingers."

- *Personal Reminiscences*

Apparently therefore following the lament of our very capable scientist Albert Szent-Gyorgi the meaning of life will probably never be grasped as a pure crystalline gem of truth. It can therefore be concluded that life's many meanings, if they ever exist, should probably lie somewhere in the very complexity that Szent-Gyorgi so valiantly worked through.

But whatever the meaning of life may be, among the small changes that were continually arising by chance in early cells on earth, some would have resulted in the cells producing sorts of molecules, a few of which perhaps quite unusual. If a cell began to produce, say, one of the rare "food molecules" or a reasonable substitute, then the pressure to compete for that molecule would be relieved. The cells that were able to chemically manufacture their own food are now known as autotrophs or self-feeders. As time passed the autotrophs became quite efficient at manufacturing their food. The biochemical chains became long, complex and refined. Today the result is most evident in our silent partners on our only planet, the green plants. They actually use the energy of sunlight to power their intricate food manufacturing machinery. They obviously had an advantage in the early days and so their number would have multiplied. However, their food-laden bodies would not have gone unnoticed by other life forms. Other kinds of cells soon developed means of taking away the food materials from the food makers. These became the heterotrophs or other-feeders. Today the earth abounds with heterotrophs. Some eat autotrophs and are called herbivores while some eat the species that eat the autotrophs. Since they eat the flesh of the herbivores who eat the autotrophs they are called carnivores. Most species, however, eat both the autotrophs and the heterotrophs and are called omnivores. Oxygen, produced by photosynthetic autotrophs, started accumulating in the atmosphere and killed many life forms. Some cells developed the ability to withstand the damaging oxygen. Lines of cells less vulnerable to oxygen developed the capability of utilizing it. Oxygen formed a layer of ozone in the upper atmosphere that shielded the lower parts of the earth from the damaging ultra violet rays of sun and made the dry land of the earth safe to inhabit.

Species and their Meaning

Another important aspect of biodiversity is the species diversity. But what is species? It may seem like a simple question, but apparently it is not. Biologists find it quite difficult to announce, and, in fact, it is said by such authors as Robert Wallace of the University of Florida that there is no record of any two biologists ever agreeing on one answer. If they seem to agree, it is generally because each one has stifled of what he or she knows about this exception or that. The question of species looks quite easy because all of us can distinguish between a cat and a carrot. But a few others who may look very much similar to look at may be different from each other when examined carefully. Even in a small area, as mentioned before at Galapagos islands or even in one single state of US we may find a vexing situation in the form of the red-bellied woodpecker and the golden-fronted woodpecker. At first sight

they are difficult to tell apart. Their voices, feeding habits, and nest sites are also similar. Yet they are quite different species and obviously we have no trouble telling each other apart. They do not attempt to interbreed and no hybrids have been seen. However, far more dissimilar species than these, at least to the human eyes, are known to interbreed. However the renowned zoologist Ernst Mayer has put forward the definition of species in the following words, "A species is a group of actually or partially interbreeding population that is reproductively isolated from other such groups." Reproductive isolation occurs when members of one group will be rendered unable to successfully interbreed with another. Such isolation ensures that the genes from one group will not be combined with those from another group, thus each can accumulate its own genetic distinctions. There are several ways that groups can be reproductively isolated. Among them are geographical isolation, behavior isolation, mating isolation, genetic isolation and hybrid isolation.

One of the most interesting and challenging questions in biology involves speciations, the formation of new species. The question is how do they arise? The answer is strongly dependent on geography. Most species arise through allopatric speciation, the formation of new species after the geographic separation of once continuous population. The process involves a population being somehow divided and each group taking a different evolutionary route until they have diverged so much that interbreeding is no longer possible even if they should rejoin. In 1912, as is known to us geographers, Alfred Wegener, apparently putting the prevailing theories such as the "displacement globe" that was presented by Howard Baker in 1911 to test, published a paper which proposed the theory of continental drift. He suggested that 200 million years ago all of the continents of the earth were joined together into one enormous land called Pangaea which later broke apart in discernible fragments that began to drift northward to their present situation. His idea was seriously attacked by geologists of his time, who called it rather naive since, in their opinion it was triggered by the simple observation of the apparent jig-saw fit between South America's east coast and Africa's west coast. But recently, after 1960 a new generation of scientists revived the idea enshrined in his apparently simple theory on the basis of the geological and palaeo-climatological as well as palaeo-botanical conditions. They, therefore, further subjected it to revised scrutiny based on recent findings, with the result that we now have come to believe that not only has the continental drift occurred as Wegener hypothesized but even that it continues to occur today and this movement is christened as "plate tectonics". An understanding of such an occurrence is vital to the study of distribution of life on earth today. Another type of speciation is what is known as sympatric speciation which is a less common event, involving the formation of two species from one, continuously interbreeding population. It is, by far, more common in plants than animals, but a few rather clear-cut examples can be found in nature. One of the best known cases involves flightless grasshoppers. The grasshoppers appear to be one species across their range, but chromosomal analysis reveals them to be of two different species. It is worthwhile stating as an example of sympatric speciation in progress, the case of the maggot fly.

The fly has long parasitised the North American hawthorn trees, and when apple trees were introduced into North America in the 19th century, the fly began to infect them too. Now the fly has become divided into two groups of specialists, one line infecting hawthorn trees, the other preferring apple trees. The two lines can still interbreed, but they differ in some important respects such as in several genes and in their maturation time.

It has been found that environments play an important role in evolution. Divergent evolution increases the differences between species living in different environments. Convergent evolution increases the similarities of species living in similar environments. There is likely to be a great deal of varieties within population. If the environment changes, variation is advantageous, because it increases the chances that some individuals will survive and reproduce,

leaving offspring that also fare well under the new conditions.

An interesting example of selection can be seen in the change in the frequency of light-or dark-colored moths in the population that occurred in England after Industrial Revolution. In the 1700s, the British countryside was as green as its poets said as the "Sweet Auburn, loveliest village of the plain" in Oliver Goldsmith's "The Deserted Village" which is almost an elegy written to lament the exodus of the rural population to the slums of the cities following the mass production movement as a consequence of the industrial revolution. Formerly the trees were numerous in the village, and many of them were covered with a light gray-green lichen. Furthermore, it was sometimes possible to discern a light-colored moth concealed upon the barks. One might also occasionally spot a black moth perched rather conspicuously as the light colored lichen. The black moths were quite rare, largely because they were easily spotted by hungry birds and quickly removed from the population.

But "progress" had its way, and England's entry into the industrial revolution was marked by the construction of huge coal-burning factories which belched forth their billowing, black smoke and soon the English countryside quietly submitted to its cloak of soot. As the trees darkened, the more common white moths became increasingly easier to see, while the darker moths became less visible. Thus birds began to eat more of the light moths and their light genes began to disappear from the population. Finally, by the late 1840s, 98 percent of the moths were dark. The transition, then, from the light to the dark form was virtually completed in only fifty years. Interestingly, however, the use of pollution-control devices in British manufacturing has produced cleaner air, and as a result, there has been a perceptible resurgence of the lighter moths.

Variation in environment is a factor that maintains variation in population. Shifting environmental conditions bring about variability in a population if the population lacks sufficient time to adjust to the new set of conditions. An environment consisting of patches of different habitats or with gradual changes across the habitat, also causes variability because subgroups adjust to local conditions. This sort of environmental influence or variation is called geographical dine. It is to be specially noted that the individuals at the extremes of such a wide range of changes may be so different from one another that they may eventually be quite able to interbreed successfully.

