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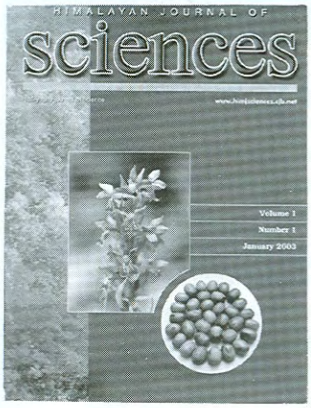

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Welcome to a new journal !

There is a limit to the transferability of scientific learning between two countries

Dayananda Bajracharya

There is an unmistakable correlation between the research base and productivity growth of a country. This reality has been fully recognized by developed countries and some developing countries such as India, China and Brazil. However, there is a general tendency in most of the developing countries to believe that poor and underdeveloped countries do not have adequate resources to support scientific research. Moreover, many people in these countries tend to believe that enough knowledge is being generated by research in developed countries that can be adopted by developing countries and, therefore, there is no need for developing countries to generate their own independent research base. Such belief ignores the fact that there is a limit to the transferability of scientific learning between one country and another due to the uniqueness of each country. Each country has its own specific problems related to its development that can be solved only by indigenous scientific research. Solutions to a country's problems cannot always be found externally. Each and every country needs to develop the capacity to do its own research. A country without an indigenous scientific and technological capacity has no means of being aware of its own needs, nor of the opportunity existing in the field of science and technology elsewhere.

The good news is that despite many limitations from national to individual level, there is a rise in research activities in Nepal. But the bad news is that the lack of standard and regular scientific journals within the country always discourages researchers when they prepare to publish their findings. This journal should be effective towards meeting the dire need of the researchers.

In Nepal, culture of scientific research has yet to take firm roots. Research is not yet accorded the due priority it deserves. There is still no national policy on research. Investment in research and development is one of the lowest, even by regional standard. Researchers have very few motivations and incentives. They are compelled to work under conditions of extreme limitations. Most laboratories lack even basic minimum requirements. Access to scientific information is hampered due to the limited access to such modern facilities as internet etc. Research is still a ten-to-five business in Nepal. Many highly qualified teachers with great research capability are enticed away from their research activity by monetary attraction to teach in several campuses. There are very few researchers for whom the primary motivation is the urge to discover.

In spite of all these limitations, research activities in Nepal are on the rise compared to few decades ago. This is evidenced by the large number of research papers that are being presented in national and international science conferences held in the country from time to time. One of the major problems faced by the researchers is the lack of standard and regular scientific journals within the country to publish their findings. It is my earnest hope that the present journal will be effective towards meeting this need of the researchers. In the past, many journals have appeared and disappeared in quick succession. I hope that editorial board of Himalayan Journal would strive hard to maintain the quality and the regularity of the journal. I wish them all the success.

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Research and its social significance

Biophilic attitude should be the indispensable factor in scientists; investment priority should be given to current social problems

Kumar P. Mainali

It is we human beings who are to be blamed for the near or total extinction of many life forms with whom we coexist in this planet. Current rates of loss of biodiversity are high and accelerating. However, preventing extinction is practical, but requires enough investment. It is always a nice idea to fund new ideas. However it is imperative that the first and foremost investment priority should be concerned with the current and imminent threats in our well being.

In an essay in the journal *Science*, Roger Highfield writes, "I was the first person to bounce a neutron off a soap bubble. It wasn't much of a contribution to the scientific canon, I know, but it was a fun." (*1*) It is one of those many researches which are carried out without considering their social significance and without focusing on current social problems. How wise is it to invest fund and use sophisticated equipment just for fun in this resource-strapped world beset with innumerable problems where, for instance, degradation of environment, climate change and loss of biodiversity have created and are creating undesirable consequences threatening our very existence in this planet?

Let us take an example of tropical forests of Amazonia, Congo and New Guineas, which form one of the biggest carbon sinks of this warming planet. The forest is being cleared so rapidly that hundreds of species are on the verge of extinction. Edward O. Wilson, the distinguished Harvard biologist calculates in his new book that to protect one tenth of Amazonia from all threats would cost a mere $250 million, an amount equal to the bill for the failed Pathfinder probe to Mars (which was sent with the primary purpose of seeking new life forms) (*2*). We are allowing a big carbon sink to shrink and hundreds of life forms to be endangered in the Earth, and seeking new forms of life in Mars. The Pathfinder has more to do with the ambition of the scientists, or those who direct them than to the service of humanity.

It is not that scientists need not work in those fields which do not seem to contribute anything to human welfare; they have to. When studies on spin of proton were going on few people might have thought it would have any significance to human beings. NMR imaging which is the outcome of that study is one of the indispensable tool in medicine now (NMR imaging is used to detect brain haemorrhage).

Jayant V. Narlikar recalls a story told by Subrahmanyan Chandrasekhar, the Noble prizewinning astrophysicist in an essay in the journal *Nature* : During a press conference in the 1930s, about the proposal to build a 200-inch telescope on the Palomar Mountain, Edwin Hubble and Arthur Stanley Eddington were asked what they expected to find with the new telescope. Their reply was : "If we knew the answer there would be no purpose in building it." (*3*)

Even the scientists were not 'sure' what they were going to find out. But it doesn't mean the funding is meaningless. In fact astronomy has advanced whenever the unexpected has occurred. Progress of human knowledge comes to a standstill if new ideas, which apparently lack social significance at the moment, are not funded. Importantly, no scientific knowledge can be value free. Sooner or later it will be applied for the service of humanity.

We, the Nepali scientists, have a totally different story. Very small fund is allocated for research and scientific development. We cannot make fun with research like that of Roger Highfield who had a wine-soaked life style, neither can we invest in study of extraterrestrial life. Researches at the frontiers of human knowledge cannot be our part. Even we should be careful to invest in basic science. The most important thing is that our scientific investment should primarily be concerned with the major social and national issues. Besides that, investments in basic science and applied science can give a big return for a long time in poor countries. Such investments strengthen economic status building expertise capability which, on one hand smoothen lifestyle alleviating poverty and, on the other hand prepare the nation to follow the research model that led to the scientific enterprise of the industrialized countries.

The purpose of all human doings is – and should be – life. It is the ultimate purpose behind all activities. Once we accept human life as the ultimate purpose, it raises issues not only with the climate/environment and resources, but also with other living beings. Humans are always related to plants, animals and microorganisms for their survival. The dependency of humans on a particular organism is not so intense as of other organisms because of our high level of intelligence which is utilized for our benefits. But it is only a matter of quantity, not of quality. In the intricate relationship of various living beings in nature, all life forms are connected to each other, and this is what we call ecology. By extension it means for the smooth living of one form, others should not be disturbed. Thus any advantage for humans should not mean adverse impact to oth-

Loss of biodiversity alters the ecosystem and makes human life increasingly difficult in many defined ways. But that is only the tip of the iceberg.

ers.

And, the bad news is that as we are discovering more and more about the relationships between different life forms for their survival, biodiversity is being lost at an alarming rate for our petty interests. Current rates of extinctions are high and accelerating (*4*). But the good news is that different groups of experts have concluded that preventing extinctions is practical, but requires innovative measures (for e.g., *5*), at the top of which remains sufficient fund investment.

The 25 biodiversity hotspots of the planet, areas with exceptional concentration of endemic species facing exceptional threat of habitat destruction, cover only 1.4% of Earth's land surface and contain the last remaining habitats of 44% of the planet's plant species and 35% of terrestrial vertebrate species (*2*). The hotspots represent ecosystems that have already lost at least 70%, and many have lost 90% of their original vegetation. It would require one time cost of $25 billion for the protection and adequate management of all hotspots. However, the hotspot strategy has received only $700 million (cf *6*). The sum required for protection and adequate management is large but it is of the same order of magnitude as the individual wealth of world's richest citizens – and, *importantly*, 1/1000th (or 0.1% of) the value of the ecosystem services that biodiversity provides annually (*7*).

Scientists have explained many ways how loss of biodiversity alters/affects (?) the ecosystem and makes human life increasingly difficult. But that is only the tip of the iceberg. Unseen consequences can be far more threatening. Preserving biodiversity should be the first, or one of the first priority in public, governmental and inter-governmental investment.

It is not that the search for life in Mars is value free. Some day it may have implications for humanity. Funding new ideas is always a good thing. But ironically biodiversity is being lost at an alarming rate in Earth due to lack of (sufficient) investment and such huge funds are allocated for 'Pathfinder' or other ambitious projects. Researches which have less social significance should not be done at the cost of biodiversity and environment or by cutting back on funds which could otherwise be invested in improving public health and keeping cities clean. A scientific knowledge should not be gained at the cost of smooth living because the purpose of whole study is life. As Wilson postulates, we should have a sense of biophilia, "the innate tendency to focus upon life... and to affiliate with it emotionally." ■

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Chemical education and research in Nepal

Chemical education in Nepal has a strong potential for nation's development

Shiva P. Dhoubhadel

Chemistry is a science of materials at the atomic and molecular level. The knowledge obtained thereby is utilised for solving the problems of man and his environment and society. Chemistry occupies a central position in natural phenomena and in the processes that are the base of technological society. Chemical knowledge is fundamental aspect of our general education because chemicals have a major influence in our daily lives and chemistry is the base upon which many industries operate and upon which new technologies are being developed. We all know that chemistry has contributed to technological revolutions in family planning, medicine, public health, agriculture, newer and more efficient source of energy, metallurgy, textiles, building materials and a large number of other fields of the highest social relevance.

Chemistry plays a central role in economic development. Chemical knowledge and technologies are key components in industrial and agricultural development. Chemical knowledge is also crucial to good nutrition and health, and to the overall quality of life. The latest applications of chemical principles are in the areas of environmental protection and

conservation providing solution to such problems which arise during developmental planning or by uncontrolled expansions of technology.

For the successful economic growth, Nepal needs to be transformed from a commodity based economy to manufacturing based economy and a minimum of 20% of total manufacturing output should be maintained by chemical industries.

Chemistry and development of Nepal

It is a fact that the crux of the problems of Nepal's economic development lies in the proper utilization of her natural resources such as air, water, mountains, forests, agricultural products and wastes, and the human resource. Proper industrialisation based on development of chemical industries and raw materials or natural resources is another important aspect of her developmental problems. Nepal has to be transformed from a commodity based economy to a manufacturing based economy. This transformation can be achieved by macroeconomic and structural adjustment policies and strategies of HMG which can contribute to major inflow by foreign direct investments and the rapid growth of manufacturing sector. The successful growth and transformation of the economy requires the nation to address the challenges of efficient and optimal utilization of existing resources in order to sustain and further improve the national competitiveness. The rapid changes in global trading and investment environment necessitates the enhancement of the competitiveness and resilience of the manufacturing sector. For this, industrial master plan (IMP) including an overall development plan for chemical industries must be drawn. The IMP should thus focus on increasing competitiveness through strengthening industrial linkages, both forward and backward enhancing value added activities and increasing the productivity of the manufacturing sector. The manufacturing sector should overtake the agriculture sector as the engine of growth of the economy and should be the backbone of the Nepalese economy bearing on macro-economic performance of the economy.

Broadly speaking, the manufacturing sector can be classified into resource and non-resource based industries. Resource based chemical industry plays an important role in revitalising and sustaining the long-term growth of economy. Thus chemical industry development in Nepal is very crucial. Chemical industry is a very important part of industries and it must grow in proportion to the rest of the manufacturing economy and should maintain a minimum of 20% in comparison to the total manufacturing output of a nation.

In order to sustain significant growth in the chemical industry, it is extremely vital to have sufficient manpower equipped with right sets of skill by training human resources, attracting overseas talents and producing speciality chemicals to support the would-be growing electronic and food processing industries in Nepal. Herein lies the immense importance of our chemical education and research in Nepal.

Brief history

The beginning of chemical education in Nepal may be traced back to 1921 when I.Sc. level of chemistry teaching took place in T.C. College Kathmandu. B.Sc. level of chemistry teaching started in 1947 in the same college. M.Sc. level of chemical education started in 1965 in T.U. Meanwhile with the mushrooming of I.Sc. and B.Sc. level science teaching campuses in the country, the undergraduate level of chemical education was extended to the whole length and breadth of the country and chemical education assumed the position of national importance. With the recent growth of 10+2 and 3 year B.Sc. programs all over the country, the undergraduate level of chemical education has assumed a colossal dimension in the country which need proper attention and care. Thus the volume of undergraduate chemical education has been very big with its own specific problems and prospects. Academically the huge mass of undergraduate chemical education all over the country is guided by a single chemistry instruction committee composed under the auspices of Central Department of Chemistry, T.U. so far as the affiliates and the university campuses are concerned. The technical institutes have their own separate subject committee for chemistry education. The introduction of multi-university concept in the country has brought some difference of chemistry curriculum from university to university. One notable point is that even after 37 years, the Central Department of Chemistry of Tribhuvan University has remained the only place for post graduate chemical education in Nepal and has played a significant role in the development of chemistry in Nepal. The department offers courses in general chemistry (inorganic, organic and physical) in part I and specialized course in any of the three branches of chemistry in part II.

So far as research in chemistry is concerned, research was initiated on the interest of the concerned teacher and student. There was no regular research program introduced on the regular budget basis. However, on the same basis, the research activity in the department started right from the beginning of the department in 1965. Candidates seeking admission to Ph.D. program used to be academically administered as per Ph.D. rules and regulations of the university, and so far five Ph.D. degree holders have been produced from the department. Also, a number of research publications in international journals have been published regarding the research works conducted in the department. However, research in chemistry has never been a regular program giving the required priority for the activity. Yet, research in the department has established its recognition in the international arena, besides it's standard and recognized M.Sc. teaching program.

Although some reseachers carried out at Central Department of Chemistry has established their recognition in the international arena, research activity has never been a regular programme in the department even after 37 years of its establishment.

Present status

One of the notable point of present status of chemical education is that new curricula of chemistry in 10+2, B.Sc. and M.Sc. levels have shown high aspirations for meet-

ing the international standard. 10+2 and B.Sc. chemistry curricula catering the need of different courses have wide variations in the matter of objectives and its achievements. So, the programs are fully managed by the individual campuses themselves as per their capacity and facilities. It is beyond the control of T.U. Regarding M.Sc. chemistry teaching the department, T.U. has seen its big change in its program which started with 12 students in 1965 and new enrolls 180 student in each year. At present 90 students are enrolled annually in the program.

At present the department in its running partwise program has about 180 students distributed into three different branches of chemistry namely inorganic, organic and physical. The enrollment of students in chemistry has been in increasing trend. The students are admitted on the basis of entrance examination in the part first program. In the part second, there is specialization as well as offering of electives e.g. natural products, nuclear chemistry, spectroscopy. Upgrading the facilities within the department to keep pace with pressure of enrollment has been inadequate, and the department is struggling very hard. Some facilities in terms of sophisticated instruments have been added under the Higher Education Project (HEP). The department has now annex building constructed under H.E.P. So, there is not problem of space but the department has not been able to run those newly added sophisticated instruments properly and regularly because of the lack of budget for bringing them into working conditions. At present, the fields of research have been in the following areas: synthetic chemistry, reaction mechanism, natural product chemistry, solid state chemistry, electrochemistry, analytical chemistry, radio chemistry, applied enzymology and biotechnology, chemistry of clay minerals, environmental chemistry, organic sulphur chemistry.

Many part time teachers are working in the department. The department is unable to defray their remuneration in time. However, the department has carried out extra curricular activities, seminars, symposia and talk programs which are very useful to both students and teachers. In this respect, the department has a vibrant atmosphere.

Chemistry and it's achievements in the Nepalese context

Since the inception of chemical education in Nepal, the problem of supplying low, medium and high chemistry manpower needed for the country has been solved. Many students of chemistry have been working in various developmental laboratories, in industries and in private laboratories in Nepal. Many have rendered services in disseminating chemistry knowledge by teaching. Many are serving in health, agriculture and other fields in Nepal. Beside this, a number of students have been able to work in various laboratories and institutions worldwide.

Our chemists are competent enough for designing the programs for the applications of chemistry in the development of nation. Be it with reference to her natural products, that are still awaiting to be exploited, or proper utilization of her water and vast hydropower, or the sustainable development of her agriculture, or her industrialization which is in infancy and has not been able to provide challenges for chemists. Thus the importance of chemical education and research in Nepal may again be emphasized. ■

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The search for Kathmandu's new landfill

Science and logic needs to prevail over politics

Bhushan Tuladhar

The total waste of Kathmandu and Lalitpur cities can be recycled by setting up a 300 ton/day organic fertilizer plant for which an India-Nepal joint venture project is already selected. By doing this, the waste disposal problem is reduced by 80% with minimal environmental impacts, and high quality fertilizer can be generated. But despite the suggestion of different experts, the government is ignoring this simple solution to valley's difficult problem and using Okharpauwa as landfill site following the advice of politicians who want to build a road to Okharpauwa. Experts have concluded that Okharpauwa is technically, environmentally and economically unsuitable as landfill site.

The search for a landfill site to manage Kathmandu's waste has been going on for over a decade. Yet we have nothing to do for it except a few reports and few kilometers of new roads. National and international experts have time and again said it in many reports and seminars that the technical solutions to Kathmandu's most talked about problem are readily available. Yet we continue to dump all of the city's waste in sacred Bagmati river every day. And we will probably continue to do so until science and logic prevails over the greed and short sightedness of politicians. Politicians and decision makers must understand and respect the technical aspects of waste management and stop making this a political issue.

Waste management was not a major issue in the past primarily because not much was produced in the first place and whatever was produced was recycled. According to a study done about 40 years ago, human waste generated by Kathmandu residents at that time were sold for NRs. 0.50 per tin (*1*). Furthermore, several houses used to share a '*sagaa*' to manage their waste (*Sa* means compost and *gaa* means pit in the Newari language). We can draw three conclusions from this: (a) waste had a value, (b) waste recycling was a standard practice, and (c) people felt it was their responsibility to took care of their waste themselves. These basic principles of waste management are relevant even today and Kathmandu's waste management system needs to be built upon these foundations. Waste should be seen as a resource that needs to be recycled to the extent possible, not dumped (*2*).

Today the cities of Kathmandu and Lalitpur produce about 300 tons of waste per day and almost all of this waste can easily be recycled. About 70 percent of this waste is organic in nature, which can and should be converted into organic fertilizer. Although composting of organic waste has been done since ancient times, recent innovations such as the use of efficient microorganisms and mechanized screening of the finished product, allow us to accelerate the entire process and produce high quality fertilizer. This has now made waste composting a profitable venture and many cities in India are setting up large scale compost plants. This can be done in Kathmandu as well. Once the organic waste is converted into organic fertilizer, most of the other waste such as plastics and paper can be recycled by the private sector. Whatever remains (about 20 percent of the incoming waste) mainly consists of inert materials such as stones and dust, that can be landfilled with minimal environmental impacts.

Three years ago, Kathmandu Municipal Corporation (KMC) had called for proposals from the private sector and selected an India-Nepal joint venture project which would use Indian technology to set up a 300 ton per day organic fertilizer plant. All the municipality would have to do was provide the garbage and the required land (about 10 hectares) on lease, while the private company would do the rest, i.e. make organic fertilizer, recover other recyclable materials, sell the fertilizer and recyclable materials, and landfill the rejects. KMC identified suitable land for the project and requested the government for it. All the government had to do was give the green signal for the project to go ahead and provide the requested land, which belonged to the government. It would not have cost the government anything. Yet for the past three years, the government has ignored this simple solution and followed the advice of politicians who want to build a road to Okharpauwa a proposed landfill site.