Small population may evolve through genetic drift, which is the change in the frequency of genes in a population due to chance. When a disaster strikes a population drastically reducing its size the gene frequency of the survivors may not be representative of those in the original population, creating a case of the bottleneck effect. Gene frequencies of small population may also be changed through the founder effect in which a few organisms become separated from the main population and establish their own breeding group. The gene frequencies of the new group changes further in response to selection pressure in the new environment. Small population may become extinct very easily because they lack genetic flexibility. There is another factor that places small populations at high risk of extinction. As a population grows smaller genes that interfere with reproductive process tend to accumulate and cause unusual acceleration in the process of extinction. Human beings have caused species to become extinct by destroying their habitats and by hunting extensively. People have built dams and consequently small pockets of isolated species have been created. The dodo, the carrier pigeon and the last common ancestor of the horse and zebra have been made extinct because of excessive hunting.

Thus life on earth is subjected to countless pressures as it continues striving for its own existence. It must continuously react to the nature of its situation or its predicament and it must change. The world, we live in, is a variable and changeable place and different life

forms have evolved that are uniquely able to utilize one aspect of place and different life forms have evolved that are uniquely able to utilize one aspect of the earth or another in several ways. Put simply, life must change in order to take advantage of its part of this world.

Adaptiveness of Behavior among Living Beings

The National Geographical Channel in the television today gives us in a very vivid and most interesting manner the life and behavior of different organisms in nature. For example, a striped skunk sniffs the air and squints into the cool mountain dusk, then whirls and aims its rear at a lynx that leaps backwards quickly and then pads away, glancing over its shoulder. Some distance away, a burly badger ceases from its digging and lopes, hairs a-bristle, toward a browsing bear that had wandered too close. The bear retreats, and both return to their foraging. Overhead, a flock of geese beats against a steely sky.

We may wonder how the lynx, a beast, came to understand about the rear end of skunks, and we may ask what triggered the charge of the badger and what motivated the geese. These questions are difficult to answer but there are others, of another type, that may be easier to answer. For example, we can ask how these behaviors are useful and how they help the animals to succeed. Then we start asking questions about the adaptiveness of recognition, aggression, cooperation and altruism. The answer should provide us not only with information about behavior, but they may also illustrate some fundamental points about how natural selection of Darwin that is seen in practice influences animals.

In fact species recognition is adaptive because it prevents animals from wasting time and energy by trying to mate or to compete with a member of a different species. Population recognition when it allows sub-groups to adapt to different conditions across a range of species. Kin recognition may be advantageous, may preserve one's own type of gene by preventing cannibalism of relatives, by preventing inbreeding, or by warning relatives of danger or assisting them. Individual recognition of one's mate may allow offspring to be produced more effectively. Recognition of member of one hierarchy may prevent dangerous fights over food or other commodities.

The old image of "Nature, red in tooth and claws" has really been superseded by the popular notion that human beings are the only notorious animals that regularly kill members of their own species while the other so called unsocial and non-political animals get along with their own kind. We should, however, note that aggression is belligerent behavior that normally arises as a result of competition. An animal shows aggression mainly toward other individuals that tend to utilize the same resources. Thus it is likely to be aggressive toward those most like itself. The most like itself are, of course, of the same species and sex. And most aggressive interactions occur within species, between members of the same sex. Predatory behavior, by the way, is not aggressive. A leopard is about as aggressive toward an antelope as we are toward a dumpling of *mamacha*.

The most blatant form of aggression is fighting, and fighting is more likely between competitors. Animals of different species do sometimes fight. The precise method of fighting vary widely but in whatever way the animals fight, most species have means of avoiding injury to each other. Fighting between dangerous combatants is normally a stylized ritual and relatively harmless. A horned antelope may go on attacking its predator, but when they fight each other, the horns are never directed toward the exposed flat of the opponent, such stylized fighting enables to escape any serious injury; the loser is usually permitted to retreat without being physically harmed.

Cooperation may seem to be at the opposite end of the behavioral spectrum from aggression. Cooperative behavior occurs both within and between species. As an example of inter-spe-

cific, or between species, cooperation, we can realize it when we consider the relationship of the rhinoceros and the tick bird that may be found clinging to the rhino's thick hide. The little bird gets free food while the rhinoceros gets rid of the ticks. As an example of intra specific, within species, cooperation, we may consider the cooperation among mammals, which is most commonly found in their defensive and hunting behavior. Usually they protect the animals of their own kinds, particularly the younger ones by standing in front of them in such a manner as to form a strong barricade of living wall against the invaders. Such a defence is very effective against all predators, except human beings of course, since the beasts try to maintain their stance while they can be shot one by one by men who carry some external artifacts such as guns and some other weapons. It is a bit surprising that cooperation is very highly developed in certain lowly insects. Weaver ants working together repair a damaged leaf art. A very high degree of coordination and cooperation is to be seen among them. When the sides of the leaves are pulled together they are sewn tight as other ants pass silk-spinning larvae back and forth across the gap, pressing them against the margins of the leaves. In honey bees, the queen lays the eggs and all the other duties are performed by the workers, sterile females. Each worker has a specific job at any given time. The newly engaged workers prepare cells in the hive to receive eggs and food. Then in a day or so, their "brood glands" develop and they begin to feed larvae. Later they begin to accept nectar from field workers and to pack pollen loads into cells. At about this time their wax glands develop, and they begin to build combs. Some of these "house bees" may become guards, patrolling the area around the hive. Eventually, each bee becomes a field worker. She flies afield and collects nectar, pollen or water, according to the needs of the hive. These needs are indicated by the eagerness with which the different loads of the field bees are accepted by the house bees.

The most striking characteristic feature of a beehive is 'efficiency'. In the more "feminist" species, the drones exist only as sex objects, reproduction partners. Once the queen has been inseminated, the rest of the drones are quickly killed off by the workers. They are of no further use. The females themselves live only to work. They serve the queen, rear the young and maintain and defend the fort of hive. When their wings are so torn and tattered that they can no longer fly, they either die or are killed by their sisters. But the hive goes on and on.

Life: A Grand Panorama

Despite the fact that meanings of life are difficult to understand life goes on in different forms and shapes and sizes, behaviors and traits. On the surface of the earth life appears to be a modern painting of any member of the famous SKIB group of Nepalese painters. If the art galleries were not generally large these modern artists would be completely out of luck. Their canvas when viewed from close ranges will be seen as a confused, chaotic collection of drips and blobs and smears, so much so that many stories are fabricated and told about them, such as how two small urchins who visited such an exhibition of modern painting were afraid of being blamed for throwing ink on the great works of modern painting or even how a great painter failed to find his own painting which had earned him a first prize in a stiff competition of modern art, and after inquiry for that prize winning piece of art, his painting was at last discovered but to the utter dismay of the creator of art it was found to have been hung upside down and was actually admired and evaluated that way. So it is with life on this only planet of ours. When the viewer of the painting stands back so that the canvas can be viewed as a whole, the various parts begin to fit and the real organization appears. Almost any aspect viewed up too close seems to stand alone, a part of no grand scheme; but when one steps back, allowing the various parts of the painting to play together on the mind, the wholeness and completeness of it all becomes more apparent. The parts begin to be seen nicely and almost invisibly juxtaposed as one grand panorama.

Before the large picture could be seen, the smaller parts had to come into focus. Specialists provide people with these narrow views and we ecologists put them into place to form a larger picture since ecology is the study of the interrelationship of the organism and the environment, and geographers very conveniently can lead people to take a look at the grand scheme of life and see how its components interact in the formation and maintenance of it all.