Okharpauwa is not the solution to Kathmandu's waste management problems. It is technically and environmentally not suitable and is very expensive. The Environmental Geology Project of Department of Mines and Geology conducted a geological evaluation of the site and concluded that it was not a suitable site for a landfill. Similarly, a study done by Kathmandu Valley Mapping Programme indicated that cost for operating a landfill site at Okharpauwa, which is 28 km from Teku Transfer Station, will be more than four times higher than locating the landfill at Chovar (*3*). Furthermore, KMC will have to invest in several large trucks to transfer the garbage to Okharpauwa. The municipality will not be able to handle this additional cost. As a result KMC has made its position clear that it does not want a landfill site in Okharpauwa but rather prefers to have a compost plant and landfill at Chovar, located six kilometers south of Kathmandu.

Chovar has an old limestone quarry

belonging to the government owned Himal Cement Factory, which is now closed. The quarry can be used as a landfill for rejects from compost plant and the land next to the quarry can be used to set up the compost plant. The nearest house is about 300 meters away. The fact that the land is government owned and it already has a good quality road leading up to it means that it can be quickly developed into a waste treatment facility. Several experts have seen the site and said that it is a good one.

Therefore to solve Kathmandu's waste management problems, the government should first treat the waste as a resource and look for a site to set up a compost plant instead of a place to dump it. Setting up a compost plant instead of a landfill is a far better option from an environment as well as economic point of view. Furthermore it will be easier to find a land for a compost plant than for a landfill. Chovar seems to be good place to set up the compost plant as well as a landfill for the rejects from the plant. The site needs to be further studied and the process of involving a private company to build and operate the compost plant needs to be initiated immediately.

The government has now acknowledged the importance of a compost plant but is planning to import European technology for this purpose. This will be a mistake as high tech facilities usually do not work in Nepal. We need technologies that are suitable for Kathmandu. It should be simple to operate and maintain and it should have proven its effectiveness in places similar to Kathmandu. This would mean that an Indian technology, is probably more suitable than European. Here once again several experts have told the government to go for Indian technology, but the Ministry of Local Development is still pursuing a high tech solution, which is attractive to look at but its efficacy in place like Kathmandu is questionable.

The problem of waste management in Kathmandu is technically not very complex, but the government needs to listen to technical logic and ensure that simple solutions do not go to waste. ■

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Scientific research in Nepal: Where we are

A different attitude in researchers is more essential than a big fund

Bharat B. Shrestha

Role of science and technology (S&T) in national development is obvious. Recent advances in medical science, computer engineering, genetic engineering, space technology etc are due to enthusiastic research in basic and applied science. However, developing and poor countries are less benefited from these researches than developed countries. Governments of these countries cannot allocate big funds for research in S & T which is a major constraint in development. Some of the developed countries have their international agencies for bi- and multilateral co-operation and funding in developing countries. Development of S&T in countries like Nepal largely depends on such funding. The amount of funding may be relatively small but it can bring significant change if properly utilized.

Lack of big funds is not the primary constraint in development of science and technology in Nepal. More important and subtle factors – lack of exchange of information between researchers; lack of co-operation and unhealthy competition between professors and among big institutions (although co-operation is essential for integrated study); data manipulation which prevails from beginners to some established researchers; and professors, the highly expert people in university, being enticed away from their research activity by private teaching institutes.

In Nepal research in biological science has 40-50 yrs long history. In early days of this period research was limited to few foreign scientists and occasional visitors. With the establishment of research divisions, councils and introduction of Masters and Ph. D. programs in University, the number of Nepalese researchers also increased. Many Nepalese studied abroad and returned Nepal to work in their fields. Now we have many researchers working in almost all branches of biological sciences. But none of these disciplines have strong foundation, which is unfortunate for the nation. Beside lack of funding there are many technical problems. Some of these problems seem to be simple and very often neglected but important for authenticity of the research output. Knowingly or un-

knowingly we are committing some mistakes and if not corrected soon we will lag behind many decades in S&T.

There is a Chinese saying which states "when you exchange apple you will have the same number of apple but when you exchange knowledge you will have double." This is a fact we must learn. This is still more important in research because it is not possible for a scientist to work in all fields. An ecologist may not be able to solve taxonomic problems; for a taxonomist it may be difficult to solve physiological problems. But for understanding, say ecosystem dynamics, information from wide range of fields such as ecology, genetics, microbiology, pathology, physiology, taxonomy, etc are needed which is not possible for a scientist to collect them all. So exchange of information between researchers working in different but related disciplines is indispensable. Lack of this tradition is one important weakness among our researchers. Still more unfortunate in this aspect is the lack of co-operation between researchers working in the same field. We have seen this problem between professors working/teaching subjects, senior and junior researchers, NGOs said to be devoted in same field etc. Just to mention an example, we can take the case of Nepal Flora Project. There is a triangular conflict among Department of Plant Resources (DPR, HMG/N), Royal Nepal Academy of Science and Technology (RONAST) and Central Department of Botany (CDB, TU) to hold leadership. Due to this there has been delay in completion of the project. If we are really dedicated to work leadership should not be the important matter. Conflict like this may have negative feedback effects to donors.

Researchers collect primary data by themselves. For a research there may be various methods of data collection. One may raise questions regarding the reliability of methodology but data collected by following accepted methodology cannot be challenged. We should agree with data if the methodology is correct. Sometimes results may not follow usual/normal patterns. In such case if researcher manipulates actual data to avoid the so called "abnormality" it becomes a serious academic/scientific crime. We are giving wrong information. Somebody else working with such results as a base will also be cheated. In our context data manipulation is another serious problem in research. It prevails from beginners to some established researchers. It is most probable that we are not properly following methodology, have less frequent visit to field in field base works, and/or spend shorter period in field. This makes us less confident to our own result and we are generally encouraged for data manipulation. So one should have "scientific discipline" to work in this field.

University is not only teaching institution but also research center. To achieve goal teaching should be integrated with research. Beside specific research centers, university teachers are also involved in research. Publication of research work is an important criterion at the time of evaluation for promotion. To accomplish this, many teachers are involved in research in one way or another. The highest honor to university teacher is professorship. Once a teacher is promoted to a professor he/she is expected to have a leading role in research of their specific field. Their able leadership is important for beginners. Unfortunately many of our professors abandon the career as researcher and busy themselves with teaching at higher secondary school level. Some are working as principal in different names such as honorary principal, consultant etc. By this they are making better economic profit but cannot show academic progress, and for the society a research expert in a field is lost.

Needless to say, contemporary scientific world is many years ahead of our national level. We may be benefited from the scientific achievements of other countries in fields such as communication, biotechnology, transportation, computer science etc. But in other discipline such as ecology, medical science, pathology, taxonomy etc. we need research from basic level in our own context. Presently we have ambition to follow the current trend of research in these area but we cannot get significant output from this unless we have strong foundation. For example, although we have a long history of taxonomic study we do not know our actual biological resource. We are rich in such resource but cannot exploit it for national development. Most probably some plants and insects will disappear before we know them. Documentation of every possible details of flora and fauna of Nepal is foremost important pre-requisite for biological research.

Despite these dark faces we have many opportunity and challenges. Nepal is a center of attraction, specially for biological and geological research due to her location, geomorphology, geodynamics, environmental gradient and biodiversity. We should have long-term integrated planning for research on basic, advanced and applied sciences. If we develop the tradition of "scientific discipline" and close coordination between individuals and institutions actively involved in research we can bring expected change within time frame. RONAST and Tribhuvan University are expected to take leading role for this goal. It should be taken in serious consideration that we have very limited time to take giant leap in S&T. ■

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Arsenic controversy needs conclusion

The potential threat of arsenic poisoning in Nepal lacks solid empirical evidence

Rajendra Uprety

Although many more pollution-neutralizing modules have been implemented on the global interest, both the developed and developing countries cannot get rid of the environmental difficulties. At present, environmental hazards entirely cover the whole world posing a strong stress over the living heads of the planet.

Most of the pollution causing agents, spread on globally, has some sort of similarities and a few of them are continental or regional in nature. Arsenic pollution in water in Bangladesh and West Bangel of India could be a typical example. In Bangladesh, over seventy two million people throughout the country have the serious problem of 'Arsenicosis' that resulted from arsenic contamination in water and other feeding sources with arsenic residue.

Environmental Protection Agency (EPA) has already suggested for lowering the value of maximum tolerable limit of arsenic content in water from 0.05 to 0.005 mg/l. Bangladesh, India and Nepal have adapted the value 0.05 mg/l whereas WHO guideline indicates that the value for safe drinking water must not exceed 0.01 mg/l.

West Bangel has the same plight as of Bangladesh. It is predicted that Nepalese water resources may contains the hazardous substance due to the similar regional geo-chemical condition in Terai belt but the need is it must be identified weather the symptoms be a topic of national interest in the present public health scenario.

Several weeks ago Nepal Chemical Society organized a talk program concerning arsenic pollution and its health impact in Nepal, a challenging topic of hot discussion.

Experts were from Royal Nepal Academy of Sciences and Technology (RONAST), Department of Irrigation HMG/N, Environment and Public Health Organization (ENPHO) and Ministry of Science and Technology (MOST) opined with their experimental evidences and results to the floor.

Although there are several events of arsenic poisoning in Bangladesh and West Bangel, it has never existed in Nepal as a public health problem. Arguments on the basis of location of Terai belt in the same regional geo-chemical condition are non-logical and under controversy. The bad news is that the experts discussed with contradictory figures and non-convincing analysis. Serious scientific discussions are required to find out the status and threat of arsenic poisoning in Nepal.

At the beginning, the participants have shown a deep interest to the arsenic poisoning in their own home land because they, however not in detail, have listen to some extent about the people suffering arsenic poisoning terribly in Bangladesh and West Bangel of India.

During the presentation, the floor ready to listen the hazardous effect of the arsenic poisoning or its potential threat in the days to come turned its face tired. The contradictory and different nature of presented figures from the experts led them in confusion. They probably raised a question of doubt in their minds weather the arsenic poisoning issue be the topic of national interest in Nepal, where a paracetamol tablet is at far more distance then their death for the country people to meet.

Though the experts were from the apex organizations, the presentation was very poor. The weak and unfulfilled statements from them clears either they presented the facts without any homework or in hurry or without any responsibility to the concerned topic.

There, at the corner, raised voices on the credibility of the analysis. Their arguments made emphasis on the truth; unless the analysis is carried out in inter-laboratory exercise basis it is very difficult to understand the figure and the facts.

On hearing with them I have remembered a statement from an official of the Ministry of Population and Environment when I visited him for preparing a series on environmental bad news. The official explained that they have difficulty in analyzing the various figures on environmental issues obtained from different organization due to the associated credibility on facts and figures.

Arsenic poisoning and its potential threat is dangerous, and it is obvious. Today, People in Bangladesh and West Bangel in India are compelled to live under the strain of perilous arsenic poisoning threat but in Nepal, arsenicosis has never existed as a common symptom of public health problem and its effect can be supposed to be less hazardous.

Whatever the situation is in fact, some of the scientists claim that arsenic poisoning is not a great issue in Nepalese environment where millions of the people lack access to safe drinking water, proper solid waste management and have to face dangerous outbreaks annually.

Public health is the concern of all. Therefore, health sector and related experts need to clear that how arsenic poisoning in Nepalese societies is dangerous compared to typhoid or diarrhoea and any other seasonal epidemics.

The most responsible organization generating a database on arsenic and in coordinating with concerned agencies, National Arsenic Steering Committee (NASC), need to crystal clear the status of arsenic problem in Nepalese ground water through a lot of discussion with the related experts in the days to come. ■

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Nice work — but wrong label

'A tale of two countries' going successfully

Krishna K. Shrestha

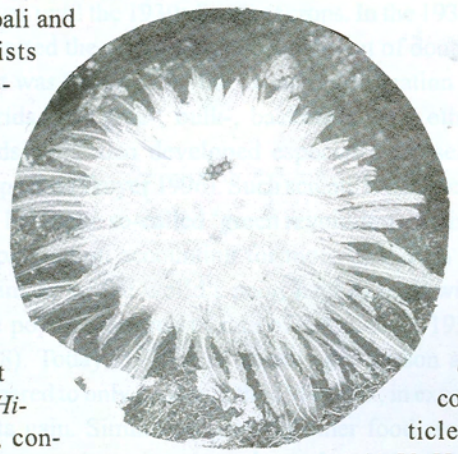
Toshio Yoshida

Plates: *Primula soldanelloides* G. Watt at 4400 m in the Jaljale Himal (right), *Rheum nobile* Hook. f. & Thomson at 4400 m near Topkegola in the Jaljale Himal (bottom), *Saussurea gossipiphora* D. Don at 4570 m on a rocky slope around Dudh Kunda in the Hinku valley (bottom left)

Toshio Yoshida

Himalayan Botany in the Twentieth and Twenty-first Centuries
By S. Noshiro, and K.R. Rajbhandari (eds.)
The Society of Himalayan Botany Tokyo, Japan, 2002, 212 pp. ISBN 4-9900825-2-4, price not mentioned
Contents: Foreword by M.S. Bista and H. Ohba, general articles, review articles, research articles, and index

The Society of Himalayan Botany is contributing since two decades back, by publishing series of books on Himalayan botany. The present captivating book entitled "*Himalayan Botany in the Twentieth and Twenty-first Centuries*", is another welcome publication of the society, edited by Shuichi Noshiro (Japan) and Keshab R. Rajbhandari (Nepal). The editors have compiled more than 30 articles of Nepali and Japanese botanists that directly reflects on collaborative botanical explorations in the last forty years, to explore and document the plant resources of Nepal. The first part, *History of Himalayan Botany*, consists of eight general papers by veteran botanists of Nepal (S.B. Malla, S.B. Rajbhandary, T.B. Shrestha, M.S. Bista, Y. Vaidya, and K.R. Rajbhandari), and two review papers by Japanese veterans (H. Kanai and H. Ohba). The second part, *Achievements in Himalayan Botany*, consists of 13 research articles by Japanese authors, and two review articles by Nepali (K.R. Rajbhandari) and the Japanese (M. Suzuki) botanists. Similarly, the third part, *Sharing of Field Experience*, consists of eight general articles by Nepali botanists (A.V. Upadhyay, P.R. Shakya, M.K. Adhikary, H.K. Sainju, L. Joshi, M.N. Subedi, K.J. Malla, and B. Roy).



Kazumi Fujikawa

Apparently, the contributed articles are the compilation of the papers presented in a seminar organized jointly by Department of Plant Resources (Nepal) and Society of Himalayan Botany (Japan) on 14-15 May 2001, in Kathmandu, to commemorate the forty years of collaboration for botanical explorations in Nepal. Obviously, this book is considered as the 'proceedings' of the seminar. Focussing on the contributed articles, it can be noted that almost all papers contributed by

The book cannot claim to be a history of Himalayan flora for two reasons: first, it basically deals with history of Nepal-Japan collaboration rather than with botanical advancement, and second, the taxonomic development is exclusively confined within the last 40 years' period.

The book brings out a fascinating information on history of botanical exploration in Nepal, and on-going taxonomy research pertaining to flora of Nepal. But paradoxically, the entire research articles on Himalayan flora are contributed by Japanese botanists.

Nepali botanists are based on sharing of experiences working with the Japanese botanists during and before the field trips, whereas, the entire research articles are contributed by the Japanese botanists. For the taxonomists this book is of special interest, due to two exciting review articles by Nepali botanist (K.R. Rajbhandary), and three review articles by Japanese botanists (H. Kanai, H. Ohba, and M. Suzuki). Moreover, the spectacular book comprises about a dozen short research articles by Japanese botanists, based on the plant materials of Nepal and Sino-Himalayan regions. Certainly, the readers would be highly disappointed by the lack of research articles from Nepali botanists. We hope Nepali botanists will fulfil this huge gap, by contributing research papers in the forthcoming 'proceedings'.

The review articles by Hideaki Ohba, '*Three epochs of Himalayan Botany*' and K.R. Rajbhandari's '*Flora of Nepal: 200 year's march*' are outstanding articles in the book. In his article, Ohba has presented his last 20 years of involvement in botanical research in Nepal, narrating his experience and active contribution in exploration and tireless efforts to publish 'Flora of Nepal' — comprehensive description of vascular plants of Nepal. He is disappointed with the authorities of Nepal government, due to lack of commitment and interest to publish a series of publication on 'Flora of Nepal'. Bibliography related to Flora of Nepal and Himalaya, from 1960 to 2001, summary of the botanical explorations by Japanese botanists from 1983-2001 in chronological order, and expedition routes shown in the maps are invaluable references. Similarly, in Rajbhandari's article, he has thoroughly summarized the history of botanical explorations in Nepal from 1802-1948, 1949-1982 by foreign expedition group, collections during 1962-1988 by the Department of Plant Resources, and recent collections during 1983-2001 by foreign botanists in collaboration with Nepali botanists are well documented. List of new species of flowering plants described from Nepal in the years 1983-1996 is also given. Both articles are no doubt invaluable source of information leading to history of botanical explorations, taxonomic research and publications on Flora of Nepal, including Flora of the Himalayas.

It is worth mentioning here that the title of this book needs explanation, because the title and its contents appear to be not matching at all. For example, almost all articles in Part I and Part III deal with the history of collaboration between Japan and Nepal from 1960 onwards. All research articles in Part II are based on recent taxonomic research. Only two review articles by Rajbhandari deals with a brief account of the history in 19th and 20th century, but more on the historical events during last forty years. Moreover, except one review article by Ohba, and couple of research articles on Sino-Himalayan region, almost all articles deal with the Nepalese botany. Hence the title of the book should be 'Botanical Research in Nepal in the last forty years: 1960-2000 (Proceedings of the Seminar to commemorate forty years of Japan-Nepal collaboration)' or 'Forty Years of Collaboration between Japan and Nepal for Botanical Exploration in Nepal'.

In general, this nicely produced book reveals an overview of collaborative research in the field of botany during the last four decades. The heart of the book, however, is indeed the compilation of thorough references on Himalayan botany. The high grade paper and printing, as well as size and format of the book is outstanding. Several photographs, maps, graphs and other illustrations greatly enhance the attraction of the book. Though minor typological mistakes and misleading information exist in the book, it has not reduced the value of the book at all. Overall, this book is a most welcome and interesting series of publications by Society of Himalayan Botany, with lots of fascinating information about history of botanical exploration in Nepal, and ongoing taxonomic research pertaining to Flora of Nepal. ■

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Future of plant biotechnology in crop improvement

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Cultivation of crops having multiple durable resistance to diseases and pests will be made easier by plant biotechnology. Transgenes and marker-assisted selection will aid in the development of high yielding crops, which will be needed to feed the world and save land for the conservation of plant biodiversity in natural habitats. The genetic base of crop production will be conserved and further widened by the integration of biotechnology tools in conventional breeding. Utilization of specific genotypes to particular cropping systems will be facilitated. Value-added high quality crops will be obtained through multidisciplinary collaboration among plant breeders, biotechnologists, natural product chemists and other plant scientists.

Background information

Rapid advances in plant biotechnology make it rather difficult to analyze its future in crop improvement. Within the last 100 years the mankind has witnessed the rise of genetics as a scientific discipline (1900s), the discovery of DNA as the hereditary material (1944), the elucidation of the double helix structure of the DNA molecule (1953), the deciphering of the genetic code (1966), the ability to isolate genes (1973), and the application of DNA recombinant techniques (from 1980 onwards).

Methods of crop improvement evolved dramatically throughout the 20th century. Mass and pure line selection in landraces, consisting of genotype mixtures, were the popular breeding techniques until the 1930s for most crops. In the 1930s maize breeders started the commercial development of double cross hybrids that was followed by the extensive utilization of single crop hybrids. Pedigree-, bulk-, backcross- and other selection methods were also developed especially for self-pollinating crop species (Troyer 1996). Such scientific advances in plant breeding led to the so-called 'green revolution', owing to which cereal production accounting for more than 50% of the total energy intake of the world's poor, kept in pace with the high average population growth rate of 1.8% since 1950 (Daily *et al* 1998). Today, 370 kg of cereals per person are harvested as compared to only 275 kg in the 1950s; i.e., in excess of 33% per capita gain. Similar progress in other food crops resulted in 20% per capita gains since the early 1960s (FAO 1995). There are 150 million fewer hungry people in the world today than 40 years ago, though there are twice as many human beings. Despite such an impressive progress in crop productivity, even greater progress must be made in order to feed an additional two billion people by the early part of the 21st century (Anderson 1996). Around 800 million people are hungry today and another 185 million pre-school children are still malnourished owing to lack of food and water, or disease. Hence as suggested by the Nobel Peace Laureate, Norman Bourlag (1997) new biotechniques, in addition to conventional plant breeding, are needed to boost yields of the crops that feed the world. Careful choice of such biotechniques as well as a realistic assessment of their potential in crop improvement are needed to avoid not only the criticism of the anti-biotechnology lobbyists but also the permanent distrust of pragmatic traditional breeders.