Habitat and Niche

It is said that habitat is the address of an organism and the niche is its profession. Simply speaking the habitat is the place where an organism is found, and it can be described in several ways. For example, an animal may live in a big forest habitat, or more specifically, in a wetland pool in the same forest such as the *Bees Hajar Tal* at Tikauii in Chitwan. Furthermore, it may live in a certain part of that pool, its microhabitat. Whenever an organism lives, it interacts with its surroundings in myriad ways. The interaction involves the environment influencing the organism, which, in turn influences the physical environment. The organism may also interact with the living things around it. The sum of all such interactions, along with the organism's own requirements, describe its niche.

It has become axiomatic that two species cannot occupy the same niche indefinitely. If two species were to find themselves in such a situation it is generally predicted that one would be superior to the other under these conditions and would eventually replace the less fortunate species. Where species do coexist then it can be assumed that they are interacting with the environment in different ways, i.e. occupying different niches. This means that when we walk through the woods and see various species of small seed eating birds in the same area, they may be found utilizing the habitat differently. This principle was nicely demonstrated by the ecologist Robert H. MacArthur, who showed that five species of American warblers that feed in spruce forests and seem to be occupying the same niche were actually dividing the trees into different feeding zones. Interestingly, the zones overlap more during times of food abundance. Animals may also divide up a habitat in other ways. For example, they may utilize the resources at different times of the day or at different times of the year, or they may utilize different commodities within the same part of the habitat. Partitioning a habitat obviously reduces the level of competition between the species. Generally, competition occurs when organisms utilize resources that are in short supply, or when they harm each other while seeking the same resource that is not in short supply although the latter cases are probably much more rare in nature.

It is, therefore, clear that the living beings on earth will have to have a habitat, an address, where they can stay and lead their life, as successfully as possible as long as they live. Earth itself looks like a ponderous place that unfailingly provide its denizens with those things necessary for life. We often seem to forget, however, that life exists only in a thin film that veils the surface of this big ball - a delicate shell known as crust wherein wondrous form of sunlight and water interact to permit life. This fragile frame is responsive to a number of influences and, hence, is highly variable from one place to another.

A. J. Herbertson, after whom the Oxford University Geographical Society is called Herbertson Society has left for us the twelve different types of climate and therefrom the twelve different regions which have very clearly given rise to a simple and yet most justifiable way of categorizing different kinds of places in which life exists on earth which in itself is such a great combined sphere of complex and intergrading areas. In the similar strain the earth is also divided into several kinds of mega units called biomes, defined according to the generalised picture of the distribution of plants that are supported by each of the mega units. Of course the make up of the plant community is dependent on several factors such as soil conditions, available water, weather, length of the day, competition etc. but as envisaged earlier by

Herbertson the meteorological factors, available water and temperature are the main determinants. Certain types of animals occupy each type of biome, since different types of animals are dependent on different sorts of plant communities for food, shelter, building materials and hiding places.

Generally, people count as many as 10 biomes namely Polar ice caps, Tundra, Taiga, Coniferous forest, Temperate Deciduous forest, Grassland, Chaparral, Desert, Tropical Rain Forest, Tropical Deciduous forest and paying due recognition to Mountain Geography the eleventh one is termed the Snow capped mountains. Thus they also realize that in the high mountains all these biomes that are to be found in successive divisions within a horizontal distance of 10,000 Km are representative within the horizontal distance of just about 200 Km. in the Himalayas because of the sharp variation in altitude and, therefore, in biomes. This is a sufficient reason for the occurrence of exceptionally rich biological diversity in Nepal. Even in the case of other important determinant namely water Nepal is quite rich and at present lakes and ponds serve as very much a useful habitat for myriad of organisms in different forms, ranging from zooplankton to swamp deer, mugger crocodiles and pythons since the term wetland encompasses a variety of condition such as inland marshes, wet meadows, mudflats, ponds, bogs, bottomlands, wooded swamps, fens, alpine ponds and lakes.

From the division of the earth into distinct natural regions and categorisation of the biomes we may come further down to the concept of ecosystem which has been conveniently formed by further breaking down of the natural regions and biomes. Technically, an ecosystem is a group of interacting living things together with all the environmental factors with which they interact. An ecosystem is considered an independent unit and light is usually its only outside source of energy which comes primarily from the Sun. In the morning Sun we can see the sunlight dancing and coursing its way through living systems in innumerable directions. Essentially photosynthesis is the process by which organisms use the energy of sunlight to make organic compounds or food in the form of sugar. Green plants get their color from pigments called chlorophyll, which initiate the photosynthetic mechanism by capturing the energy in light. Conceptually therefore ecosystem might be a small pond, a wooded area or a green field. Even ecosystems are further broken down into conveniently manageable units. One such unit is community, which is an identifiable interacting groups of organisms within an ecosystem; but it should be remembered that ecosystems include abiotic or nonliving factors and biotic or living factors while community includes only biotic or living factors. Each community has its own defined and interacting population.

It will sound rather astonishing to hear population geographers and ecologists predicting that within the next twenty years, about a million species of plants and animals will become extinct. Most of these extinctions will occur in the poorer, developing countries of the tropics as in these parts of the globe expanding human populations are encroaching into the habitat of countless other species, species that may so well be adapted to their comparatively small area that they can survive nowhere else.

It does sound rather selfish when the human beings on earth sometimes declare that they need not worry about other species while they need to live a life of plenty and prosperity. However, there are at least a couple of ways that might justify worrying about them. For one thing these species may have something that we can use for our welfare especially considering our emerging abilities in genetic engineering. Such species may serve as genetic reservoirs. Their eventual death may spell the end of unusual or intriguing combination of genes that might have proven very useful later on. Second, it is argued that the other species of the earth may be our only companion in the entire universe and they have right to exist. But will it not be perhaps a bit esoteric for a Nepalese hill farmer who has already six or seven mouths to

feed and another one may be on its way to this ailing world and who wants to clear more land by felling the trees along the rather steep slope of the hills even if it could mean scratching the marginal lands uphill? However, an incident in the hillside of Mexico has shown just how some of such esoteric sounding arguments can be very valid even to a pragmatic farmer. On a rather ordinary hillside of Mexico, scientists have discovered a new plant species which was found to be in the same genes as domestic corn which was named *Zea diploperinis*. These plants were of great interest because they turned out to be perennial, they do not require planting each year. Furthermore, they are immune to a number of viruses that infect corn, and they are able to grow in wet area where corn cannot. This is all particularly interesting because there is some promise of being able to cross the wild strain with domestic corn. In fact it is out of such things that agricultural revolutions are born. Such eleventh hour discovery of a remarkable species, on the other hand, can only suggest how many more we might have already unknowingly sent on their way to extinction. We are reminded of the fact that 95 percent of the genetic variation of wheat native to Greece have become extinct in the last fifty years. We may thus have lost forms with a genetic resistance to whatever disease might next strike the world's wheat crops.

It is for these reasons that nowadays people are very concerned to the extent of obsession with the potential loss of species and habitats- so much so that the UN Convention was signed in Rio and duly ratified to put a legal full stop to unrestrained damage. The term "Biodiversity" applies to the variety and variability of living organisms from genes to elephants. The evolution of biodiversity is not so much a matter of numbers as of functional redundancy. The loss of one species upon which others critically depend is far more serious than the removal of a species whose ecological niche can readily be replaced by other species. So a major task for scientific inquiry is not just to record but also to establish the genetic functional significance of species in varieties of space called ecosystems which themselves together form landscape which is a part any one biome of the biosphere which is known to the general public as our only abode, the earth. This is why the analogy of losing a library even without cataloguing the books is only partially correct. Of much greater interest is the relative importance of each species for the resistance and robustness of genetic stock to enable them to survive against any stress that is caused by human activities or through natural processes. It is, therefore, not a matter of how many species the earth can afford to lose, but how many critical species must be retained.