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Modern biotechnology

Tissue culture, developed in the 1950s, became popular in the 1960s. Today, micropropagation and *in vitro* conservation are standard techniques in most important crops. At the beginning of the 1980s genetic engineering of plants remained a promise of the future, although gene transfer had already been achieved earlier in a bacterium. The first transgenic plant, a tobacco cultivar resistant to an antibiotic, was reported in 1983. Transgenic crops with herbicide, virus or insect resistance, delayed fruit ripening, male sterility, and new chemical composition have been released to the market in past decade (NCGR 1998). In 1996, there were about 3 million ha of transgenic crops grown in the world (mainly in North America) whereas an excess of 34 million ha (a 12-fold addition) of transgenic crops were supposedly harvested this year in North America, Argentina, China, and South Africa among other countries. Argentina is the leading developing country with an excess of 4 million ha of transgenic herbicide-resistant soybean. There are more than 4.4 million ha of transgenic corn (14% of total acreage), 5 million ha of transgenic soybean (20%), and 1.6 million ha of transgenic canola (42%) grown only in North America. It has been calculated that in 1998 US farmers grew over 50% of their cotton fields with transgenic seeds, the largest percentage for any crop ever. Trees are the next target in the agenda of genetic engineering.

Genetic markers

In 1950s allozymes were employed as the first biochemical genetic markers. Population geneticists took advantage of such marker system for their early research. In the 1970s, restriction fragment length polymorphisms (RFLP) and Southern blotting were added to the toolbox of the geneticists. Taq polymerase was found in the 1980s, and the polymerase chain reaction (PCR) developed shortly afterwards. Since then, marker-aided analysis based on PCR has become routine in plant genetic research and marker systems have shown their potential in plant breeding (Paterson 1996). Furthermore, new single nucleotide polymorphic markers based on high-density DNA arrays (Chee *et al.* 1996), a technique known as 'gene chips', have recently been developed (Lemieux *et al.* 1998, Marshall and Hodgson 1998, Ramsay 1998). With 'gene chips', DNA belonging to thousand of genes can be arranged in small matrices (or chips) and probed with labeled cDNA from a tissue of choice. DNA chip technology uses microscopic arrays (or micro-arrays) of molecules immobilized on solid surfaces for biochemical analysis. An electronic device connected to a computer may read this information, which will facilitate marker-assisted selection in crop breeding. In summary, since Mendel's work on peas, there have been five eras in genetic marker evolution: morphology and cytology in early genetics (until late 1950s), protein and allozyme electrophoresis in the pre-recombinant DNA time (1960 - mid 1970s), RFLP and minisatellites in the pre-PCR age (mid 1970s - 1985), random amplified polymorphic DNA, microsatellites, expressed sequence tags, sequence tagged sites, and amplified fragment length polymorphism in the oligoscene period (1986 - 1995), and complete DNA sequences with known or unknown function as well as complete protein catalogs in the current computer robotic cyber genetics generation (1996 onwards).

Bioinformatics

Development of fast and more dependable computers has allowed easier management and analysis of data as well as publication of scientific reports. More publications and easy means for retrieval of this information have brought about phenomenal growth of knowledge dissemination in plant genetics and breeding. Rapid information exchange has been further facilitated by electronic mail and access to the internet. Information technology and biotechnology are beginning to merge into the new field of 'bioinformatics'. Scientists working in this field are developing biological data banks, which can be downloaded through internet by other scientists.

Crop genomics

This new term refers to the investigations of whole genomes by integrating genetics with informatics and automated systems (Briggs 1998). Genomic research aims to elucidate the structure, function and evolution of past and present genomes. Some of the most dynamic fields concerning agriculture are the sequencing of plant genomes, comparative mapping across species with genetic markers, and objective assisted breeding after identifying candidate genes or chromosome regions for further manipulations. As a result of genomics, the concept of gene pools has been enlarged to include transgenes and native exotic gene pools that are becoming available through comparative analysis of plant biological repertoires (Lee 1998). Understanding the biological traits of one species may enhance the ability to achieve high productivity or better product quality in another organism.

DNA markers and gene sequencing provides quantitative means to determine the extent of genetic diversity and to establish objective phylogenetic relationships among organisms. 'Gene chips' and transposon tagging will provide new dimensions for investigating gene expression. Molecular biologists will study not only individual genes but how circuits of interacting genes in different pathways control the spectrum of genetic diversity in any crop species. For example, more information will be available on why plant resistance genes are clustered together, or what candidate genes should be considered when manipulating quantitative trait loci (QTL) for crop improvement (Paterson 1997, Liu 1997).

Functional genomics

Genomics may provide a means for the elucidation of important functions that are essential for crop adaptedness. Regions of the world should be mapped by combining data of geographical information systems, crop performance, and genome characterization in each environment. In this way, plant breeders can develop new cultivars with the appropriate genes that improve fitness of the promising selections. Fine-tuning plant responses to distinct environments may enhance crop productivity. Development of cultivars with a wide range of adaptation will allow farming in marginal lands. Likewise, research advances in gene regulation, especially those processes concerning plant development patterns, will help breeders to fit genotypes in specific environments. Photoperiod insensitivity, flowering initiation, vernalization, cold acclimation, heat tolerance, host response to parasites and predators, are some of the characteristics in which advanced knowledge may be acquired by combining molecular biology, plant physiology and anatomy, crop protection, and genomics. Multidisciplinary co-operation among researchers will provide the required holistic approach to facilitate research progress in these subjects.

Gene banks and plant breeding

The sequencing of crop genomes opened new frontiers in conservation of plant biodiversity and its genetic enhancement. The advances in gene isolation and sequencing in many plant species allow to envisage that within a few years, gene-bank curators may replace their large cold stores of seeds with crop DNA sequences that will be electronically stored. The characterization of plant genomes will ultimately create a true

gene bank, which should possess a large and accessible gene inventory of today's non-characterized crop gene pools. Of course, seed banks of comprehensively investigated stocks should remain because geneticists and plant breeders, the main users of gene banks, will need this germplasm for their work. Genomics may accelerate the utilization of candidate genes available at these gene banks through transformation without barriers across plant species or other living kingdoms. Nonetheless, genetic engineering should be seen as one of the methods of plant breeding that permits the direct alteration and re-building of a crop population. "Shutting-off" genes coding for undesired characteristics may be another application of transgenics in crop improvement.

Plant breeders will change their *modus operandi* with the development of objective marker-assisted introgression and selection methods. Backcross breeding will be shortened by eliminating undesired chromosome segments (also known as linkage drags) of the donor parent or selecting for more chromosome regions of the recurrent parent. Parents of elite crosses may be chosen based on a combination of DNA markers and phenotypic assessment in a selection index, such as best linear unbiased predictors. To achieve success in these endeavors, cheap, easy, decentralized, and rapid diagnostic marker procedures are required.

Bioresource technology

Nowadays, the finding of new genes that add value to agricultural products seems to be very important in the private sector. Unique gene databases are being assembled by the industry with the massive amount of data generated by genomics research. A new term 'biosource' has been coined recently to refer to a fast and effective technology of pinpointing genes. With this method, a 'benign' virus infects a plant with a specific gene that allows researchers to observe directly its phenotype. Biosource replaces the standard time-consuming approach of first mapping a gene to subsequently determine its exact function. Gene identification in DNA libraries coupled with biosource technology and an enhanced ability to put genes into plants will be routine for improving crops in the next decade.

Farming and pharming

The aims of applied plant science research for agriculture are to enhance crop yields, improve food quality, and preserve the environment where human beings and other organisms live. The best way for conservation of plant biodiversity and its environment, would be to achieve high crop productivity per unit area. In this regard, it has been reported that as yields treble, soil erosion per ton of food decreases by two-thirds. There has been a significant yield improvement owing to enhanced crop husbandry, but in the next years progress will be achieved by changing plants that could be more suitable to sustainable and environmentally friendly farming systems.

In the next decades meiotic-based breeding will still generate cultivars for farmers. Genetic improvement through biotechnology needs conventional breeding because (1) the elite cultivars will be the parents of the next generation of improved genotypes, (2) field testing across locations or cropping systems and over years will be needed to determine the best selections due to the genotype-by-environment interaction. Transgenes must be viewed as improvements rather than replacements for elite germplasm. Indeed, genetic engineering may provide a means to add value by introducing synthetic or natural genes that enhance crop quality and yield, as well as protect the plant against pest and diseases. Farmers will pay more for transgenic crop propagules if they obtain extra-income after adopting biotech-derived products. For example, seeds of insect resistant transgenic crops will be more expensive than those of available cultivars but the farmer will not need to apply pesticides in their transgenic fields. Of course, patents make transgenic seeds more expensive but also farmer's benefits may be higher.

Growth of cities is rapidly replacing farmland with shopping complexes, parking lots, and housing developments. Peri-urban agriculture and home gardening are also becoming very important for national food security in the developing world as a result of rapid urban expansion. Hence, new cultivars will be needed to fit into intensive production systems, which may provide the food required to satisfy urban world demands of the next century. Specific plant architecture, tolerance to urban pollution, efficient nutrient uptake, and crop acclimatization to new substrates for growing are, among others, the plant characteristics required for this kind of agriculture. Genes controlling these characteristics may be available in gene banks for further cross breeding, which can be assisted by genomics. Peri-urban and home garden 'farmers' will have to adapt to new demands from emerging urban populations with higher income. These consumers may request a more varied diet. For example, food crops with low fats, and high in specific amino acids may be needed to satisfy people who wish to change their eating habits. If genes controlling these characteristics do not exist in a specific crop pool they may be incorporated into the breeding pool using transgenics.

Often plants provide the raw materials for agro-industry, and not only for food or fibre processing. Active ingredients of plants have been transformed into commercial products such as medicines, solvents, dyes, and non-cooking oils for many years. Hence, it would not be surprising to see, in few years from now, entire farms without food crops but growing transgenic plants to produce new products, e.g. edible plastic from peas or plant oils to manufacture hydraulic fluids and nylon. This new rural activity may result in important changes in the national economic sector.

'Pharming' indicates a new kind of system to obtain medicines (Anderson 1996). For example, oral vaccines appear to be a convenient delivery system for vaccination throughout the world. Biotechnology has been used to engineer plants that contain a gene derived from a human pathogen (Tacker *et al.*

1998). An antigenic protein encoded by this foreign DNA can accumulate in the resultant plant tissues. Results from pre-clinical trials showed that antigenic proteins harvested from transgenic plants were able to keep the immunogenic properties if purified. These antigenic proteins caused the production of specific antibodies in injected mice. Mice, which ate these transgenic plant tissues, also showed a mucosal immune response. The ability of transgenic food crops to induce protective immunity in mice against cholera toxin has been recently demonstrated (Arakawa *et al.* 1998). Potato tubers have been used successfully as a biofactory for production of recombinant single chain antibody (Artsaenko *et al.* 1998).

Epilogue

Banning transgenic crops in the farming system will be foolish because the potential benefits are so great. Whatever scientists do to develop crops that eliminate or reduce the utilization of polluting agro-chemicals in the farming systems must be welcome by farmers and consumers. The general public should not fear biotechnology, rather consider it as a safe tool for scientific crop improvement, because it helps in the fight against hunger and poverty. Therefore, research funding should be allocated accordingly to long-term plant breeding programs, which include biotechnology as one of its tools. In this way, we may effectively face the serious challenge of feeding the rapidly growing world population in this millennium.

Within the next 10 or 20 years, five research areas may become very important for crop improvement: (i) apomixis to fix hybrid vigour, (ii) male sterility systems with transgenics for hybrid seed in self-pollinating crops, (iii) parthenocarpy for seedless vegetables and fruit trees, (iv) short-cycling for rapid improvement of forest and fruit trees, and (v) converting annual into perennial crops for sustainable agricultural systems. The development of perennial crops will be especially important to protect the soil from erosion. Plant biotechnology will play, of course, an important role in achieving research and development success in these areas. ■

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Plasma physics: A review and applications with special reference to inertial confinement fusion energy

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A brief description of plasma, its types and fundamental requirements necessary to study the physics of plasma has been presented through this article. Information given here would be useful to those who have the basic knowledge of physics. Mathematical complications have been avoided to suit the purpose. Varied applications of plasma have been introduced. A little detail has been devoted to one of the major applications of plasma physics known as theoretical thermonuclear fusion studies. Physics of inertial confinement together with the role of self-generated magnetic field in the design of fusion targets have also been described.

Introduction

The term plasma was first introduced by two Americans, Langmuir and Tonks in 1923. It is natural to ask a question: what is plasma? The first answer may be ***the fourth state of matter*** whereas solid, liquid and gas are three commonly known states of matter.

Plasma is an ionized state of matter. It may be in the solid, liquid or gaseous form. Gaseous form of plasma is most widely studied. In contrast to an ordinary gas containing neutral molecules of atom, plasma contains mostly the charged particles and partly neutral particles. The charged particles are electrons and singly or multiply charged ions in such a number that make the plasma electrically neutral. Another basic difference between a neutral gas and plasma arises due to the entirely different character of the inter-particle interaction in them. In a neutral gas this force is of van der Waal's type, which is long range interaction and weak at large distances. As a result, each particle of the plasma can simultaneously interact in many ways with its innumerable immediate and distant neighbors. That is why plasma is rich with information but complex in character and so a rather hard nut to crack to understand its varied applications with proper theories associated with it. An ordinary gas is a good insulator at normal temperature and pressure. On the other hand with a sufficient degree of ionization and sufficiently high temperature plasma can become a conductor with high electrical conductivity. Because of the high conductivity, even a weak applied electric field can produce a large electric current. It is due to the fact that the electrons and ions in the plasma are completely free to move and hence can give rise to current. Electrons, due to their light mass are mobile in nature, and ions, being very heavy, are sluggish and mainly provide neutralizing background. Hence, electrons are main contributors to current in the plasma. The implication of large current in plasma due to mobile electrons is that in the external magnetic field plasma behaves like a diamagnetic substance (Chen 1974).

Regarding the average kinetic energy and temperature, particles (molecules or atoms) of gas have same kinetic energy and hence have the same temperature. But in the plasma, the average kinetic energies of the electrons, ion and neutral particles are generally different. Electrons have the highest average kinetic energy and neutral particles have least energy. The average kinetic energy of the ions lies between that of electrons and neutral particles. Hence, plasma is mixture of constituent particle at different temperatures at the same time.

Plasma strongly reacts with electromagnetic waves because it behaves like dielectric medium with a high dielectric constant. Electromagnetic waves below certain frequency, determined by the parameters of the particular plasma, cannot transmit through the plasma and are reflected back. Reception of radio signals throughout the earth stations may be example of an application based on the properties of ionospheric plasma. As a whole, plasma is a quasi-neutral system. It means that there cannot be significant excess positive or negative charge accumulated at any point in it. If there arise even slight deviation from charge neutrality, say one percent, it may give rise to very strong electric field. This strong field neutralizes the region of excess charge by transfer of electrons.

Thermodynamic equilibrium is attained through collisions in gases. Collisions among the molecules of a gas are like collisions between two billiard balls. Collisions in gas evolving more than two particles are extremely rare. In contrast, collisions between plasma particles are of an entirely different character.

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As mentioned already, the plasma particles interact with each other through long-range coulomb interaction, and a single electron can simultaneously interact with its innumerable neighbors, near and far. Hence, each particle of the plasma is always in the electric field produced by the rest of the electrons and ions. This electric field, again, is not static but changing incessantly in the magnitude and direction. However, on the averaging over a long time, the average field due to the random fluctuation will be zero, although this does not mean that average field is entirely zero always and everywhere. Thus, the internal micro-field inside the plasma, however small, constantly changes the magnitude and direction of velocity of charged particles. The intensity of the micro field being small on the average and of long range, the change in the direction of motion of the particles occurs continuously, not abruptly. So the role of the Coulomb force is dominant in plasma. For this reason it is also called ***coulomb gas.*** It is however, to be noted that the limit of the Coulomb force is not infinite. Polarization phenomenon shields it. The polarization occurring in the plasma limits the Coulomb force up to a certain length, known as the Debye length. This length is much smaller than dimension of the plasma but greater than inter particle spacing so that there are large number of particles within the sphere of radius equal to Debye length.

Because of the physical properties of plasma, a large number of applications related with its types have been devised in the laboratories in addition to natural ones. Examples of laboratory plasmas are plasma torch, arc, fluorescence etc. Commonly known three (solid, liquid and gas) states are only one percent or less in the scale of our universe. Some of the details on natural plasma have been discussed below.

Natural plasma

Plasma is the most natural state of matter. Most of matter (~99%) in the universe is in this state (Goswami 1995). Examples are sun, stars, nebulae, the Milky Way etc. Each of them is a vast plasma at very high temperature. Ionosphere, an important region of the atmosphere, is geophysical plasma and created due to photoionization when gases like N_2, O_2, CO_2, H_2O etc absorb solar radiation in daytime. The ionosphere is further divided into different layers designated by D, E, E_1, E_2, F_1, F_2 according to their height, electron number density, temperature etc. For example D layer has an average height of about 70 km and electron number density of about 10^{10} m^{-3}, while the F_2 layer has the corresponding values of 300 km and 10^{12} m^{-3}. Further in D region, density of neutral particles is so high that recombination processes are much affected there. In the E-layer several types of positive ions that have been observed are N_2^+, N^{++}, Al^{++}, etc. Metallic ions have been assumed to arise from burning of meteors and satellites etc. In the upper atmosphere of the Earth a few types of plasmas exists. One of them is airglow. There are two types of airglows, one observed at night and so called *night glow* and other observed during the day and called *day glow.* These are believed to originate from photoemission produced by various reactions. Likewise another spectacular glow known as the twilight glow is observed during sunset. Lighting, aurora, Van Allen radiation belt, solar wind, solar flare are other geophysical plasmas. There are two beautiful sceneries of aurora borealis and aurora australis in the upper atmosphere near the north and south pole regions. They occur due to deflection of charged particles ejected from the sun during magnetic storm from the equatorial to the Polar Regions in the earth's magnetic field. Similarly, Van Allen radiation belt is formed by electron and protons trapped by the Earth's magnetic field. Solar wind, solar flare, having all properties of usual plasma consist of charged particles. This wind compresses the Earth's magnetic field due to its pressure.

In the processes occurring in interstellar space plasma five kinds of molecules are involved such as CH, CH^+, CN, NaH and OH. First four molecules have been identified by optical spectra whereas the presence of OH molecules has been established through the experiments performed with radio waves. There are opinions in favor of the existence of polyatomic molecules as well but the fact has not been well accepted.

Application of plasma

There are many applications of plasma in our daily life. Plasma research varies from cheaper to very expensive ones. Thermonuclear fusion energy research is one of the most important and costly affair of plasma research. But every developed nation has been investigating on it because of its potential to meet global energy crisis of the future. It is because almost all resources on the Earth will be exhausted in a few decades when the rate of energy consumption will be more for vast population of the future.