Diversity in Geography

Since Nepal is a signatory to various international conventions we are committed to maintaining the diversity of the flora and fauna on their communities and habitats, the ecosystem. For this reason it is essential that a very special attention should be paid to the broad types of provinces that Nepal can be divided into. Biogeographical classification system has been developed by geographers as well as conservation or biodiversity specialists in different ways. They have taken into consideration the following most important categorizations:

- the overall main association by biogeographical realms
- the main geographical animal association by such regions and
- the main physiographical association by biogeographical province

These classification systems range from the overall continental scale systems such as Udavardy's biogeographical realm of which there are eight worldwide to Dobromez's ecosystems of which 114 were described for Nepal. Other authors also have attempted classification at different levels of resolution; for example the LRMP's classification of vegetation types by broad physiographic zones and by detailed forest types. Nepal is of major importance from the biodiversity point of view for its altitudinal range and its geographical position.

This is reflected by a number of subdivisions of the various classification systems that cover Nepal.

As geographers we join the other specific Scientists by defining geo-ecology as the science which deals with the full and complex interrelationship between the organisms or biocoenosis, and their environmental factors. Troll in 1970 has argued that there are two main aspects of geo-ecology:

- (a) the differentiation of the regionalization of ecosystem and the spatial arrangement or simply speaking landscape pattern of ecotypes in a geographical region leading from climate, consequent vegetation, soil and landscape belts to smaller units within the general landscape hierarchy and
- (b) analysis of single ecosystems functionally, structurally and quantitatively with respect to the full interrelation between biotic and non biotic elements such as micro climate, rock material, soil types, water amount and movement, varieties of land forms and biocoenosis with plants, animals, microorganisms and so on.

Although the first aspects sound spatial and second biological, in essence, both spatial and biological approaches are not alien to geographical aspects in interpretation since both of them must be used to have a proper understanding of specific landscape components.

Ecology, after all is the study of plants and animals in relation to their environment and to one another. But it is also more than that: it is the main intellectual discipline and tool which enables to hope that human evolution can be mutated, can be shifted on to a new course, so that man will cease to knock hell out of the environment on which his own future so strongly depends. Thus environment plays a crucial role in ecology which in itself is derived from the Greek word *Oikos* which literally means house, abode habitat. Ecology also deals with the interrelationship between the living thing, and between their non living environment. Such an interrelationship reminds me of an interesting cartoon which appeared in New York dated April 4, 1974. The cartoonist had apparently understood the spirit of "the Silent Spring" of Rachel Carson, which captured the sentiments and imagination of the then public which was expressed regarding the colossal mistakes of having blind faith in the power of technology. The cartoonist showed a forlorn figure in bed and wrote:

This is the man,
 who ate the steak,
 that came from the steer,
 that nibbled the grass,
 that grew in the field,
 where roamed the cat,
 that caught the bird,
 that ate the fish,
 that fed on the bug,
 that floated on the oil slick.

Well, when we speak of environment, we literally mean our "surroundings", anything that surrounds us or any organism that we are studying about. The word "environment" has therefore very wide connotation. Within its purview, entire physio-climatic and biochemical, including human, aspects of the earth, our only abode, are included conveniently and precisely. It embraces the earth surface with all its physical features, natural resources, the uneven distribution of land and water, mountain, plateau, plains and beaches, minerals, plants, animals and micro organisms, climate along with light, including infrared radiation, ultra violet radiation, visible light, humidity, absolute and relative, precipitation in the form of rainfall, hail

and snow temperature with all its variants such as maximum, minimum, mean, range of temperature etc., pressure, wind, edaphic factors of soil, its texture, composition and profile, various genetic classifications into alluvium, black soil, red soil, desert soil, peaty soil along with other soils with varying chemical compositions, and all the cosmic forces that play upon the earth and affect the life of man.

In the same strain, ecosystem is defined as an integrated system in nature which may be studied as an independent entity ranging from a pin head to the entire earth. It may be a rolling log in the forest, a coral atoll, a continent or even the earth with all its biota. Earthly environment works like an integrated system in which every element as well as creature has definite role to play in the symbiosis. Hence it is a study of organisms in the natural home or habitat or its objective is to discover or understand the relationships which exist between the living things within their environment.

The wide area of sphere that Geography as a discipline encompasses has led to the popular concept that Geography is the mother of all sciences and since literally speaking it means the description of the earth, owing to the vast expanse of the area it covers the subject Geography is known to different people in different ways. The dictionary of Geography says, "Geography is a description of the world and its inhabitants or the science of the earth or its life or human ecology." Although it seems that the definition has separated it from animal or plant ecology actually speaking it has not, because after all the definition does mention the inhabitants of the world, and the human beings alone are not the only inhabitants of the earth, it should include also other creatures of various descriptions and when we stretch the term still further we can include the plant life as well. Finch and Frewartha put their heads together and came to the conclusion that Geography is the science of earth's surface. "It consists of systematic description and interpretation of the distribution pattern and the regional association of things on the face of the earth." So the definition suggested by these two great geographers encompasses a very wide task for a geographer although to start with it appears that they were trying to confine themselves in the physical aspects of geography in term of landforms and landscape. They proceeded further on to that it consists of a description and interpretation of the distribution and its pattern along with how various objects on the surface of the earth have been where they are, not as an independent, separate entity in themselves in total isolation but as a system of components exhibition of such phenomena which are interrelated to one another in a distinctly specific manner so that it has given rise to a situation which itself is a very important concern of geography, in a spatial context. Geography no doubt provides the base, or the stage where various biospheric drama is enacted. Next important aspect that is usually ignored by many is the temporal context of the various events or happenings or activities. Whenever people hear the word "time" they tend to think that it belongs to the domain of History. But if we accept the definition of Geography as "interpretation" and "regional association" of the "things" on "the face of earth" it requires the inclusion of history since, after all, anything that we see on the surface of the earth today is the product of its past, the result of the various happenings in the immediate past or very distant past, as the case may be. Even the inanimate objects like simple landform, in the words of William Morris Davis is "the function of structure, process and stage". All these three terms, also as they stand denote the present tense, but their interpretation takes us to the past to the historical events that took place before the landscape took the present shape. The lacustrine deposits of Kathmandu Valley indicate to us different historical periods when all these processes of mountain building, folding, differential uplifting, damming, erosion, deposits, landslide etc. happened and worked together to form what it is today. Thus as it is said, History without geography has no basis for its development, geography without history has no dynamism which has shaped what we find today not only in the different stages of land sculpturing or flood plain formation but also in the case of the nature of distribution pattern of all the living

and non living things on the surface of the earth and its various parts.

Some writers have shown by elaborate wheel chart how codification and classification of all "geographic materials" have been done within the basic framework of the Dewey Decimal System, a system that prevails in the cataloguing of different books and journals and as reflected by the editor of the decimal classification is considered functional. The chart illustrates the substantive relationship of geography to other cognate disciplines and services, as a convenient indicator for separating the various branches of geography in a distinctive manner so that the existence of each one of them is very well recognized as a separate entity in itself, although, in essence, they are individual parts of the one discipline namely geography. Thus according to the scheme of codification and cataloguing Dewey has made an attempt to classify the various divisions of Geography and codified them under 910 such as, Philosophical Geography, Biblical Geography, Social Geography, Demographic Geography, Political Geography, Military Geography, Commercial Geography, Mathematical Geography, Physical Geography, Oceanography, climatography, Biogeography or Plant- Animal Geography, Anthropogeography, Soil Geography, Crop Geography, Industrial Geography and Planning Geography. Further on the wheel also shows that code 910.2 denotes Travellers' manuals, guidebooks etc., 910.3, Dictionaries and Gazetteers; 910.4, Circumnavigation; Ocean Travels etc; 910.5 periodicals; 910.6, societies; 910.7, Study of Teaching of Geography, Map Drawing; 910.8 Collection of Travels, etc; 910.9, History of geography, Travels, Explorations; 911, Historical Growth and change in Political development, Historical Geography etc; 912, Maps, Atlases etc. and 913.3, Antiquities, Archeological and ancient countries.

While enumerating several such branches and sub-branches in geography *Orbis Geographicus 1992/1993* list the following topical specializations:

Administrative Geography,	Agricultural Geography
Economic Development Geography,	Applied Geography,
Arid Region Geography,	Bio-geography,
Climatology,	Coastal Geography,
Conservation Geography,	Environmental Geography
Cultural Geography,	Economic Geography,
Educational Geography,	Locational Theory,
Geomorphology,	Historical Geography,
History of Geography,	Marine Geography,
Manufacturing Geography,	Marketing Geography,
Medical Geography,	Military Geography,
Natural Hazards,	Oceanography,
Physical Geography,	Planning-Regional Geography,
Planning-Urban Geography,	Political Geography,
Population Geography,	Recreational Geography,
Regional Geography,	Resource Geography,
Rural Geography,	Soils Geography, Transportation and Communication Geography,
Tropical Geography,	Urban Geography,
Water Resources,	Field Methods in Geography,
Landuse,	Quantitative Geography,
Teaching Techniques in Geography,	Audio-visual materials & Techniques

Remote Sensing,
Geography of Energy,
Cartography General,
Electronic Data Processing and

Social Geography,
Geographic Information System,
Geographical Librarianship,
Environmental Perception etc.

The 27th International Geographical Congress, 1991 noted: "Geography is discovery". Themes are getting wider and wider and Pandey adds that a global list of Geographies will contain more than 200 entries from academic Geography to Zoo-geography.

But whatever number we may divide the discipline of Geography into, the essential themes of Geography is concerned with the study of space and place. As Hukein 1994 has reiterated:

"The modern Geography is concerned primarily with interpreting and explaining the occurrence, distribution and interrelationships of physical and cultural patterns which can be discerned. Modern Geography analyses patterns according to the attribution of the location, extent and density.

In the biogeoclimatic map of the world Nepal lies within both the Palae- arctic and Indo Himalayan realms at the cross roads of south-east Asian, north-east Asian (Chinese) and Mediterranean tracts. While its northern parts, consisting of mixed high mountain and highland ecosystems with complex zonations, lie within the Palaeartic Realm, the tropical deciduous and monsoon forests and cropland of the southern Terai plains fall within the Indo Himalayan Realm. The Palearctic component is more interesting because of its complex zonation showing a high level of biological diversity. Prater (1928) divided the country into three zoogeographical zones -Indian, Himalayan and Palacartic. The Palacartic zone of Nepal is further subdivided into three subzones, namely the Mediterranean, West Chinese and Indochinese sub region (Wallace). At the ecosystem level Nepal presents great diversity in its land and water ecosystems. It ranges from the dense tropical monsoon forests of the Terai in the South, with rich paddy field and warm water, the deciduous broadleaved forests of the sub-tropical and temperate middle regions to the sub-alpine or alpine pastures and snow covered Himalayan peaks with many cold streams, glaciers and lakes in the north.

Nepal is centrally located in the Himalays and occupies a third of its entire length of 2500 km from the Indus trench below Nanga Parbat to Yarlung-Tsanpo- Brahmaputra gorge below Nameche Barwa. Nepal is a land locked country sandwiched between the giant neighbours. Although the country covers an area of 147,181 sq. Km. it is known as a tiny kingdom. It was during the middle Permian times, more than 200 million years ago that the geosyncline of Tethys was gradually filled in from both the Indian and Eurasian Tectonic plates. The seabed was raised and folded about 70 million year ago starting the orogenesis of the Himalays. During upper Eocene times, some 65 million years ago, a second upheaval elevated the Tethyan sediments into mountain ranges with large river valleys in between from where the deposited debris formed the Siwaliks about 20 million years ago. In the late Pleistocene period the outer foothills were created and played a dominant role in determining the present physiographic forms of the Himalayan System consisting of the Main Central Thrust (MCT), Kathmandu Nappe, Mahabharat Thrust, Nuwakot Nappe, Main Boundary Fault (MBF) and the Siwaliks. At present the subduction is still known to be active with frequent tremors where by the Indian plate is supposed to have been moving at the rate of about 6 cm. per year.

About 77 per cent of the total area of Nepal is mountainous and it contains a huge number of high peaks, steep hills, elevated flat uplands punctuated by river valley of varied extent and width. Some of them are frequently covered by fertile alluvial soil while some others are strewn with boulders and screes. Depending upon the specific perception of individual authors, many of them have divided the country into several divisions and have used different terminologies to define Nepal's physiographic units.

Prof. U.M. Malla in 1957 divided Nepal into several units and called them Madhes, Chure, Bhitri -Madhes, Mahabharat, Broad inter-montaine valleys, Zone of spurs and Valleys, Great Himalays, Bhots, Border ranges and Tibetan Plateau. In 1960 Hagen travelled along the length and breadth of Nepal and reduced the number of units to six and named them Terai, Siwalik, Mahabharat, midlands, Himalayas and Tibetan Marginal Mountains with inner Himalayas. Gurung in 1960 almost followed the same line but recognized the existence of the inner Terai and divided Hagen's Siwalik into two units-Chure and Madhes, the highland and lowland of inner Terai respectively. In 1968, Burathokey and Malla once again revived the several units and called them Terai, Bhavar, Chure, Bhitri Madhes, Mahabharat, Hinterland Valleys, Pahar, Great Himalayas, inner Himalayan Valleys, Border ranges and High Plateau. LRMP in 1986 and FSMP in 1989 simplified the division into Terai, Siwalik, Middle Mountain, High Mountain, and High Himalaya. Ives and Messerli in 1989 endorsed what Hagen has written in 1960 but divided Hagen's Himalays into two divisions - Transitional Belt and Greater Himalaya.

In the land locked country like Nepal the entire country can be said to have only the terrestrial ecosystem, in which we may include the rivers as well. But since the environmental aspects are so different on land and water bodies it is worthwhile dividing of ecosystem into Terrestrial and Aquatic types. The Terrestrial ecosystem is based upon many variables which govern its nature and functions, such as altitude, latitude, topography, temperature, soils, moisture as well as wind and sunlight. It is for this reason that scientists recognise three fundamental categories of biodiversity namely Ecosystem diversity, Species diversity and Genetic diversity. An ecosystem consists of a dynamic complex of plant, animal and microorganism in their non-living environments which interact as a functional unit. It can be therefore said to be an integrated set of biological components making up a biotic community and its abiotic environment. There are three primary axioms which define ecosystem structures and functions namely (a) recycling of essential elements including biomes in different tropic levels following characteristic spatial and temporal pattern in each type of ecosystem and (b) certain emergent properties such as homeostatis and self regulation are definable and measurable in the highly aggregate unit of study. Homeostatis, by the way, is the tendency of living beings to maintain a stable environment; but when we say so homeostatis, appears to be a very ideal state, the sharp edge of a sword which is sometimes compared to the concept of "grade" in the development of a river valley, which, according to physical geography is a state of equilibrium between the energy of the river and the load it has to transport and such an equilibrium is often found to get disturbed even at the slightest change in the load or in energy at any specific spatial place or point of time. It is therefore that the homeostatis is also taken in a modified form to denote a fairly steady state within certain, tolerable recognizable limits.