Thermonuclear fusion

There are two schemes applied to harness nuclear energy: nuclear fusion and nuclear fission (Mukhin 1987). In the fission, heavy nuclei are broken into two nuclei having higher binding energy per nucleon, as the result there is release of energy. In fusion two light nuclei, such as deuterium-deuterium, deuterium-tritium, are combined together into a single nucleus having higher binding energy per nucleon. So there is also release of energy. A point to be noted here is that energy release per nucleon in fusion is greater than that released in fission. The energy release per nucleon in fusion of two nuclei ${}_1H^2$ and ${}_1H^3$ is about 6 MeV per nucleon whereas in fission it is about 0.8 MeV per nucleon. In addition nuclear fuel that is used in fission is isotope ${}_{92}U^{235}$ and in fusion the fuel is deuterium, ${}_1H^2$. In naturally occurring uranium there is only 0.7% of ${}_{92}U^{235}$ whereas ${}_1H^2$ are abundantly found in nature. Hence, fusion has merit over fission.

In the fusion, two interacting particles are brought sufficiently close to each other, about 2×10^{-15} m against coulomb repulsive force, so that they come in attractive nuclear field of each other. So, if there were no coulumbic repulsive force, it would have been very easy to fuse two nuclei. In order to overcome this difficulty, nuclei are heated in an excessively high temperature, about 100 million-degree. At such high temperature, interacting particles can no longer remain a neutral medium. It is converted into fully ionized plasma composed of electrons and nuclei. The random motion of nuclei would bring them within the range of nuclear force for fusion to occur. For this reason, fusion is also termed as thermonuclear reaction.

One more point to be noted here is about the confinement

of fantastically hot fusion nuclei. Obviously, no material containers can be used for this purpose because they cannot exist in the solid state at such temperature. In addition since the heat conductivity of plasma is very high, thermal insulation is essential otherwise all the energy goes to the wall of the container and the desired high temperature cannot be reached. However, there is another possibility i.e. the use of specially shaped magnetic field called *magnetic bottles*, where fusing nuclei can be confined.

There are several magnetic confinement systems. These systems come in to sub-systems: open and closed systems. The open systems are Z-Pinch and θ-Pinch and mirror machine. The closed systems are Stellator, Tokamak and Levitron. Confinement time and number density of nuclei play the vital role in sustaining thermonuclear reaction. A condition, first given by J. D. Lawson, states that for the high probability of fusion, the product of confinement time and nuclear density of nuclei should be greater than or equal to 1.5×10^{22} m^{-3} sec. In the honor of its founder, the condition is called 'Lawson criterion'.

The other important possible application of plasma is the direct conversion of thermal energy into electric energy with the help of a magneto-hydrodynamic generator. In this case plasma jet is formed at first and then inserted perpendicular to magnetic field. Then an electromotive force will be induced in the plasma due to the interaction of the jet with the magnetic lines of force, which induces current. The current is made to pass through the load to obtain power.

In the reverse by applying large electric and magnetic cross-fields to the plasma one can obtain plasma beam with high velocity enough to act as an ordinary rocket propulsion system. In addition to the fusion reactor, MHD generator and plasma propulsion systems, there are a number of other plasma devices, which must be mentioned. The thermionic converter in which cesium plasma is used to produce high currents and significant portion of the thermal energy applied to the cathode is extracted as electric field. Plasma amplifiers, gas lasers, arc jets, fluorescent tubes are the additional plasma devices. Arc jets provide temperature as twice as of the hottest gas flames. So they can be used to melt metals like tungsten, carbon or molybdenum as well as for cutting or welding. Besides these, there are attention number of specialized tubes like the thyratron, grid-controlled thermionic arc-type rectifier and the ignitron that is used for switching.

Intertial confinement fusion

The possibility of heating of small volumes of dense hydrogen plasma by concentrating laser light up to the high temperatures at which thermonuclear reaction arise excited the scientists towards the inertial confinement fusion (ICF) (Duderstad and Moses 1982). The first demonstration of a man made inertial confinement fusion device came with the explosion by the United States of the first hydrogen bomb in 1952. In the intervening years a number of concepts were generated for laboratory inertial confinement devices using particle beams or intense laser pulses. In this high-density laser fusion the key idea is laser implosion of hydrogen isotope micro spheres to approximately 10^4 times liquid density in order to initiate efficient thermonuclear burning. Such fusion yields 50 to 100 times larger energy than the laser energy of 10^5 to 10^6 joules.

The laser fusion implosion system consists of a tiny spherical pellet of deuterium-tritium located in a large vacuum chamber, and a laser capable of generating an optimally shaped pulse of light energy. Laser irradiates this spherical target shell and delivers several megajoules of energy in a time of the order of 10 nanoseconds (Pokhrel 1983). At such high intensities, the irradiated areas of the target undergo rapid ionization initiating ablation (blow off) of its material in surrounding vacuum, which forms plasma with density below that of solid target. This plasma is called corona. The ablation generates enormous pressure or shock due to the rocket action, which implode the fuel (target) to density as high as 10^3 to 10^4 times that of solid density (Nuckolls *et al.* 1972). This compression would also raise the temperature of the fuel to fusion temperature, so that a thermonuclear burn is ignited. This burn would then propagate outward through the rest of the fuel pellet, igniting and burning it, to result in the explosive release of fusion energy. This scheme of fusion is called ***inertial confinement fusion***. The process of compression and thermonuclear ignition and burn would occur in a time much shorter than the time required for the pellet to blow apart (10^{-9}s). Hence, a premium is placed on developing driver beam capable of delivering large quantities of energy onto tiny targets (1 to 1000 mm in diameter) in a very short pulse (0.1 to 20 ns). It has to be noted that the blow off of plasma particles is not instantaneous process, but it takes certain time, because the inertia opposes such blowing apart. So one can take advantage of this fact and heat the fuel to thermonuclear temperature so fast that an appreciable number of fusion reactions occur before it is blown apart. It is the inertia that confines the fuel and for this reason the scheme is called inertial confinement fusion. Naturally, it requires an extremely large energy source to heat an appreciable mass of fuel to such high temperatures. In the corona, density of electron decreases away from pellet surface. So, as the laser penetrates the corona it encounters gradually increasing density and hence gradually gets absorbed more and more due to inverse bremsstrahlung. After penetrating certain depth it is completely absorbed and reflected back. At this stage, laser, being prevented from reaching the ablator by the coronal plasma, ceases its action of giving its energy directly to the ablator. The region where laser is completely absorbed is called critical surface and corresponding density is called critical density, n_c, which is given by $n_c = 10^{21}\lambda^{-2}$ where λ is wavelength of laser in μm. Since density is inversely proportional to square of wavelength, laser light of shorter wavelength is suitable for laser fusion. It is clear that critical surface shields the target from laser radiation. In such circumstances, the energy absorbed by inverse bremsstrahlung in the coronal plasma at densities equal to or less than the critical density is then conducted by electron to the cold ablation surface of solid target material (Nakarmi 1999).

In order to make ICF a success, it has been accepted that the morphology and magnitude of self-generated high order magnetic field be mapped and thus be taken care of so that fusion target designs be done. A brief description on self-generation of magnetic field is discussed below.

Self generated magnetic field

A self generated magnetic field in the corona of laser produced

plasma has been an important phenomenon. It has been started with great interest in many laboratories since 1970's. For diagnostics of magnetic field in laser plasma, phenomenon known as Faraday rotation is employed. The plasma density and the magnetic field strength determine the amount of rotation. Zeeman effect is another optical method for the same.

The first report on detecting mega gauss magnetic fields was of Stamper of US Naval Research Laboratory when plasma at the surface of a solid target was exposed to powerful pulses of a Nd glass laser. The report was based on the measurement of the Faraday rotation of the polarization plane by plasma probing laser beam near the surface of the target (Stamper and Bipin 1975). Similar work has also been carried by Raven *et al.* (1978) in Rutherford Laboratory, UK.

Interferrometric measurements of the distribution of electron density in the plasma corona using slab, spherical and wire targets at irradiance of 10^{16} W cm^{-2} and wavelength 1.06 μm (Nd laser) showed strong steepening near the critical density. From these experiments it is concluded that strong toroidal shaped magnetic fields are generated at a distance approximately corresponding to the position of the critical density surface. These toroidal fields have closed lines of force embracing the axis of the incident laser beam. Soon after the experimental report of Stamper and Bipin (1975) on the measurement of magnetic field, thermoelectric mechanism has been suggested for the generation of the magnetic field. Also intensive numerical simulation has been launched to study this effect. Thermoelectric mechanism suggest that when the gradients in density and temperature are non collinear, a magnetic field will spontaneously builds up in the plasma.

There are two approaches to obtain self-generated magnetic field in laser plasma. First approach is to solve the evolution equation. This equation for the self generated magnetic field can be derived by combining generalized Ohm's law and Maxwell's equations, the equations of magnetohydrodynamics (MHD), namely the momentum conservation equation. In MHD approximation plasma is considered as electrically conducting perfect gas where details of interaction between ions and electrons are neglected. The evolution equation consists of many terms, which are responsible for self-generation of the magnetic field such as convective, diffusive, source, Hall term, thermal force and radiation pressure term. Since it is a non linear equation, it is difficult to solve full equation and is effortless. In practice only certain terms are considered dominant such as convective, diffusive and source terms (Jha and Srivastava 1986).

In the second approach a different model is used in which effect of pondermotive force has been included. When high power laser beams are applied to plasma, the force due to radiation pressure is coupled to the particles non linearly and the force is termed as pondermotive force (Ghimire and Jha 1996). In the case of s-polarized light, this radiation pressure effect gives rise to EMF, which in turn produces current density and excites the magnetic field. Because of the fact that steep gradients of temperature as well as density are created in plasma it has been shown that large order of megagauss (MG) magnetic fields are generated.

In a short pulse laser of finite spot size with amplitude modulation in time, laser exerts a time dependent curl free ponderomotive force on the electrons. When equilibrium plasma density has a gradient normal to ponderomotive force, electron current density is irrotational, producing a quasistatic magnetic field. With the development of ultra-intense short pulse laser, a new parameter regime has been opened up in the study of non-linear laser plasma interaction. The numerical simulations have revealed extremely high self generated magnetic fields of the order 250 MG in the interaction of ultra-intense laser pulse with over dense plasma target. It has been argued that generation of such extremely high magnetic field is the result of DC current driven by spatial gradients and temporal variations of the pondermotive force of the laser light on the plasma electrons. The DC magnetic field is found to be the same order of magnitude as that of oscillating magnetic field of the laser.

Such intense magnetic fields can also be explained by a very attractive mechanism in which non-uniform intense laser beam interacts with non uniform collissionless plasma having equilibrium electron temperature and density gradients. With the relativistically intense laser pulse, two spatially separated toroidal magnetic fields in the megagauss range have been detected with Faraday rotation. In the outer region of the plasma, conventional thermoelectric field has been observed and a field with the opposite orientation closely surrounding the propagating axis is observed. It can be pointed out that magnetic field can be generated in a non-linear medium if the intensity distribution of the incident electromagnetic beam is radially inhomogeneous. Due to pondermotive force, a radially inhomogeneous laser beam drives a plasma current which in turn produces an azimuthal (with respect to beam axis) DC magnetic field.

Discussion

A brief informative account of the fundamentals of plasma physics, its importance in the studies of fusion energy and self generated magnetic field have been presented in the article. Several other useful applications of academic and technological interests are under study these days. Important ones are plasma processing, surface treatment, space propulsion, reconnection, turbulence etc. Present article may be useful in defining path to interested researchers to understand the concepts about these applications. ■

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Ethnobotanical notes on flora of Khaptad National Park (KNP), far-western Nepal

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The complex geomorphology, climatic variations and vegetation have made Khaptad National Park (KNP) flourish with diverse flora, which, in turn, has made a treasure home for luxuriant growth of plant resources especially medicinal herbs. This paper aims at highlighting the ethnobotanical account of wild plants, their traditional utilization, chiefly as medicine, food supplements and other economic uses in KNP. Personnel interviews and group discussions with local inhabitants (local healers, traders, women and experienced and aged persons) were consulted for seeking information on local uses of plants, which was further authenticated by crosschecking. Different sites were accessed along altitudinal gradient from Silgadhi to Chhodipatan comprising 1400-3250 masl. Altogether 211 plants species comprising 188 genera belonging to 88 families were recorded. Among them, 81 species were used by local people for various domestic purposes. It has been found that 51 species of them were used for medicinal purposes, 11 species as vegetables, 6 species for ornamental purposes, 18 species for construction, furniture and making agricultural implements and 10 species for miscellaneous purposes. This wide ethnobotanical uses, diverse ecology and its great natural beauty deserve the attraction for researchers, tourists and other people. However, at present, the rich wild flora of KNP is under threat due to habitat destruction, overexploitation, and gradually declining traditional ethnobotanical knowledge, indicating an urgent need for conservation.

Key words: Ethnobotanical study, Khaptad, cross-checking, folk name, *Patan* or *Kharka*

Introduction

Nepal, a small Himalayan kingdom nestled in between two large countries India and China, is a repository of wild flora and fauna. It harbors 2.2% of world's flowering plants while it shares only 0.1% of the total land area of the world. It has a natural gift of over 7,000 species of higher plants out of which over 800 species of medicinal herbs used in tradition medicinal practice, about 100 species for fodder, 70 for fibre and 450 species for food (Manandhar 1995). Recent literature has reported a far higher number (1463 species) of medicinal plants (Tiwari 1999) which represents about 20% of the total country's flora, including 250 indigenous species. This is largely due to diverse topography, climate, altitude and edaphic factors. The country has a rich tradition of folk practices for utilization of wild plants. People have used plants, particularly wild plants for treating disease since time immemorial and they are still doing so. Especially wild plants play an important role in food security and as an income-generating source for the rural community. About 70-80% rural population in the mountainous and hill region depend on traditional medicine for health care (Manandhar 1980). About 100 species are currently exploited for commercial uses (Karki 1999). In fact, in the mountainous region traditional exploitation of plants has its root in the remote past. Thus, the useful plants are now found growing sporadically in forests as well as in village groves. But due to lack of organized and scientific cultivation, proper management and their sustainability, and awareness of social factors, the number of these plants are decreasing at an alarming rate.

Indigenous knowledge is defined as "cumulative body of knowledge and belief handed down through generations by cultural transmission about the relationship of livings (including humans) with one another and their environment" (Berks 1999). According to Rao (1996), tribal people and forest dwellers throughout the world are the true conservators of forest and indigenous cultures. However, due to changing perception of the forest dwellers, commercialization and socio-economic transformation all over the world, there has been a general observation that the indigenous knowledge on resource use has degraded severely (Gadgil *et al.* 1993; Silori and Rana 2000). Recognizing these facts, although lately, efforts have been made in Nepal to document such knowledge that has accumulated through a long series of observation, interactions and practices with and of local people (primary consumers of forest resources) and thus contains important information relevant to sustainable use of resources.

There are very few scientific researches in Khaptad National Park (KNP). Information on the ethnobotanical plants of the area is lacking and work related to useful plants and ethnic groups, cultures etc. hasn't been conducted so far. Hence, an attempt has been made to collect ethnobotanical information

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and document the indigenous knowledge on useful plants with their habitats and uses by the local communities inhabiting KNP and emphasis has been given to highlighting the account of wild plants, their traditional utilization, chiefly as domestic treatment, food supplements and other economic uses which can contribute to some extent.

Study area

The KNP covers an area of 225 sq. km. and includes vertically distributed ecozones ranging from about 1,000 to 3,276 masl. Still most of its part is unexplored and it is often considered as the naturalist's paradise. The beauty of this park is that it can all be physically traversed and experienced within a short period of time and it can boast of nature, science and religion, all three combined into one (Kunwar 2000). It was established in 1984 and gazetted in 1986 on the advice of the religious remarkable Hindu holy man, Khaptad Baba. He contributed a lot to the promotion and conservation of local culture, civilization, history and biodiversity.

KNP is characterised with very diverse ecology and richness in flora and fauna. It reveals a remarkable fecundity and plentitude of dense ambient forests of *Shorea*, *Pinus* and *Alnus* in subtropical zone; *Quercus* sp., *Aesculus* sp., *Daphniphyllum* sp., *Abies* sp., *Picea* sp. in temperate zone and *Quercus* sp., *Taxus* sp., *Betula* sp., etc. in subalpine zone (HMG 1999). Subalpine meadow, locally called *Patan* or *Kharka,* is the main attraction of this area (Chaudhary 1998). It is endowed with great natural beauty and sprawling plateaus with green grassland, carpet of flowers full of medicinal herbs and teeming with wide varieties of flora and fauna and used by local inhabitants for their sustenance (Duwadee and Kunwar 2001). Rural livelihood rely on their surrounding forests for almost everything. About 42% of the total digestible nutrient to cattle is obtained from the forests (MOPE 1998). Forest products continue to be items of daily requirement of the ordinary people (Dhungana 1999).

The people of Khaptad are heterogeneous, most of them speaking Nepali (Doteli and Khas). Ethnic and so called lower cast people such as Chhetri, Khas, Thakuri, Kami, Sarki etc are major groups in the periphery of the National Park mainly being involved in agriculture, livestock grazing and animal husbandry. They always do their work (cleaning and maintenance of cowshed) in the morning and go for collection of forest products in the day time. They are still using a number of plants growing in the surrounding forests to cure their common ailments and to fulfill their subsistence needs. Rural people residing in the vicinity are greatly relying upon the forest resources. They are engaged in collecting medicinal herbs and raw food items as part of their traditional ventures. Though it is potential in natural resources, the socio-economic condition of nearby villagers is not so good which may be due to lack of the knowledge about proper management of natural resources (Kunwar *et al.* 2000).

Materials and methods

The complex and sprawling landscape, vegetation and climate have made KNP flourish with diverse flora, which, in turn, has made a treasure home for luxuriantly growing socio-economically important species. Almost the entire population makes it's living through agriculture. Wild plants mostly supplement their food and agricultural implements. Local people have their own traditional systems of using plants to meet their day-to-day requirements. Among the most basic skills in ethnobotany is plant collecting.

Ethnobotanical notes of wild plants being used by rural inhabitants were taken in trips, observations and collections during June and July 2000. Different sites were accessed across the altitudinal gradient from Silgadhi to Khaptad (Chhodipatan) comprising 1,400–3,250 masl. Collections are valuable because they serve as voucher specimens, records of the plants that are known by community and function as specimens for systematic identification (Martin 1995). A voucher specimen facilitates the identification of species encountered during research and permits colleagues to review the results of the study (Hunn 1992). Personnel interviews and group discussion with local inhabitants revealed some very valuable and specific information about the uses of plants. Local healers and experienced and aged persons were consulted for seeking information on local uses of plants, which was further authenticated by cross-checking. In addition to cross-checking and recording folk names of plants through collecting voucher specimens, it is important to cross-check information with different people and compare the results from different methods (Cunningham 2001).

Interviews with people out of the village, in fields, pastures or forests were conducted on a systematic basis to know more details about species, their management and distribution. The plants were identified comparing with authentic specimens at Tribhuvan University Central Herbarium (TUCH), Central Department of Botany, TU and National Herbarium Godavari (DPR, HMG/N). The consulted literatures during field time for identification of species were Stainton and Polluniņ (1984), Stainton (1988), Haines (1961), Hara *et al.* (1978), Hara and Williams (1979), Hara *et al.* (1982) and for ethnobotanical knowledge were Rajbhandari (2001) and Joshi and Joshi (2001).

Ethnobotany has been practiced since 1895, though definitions and scope has changed since then. Current definitions still vary greatly, but in effect, it is about the study of local people's knowledge and relationships with plants (Wong *et al.* 2001). Ethnobotanical studies have been carried out by different contributors at different places of Nepal, important among them are Sacherer (1979), Manandhar (1980, 1995, 1996), Shrestha (1987), Bhattarai (1989, 1992, 1993), Joshi and Edington (1990), Joshi (1991), Siwakoti and Siwakoti (1998), Bhatta (1999), Parajuli (2000) etc. but complete ethnobotanical notes on flora of Khaptad area has not been carried out so far.