The terrestrial ecosystem of Nepal can be divided into several units on the basis of nature of vegetation and its type of which forests, pastures, shrubland and marsh are important. Ecosystem diversity is best understood on the basis of the landforms, altitude, moisture and temperature and also when we attempt to find out the occurrence of communities in different niches within different ecosystems, each of which is associated with definite and complex assemblage of species. Each community of organisms will have its own relative abundance of species and population complexes which are all related to the composition and structures of biodiversity. However we take into account the fundamental bases of the physiographic divisions of the country as the three broad areas namely the Terai and Siwalik, Midhills, and the Highlands.

It is obvious that these broad ecological belts are mainly based on altitudinal variation which has given rise to difference in natural vegetation of the area in terms of different forest types, shrubland, grassland of varied nature and extent. They are differentiated on the basis of their

individual plant species which again are determined by the other various elements of environment. About half of the country surface area is covered by some sort of vegetation - forests along with shrubland, for example, cover some 40 per cent of Nepal and grassland, about 12 percent. Among the five Development Regions Far Western Development Region is the most undisturbed region since in this region where about 35 percent of the total forest area. Shrubland is entirely distributed in a region ranging from 8.5 percent in the Central Development Region to 13.5 percent in the Mid Western Development Region.

Nepalese culture is very rich in traditional customs and rituals concerning the use and, therefore, protection of certain parts of species for various purpose. *Peepal tree*, *Bar Tree*, *Parjat*, *Tulasi* and even *Amala* are considered sacred plants. Biological species are also major food stuffs and source of protein. An estimation has pointed that over 190 species of plants that are found grow-wildly in different parts of Nepal are commonly used by local people as nutritive food and nourishing fruits. Domesticated species of animals have been especially reared and agricultural plants are carefully cultivated for fulfilling the food requirements of the population. In Nepal majority of the population still on agriculture, horticulture and livestock raising for a living.

Let me once again remind that though the country constitutes only about 0.03 percent of the whole land area of the world and 0.3 percent of Asia, yet it has about 2 percent of the flowering plants, 3 per cent of pteridophytes and 6 per cent of bryophytes of the world's flora. Nepal is a home to about 246 species of flowering plants and 248 species of non flowering plants. More endemic species may be further recorded after completing the country wide plant exploration activity. Distribution of these endemic species seems to be mostly limited to the Himal area out of which the Annapurna Conservation Area (area) with about 55 species is considered rich in endemic plants followed by Dhorpatan Hunting Reserve with 36 species and Shey Phoksundo National Park 30 species of endemic nature.

In view of the over-exploited nature and, therefore an urgent need for their conservation HMG has provided legal protection status to 13 plant species under the Forest Act, 1992 according to which *YarsaRumba* and *Panchaunle* are restricted for collection, use, sale, distribution, transportation, and export, while *Sugandhakokila*, *Sarpagandha*, *Loth Salla*, *Talispatra*, *Jatamasi*, and *Suaandhabala* have been banned for export except when they are processed in the country and the necessary permit is issued from the Department of Plant Resources (DOPR). However, *Khayar* (*Accacia catechu*), *Chanp* (*Michelia champaca*) and *Sal* (*Shorea robusta*) Lecommercially used for transportation and export when they are fallen.

Establishment of the Protected Areas

Establishment of Protected areas in the forms of National Parks, Wildlife Reserves and Conservation Areas in Nepal has actually enhanced the possibility of conserving biodiversity in the strictest sense of the term. Although distinguished colleagues I would not like to take any more of your time by enumerating the various forms of the plant and animal life in each of the protected areas I would definitely like to present here a quick picture of these different areas and their locations. In order to do so they can be conveniently grouped into three different categories on the basis of their location in one or other type of the three ecological belts - Terai and Siwalik, Midhills and Mountains.

Terai and Siwalik Ecological Belt

Terai and Siwalik ecosystems are of international importance both in view of the number of globally threatened wildlife and flora elements as well as the diversity of ecosystems contained within the area. Species diversity is high within Royal Chitwan National Park (RCNP) which can claim to be having over 500 species of birds and supporting the largest population

of Indian Rhinoceros. This park was declared a World Natural Heritage Site on account of its biodiversity and the level of research carried out on its natural history.

Despite the protection of the fauna and flora in five large protected areas; two of which are contiguous with parks on the Indian side; the biodiversity in these physiographic zones is entering a stage of crisis, especially in the Terai. The human population density is high and increasing annually by at least 3 percent. With the exception of Parsa Wildlife Reserve (PWR), the conservation areas are surrounded by large settlements. Some 275,000 people live within a short distance of RCNP, all with subsistence demands. Development across the Terai, including the road improvement programmes, irrigation and hydro-power projects, the possible de-centralisation of industry, protected areas and across the whole of the Terai-Siwaliks have been the main causes of attracting the migration of the population from other ecological belts. The Siwaliks are threatened mainly due to the increasing population densities in the Terai and Midhills. The frontier for pioneer settlement of Nepal's poor landless people is shifting to the ecologically fragile Siwaliks.

The Terai protected areas have played an important role in the development of Nepal's tourism sector. RCNP has been one of the most popular tourist destinations outside the Kathmandu Valley. Wildlife tourism is unequally concentrated around RCNP which has about forty times the number of visitors as compared to the total of the other four protected areas combined. RCNP receives some 60,000 tourists a year, whereas its neighbouring PWR has no provision for visitors and received only eight tourists during 1994/95.

Within the Department of National Park and Wildlife Conservation (DNPWC) managed areas major issues are the lack of adequate manpower and budget, the conflict between tourism and conservation in RCNP, and encroachment in protected areas. Terai/ Siwalik wildlife habitats outside of the Protected areas lie under the jurisdiction of the Department of Forests (DOF). They are also very important from the point of view of the conservation of the wildlife in the area. But it is very unfortunate that in some parts there has been a very serious laxity in management and an equally serious problem is the continuing forest degradation. It is therefore felt that due regard should be given to conservation alongside utilisation. HMG in co-operation with some NGO's has initiated a number of projects that aim to reconcile the protection of biodiversity with the livelihood of the local people. The buffer-zone concept in particular is being promoted. The Terai is an important area from the point of view of human occupancy as well as suitable habitat for fauna and flora and the increasing conflict between humans and wildlife in the Terai can only be contained by realizing the economic benefits of the biodiversity including the sustainable exploitation of the timber, and non-timber forest products and the promotion of eco-tourism across the Terai.

Midhills Ecological Belt

The biodiversity contained in the Midhills ecosystems is also of international importance both in view of the number of globally threatened wildlife and floral elements as well as the diversity of ecosystems contained within the area. The Midhills has a very great assemblage of diverse ecosystems. This is due to a very significant variety of terrains providing a wealth of vegetation associations and different habitat types. As a result species diversities are also very high. Nearly 60 percent of Nepal's forest is within the Midhills belt. Among the 181 species of mammals recorded in Nepal, 31 (17%) have their entire known range within the Midhills. Of the 416 bird species which are round breeding in Nepal 557 have been observed in the Midhills with 244 (38%) restricted to this zone. Biodiversity studies, however, have mainly concentrated on Terai and Highland habitats. Little attention has been given to the collection of baseline information in the Midhills.

Due to the high and increasing population density and the utilization of every accessible niche for subsistence farming the natural ecosystems of the Midhills are depleted and under serious threat. The human population density is high in the Midhills.

Midhills ecosystems are under-represented in Nepal's protected area system. Although 12.9 percent of the Midhills' surface areas are within the protected areas, 82 percent of the 5,739 km² comprises Conservation Areas below 3000 m in Annapurna Conservation Area (ACA) and Makalu-Barun Conservation Area (MBCA). These conservation areas are, however, both heavily disturbed by human activities and the protection of wild fauna and flora is compromised by community development initiatives: MBCA is effectively a buffer-zone of Makalu-Barun National Park and contains few undisturbed areas. The natural vegetation over a large area of MBCA is *Schima-Castanopsis* forest. Most of this is, however heavily degraded due to over exploitation for grazing, fodder and firewood collection and timber harvesting. With sound management these areas can recover some of their biodiversity value but as long as they are managed for subsistence needs of the local people this value cannot approach that of undisturbed forests. There are also few undisturbed areas of natural or semi-natural vegetation in ACA. It is only the Shivapuri Watershed and Wildlife Reserve that lies wholly within the Midhills whilst more than 70 percent of Khaptad National Park (KNP) are below 3000m. There is a major gap in the protected area system in the altitude range between 1000 to 3000m but well represented in the southern river valleys of a number of the high altitude protected areas. Midhills areas between 1000 and 2000 m are very poorly represented being the area of the country longest settled with the highest population density and the least remaining forest cover. Only 2% of the Midhills area lies within protected area west of Annapurna Conservation Area. The only exclusively Midhills protected areas and the most likely proposed protected area of Religious Forests and the Royal Forests all lie within the Kathmandu Valley.

The majority of Midhills' natural and semi-natural forests and wildlife habitats are under the jurisdiction of the DoF including a large number of forest ecosystems not covered in the protected areas. These habitats are rapidly degrading due to over-exploitation for fuelwood collection, livestock grazing and the conversion of national forests to farmland. Some important populations of threatened species are not represented in the protected area. They include several bird species such as Lesser Shortwing (*Brachypterix leucophrys*), Hill Prinia (*Prinia atrogularis*), Sapphire Flycatcher (*Ficedula sapphira*), and Chestnutbacked Sibia (*Heteropneustia anectans*), which have only been recorded in Mai Valley, in 11am. Several endemic and rare butterfly species have only been recorded in Phulchoki.

Any human interference in natural ecosystems will lead to a decrease in the valuable biodiversity. This also applies to the activities of the various community forestry programmes. The possible positive impact of community forestry projects on biodiversity conservation of endangered species of flora and fauna is unproven. There is no baseline information on Nepal's Midhill forests as to the impact of community forest management of genetic, species and ecosystem biodiversity as community forestry is driven by the need to obtain sustainable outputs and services to users rather than by the need to sustain biodiversity.

Fifty-two of the biogeographical regions are found within the Midhills. Only 33 of these are represented within the protected area. Nineteen ecosystems are not covered within these whilst ten only have a very small presence. Some of the areas not included have only a limited occurrence but no matter how small an area covered by any ecosystem each one provides a unique set of habitat conditions for fauna and flora.

There is a strong case for extending the protected area in the Midhills. The forests under the aegis of the DoF are important habitats. But they are mostly subjected to continuing forest

degradation, and, therefore, due regard must be given to conservation alongside utilization. The improved provision of facilities for eco-tourism and better management of the non-timber forest product trade offer large direct benefits from the protection of biodiversity.

Fourteen forest sites were recommended for protection in eight areas, with a combined total surface area of 440,000 ha have been identified as important repositories for biodiversity and in need for designation as conservation areas as defined under the National Park and Wildlife Conservation Act. They should be managed to conserve biodiversity alongside improving the living standards of local people. One of the eight areas comprises the unprotected Mai Valley forest in eastern Nepal. This area supports a large number of bird species. Breeding species total over 230, including a number of international important number of bird species. It is obvious that the biodiversity contained within the many national forest areas so far surveyed would benefit if they are handed over to forest user groups. Designation as Protected Forest as defined under the Forest Act, 1993 should also be considered for those forest areas which can be as areas of biodiversity importance.

One protected area Singlila National Park lies within the Midhills ecological belt in India across the border with Nepal. Gairibans-Santapur (Ilam District) at Nepal's easternmost border is connected to Singalila and is a potential site for trans-boundary conservation. It is sparsely populated. The forest supports a number of threatened mammal species including Red Panda (*Ailurus ftdgens*) and Grey Wolf (*Cardis Lupus*). About 500 species of birds, and a number of threatened floral species have been recorded.

The pristine natural beauty and cultural diversity around Nepal's Midhill forest could attract many tourists provided that the Ministry of culture, Civil Aviation and Tourism promotes these areas as tourist destinations. For this the Transport and communications infrastructure needs to be improved and credit extended to local people for the provision of facilities such as good standard lodges. Sites like Thodung axjd Milke Danda are easily accessible and would be a good alternative for elderly trekkers who may not find the popular destinations such as Namche Bazaar and Jomsom too arduous but who will not be allowed by other nears as dears to go on trekking.

Poaching of wildlife is a serious issue in most of the forested areas. Action should be taken by the concerned authorities to stop these activities and punish those who violate the NPWC Act.

Biodiversity is far reaching concept included in the work of many governmental and nongovernmental agencies. The DNPWC and the DoF are the main bodies of HMGN for implementing any programme of this nature. It is hoped that a National Biodiversity Coordination and Information Centre be set up to co-ordinate activities with a major thrust for the conservation of Nepal's biodiversity in accordance with the priority set by the DNPWC.

Most on-going, donor-assisted projects are working for the improved management and development of forests resources through community participation. The emphasis of mast projects is on community development activities with few involved in wildlife habitat preservation and none in advancing knowledge on the status and distribution of Nepal's rich biodiversity. A number of projects should be aimed at school children and those who gather many of their daily needs from the forests. Programmes for training community forest FUGs in natural resources management to enable them to manage their forests should include management practices for conserving biodiversity. Human interventions, such as the exploitation of forest products inevitably affect the biodiversity of an area. The effects are however not clear and demand further closer investigation.

Mountain Ecological Belt

It is to be noted that the biodiversity contained in the Highlands ecosystems is of international importance both in view of the number of globally threatened wildlife and flora elements as well as the diversity of ecosystems contained within the area. Species diversity is high. The Highlands are the meeting place of two major zoogeographical regions of the world - the Palaearctic region to the north and the Indo-Malayan region to the south. The upper altitudinal range of the two important Endemic Bird Areas (EBA) fall within the Himalayan range of Nepal; the endemic species rich Eastern Himalaya (between 900-4000 meters) and the Western Himalaya (between 1600-3600 m). The political border of Nepal touches the Eastern Himalaya EBA and most of the Nepal Himalaya falls within the Western Himalaya EBA.

The Highlands supports 39 percent of the vertebrates (521 species) found in Nepal. Over 25 percent of the threatened vertebrates of Nepal are found in the Highlands. Ten threatened mammal species are confined to the Highlands, of those six are legally protected. Thirteen percent of the Nepal's butterfly species (82 species) have been recorded from Highlands of Nepal. The distribution of twenty eight butterfly species are confined to Mountain ecological belt. In this belt one hundred and fifty nine butterfly species are considered as threatened.