Results and discussion

Altogether 211 plants species belonging to 188 genera and 88 different families were recorded. Among them, 81 species were reported to be used by the local people for various purposes. It is found that 51 of them were used for medicinal purposes, 11 as vegetables, 6 for ornamental purposes, 18 for construction, furniture and making agricultural implements and ten for miscellaneous purposes (see Table 1-5). Plant species are documented in ascending order of family names for easier access.

Table 1: Plants used for medicinal purposes. Plant species are documented in ascending order of family names for easier access.

S. No.	Name of Species (with voucher number)	Vernacular Name	Family	Uses
1	*Achyranthes aspera* L. (564/00)	Chirchiri	Amaranthaceae	Roots for easy delivery. Leave juice for ear problems.
2	*Rhus javanica* (L.) Urb. (95/00)	Bhakiamilo	Anacardiaceae	Fruits for curing dysentery.
3	*Centella asiatica* L. (580/00)	Ghodtapre	Apiaceae	Leaves extract as blood purifier and to increase memory.
4	*Arisaema jacquemontii* Blume (562/00)	Sarpako makai	Araceae	Rhizome juice for ear pain.
5	*Panax pseudo-ginseng* Wall. (207/00)	Mangen	Araliaceae	Root and rhizomes as general tonic, remedy for troubles, diseases.
6	*Artemisia indica* Willd. (561/00)	Titepati	Asteraceae	Dried flowers and leaves as insecticides. Leaf juice used to cure skin diseases.
7	*Ligularia fischeri* (Ledeb.) Turcz.		Asteraceae	Seed oil used for sprain, rheumatism.
8	*Impatiens* sp. (570/00)		Balsaminaceae	Plant extract as growth stimulator of hair.
9	*Berberis asiatica* Roxb. Ex DC. (558/00)	Chutro	Berberidaceae	Root decoction for abdominal pain.
10	*Podophyllum hexandrum* Royle. (583/00)	Laghupatra	Berberidaceae	Root juice for liver wound.
11	*Betula utilis* D. Don (556/00)	Bhoj patra	Betulaceae	Bark is scraped for manuscript writing as paper. Decoction of bark for sore throat.
12	*Maharanga emodi* (Wall.) A.DC. (158/00)		Boraginaceae	Whole plant as antihelminth.
13	*Lobelia pyramidalis* Wall. (569/00)	Aklebir	Companulaceae	Leaves and flower as antispasmodic.
14	*Cuscuta sp.* (509/00)	Janailaharo	Cuscutaceae	Seeds are used as antihelminth.
15	*Drosera peltata* (Buch. - Ham. Ex Dc.) C.B Clarke (568/00)		Droseraceae	Plant decoction for syphilis.
16	Equisetum debile *Roxb. (555/00)*	Kurkure ghans	Equisetaceae	It is given in gonorrhoea.
17	*Rhododendron campanulatum* D. Don (89/00)		Ericaceae	Seeds for digestive disorders.
18	*Rhododendron arboreum* Sm. (87/00)	Lali gurans	Ericaceae	Flower employed for throat pain.
19	*Euphorbia hirta* L. (582/00)	Dudhe jhar	Euphorbiaceae	Whole plant for asthma and diarrhoea.
20	*Evolvulus alsinoides* (L.) L. (581/00)	Aakuri phul	Fabaceae	Decoction of whole plant to increase memory.
21	*Corydalis govaniana* Wall. (510/00)		Fumariaceae	Decoction of roots valued as tonic and for liver problems. Dried leaves as insecticides.
22	*Swertia petiolata* D. Don (554/00)	Chiraito	Gentianaceae	Decoctions of roots for fever to promptly reduce temperature.
23	*Aesculus indica* (Colebr. Ex Cambess) Hook (563/00)	Pangro	Hippocastanaceae	Seed oil for Rheumatism.
24	*Anisomeles indica* (L.) Kuntze (167/00)	Rato charpate	Lamiaceae	Plant extract for urinary complaints.
25	*Leucas sp.* (134/00)		Lamiaceae	Plant decoction is given in fever, asthma and cough.
26	*Asparagus racemosus* Willd. (560/00)	Kurilo	Liliaceae	Powder of tuberous root is employed in acidity and nursing mother.
27	*Paris polyphylla* Sm. (565/00)	Satuwa	Liliaceae	Rhizome as antihelminth.
28	*Polygonatum verticillatum* (L.) All. (105/00)	Keruwa	Liliaceae	Green foliage as nutritive items.
29	*Woodfordia fruticosa* (L.) Kurz. (199/00)	Dhanyaro	Lythraceae	Flower decoction considered in fever.
30	*Myrica esculenta* Buch. –Ham. ex D. Don. (567/00)	Kafal	Myricaceae	Fruits for dysentery and bark for bronchitis.

(Table continued)

31	*Dactylorhiza hatagirea* (D. Don.) Soo (507/00)	Pachaunle	Orchidaceae	Roots are applied on cuts. It stops bleeding and it is considered as a common medicine.
32	*Meconopsis sp.* (121/00)		Papaveraceae	Fruits are narcotic and poisonous.
33	*Parnassia nubicola* Wall. ex Royle. (205/00)	Mamira	Parnassiaceae	Root paste is used for inflammation and Leaf juice for eye problem.
34	*Abies spectabilis* (D. Don) Mirb. (571/00)	Bunge Salla	Pinaceae	Leaf juice is used as expectorant.
35	*Rumex hastatus* D. Don (103/00)		Polygonaceae	Crushed roots with water relieves cough.
36	*Aconitum heterophyllum* Wall ex Royle (112/00)	Bikh	Rananculaceae	Dried roots are used to treat fever and stomach pains.
37	*Aconitum spicatum* (Bruhl) Stapf. (86/00)	Bikh	Rananculaceae	Poisonous tuberous root.
38	*Delphinium sp.* (508/00)	Maure	Ranunculaceae	Dried roots are chewed as stimulant and are also valued as anti-toothache.
39	*Cotoneaster microphylla* Wall. ex Lindl. (88/00)		Rosaceae	Fruits are astringent and are frequently eaten by shepherds.
40	*Potentilla fulgens* Wall. Ex Hook. (93/00)	Bajradanti	Rosaceae	Dried roots are used as dentifrice.
41	*Prinsepia utilis* Royle (91/00)	Dhatelo	Rosaceae	Root bark is used for stomach disorder.
42	*Rubia manjith* Roxb. ex Flem. (97/00)	Majitho	Rubiaceae	Stem is used in snake and cobra bite.
43	*Skimmia anquetilia* G. Taylor &Air (210/00)	Narpati	Rutaceae	Leaf smoke is used for purifying air.
44	*Zanthoxylum sp.* (305/00)	Timur	Rutaceae	Fruit paste is given to kill roundworm.
45	*Osyris quadripartita* Salz. Ex Decne. (566/00)	Nundhiki	Santalaceae	Leaf infusion is valued as powerful emetic and use to treat swellings.
46	*Astilbe rivularis* Buch. – Ham. ex D. Don (559/00)	Thulookhati	Saxifragaceae	Rhizome juice is given to lower fever.
47	*Bergenia ciliata* (Haw.) Sternb. (557/00)	Pakhan Bed	Saxifragaceae	Root decoction for fever, diarrhoea etc.
48	*Smilax microphylla* Warb. (101/00)		Smilacaceae	Root decoction for venereal diseases.
49	*Symplocos paniculata* (Thunb.) Miq.190/00)	Kharane	Symplocaceae	Bark is used in menorrhoea.
50	*Taxus wallichiana* Zucc. (99/00)	Loth Salla	Taxaceae	Leaves juice for bronchitis, cancer.
51	*Valeriana hardwickii* Wall. (122/00)	Samayo	Valerianaceae	Dried stems used to provide protection to clothes from insects.

Table 2: Plants used as vegetable

S. No.	Name of Species (with voucher number)	Vernacular Name	Family
1	*Rhus javanica* L. (95/00)	Bhakiamilo	Anacardiaceae
2	*Rhus parviflora* Roxb. (94/00)	Sati Bayar	Anacardiaceae
3	*Diplazium* sp.(574/00)	Jire niuro	Athyriaceae
4	*Dioscerea* sp. (573/00)	Bhyakur	Dioscoreaceae
5	*Dryopteris cochleata* (D. Don) C. Chr. (300/00)	Gheu neuro	Dryopteridaceae
6	*Rhododendron arboreum* Sm. (89/00)	Lali gurans	Ericaceae
7	*Asparagus racemosus* Willd. (560/00)	Kurilo	Liliaceae
8	*Ophioglossum reticulatum* Hook. (206/00)	Jibre sag	Ophioglossaceae
9	*Arundinaria falcata* Nees. (572/00)	Nigalo	Poaceae
10	*Smilax aspera* L. (92/00)	Kukur daino	Smilacaceae
11	*Smilax microphylla* Warb. (101/00)	Kukur daino	Smilacaceae

Table 3: Plants used for ornamental purposes

S. No.	Name of Species (with voucher number)	Vernacular Name	Family
1	*Hydrangea sp.* (98/00)	Hans phul	Hydrangeaceae
2	*Habenaria pectinata* D. Don (96/00)	Sunpati	Orchidaceae
3	*Malaxis muscifera* (Lindl.) Kuntze. (100/00)	Sunpati	Orchidaceae
4	*Roscoea alpina* Royle (208/00)	Sunpati	Orchidaceae
5	*Rosa brunonii* Lindl. (303/00)	Ban Gulab	Rosaceae
6	*Rosa macrophylla* Lindl. (304/00)	Bhaise kanda	Rosaceae

Table 4: Plants used for construction, furniture and agricultural implements

S. No.	Name of Species (with voucher number)	Vernacular Name	Family
1	*Rhus javanica* L. (95/00)	Bhakiamilo	Anacardiaceae
2	*Ilex dipyrena* Wall. (202/00)	Lekh chutro	Aquifoliaceae
3	*Alnus nepalensis* D. Don (209/00)	Uttis	Betulaceae
4	*Alnus nitida* (Spach) Endl. (301/00)	Uttis	Betulaceae
5	*Betula utilis* D. Don (556/00)	Bhoj patra	Betulaceae
6	*Daphniphyllum himalense* (Benth.) Mull. (302/00)	Raktachandan	Daphniphyllaceae
7	*Lyonia ovalifolia* (Wall.) Drude. (113/00)	Anger	Ericaceae
8	*Rhododendron arboreum* Sm. (87/00)	Lali gurans	Ericaceae
9	*Lithocarpus sp.* (306/00)		Fagaceae
10	*Quercus sp.*(114/00)	Banjh	Fagaceae
11	*Aesculus indica (*Colebr. ex Cambess) Hook (563/00)	Pangro	Hippocastanaceae
12	*Engelhardia sp.* (203/00)	Mauwa	Juglandaceae
13	*Buddleja paniculata* Waqll. (204/00)	Bhimsen pati	Loganiaceae
14	*Myrica esculenta* Buch. –Ham. ex D. Don. (567/00)	Kafal	Myricaceae
15	*Abies spectabilis* (D. Don) Mirb. (571/00)	Bunge Salla	Pinaceae
16	*Tsuga dumosa* (D. Don) Eicher (111/00)	Thingre Salla	Pinaceae
17	*Schisandra grandiflora* (Wall.) Hook f. Thomson (115/00)	Thekifal	Schisandraceae
18	*Taxus wallichiana* Zucc. (99/00)	Loth Salla	Taxaceae

Table 5: Plants used for miscellaneous purposes

S. No.	Name of Species (with voucher number)	Vernacular Name	Family	Uses
1	*Gaultheria trichophylla* Royle. (106/00)	Kaligedi	Ericaceae	Edible fruits
2	*Bauhinia vahlii* Wight & Arn (102/00)	Bhorla	Fabaceae	Plate
3	*Gleichenia sp.* (108/00)	Hade uneu	Glecheinaceae	Thatching
4	*Engelhardia sp.* (203/00)	Mauwa	Juglandaceae	Fish poison
5	*Myrica esculenta* Buch. –Ham. ex D. Don. (567/00)	Kafal	Myricaceae	Edible fruits
6	*Arundinaria falcata* Nees. (572/00)	Nigalo	Poaceae	Baskets
7	*Clematis napaulensis* Dc. (553/00)	Junge lahara	Ranunculaceae	Ropes
8	*Rubus ellipticus* Sm. (90/00)	Aiselu	Rosaceae	Edible fruits
9	*Daphne bholua* Buch. – Ham. ex D. Don. (104/00)	Loktaa	Thymellaceae	Paper
10	*Girardinia diversifolia* (Link) Friis (107/00)	Allo	Urticaceae	Clothes

Conclusions

From this study it is concluded that KNP region is rich in indigenous and ethnobotanical knowledge and important for the scientific study with respect to ethnobotanical study. The diverse ecology, great natural beauty, vast wilderness, sprawling plateaus with green grass land, carpet of flowers full of medicinal herbs and teeming with wide varieties of flora and fauna deserve the attraction for researchers, tourists and other people. Wild plants have not only been used as food, vegetable and household items by the rural communities, but also been proven to be a source of income for the villagers. Mostly the wild plants are restricted to undisturbed and dense forests habitats. An obvious conclusion that can be drawn from the study is that the KNP is rich in wild plants and ethnobotanical knowledge. KNP has given benefits to the local inhabitants and has provided grazing rights to them for their livelihood improvements and enhancement of livestock and its products quality.

The traditional ethnobotanical knowledge has been shrunk due to popularity of allopathic treatment and transformation of rural people's life style. The existing deforestation and habitat fragmentation would pose a serious threat to the growth of wild plants. The declination of traditional ethnobotanical knowledge with over-exploitation and habitat destruction amounts to threatening in the survival of wild plant. Henceforth, documentation of traditional knowledge needs to be given high priority to help conservation of resources and preservation of the disappearing knowledge base. Indigenous knowledge is often complimentary to scientific knowledge; thus, by combining the ecological wisdom of the villagers with scientific knowledge (Millat-e-Mustafa *et al.* 2000), higher productivity of forest resources and sustainability of local approaches over local resources may be achieved without causing substantial environmental degradation. Special attention needs to be focused on highly priced and potential wild plants species like *Aconitum* sp, *Daphne bholuva, Dactylorrhiza hatagirea, Ligularia fischeri, Skimmia anquetilia, Taxus wallichiana,* etc. and multiple uses plants like *Myrica esculenta, Rhododendron arboreum, Rhus javanica, Taxus wallichiana, Asparagus racemosus* etc. ■

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Food habits of gaur (*Bos gaurus gaurus* Smith, 1827) and livestock (cows and buffaloes) in Parsa Wildlife Reserve, central Nepal

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Food habits of gaur (*Bos gaurus gaurus*) and livestock (cows and buffaloes) have been studied from January to June 1998 in Parsa Wildlife Reserve, Nepal. The study aimed to understand the diet composition and common plant used by gaur and livestock. Gaurs are both grazers and browsers. The diet of gaur comprised of 38 plant species (20 species of grass, 11 species of browse and 7 species of herb and others) and that of livestock comprised of 35 plant species (19 species of grass, 13 species of browse and 3 species of herb and others). A comparative analysis of plants consumption revealed that gaurs are less selective feeder than livestock. A total of 24 plant species (16 species of grass, 6 species of browse and 2 species of herb and others) were common in the diet of gaur and livestock. 7 species of plants (5 species of grass – *Cymbopogon* sp., *Imperata cylindrica*, *Phragmites karka*, *Themeda* sp., *Vetiveria zizanoides*; 1 species of browse – *Phaulopsis imbricata* and 1 species of herb – *Piper longum*) are comparatively more utilized by both gaur and livestock.

Key words: Gaur, *Bos gaurus gaurus,* food habits, livestock, common plants

Introduction

Habitat degradation and epidemic diseases like rinderpest and murrain, which spread through infected cattle grazing in the forest, are major threats for the survival of gaur's population in the wild (Schaller 1967, Prater 1971, Krishnan 1972). In Nepal, their population is isolated and they are surviving only in some parks, reserves and adjoining forest areas. It is reported that disease brought the declination in the population of gaur in 1960 (Gurung 1983) and in 1972 and 1973 (Tamang 1982). Most of the adjoining forest habitats are destroyed due to encroachments. As a result by the end of 1980, only 17.4% land of the Nepal remained forested, including low-quality shrubs forest (Dhungel and O'Gara 1991). The forest areas are reducing by 1.3% or 8300 ha annually (Forest Survey Division 1993). A good quality forest remains only in the protected areas. But most of the protected areas are surrounded by villages and in some cases villages lie within the protected areas. In some places, lack of public grazing lands in and around the villages forces the people to graze their livestock inside the protected areas, which instigates conflict between the livestock keepers and the wildlife managers. Koshi Tappu Wildlife Reserve in east Nepal is a good example of the problem (Heinen 1993). Wild and domestic animals that forage in the same habitat may have potential for food competition (Wegge 1976, Schaller 1977) and particularly gaurs are very sensitive to any anthropogenic disturbances.

Comparative studies on the food habits of gaur and livestock have been conducted in India by Shukla and Khare (1988), Srivastava *et al.* (1996). The food habits of gaur and livestock along with their comparison in Parsa Wildlife Reserve (PWR) have been provided in this paper.

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Study area

PWR is located at 84°41'-84°58'E, 27°15'-27°33'N in central lowland Nepal. Spread over 499 km², it was established in 1984 by the government of Nepal under Department of National Parks and Wildlife Conservation. PWR lies between the altitude ranges of 100-950 masl. It is surrounded by four districts: Chitwan, Makwanpur, Parsa and Bara. PWR adjoins Royal Chitwan National Park (RCNP) to the west, and forms a biological corridor. The present study area spans over the Tarai and the Churia foothills (approx. 13.1 km², elevation 250-450 masl). Four small villages exist inside the PWR – two in the southern side of the Churia hills (Rambhori and Bhata) and two in the Inner Tarai along the Rapti river (Ramouli and Pratappur). The people in these four villages rear a large number of livestock, which graze inside the reserve. Besides the villagers, illegal settlers as herders (*Gothalas*) also herd large number of livestock from the adjoining villages.

The climate is sub-tropical. The vegetation in the study areas exhibits sub-tropical ranging from early successional stages on the dry riverbeds and floodplains with colonizing *Saccharum spontaneum*, *Imperata cylindrica* to a mature climax type of sal (*Shorea robusta*) forest on the upper dry lands. As altitude increases in the north along the Churia hills, the sal forest is gradually replaced by pine (*Pinus roxburghii*) forest. The complexity of the Churia landscape supports a high level of biotic diversity including Asiatic elephants (*Elephas maximus*), Bengal tigers (*Panthera tigris*), leopard (*Panthera pardus*), wild dog (*Cuon alpinus*), striped hyaena (*Hyaena hyaena*), sloth bear (*Melursus ursinus*), four-horned antelope (*Tetraceros*

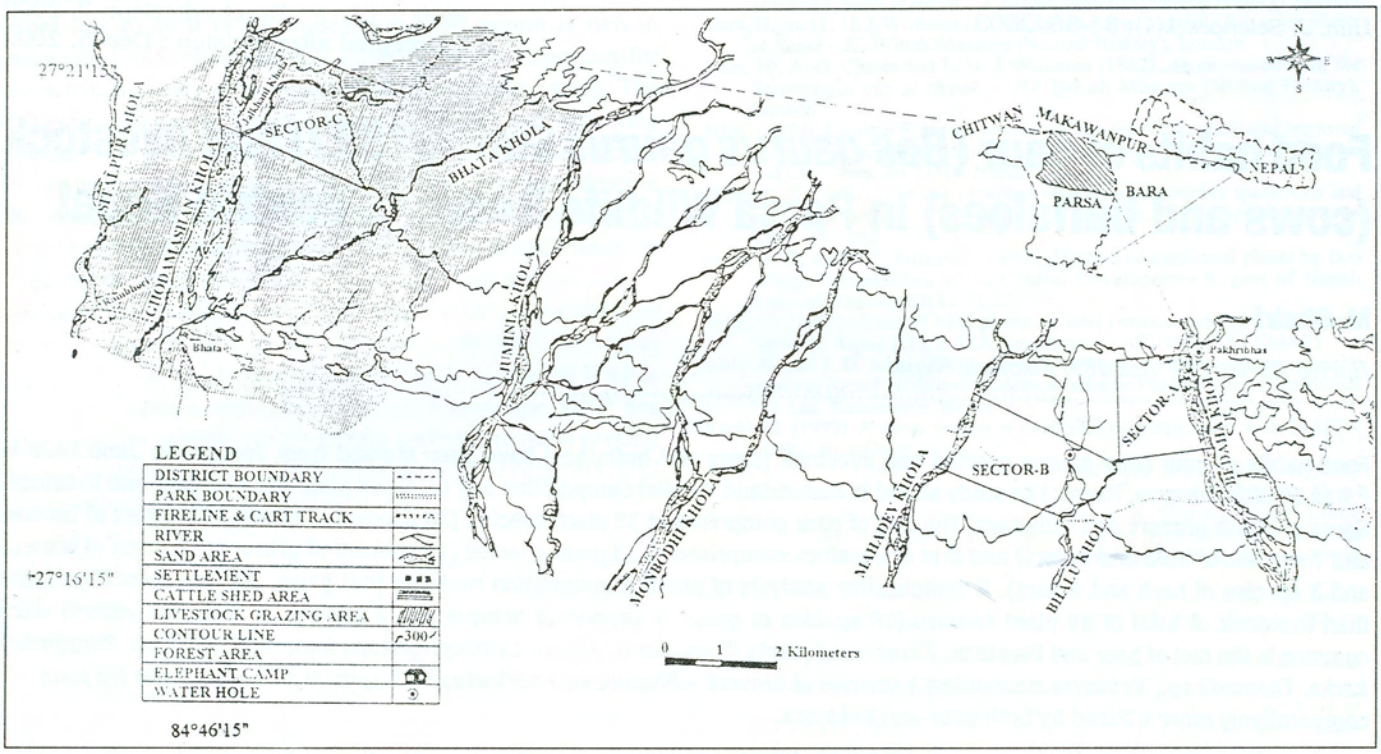

Figure 1: Map of the study area showing location and distribution of water hole used by gaur

quadricornis), barking deer (*Muntiacus muntjak*), spotted deer (*Axis axis*), sambar deer (*Cervus unicolor*), wild boar (*Sus scrofa*) and rich variety of reptiles and forest birds.

Materials and methods

To find out the major areas of gaur in PWR, two preliminary field surveys were conducted during November and December 1997. The field survey was conducted on foot, on the back of domestic elephants and occasionally by vehicles.

In the gaur inhabiting areas direct observation was done by various means ranging from walking on foot to using elephants and trees and *machans* (raised platform constructed in the trees for viewing). Observations were mainly done during the early morning and in the evening. When the animal was sighted with the help of binoculars they were observed undisturbed. The feeding site was visited immediately as soon as the animal left the area to record the number of plant species consumed. The plant species consumed were ranked into high, medium and low preference as follows: high = feeding frequency >20/ species/day, medium = feeding frequency 11-20/species/day, low = feeding frequency 1-10/species/day. Indirect observations based on fresh signs of plants recently eaten such as exudation of sap, crushed tissues and fresh clippings as mentioned by Jarman (1971) and Koirala and Shrestha (1997) were also made. The plant species utilized by the animals were categorized into three groups - grass (plants of grass families), browse (all woody plants) and herb and others (broad leaved herbaceous plants, pteridophytes and fruits). Based on direct sighting of feeding animals and Rapid Rural Appraisal (RRA), the plant species consumed by livestock (cows and buffaloes) during May was recorded. The plant species eaten by the livestock were categorized according to their preference similar to the gaurs' diet. Herbarium sheets of all food plant species consumed by gaur and livestock were prepared and brought to the Central Department of Botany, Tribhuvan University (T.U.) for identification and further authentication. For the comparison of diet composition of the gaur during May, microfecal analysis done by Chetri (1999) was utilized.

Results and discussion

Food and food habits of gaur

Field observation revealed that gaur consumes a total of 36 plants species (12 species of grass, 16 species of browse and 8 species of herb and others) (Table 1). Schaller (1967) recorded 40 plant species consumed by gaur through direct observations in the Kanha National Park, India during late March to early June and Shukla & Khare (1998) recorded 45 plant species through direct observations in the Pench Wildlife Reserve, central India. In this study, low numbers of plant species were recorded through direct observation, which was probably due to short study period and availability of plant species. Some of the food species recorded from Kanha National Park and Pench Wildlife Reserve (Schaller 1967; Shukla & Khare 1998) were not recorded in PWR (Chaudhary 1995).

The grass *Cymbopogon* sp., *Phragmites karka* and *Themeda* sp. were observed most frequently consumed by the animals and that ranked high preference during all the months from January to June. *Imperata cylindrica* and *Sacchrum spontaneum* also received the highest preference from March to June. Shukla & Khare (1988) also reported *Themeda triandra, Themeda quadrivalis* and *Saccharum spontaneum* as the main grass species in the diet of gaur in the Pench Wildlife Reserve, India. The browse species *Phaulopsis imbricata* and *Wendlandia*

exserta were observed most frequently consumed by the animals. This is mainly due to the abundance of these species in the foothills of the study area. Study conducted elsewhere does not record these species in the diet of gaur (for e.g., Schaller 1967, Krishnan 1972, Shukla and Khare 1988, Srivastava *et al.*1989). The discrepancy is probably related to different vegetation composition of the habitats. From January to April, animals were observed extensively browsing on leaves of *Dendrocalamus strictus*. Schaller (1967) and Krishnan (1972) have also recorded *Dendrocalamus* sp. in the diet of gaur. Among herb and others, *Asparagus racemosus* was the most preferred species and ranked high preference during April and May due to the availability of new shoots which sprout after the forest fire. This species is scarce in the foothills and distributed more at the edge and in the southern part of the foothills. Schaller (1967) has also recorded *Asparagus racemosus* in the diet of gaur in Kanha National Park.

Plate 1 : A herd of gaur in the dry river belt of mixed deciduous riverine forest

In this study, in comparison to grass species (12 species), higher number of browse species (16 species) is recorded. Mostly the animals are either observed in the foothills or at the edge feeding on browse species in the northern part of the Inner Khola and Bhalu Khola areas. These areas are criss-cross by numerous foothills and gullies, where the grass species are either scarce or patchy distributed only near the water sources and on the open canopy gaps. The highest number of plant species during March and April (25 and 24 species respectively) is due to high visibility. During these months, shortage of food and water in the foothills forces the animals down at low altitudes. They can be readily seen in the Inner Khola, Bhedaha Khola, Kaminidaha and Pakhribas areas of the reserve.

Food and food habits of livestock

Field observation revealed a total of 18 plant species (11 species of grass, 5 species of browse and 2 species of herb and others) are consumed by livestock during the month of May (Table 1). The result showed that livestock generally prefer the new shoots of grass during the month of May. Kirby & Parman (1986) also found that the selection of grass by cattle was significantly greater in summer when compared to the early fall grazing period. A total of 8 species (7 species of grass – *Cymbopogon* sp., *Cynodon dactylon*, *Eleusine indica*, *Imperata cylindrica*, *Phragmites karka, Themeda* sp., *Vetiveria zizanoides* and *Tysanolaena maxima* and 1 species of browse – *Phaulopsis imbricata)* are found highly preferred by livestock.

Food habits: gaur vs. livestock

The pooled data from microfecal analysis, RRA and field observation revealed that a total of 38 plant species (20 species of grass, 11 species of browse and 7 species of herb and others) are consumed by gaur, whereas livestock consumes only 35 plant species (19 species of grass, 13 species of browse and 3 species of herb and others) in May (Annex 1). The consumption of plant species as food by gaur and livestock is much less in comparison to the availability of food plants. A total of 333 plants species were recorded from PWR (Chaudhary 1995). This may be due to short study period. Comparison between gaur and livestock revealed that gaur exploits more plants and are less selective in diet selection than the livestock. A comparative checklist of the food plants of gaur and livestock during May (Annex 1) revealed that 24 plant species (16 grasses, 6 browse and 2 herb and others) are commonly utilized. Shukla & Khare (1988) reported from direct observation that gaur and livestock in the Pench Wildlife Reserve commonly utilize 12 grass species during 1987 to 1989. Srivastava *et al.* (1996) from microfecal analysis reported that gaur and livestock in the Periyar Tiger Reserve commonly utilize 12 grass species in winter. 7 species (5 species of grass – *Cymbopogon* sp., *Imperata cylindrica, Phragmites karka, Themeda* sp., *Vetiveria zizanoides*, 1 species of browse – *Phaulopsis imbricata* and 1 species of herb – *Piper longum*) are highly exploited by both gaur and livestock. Srivastava *et al.* (1996) reported 30.4% diet overlap between gaur and livestock in the Periyar Tiger Reserve. Though the diet overlap percentage was not estimated in this study, the percentage contribution would be definitely higher because a high density of cattle (132/km^2) and buffalo (7/km^2) were recorded grazing in the gaur habitat (Chetri 1999). Livestock are selective feeders, and overgrazing results in the suppression and eventual elimination of the preferred species, creating a less productive vegetation composition. Excessive livestock grazing during summer may also limit forage availability during winter for the wild ungulates if they do not move out of the area (Koirala & Shrestha 1997). It will also increase the chances

Table 1. List of plant species preferred by gaur from January to June and livestock during May in Parsa Wildlife Reserve

Plant species	Gaur				Livestock		
	Months (January -June)				Month (May)		
	Jan.	Feb.	Mar.	Apr.	May	Jun.	
Grass							
Apluda sp.	**	**	***	***	-	-	-
Cymbopogon microtheca (Hook. F.) A. Camus	-	-	*	*	*	-	-
Cymbopogon sp.	***	***	***	***	***	***	***
Cynodon dactylon (L.) Pers.	-	*	*	-	-	-	***
Dendrocalamus strictus Ness	***	***	***	***	-	-	**
Eleusine indica (L.) Gaetrn							***
Erianthus ravennae (L.) P. Beauv.							**
Imperata cylindrica (L.) P. Beauv.	**	**	***	***	***	***	***
Panicum paludosum Roxb.	-	-	-	**	**	-	-
Phragmites karka (Retz.) Trin ex Steud.	***	***	***	***	***	***	***
Saccharum spontaneum L.	**	**	***	***	***	***	*
Setaria glauca (L.) P. Beauv.	-	-	-	*	*	-	**
Themeda sp.	***	***	***	***	***	***	-
Thysanolaena maxima (Roxb.) Kuntze.	-	-	-	-	-	-	***
Vetiveria zizanoides (L.) Nash	-	-	-	***	***	-	***
Browse							
Albizia sp.					*		-
Bombax ceiba		*					-
Colebrookea oppositifolia Sm.	-	**	**	**	-	-	*
Fiscus semicordata Buch.-Ham.ex Sm.	-		*	-	-	-	-
Garuga pinnata Roxb	-	-	-	*	*	-	*
Nyctanthes arbor-tristis L.		**	**				*
Phaulopsis imbricata (Forssk.) Sweet	***	***	***	***	***	***	***
Randia sp.	-	*	*	-	-	-	-
Shorea robusta Gaertn.	-	-	**	**	**	-	-
Sterculia villosa Roxb.	-	-	-	*	*	-	-
• *Tharotherthere*	***	***	***	***	-	-	-
Thespesia lampus (Cav.) Dalz. & Gibs.	***	***	***	**	-	-	**
Trema orientalis (L.) Bl.			*				-
Urena lobata L.	**	**	-	-	*	-	-
Viscum album L.	-	-	***	***	-	-	-
Wendlandia exserta (Roxb.) DC.	***	***	***	**	**	*	-
Herb and Others							
Asparagus racemosus Willd.	**	**	**	***	***	**	-
• *Banspate*					*		-
Ipomoea hederifolia L.	***	***	***	***			-
Phoenix humilis Royle.					*	*	*
Piper longum L.			***	***	***		-
Reinwardtia indica Durmortier	-	-	*	-	-	-	-
Sida rhombifolia L.	***	***	*	*			*
Smilax ovalifolia Roxb. ex D. Don					*		-

Note: Preference level: * = high (feeding frequency >20/species /day), ** = medium (feeding frequency 11- 20/species/ day), * = low (feeding frequency 1-10/ species/day) • = local name**

Annex 1. Checklist of the plant species and their parts utilized by gaur and livestock during May in Parsa Wildlife Reserve

Species utilized by gaur	Parts eaten	Species utilized by livestock	Parts eaten
Grass		**Grass**	
Apluda sp.	Leaves, shoots	*Apluda* sp.	Shoots
**Cymbopogon microtheca* (Hoof. f.) A. Camus	Leaves, shoots	*Cymbopogon microtheca* (Hoof.f.) A. Camus	Leaves, shoots
**Cymbopogon* sp.	Leaves, shoots	**Cymbopogon* sp.	Shoots
Cynodon dactylon (L.) D. Don	Whole plants	**Cynodon dactylon* (L.) D. Don	Whole plants
Cynotis cristata (L.) D. Don	Leaves	*Cynotis cristata* (L.) D. Don	-
Cyperus exaltatus Retz.	Leaves	*Cyperus exaltatus* Retz.	-
Dendrocalamus strictus Ness	Leaves	**Dendrocalamus strictus* Ness	Leaves
Eleusine indica	-	**Eleusine indica* (L.) Gaetrn	Whole plants
Erianthus ravennae (L.) P. Beauv.	-	**Erianthus ravennae* (L.) P. Beauv.	Leaves, shoots
Fimbristylis miliaceae (L.) Vahl	-	*Fimbristylis miliaceae* (L.) Vahl	Shoots
**Imperata cylindrica* (L.) P. Beauv.	Leaves, shoots	**Imperata cylindrica* (L.) P. Beauv.	Shoots
**Panicum paludosum* Roxb.	Leaves, shoots	*Panicum paludosum* Roxb.	Leaves, shoots
**Phragmites karka* (Retz.) Trin ex Steud.	Leaves, shoots	**Phragmites karka* (Retz.) Trin ex Steud.	Leaves, shoots
**Saccharum spontaneum* L.	Leaves, shoots	**Saccharum spontaneum* L.	Shoots
**Setaria glauca* (L.) P. Beauv.	Whole plants	**Setaria glauca* (L.) P. Beauv.	Whole plants
**Themeda* sp.	Leaves, shoots	*Themeda* sp.	Shoots
**Vetiveria zizanoides* (L.) Nash	Leaves, shoots	**Vetiveria zizanoides* (L.) Nash	Shoots
Leersia hexandra Sw.	Leaves	*Leersia hexandra* Sw.	-
Oplimenus compositus (L.) P. Beauv.	Leaves	*Oplimenus compositus* (L.) P. Beauv.	Whole plants
Oplismenus burmanii (Retz.) P. Beauv.	Leaves	*Oplismenus burmanii* (Retz.) P. Beauv.	Leaves, shoots
Paspalidium punctatum (Burm.) A. Camus	Leaves	*Paspalidium punctatum* (Burm.) A. Camus	Leaves, shoots
Paspalum scrobiculatum L.	Leaves	*Paspalum scrobiculatum* L.	-
Thysanolaena maxima (Roxb.) Kuntze.	Leaves	**Thysanolaena maxima* (Roxb.) Kuntze.	Leaves
Browse		**Browse**	
**Albizia* sp.	Leaves, shoots	*Albizia* sp.	-
Bauhinia purpurea L.	-	*Bauhinia purpurea* L.	Leaves, shoots
Bauhinia vahlii Wight & Arn.	-	*Bauhinia vahlii* Wight & Arn.	Leaves, shoots
Colebrookea oppositifolia Sm.	Leaves, stems, shoots	**Colebrookea oppositifolia* Sm.	Leaves, shoots
Ficus hispida L.f.	-	*Ficus hispida* L.f.	Leaves, shoots
Ficus racemosa L.	-	*Ficus racemosa* L.	Leaves
Ficus semicordata Buch.-Ham.ex Sm.	-	*Ficus semicordata* Buch.-Ham.ex Sm.	Leaves, shoots
Gmelina arborea Roxb.	-	*Gmelina arborea* Roxb.	Leaves, shoots
**Garuga pinnata* Roxb.	Leaves, shoots	**Garuga pinnata* Roxb.	Leaves, shoots
Litsea monopetala (Roxb.) Pers.	-	*Litsea monopetala* (Roxb.) Pers.	Leaves, shoots
Nyctanthes arbor-tristis L.	Leaves	**Nyctanthes arbor-tristis* L.	Leaves
**Phaulopsis imbricata* (Forssk.) Sweet	Leaves, stems, shoots	**Phaulopsis imbricata* (Forssk.) Sweet	Leaves, stems, shoots
**Shorea robusta* Gaertn.	Leaves, shoots	*Shorea robusta* Gaertn.	-
**Stericulia villosa* Roxb.	Leaves, shoots	*Stericulia villosa* Roxb.	-
Thespesia lampus (Cav.) Dalz & Gibs.	Leaves, stems	**Thespesia lampus* (Cav.) Dalz & Gibs.	Leaves, shoots
**Urena lobata* L.	Leaves, shoots	*Urena lobata* L.	-
Viscum album L.	Leaves	*Viscum album* L.	-
**Wendlandia exserta* (Roxb.) DC.	Leaves, stems, shoots	*Wendlandia exserta* (Roxb.) DC.	Leaves, shoots

Herb and Others			
Amaranthus spinosus L.	Leaves	*Amaranthus spinosus* L.	-
**Asparagus racemosus* Willd.	Shoots	*Asparagus racemosus* Willd.	-
••*Banspate*	Shoots	• *Banspate*	-
Equisetum sp.	Leaves	*Equisetum* sp.	-
**Phoenix humilis* Royle	Shoots	* *Phoenix humilis* Royle	Shoots
**Piper longum* L.	Whole plants	*Piper longum* L.	Whole plants
Sida rhombifolia L.	-	**Sida rhombifolia* L.	Leaves, shoots
**Smilax ovalifolia* Roxb. ex. D. Don	Shoots	*Smilax ovalifolia* Roxb. ex. D. Don	-

Note: * = plant species obtained from direct observation, Unmarked = plant species obtained from microfecal analysis in case of gaur and from RRA in case of livestock, • = Local name

of transmitting epidemic diseases like rinderpest and murrain, which took a heavy toll of gaur population throughout its range (Schaller 1967, Prater 1971, Krishnan 1972, Brander 1982, Tamang 1982, Gurung 1983, Tikadar 1983, Ranjitsinh 1991). Besides, heavy grazing of large-bodied herbivores also decreases the nutrient cycling and succession, changes community organization, and causes loss of biodiversity (Fleischner 1994).

During summer the gaur might migrate towards the northeastern side because of the abundant food plants and water. Moreover according to the villagers of Rambhori and Bhata villages, gaur annually visit in an around Bhata area during March, April and May. If this is true, food interaction between gaur and livestock during June to February will not occur in the areas where villagers' livestock graze. But the illegal herders herd their livestock throughout the year in the slope of the Churia foothills and there is a chance of interaction between gaur and livestock. While facilitation or competition between gaur and livestock needs further investigation, a risk of transmitting cattle borne epidemic diseases like rinderpest and murrain, which may directly affect their survival and distribution, is always there (Chetri & Basnet 2001). ■

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On the distribution and status of Tibetan argali, *Ovis ammon hodgsoni* Blyth, 1841 in Nepal

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A team of biologists observed 24 argalis in 4 herds in a biodiversity survey of the upper Mustang region in Chhojung and Damodarkund areas. The Tibetan argalis utilize smooth slopes with low bushes and herbage at lower elevation and the alpine meadows at higher elevation in the Chhojung region. In the upper Damodarkund area at >5200m, the argali occupy the Tibetan desert steppe characterized by desolate plains and low undulating sand hills. In this desert terrain, very little food is available mostly in the form of xerophytic herbs. Anthropogenic activities have negative impacts on the argalis and their habitats. Therefore, *in-situ* conservation of this Trans-Himalayan species is urgent.