Of the 38 major ecosystems found within the Highlands, 30 of these are represented within the PAS. Of these three have areas of less than 1000 ha (10 km²). Only eight ecosystems are not covered within the protected areas, whilst three have only a small presence. Coverage of the Highlands ecosystems within protected area is good. Some of the areas not included in these have only a limited occurrence but no matter how small an area covered by any ecosystem each one provides a unique set of habitat conditions for fauna and flora. Studies using the latest techniques of satellite imagery and GIS systems are needed for a comprehensive mapping of Nepal's ecosystems.

Nine of Nepal's protected areas under jurisdiction of DNPWC lie partly within the Highlands and partly in the Midhills ecological belt. Most of the highland's natural and semi-natural habitats are however national forests lying under the jurisdiction of the Department of Forests. Five of the national parks and the one hunting reserve lie predominantly above 3000 m. Only the southern fringes and river valleys of these areas lie below this level. Twenty percent of the Midhills KNP lies above 3000 m. Of the two conservation areas over half of Annapurna Conservation Area lie below 3000 m. The total area of the Highlands is 63,090 km² of which 12,405 km falls above 3000 m within nine of HMG's protected areas.

National forests are those areas under the authority of the DoF and include grassland as well as forested areas. Although under the DoF's authority, hardly any of the extensive areas of national forest's grassland and forest in Nepal's Highlands are under active management by HMG. Two areas are already added to the existing protected areas - Kanchenjunga Conservation Area (KCA) and Manaslu Conservation Area (MCA). The KCA includes the Kanchenjunga Himal and its surrounding areas in the northern parts of Taplejung district. The new protected area covers over 2,000 km². It will adjoin the 850 km² Kanchenjunga National Park in Sikkim, India. The establishment of KCA would create nearly 3000 km² of trans-boundary protected area. The other area, MCA is also an important area which will attract the tourists from different parts of the globe and help the development of eco-tourism in Nepal.

Conclusion

It is now more than a decade that the convention on Biological Diversity was signed by a majority of the world's countries, with commitment to develop strategies for biodiversity Conservation and to push them into national plans, programmes and policies; identify and monitor

biodiversity components and activities which have negative effects on them; establish protected areas and the means of conservation of biodiversity *in-situ* and adopt measure for *ex-situ* Conservation; take measure to respect and protect the knowledge and skills of traditional communities and to show them the benefits that can be obtained from the proper use of their knowledge and skills; adopt economic and social incentives for Conservation; encourage relevant research, education and training; incorporate biodiversity concerns in environmental impact assessment procedures, with public participation; provide access to genetic resources subject to the sovereign rights of each country over its biodiversity; provide access to relevant technologies on fair and most favorable terms subject to effective protection of intellectual property rights; consider an international protocol on the Safe Transform and use of genetically modified organisms resulting from biotechnology; ensure that the exercise and rights and obligation under other international treaties does not cause destruction to biodiversity; authorize the credits of a Scientific and Technical Advisory Committee, for the purpose of finding the development of the Convention; and agree to resolve international disputes on biodiversity laid down in the Convention and its Annexes.

It was not unusual that the Treaty was followed by various reactions appreciating or criticising the summit declarations so much so that in one of the papers presented at the International Conference on the Convention on Biological Diversity in Nairobi in 1993 it was stated that 'the convention does not explicitly address the global and national roots of biodiversity destruction, and pays mostly lip- service to the genuine needs of disprivileged people everywhere.' But the same author admitted that "even with its weak and inadequate terminology, it provides some basis for action, some possibilities of revealing many historical inequities between and within countries."

There is no denying the fact that although much can be said on the topic of contribution of the developed countries to the deterioration of environment and over exploitation of the environmental resources of the earlier colonies, the Rio Summit and its decision have definitely paved a new way towards the sustainable use of the natural resources with a strong appeal to all the countries of the world to think globally. Successful action to conserve biodiversity must address the full range of causes of its current loss and embrace the opportunities that the species and ecosystems provide for sustainable development. The gamut of biodiversity Conservation is very broad since it consists of supporting sustainable development by protecting and utilising biological resources in ways that do not diminish the world's variety of genes and species or destroy important habitats and ecosystem. It is therefore necessary that the biodiversity Conservation strategy must also have a broad scope. However, such a task can be divided practically into three basic elements: saving biodiversity, studying it and using in sustainably and equitably.

The most important requirement is that of developing and strengthening human capability for conserving, thereby carefully protecting and wisely utilizing biodiversity a sustainable manner.

Conservation can succeed only if people understand the distribution and value of biodiversity, see how it influences their lives and aspiration and learn to manage area to meet human needs without diminishing biodiversity conservation. They include experts in the biological and social sciences, community organization and last but not the least, the geographers, who possess an integrated approach and holistic vision and can investigate the problem of biodiversity losses from various angles and look for practical and sustainable solution for the benefit of man and other living beings on earth. Mostofa Tolba once said, "If Charles Darwin were alive today, his work would most likely focus not on the origin but, rather, on the obituaries of species." So let us not let the great Scientist lament over the loss of biodiversity that is taking place at a rapid rate at present but launch a successful campaign of saving, studying and using biodiversity

in a sustainable and equitable manner. Slowing the rate of loss of biodiversity requires a greater understanding of its role in ecosystem and its importance to human life. Conversely to increase understanding of biodiversity, representative and viable sample of ecosystem, species and population must be maintained. Since greater incentives will exist to slow the loss of biodiversity the many current and potential benefits that biodiversity can provide to humanity cannot be sustained unless the biological resource base is maintained. Sustainable uses of biodiversity and biological resources, require a careful setting of biodiversity research priorities.

The planners in Nepal have very well recognised geo-ecological diversities as a basis for the overall development of Nepal. So in order to achieve the coveted goals of development on a sustainable basis and also to establish relationship between the natural resource utilisation and the population a long-term policy has been adopted right from the inception of the Ninth Plan. In keeping with the factors such as topographical diversity, natural resources and market feasibility every effort is made to bring forward such sectors as agriculture, forestry and irrigation in a balanced process of development. Moreover, the task of preserving bio-diversity has been further enhanced by measures including the added support to the regions already declared as protected area covering 18 percent of land of the nation. Even in the course of development of tourism, programmes contributing to the promotion and utilisation of biodiversity have been considered, with the expectations that these steps would result in the increase in rural income, poverty alleviation, rapid economic development, employment promotion and balanced and sustainable overall development of the nation. The basic document on the Tenth Plan (2002-2007) has also emphasised the same concept and stressed the biodiversity conservation as a priority area. While declaring the ten years of the tenth and eleventh plan periods (2002-2012) as the Agricultural Decade the Tenth Plan basic document recognises the close relationship existing between agriculture and natural resource management. In this context it is stated that natural resource management and biodiversity will be amply considered along with the agricultural development during the Agricultural Decade.

With these national efforts and international support of such agencies as WWF, IUCN, UNEP, FAO, UNDP, WRI and others sufficient progress will be made towards the conservation of biodiversity by understanding the nature and value of biodiversity, identifying the direct and indirect causes leading to its losses creating encouragements and incentives for local biodiversity conservation, managing biodiversity throughout human environment, including the areas beyond the political boundary, strengthening the management of protected areas, and expanding human capacity to conserve biodiversity through research training and information management. It is a very well known that conservation can succeed only when people understand biodiversity's distribution and value, see how it figures into their own lives and aspirations, and know how to manage their environmental resources to meet human needs without damage.

As the German philosopher Goethe observed, "Every man is given only enough strength to complete those assignments of whose importance he is fully convinced."

Then and then only it is hoped that if Charles Darwin will be born again anywhere in earth he will not have to write obituaries of species but will have ample reasons for enjoying the real value of the living wealth of a nation in terms of its utility, function and beauty.