Key words: Tibetan argali, *Ovis ammon hodgsoni,* sheep, habitat, Damodarkund, Nepal

Introduction

The Nayan or Great Tibetan sheep or Tibetan argali, *Ovis ammon hodgsoni* Blyth, 1841 (Mammalia: Artiodactyla: Bovidae) is the largest of all living wild sheep, some rams exceeding a shoulder height of 110cm and body mass 100kg (Prater 1971, Schaller 1998). This true sheep is a close relative of the well-known Marco polo sheep, *Ovis ammon polii,* but with somewhat shorter and more massive horns (Fox *et al.* 1991b). It occurs in herds of 3-15 individuals at elevation of 3700m or above (Chakraborty 1994). Except during the rut adult rams tends to form separate male herds (Schaller 1998). It is adapted to open terrain, to escape danger through fleetness. Its typical habitat presents a wilderness of desolate plains and low undulating sand hills (Prater 1971). In summer, it moves to higher levels and descends to lower valleys during winter. It feeds on grasses, flowers, and young plants and leaves (Walker 1964).

The Tibetan argali is by far the rarest member of its wild ungulate community. Of the six subspecies of *Ovis ammon* recognized by Geist (1991), this subspecies is so far the only one listed as endangered (Schaller 1998). It is legally protected from killing by inclusion in HMG Nepal's National Parks and wildlife Conservation Act, 1973. Insufficiently known (IK) category in the Red Data Book and banned from trade by inclusion in Appendix I of Convention on International Trade in Endangered Species of wild Flora and Fauna (CITES).

The Tibetan argali occurs in India (Ladakh, Spiti and Lahul and Sikkim), western Bhutan, China and Nepal (Gee 1967, Prater 1971, Schaller 1977 and 1998, Fox *et al.* 1991a). Although Tibetan argalis were once fairly common in some of their distribution range in Nepal (Schaller 1977), it had been recorded in the high mountainous regions of Mugu, Dolpa, Gorkha, Sankhuwàsabha, Rasuwa and Mustang districts (Mitchell and Punzo 1976, Schaller 1977, BCDP/ KMTNC 1994, Koirala and Shrestha 1997). A Tibetan argali ram trophy procurred from an unknown locality in Nepal still can be seen in the Kesharmahal, Kathmandu. It is said to be there since more than 100 years.

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Materials and methods

Information presented in this paper are partly based on the literature pertain to the previous records of the species in Nepal made by various authors and partly on the field observations made by the author. The author had visited the localities of previous records of this sheep (for e.g., Mitchell and Punzo 1976, Schaller 1977, Koirala and Shrestha 1997, Shah 1985, 1986, 2001, Shah and Giri 1992, KMTNC 1998). In addition, information were collected through the interviews with local villagers as well as by visiting potential habitats of the species.

Results and discussion

All locality records of Tibetan argali in Nepal made by various authors including recent sightings have been presented in the Table- 1. Besides these, unsubstantiated reports of this species in Nepal exist from the northern regions (Gray 1846), northeastern Nepal (Hooker 1854), northern borders areas of Nepal (Ellerman and Morrison-Scott 1966, Prater 1971). Earlier reports by Hodgson in Gray (1846) listed 4 skulls of this sheep as being collected from the northern regions of Nepal is difficult to discern the validity of these records since Hodgson was confined to the capital city of Kathmandu and had to depend on traders for his specimens (Mitchell and Punzo 1976). Prater (1971) opined that in quest of grazing the sheep occasionally cross into Nepal from the plateau of Tibet (China). It is true that some Tibetan population of the sheep may occasionally cross into Nepal due to either presence of similar habitats or more disturbances and scarcity of food in Tibetan sides. However, resident populations such as found in Mustang district also occur in Nepal.

In fact, except in the Trans-Himalayan region of Mustang district (i.e. upper Mustang area), nowadays no Tibetan argali

is found in any other localities mentioned by the previous authors in Nepal. The usual reply by the local inhabitants to this author's query about the occurrence of the sheep in Mugu, Dolpa, Sankhuwasabha and Gorkha districts was negative as they had disappeared 3-4 decades ago.

Schaller (1977) saw several skulls and was informed by villagers around Shey Gompa and upstream of Namdo in Dolpa district that though they were once fairly common. The author observed a weathered skull of an adult ram kept on the roof of a house in Mugu village in 1985. The owner of the house said that his father bought the skull some 30-40 years before from Tibet. All respondents from the village believed that Tibetan argali had disappeared 3-4 decades ago.

The author conducted a wildlife survey of Manaslu area of Gorkha district (KMTNC 1998) including the Chum Gompa area, where the sheep had been reported by Mitchell and Punzo (1976). Although the areas still have suitable argali habitat of alpine meadows, but they are no longer in existence. In fact, according to the local informants including the highland grazers argalis do not occur in any part of the Manaslu area.

Koirala and Shrestha (1997) observed 10 individuals (females and juveniles) in the Damodarkund valley, studied their food ecology and compared it with that of the blue sheep, *Pseudois nayaur* and domestic goat *Capra sp.* They found no apparent food competition during the summer between the three ungulates due to spatial separation and little dietary overlap. However, they opined if densities should increase with more overlap in habitat use, blue sheep was expected to compete more with goat and argali for food because of more similar foraging regimes than between goat and argali. While conducting biodiversity survey of the upper Mustang region, a team led by this author also observed the argali, in Chhojung (Shah 2001) and Damodarkund valley (Shah 2002). The team also found that the argali populations in these areas are not spatially separated from the local sheep, goats, horses and other livestock.

Table 1: Distribution of Tibetan argali in Nepal

Previous	-	Mugu, Dolpa, Gorkha, Rasuwa and Sankhuwasabha
Recent	-	Mustang

In June 2001, an adult ram was seen at 4900m in Chhujung, besides a skull of adult ram probably killed by a snow leopard was observed in the vicinity of Chhojung Gompa at 3900m. The survey team also observed argali's droppings (pellets) and tracks at least at the 4-5 places along the Chhojung khola, where they seemed to have visited for salt licking. The valley has large natural salt deposits between 3700m-3900m. According to the local nomad herders at least two populations of moderate size exist in the Chhojung area.

Plate 1 : A female heard of the argali disturbed by the photographer at 5540m in Damodarkund area, Mustang

In July 2002, 23 argalis in 3 herds (herd size 4, 9 and 10) were observed in the Damodarkund valley between 5200-5600m. The herds with 9 and 10 individuals (Plate-1) contain females and young, while the third herd with 4 individuals consisted of adult males only. All 3 herds were observed feeding, resting, moving and also running due to the disturbances caused by the observers on Tibetan desert steppe habitat. Skulls are useful indicators of abundance, at least of abundance in the recent past (Schaller 1998). Five weatherworn skulls (Plate- 2) of 3 adult rams and 2 adult females were observed in the premises of the both "Dharmasala" (i.e. rest house) situated between the main holy ponds at 5000m. It seems the local herders, pilgrims; previous researchers and hunters had bought these skulls from other parts of the valley for different purposes. Because of their heavy weight, it can be assumed that the skulls must have been collected from nearby localities within the valley. Presence of the argali skulls in the lower parts of the Damodarkund valley also indicates that the animals move seasonally to lower elevation, especially when local sheep and goat grazing do not take place. The team did not see the argali within the Namta khola valley, where Wegge, Shrestha and Koirala observed them in 1996 (DNPWC 1996).

These days Tibetan argali in Nepal is only confined to the Trans-Himalayan region of the Mustang district. A few populations of moderate size exist in the Chhojung and Damodarkund areas the upper parts of the district. It seems they have discontinuous distribution in the area. These areas lie

Plate 2 : Local herder with a Tibetan argali's (ram more than 7 years old) skull in Damodarkund, Mustang

on the north-eastside of the Kaligandaki river (Map-1). A vast land having alpine grass and bushes, alpine meadows and Tibetan desert steppe habitats connects both the areas to each other. These habitats are also characterized by the presence of flat lands, smooth slopes, undulating hills, and moderate to deep gullies and ravines. Based on the interviews with the local inhabitants, especially the herders, the team's observation and availability of the suitable habitats it is concluded that only about 70-90 Tibetan argalis occur in the area. Other ungulates sympatric with the argali in the areas are blue sheep *Pseudois nayaur*, Tibetan gazelle *Procapra picticaudata* and Tibetan wild ass (kiang) *Equus hemionus kiang*.

The Tibetan argalis occur in two distinctly separate habitats in the upper Mustang area. They utilize the smooth slopes with low bushes and herbage at the lower elevation and rolling hills covered by the alpine meadows at the higher elevation in the Chhojung region (Plate- 3). These habitats are more or less similar to the argali habitats found elsewhere in Nepal as mentioned in the old records by the previous authors. In the upper Damodarkund area at >5200m, the argali occupy the Tibetan desert steppe characterized by the desolate plains and low undulating sand hills. In this desert terrain, very little food is available mostly in the form of xerophytic herbs. Therefore, the argali also enters into the shallow gullies (Plate- 4) and deep ravines, some of which hold trickling streams, where banks are covered with grasses and herbs. This type of habitat in the Damodarkund area is ecologically separated from the alpine meadows of the lower elevation at <5200m.

The argali prefers alpine meadows habitat to Tibetan desert steppe habitat Schaller (1998). The alpine meadows covered habitat of lower Damodarkund valley at <5200m including the area having holy ponds is definitely a favorable habitat for the argali. But, they abandon the area during the livestock-grazing period due to disturbances. However, the blue sheep *Pseudois nayaur*, seems to have developed some tolerance against these disturbances and some still use the area with sheep, goats and horses.

The Tibetan argali once found in some northern Himalayan regions of the country is now confined only to the Trans-Himalayan part of the Mustang district. The exact reasons for their disappearance from their known distribution in Nepal are unknown. According to Schaller (1998) the animals have a relatively short life, seldom reaching 10 years, as shown by the age rings of horns of rams found in the field. Hunting could be one of the factors, but not the major one. Tibetan argali is much sought after for its flesh, pelt and horns. Its flesh said to be excellent and coat is most effective against cold. According to the local informants every year at the advent of the winter Chinese hunters visit the Damodarkund area on the horseback and hunt indiscriminately through the sophisticated arms. They include Tibetan argali, blue sheep and kiangs as main targeted species. The local tribesmen are also excellent hunters and some of they hunt for their subsistence.

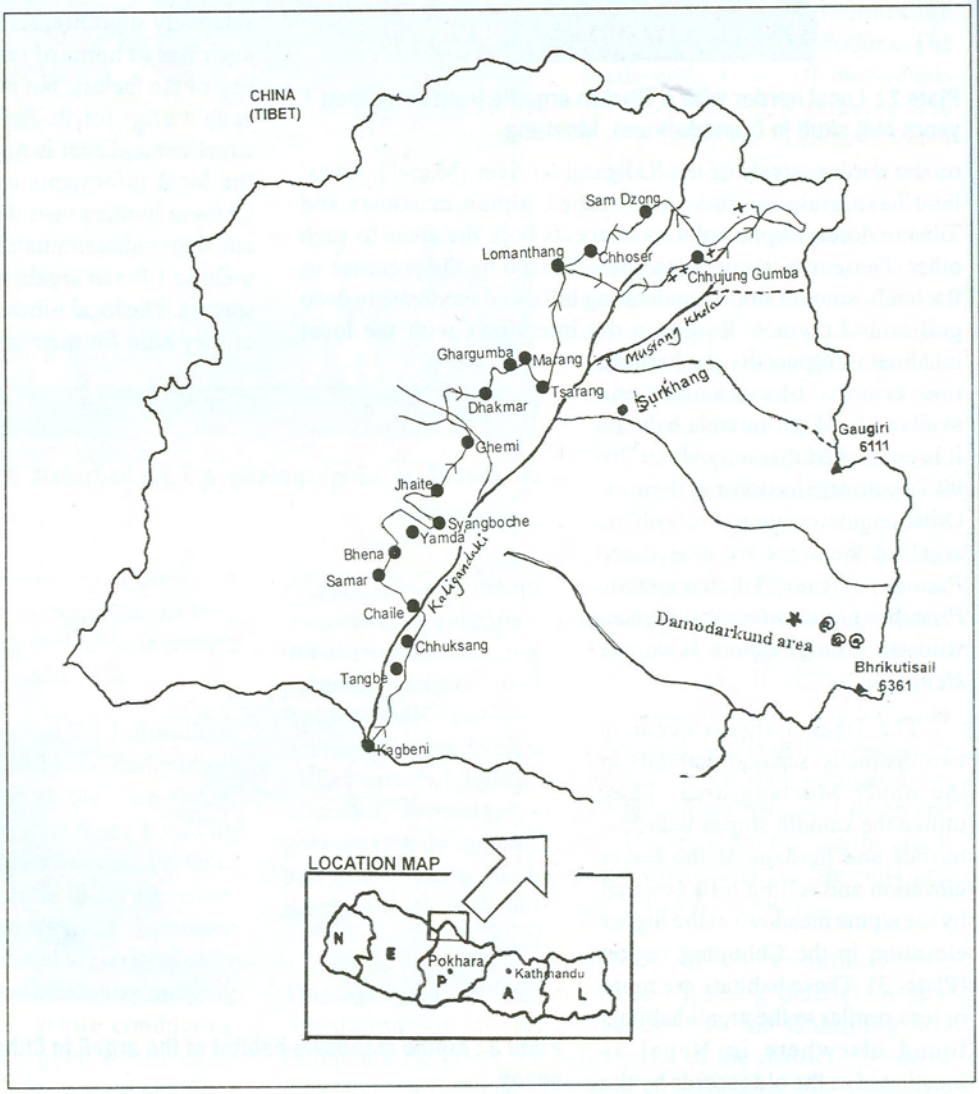
Plate 3 : Alpine meadows habitat of the argali in Chhojung. Note the grazing yaks and blue sheep

Plate 4 : Typical Tibetan desert steppe habitat of the argali in upper Damodarkunda area at 5560 m

Herders from China and Nepal, extensively use all potential argali habitats for livestock grazing. Possibly diseases transmitted from the domestic stock might have added fuel to the fire. Diseases transmitted by livestock could also have had a serious impact, as they have on North American sheep (Lawson and Johnson 1982), but no research has been done. Besides, spreading diseases the domestic stock also causes food shortage. Small, isolated sheep populations are highly vulnerable to genetic and environmental mishaps, especially if they number fewer than 50 individuals (Berger 1990). Living at the age of their range at low densities in an area where snowfall can be heavy, it is possible that the populations were decimated by several severe winters coupled with snow leopard and wolf depredation. The wolf is found to be principal predator of the Tibetan argali in Tibet, China (Schaller 1998).

The Tibetan argali has great scientific interest and potential values. Origin of domestic sheep is still unknown, and perhaps they have derived from one or more species of *Ovis* (Walker 1964). Thus, Tibetan argali may be one of the ancestors of the domestic sheep.

It is a globally protected species. Except for about 200 animals in Ladakh and a few in Nepal (70-90) and Sikkim, all Tibetan argalis, about 7000 individuals (Schaller 1998) are within China. Most populations are so small and fragmented that many will vanish in the coming decades (Schaller 1998). Contrary to Koirala and Shrestha (1997), the Mustang populations of the argali



Map 1 : Recent citings of Tibetan argali in Nepal

Koirala and Shrestha (1997)*
Shah (2001) +
Shah (2002)@

are not spatially separated from the local livestock, which causes several threats to their survival. Therefore, urgency for the in situ conservation of this Trans-Himalayan species is warranted. ■

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Vegetation and prominent flora from Begnash Tal to Tara Hill, Annapurna Conversation Area Project, Kaski district

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An investigation of vegetation and prominent flora from Begnash to Tara Hill (a very popular trekking route of Annapurna Conservation Area) was carried out. The vegetation is exposed to different levels of human-induced disturbances. The route followed ascends gradually from Begnas passing through different vegetated areas. The altitude of the study area ranges from 1000 to 3000 masl. The vegetation of the study area comprises different types of forests such as hill sal (*Shoresa robusta*), *Schima-Castanopsis*, alder, lower temperate mixed broad leaved forest, oak, upper temperate – mixed broad-leaved, *Rhododendron*, *Betula utilis*, pine and juniper and arid bushes. *Schima wallichii, Castanopsis indica, Quercus semecarpifolia, Rhododendron arboreum, Ilex dipyrena, Pandanus nepalensis, Daphne bholua, Lithocarpus pachyphylla, Pterocarpus santalinus, etc.* are the prominent flora of the study area.

Key words: Conservation, broad leaved forest, human disturbances, trekking route, vegetation study

Introduction

Vegetation structure of any forest is determined by the complex array of environmental factors, including topography, aspect and soil besides human interference (Visalakshi 1992). Soil, rainfall, altitude and other aspects are the most important factors that reflect the vegetation distribution of any area. Because these factors vary greatly throughout the country, Nepal has different types of vegetation. The variations in the climate, soil and altitude are responsible for the range of natural vegetation in the country (Chaudhary 1999). Higher plants, with tall vegetation found in Nepal are manifested by some 35 types of forests (Stainton 1972) constituted in different bio-climatic zones from tropical to sub-alpine region. Such altitudinal differences and complexity in physiography provide habitat to grow, evolve and establish diverse plant species creating distinct ecological units in the natural environment.

Population growth in the context of a traditional agrarian technology is forcing farmers on to ever-steeper slopes, slopes unfit for sustained farming even with astonishing elaborate terracing practiced there. Meanwhile, villagers must roam farther and farther from their homes to gather fodder and firewood, thus surrounding most villages with a widening circle of denuded hillsides. Ground-holding trees are disappearing fast from the geologically young, jagged foothills of the Himalayas, which are among the most easily erodable. Landslides that destroy lives, homes, and crops occur more frequently throughout the Nepalese hills (Willan 1967, HMG 1974). The forest has suffered heavily due to increased human activities, which have been the result of change in demography in different parts of the country (Eckholm 1975). Since last few decades, Nepal's forests have fallen under the axe in an unprecedented rate due to high demand for fuel wood and timber and also for agricultural expansion.

The assessment of the forest quality and its present status in relation to human-induced changes are highly essential for the long-term management and optimum utilization of natural resource. In this paper an attempt has been made to describe the present status of the major vegetation from Begnas Tal to Tara Hill (a popular trekking route in Annapurna Conservation Area Project) during spring of 2000.

Study area

The Annapurna Conservation area is the largest protected area of the country. It was officially gazetted in 1992 and covers 7000 sq. km. Within this conservation area altitude varies from less than 1000 to 8,091 masl, the height of Mt. Annapurna-I – the 10th highest peak in the world. Due to the unique geographical features and various climatic conditions (from sub-tropical and temperate to arid desert type) the area is endowed with excellent habitats for diverse flora and fauna. Being located at the central part of Nepal it occupies an area of great phytogeographical significance in the sense of being the "platform", where eastern and western Himalayan floristic elements merge together. The route followed gradually ascends from Begnas Tal passing through different vegetated areas. It contains over 100 species of orchid, 1226 species of plants (ACAP 1993). The Annapurna region, where lies some of the highest peaks in the world is one of the most popular trekking destination for the visitors in Nepal.

Methodology

This study was carried out in a single field visit from 5 to 20 April, 2000. The field visit attempted to explore the portion of

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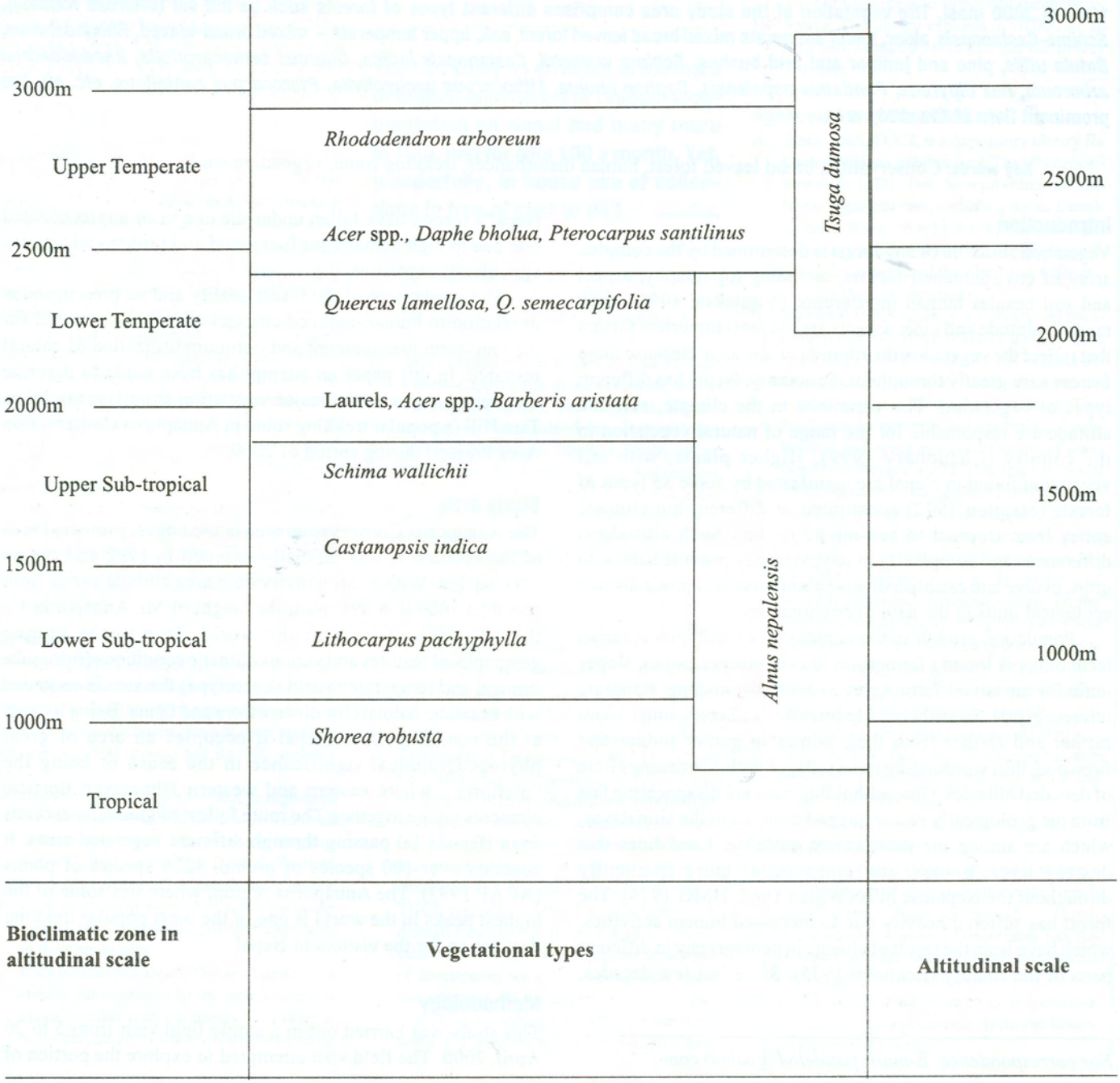
forested area within the Annapurna Conservation Area Project starting from Begnash Tal at 648 m to Tara Hill at 2940 m altitudes covering from subtropical to temperate bioclimatic zones. Quantitative methods were not applied for this study due to time limit. Different forest areas were observed very precisely. Many herbarium specimens were collected in different bioclimatic zones and were used to discuss the forest composition. The herbarium were identified in National Hebarium, Godavari (DPR, HMGN).

Results and discussion

The vegetation of the study area comprises different types of forests such as hill sal (*Shoresa robusta*), *Schima-Castanopsis*, alder, lower temperate mixed broad leaved forest, oak, upper temperate – mixed broad-leaved, *Rhododendron*, *Betula utilis*, pine and juniper and arid bushes.

From the Begnas (648 m) to Parche (2060 m), there is not any remarkable natural forest area. The area is characterised by the presence of *Schima-Castanopsis* forest along with hill sal forest. Hill sal (*Shorea robusta*) is confined to dry south slope in a range of 1000-1500 masl. *Schima-Castanopsis* forest includes *Schima wallichii* and *Castanopsis indica* which grows on north face from 1000-2000 masl. On the damp valleys it grows with *Pandanus nepalensis* and *Cyathea gigantea* (tree ferns). The area also possesses riverine forest around the Madi river. The most frequent species of this area were *Schima*

Figure 1: Vegetation types in the study area (Begnas Tal to Tara Hill)



wallichii, *Castanopsis indica*, *Shorea robusta* (hill sal), *Misua ferrea*, *Ficus glaberrima*, *Ficus roxburghii*, *Bombax ceiba*, *Rubus ellipticus*, etc. Other species found in this area were *Rhododendron arboreum*, *Brassiopsis* sp., *Smilax* sp., *Myrica esculenta*, *Prunus cerasoides*, *Phyllanthus emblica*, *Woodfordia fruticosa*, etc. Some herbaceous species present in this area were *Frageria* sp., *Chillenthus* sp., *Gentiana ornata*, *Oxalis* sp., *Eupatorium* sp., etc. The riverine forest along the Madi river was mainly represented by the *Bombax ceiba* with *Butea monosperma*. Other associated species were *Engelhardia spicata*, *Sapinus insigni* along with *Alnus nepalensis* in the moist part of the riverside.

The forest vegetation becomes more conspicious after Parche (2060 m) and the place seems to be a transitional zone between villages and the natural forests which extend right up to Tara Hill (2940m). The vegetation of lower belt of this area was much influenced by the human activity and domesticated animals. For this reason the trees of this forest were with much restricted height and forest floor was almost clear with the formation of medows at intervals due to wide canopy gaps. The whole area was characterised by presence of lower temperate mixed broad leaved forest, oak forest, upper temperate – mixed broad leaved forest and *Rhododendron* forest. From the Parche to Naulikherka (1860m), there was found dense shrub vegetation of *Barberis aristata* and *Pyricantha* sp. The lower temperate mixed broad-leaved forest species include *Quercus lamellosa*, *Rhododenidron arboreum*, *Castanopsis indica*, *Lindera nacusa*, *Litsea monoptela*, *Lithocarpus pachyphylla*. The upper region of this area comprises few pathches of *Tsuga dumosa*. These species were found to make dominant forest. According to Champion and Seth (1968) and Troup (1921), high elevation (2150m-3500m) forests of central Himalaya are composed mostly of evergreen broad-leaf species, especially *Quercus semecarpifolia* (oak) and *Rhododendron arboreum*, and conifer species. Thus evergreenness is predominant throughout the central Himalayan forests, except in some pockets where stands of winter deciduous species like *Aesculus indica*, *Alnus nepalensis* (alder) (especially along the water courses), *Acer* sp., *Betula utilis* and *Pyrus vestita* exist. Species which represent the lower forest strata were *Daphne bholua* (Lokta), *Cythea gigantea*, etc. Ground flora was represented by *Primula* sp., *Meconopsis* sp., *Saccharum* sp., *Fragaria* sp., along with different species of ferns and grasses. Heavely cut trees of *Rhododendron arboreum* were seen in this area. In the upper belt, i.e., above Naulikherka up to Tara Hill, the area was covered by luxuriant broad leaved *Rhododendron* forest dominated by *Rhododendron arboreum* with *Quercus* species. *Quercus* sp. is distributed throughout the whole length of Nepal forming principal forest type, but in this area it could not be found as major component of the forest. Other associated tree species include *Quercus glauca*, *Q. lamellosa*, *Lindera nacusa*, *Ileix* sp., *Lithocarpus pachyphylla*, *Tsuga dumosa*. At the north-west facing slope (around 2000m-3200m) the forest was highly dominated by *Pterocarpus santalinus*. Due to the presence of dense canopy cover, the ground vegetation was much reduced. The potential production of herbaceous vegetation in open area (sparse tree crown) is greater than that of beneath the canopy (Ellison and Huston, 1958) due to the fact that the shades below the trees control the herbaceous vegetation to grow. Tree effect on the herbaceous layer, which accompanied by a characteristic floristic composition for each bio-type, develops better under the sparse tree crown than in open (Apko *et al.* 1997). The ground flora was represented by *Primula* spp., *Potentila* sp., *Fragaria* sp., *Oxalis* sp., *Lycopodium* sp., *Gentiana* sp., etc. along with different species of ferns and grasses.

Conclusion and recommendation

The Annapurna Conservation Area is one of the perfect trekking destination of the country with luxurient forest. This area is less restrictive and more flexible than conventional national parks and reserve. In this area people are permitted to continue their traditional subsistence activities which are integrated into a framework of sound resource management and ecological development. The program is multi-dimentional, striving to balance the needs of the local people, trekkers and natural environment. This area is also the habitat of diverse ethnic group who are practicing their traditional knowledge of medicinal plants. Several workers have made survey on vegetation and carried out extensive research on medicinal plants of this area. On the basis of conclusion I would like to make some recommendation for the further conservation of this area.

The human interferences threst to the forest which may alter the vegetation, installing teashops, small rest houses and '*bhatis*' (small houses made for staying overnight for the long walkers), along with domestic animals, that are fed from the forest fodder, admist the jungle. Similar type of condition was observed in a next trekking route, Kalinchok area by Subedi and Sharma (1994-1995). The studied area is situated near the densely populated village. Such type of encroachment should be visualised as soon as possible by management level, and control measures should be taken effectively. Although Annapurna Conservation Area Project was implemented with the purpose of promoting biodiversity through conservation, cutting down the trees for roofing, making furnitures, and construction purpose in large quantity illegally contributed for the destruction of big trees of this area. Such practice should be immediately stopped where ACAP office should play more active role.

As mentioned earlier, this region is inhabitat by various ethnic groups. They have the long history of using plants to cure various diseases locally. Gurungs are the main ethnic group living in this area.This region harbours quite a large number of economically and medicinally important plant species. Some of the plants like *Neopicrorhiza scrophulariifolia*, *Paris polyphylla*, Chautaa Jhor (Asclipidiaceae), *Corydalis chaerophylla*, *Dactylorhiza hatagirae*, *Swertia chirayta*, *Mahonia napaulensis*, etc. are very good medicinal plants and *Daphne bholua* is economically very important plant as it is used to make Nepali paper. An inventory of the useful plants is felt highly urgent for proper management and sustainable supply of these valuable resources in future.

The midhills are most suitable place in Nepal for the visitors who come to see our luxuriant forest, ecchanting mountain views, zigzag and up and down trekking trails, serpentine perennial rivers for their natural beauty, enjoyable waterfalls and for the animals and plants that occur in them. ACAP is the

most popular trekking route of the country. By proper management, it is essential to promote eco-tourism in this area. To promote the eco-tourism, the local community must be made aware of the role of threatened, economically and ecologically important biodiversity that helps to utilize the biodiversity wisely for their basic needs. ■

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Concept of environmental justice in Nepal: Environmentalism of poor for sustainable livelihood

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Environmental justice has emerged as a new concept to address environmental problems of grassroots level from the perspectives of affected and less privileged communities or individuals of a society. This paper relates environmental justice as environmentalism of poor to their livelihood security through the access to resources, decision making power and clean and healthy environment. There are several discriminatory and unjust practices in both urban and rural areas of Nepal. Those vary from disproportionate sharing of ecological benefits and hazards in society to the unequal access to resources, healthy environment, decision-making, information and other civil rights. These injustices are mainly rooted in existing social structure with differential distribution of economic and political power. Some approaches are also discussed to correct environmental injustices, which include essential legal, political and social provisions for improved participation, access to information and access to justice.

Introduction

Environmental problems are getting more attention in recent years in academic field, political and government agencies, media and grassroots level as well. Hardly a day passes without hearing increased air pollution, water pollution, increased solid waste in city areas, landfill sites and associated conflicts, loss of forest and biodiversity, problems in managing natural resources and so on. Such increased concern helps to design some technical, social and legal mechanism in order to address and improve protection and preservation of nature and environment. Despite significant improvements in environmental protection over this period, people continue to live in unsafe and unhealthy physical environments. The environmental justice movement emerged in response to environmental and social inequities, threats to public health, unequal protection, differential enforcement and disparate treatment received by the poor and less privileged people (Bullard 2001).

Fair treatment of all people of caste, ethnicity, race or income groups for the equitable distribution of benefits of environmental conservation or hazards of environmental degradation is known as environmental justice (Adhikari and Ghimire 2002a). It regards the meaningful participation in planning, or implementation of any environmental projects or policies or decision-making mechanism, as well as access to authority for information and justice in matter of environment and resource utilization. EPA defines the goal of environmental justice as to ensure all peoples, regardless of race, national origin, ethnic background or income, are protected from disproportionate impact of environmental hazards (EPA 2001). The ultimate goal of environmental justice is sustainable livelihood for all sectors of a society.

This paper intends to discuss origin of environmental justice and its different aspects with reference to Nepal. It will present various issues of environmental justice based on findings of past studies related to access to resource, decision-making power and clean and healthy environment. The concept of environmental justice is relatively new and not many studies have been conducted in Nepal. So hopefully the paper will help to conceptualize the subject in the context of Nepal and to make some recommendation for improvement of environmental justice.

Environmental justice for poor people

It is the poorest that suffer most by environmental degradation and have least access to environmental resources all over the world but nature of injustice is quite different in developed and developing country. In developed country, societies have already urbanized and people need not directly depend on natural resources for their livelihood. Therefore common environmental injustices in those region includes- not preserving nature and its wilderness, dumping of municipal and other waste material near the communities of color or low income group and establishing hazardous industries and waste facility sites close to poorer neighborhood. Such inequalities are outcomes of unfair distribution of social and political power and awareness level in a community. In response of such injustices a movement was emerged in USA beyond a decade ago, which was termed as movement of environmental justice. In 1991 the first summit of National People of Color Environmental Leadership (USA) adopted 17 "Principles of Environmental Justice" as a guide for organizing, networking, and relating to government and nongovernmental organizations (Lee 1992). It put the issue on international radar screen. Since then several debates, discussions and researches were carried out to conceptualize

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the issue more clearly and more broadly which help to spread the concept in other regions and countries.

In Nepal natural resource has been the main mean of livelihood for majority of poor, disadvantaged and landless rural people as the case of most of the developing countries. The main role of nature at least for here is to serve needy people who take care of it and to provide material support for their living. Therefore the movement of environmental justice includes all movements and campaigns, which help livelihood security of affected communities. Adhikari (2002) defined livelihood security as the capacity of the individual or the household to improve their various assets (physical, financial, human, social and political) so that even they are struck by disaster of various types, they are capable to cope with them and regain their assets.

In our case environmental justice can be regarded as 'Environmentalism of Poor' as it addresses health security and other livelihood security issues for poor, less privileged and minority people or communities. Environmentalism of poor deals with social conflict with an ecological content (today and history), of the poor against the (relatively) rich, not only but mainly in rural context (Guha 1989). It accentuates the defense of livelihood and communal access to natural resources, threatened by state or the market as well as reaction against environmental degradation caused by unequal exchange, poverty and population growth (Martinez-Alier 1998).

There is arising logic to give preference on environmental security like food security. Food security ensures access of each individuals to enough quality food as practicing from generation to generation whereas concept of environmental security ensures access to safe and secured environment. However the opportunity to exercise both of these securities can be achieved by the condition for secured civil right. Environmental right and justice cannot be separated from civil rights although environmental right along with many other social, economical and cultural rights are not included in fundamental civil rights in constitution of Nepal and many other countries. But courts and judicial bodies have established a trend to ensure the right to live in safe and healthy environment while solving many cases related to degraded environment limiting the right to life (Shrestha 1998).

In Nepal with the promulgation of constitution of the kingdom of Nepal 1990, cases in the field of increasingly coming up before the supreme court. The court has also recognized the environmental problem under public interest litigation and delivered many environmentally friendly decisions and principles (Bhattarai 2000). One of the important cases on this aspect is the case of Surya Dhungel v. Godavari Marble Industries (P.) Ltd. In this case petitioner alleged that the respondent (Godavari Marble) is destroying the ecology of Godavari hill and thereby threatening the biodiversity of the valley by its marble mining operation. The Supreme Court of Nepal issued a verdict to the respondent to apply necessary mechanism for effective environmental protection.

We can simply say that environmental justice can be achieved only after we have secured civil right. Most of the degradation of environmental right is created in such situation when affected communities are unable to protest them. Therefore civil rights such as free press, right to information, right to speak and write freely, free election and right to participate in any organization or group are preconditions for environmental justice. Unless all of these preconditions are met, affected communities cannot raise their voices and protests that result continued degradation of nature and environment.

Socio-politico-economic causes for injustices

Consequences of current proliferation of globalization can create impacts on activities of local inhabitants arising mainly by the decisions made from world's major economic and political power situated in a far distance. Not only the affected communities are denied access and participation in such decision making mechanism, but also decision makers need not pay any cost for damages in local environment created by their own decisions. In such conditions environmental degradation and human exploitation proceeds that ultimately lead to the environmental injustice. It continues until local people can fully enjoy the right for utilization and conservation of their natural resources.

The main cause for environmental injustice is prevalent social injustice arising from unequal treatment of all people of class, caste, ethnicity, gender, or geographical origin. It results in environmental degradation as stated in previous paragraphs, which again prepares the condition for different social discrimination and injustices. Here simply a cycle of injustice perpetuates in a society, which justifies the fact that social and environmental conditions go along with and issue of environmental justice becomes a political issue.

Impacts of adverse environmental consequences and other hazards usually come to the side of socially deprived or disproportionably affected section in the society where discrimination and unequal treatment is quite common. It results into environmental classism or environmental racism or environmental casteism or similar situations. Elite and highly privileged section of the society can use and privatize common resources for the sake of their own benefits including environmental benefits through their easy access and strong hold in political power. Similarly their strong hold of political power also becomes a mechanism to suppress the voice and protest of affected communities. The reaction commonly seen during the discharge of waste material in urban neighborhood 'Not In My Backyard (NIMBY)' is also a product of such social disparity, which makes the disposal of waste in or close to the communities of poor and disadvantaged people.

Since capitalist economic and political system strengthens such situation of injustice and inequality, it helps to establish and advance environmental injustice and consequently environmental degradation. So the current trend of development of capitalism and globalization, which indicates the increase in power to control economic and political system by a handful of individuals and private corporations, is continued to encroach the common resources as well as public voice and protests. Policy makers are not paying attention to the voice arising from the lower section of the society. Because the economic system in capitalism is completely focused only on how to earn more benefits, it does not care other aspects different from anthropocentric view. Thus the social destruction happens.

Therefore unless different social injustices and problems are corrected and participatory communicative democratic processes are adopted, situation of environmental justice remains unchanged that obstructs achievement of sustainability.

Status and problems of environmental justice in Nepal

Following paragraphs enlist some issues of environmental justice in Nepal that came across while preparing its bibliography. It is clear that no researches were carried out in the name of environmental justice in Nepal except very few legal studies (Adhikari and Ghimire 2002b). However many works and studies related to environment and natural resource management included the different aspects of environmental justice. Another interesting conclusion that can easily be drawn is most of the cases of injustices in environmental matters are emerging from the roots of our social structure because environmental injustice also reflects our social disparity. Therefore caste, class, gender, unawareness, and political power have been main causes to affect environmental justice. Some of commonly found injustice issues are briefly described in following paragraphs.

Community forestry, widely appreciated for its success, is seen as one of the ways to safeguard forest with participation of local people and at the same time it benefits them. But sharing of benefits from community forest has not been always fair and equitable. Occupational castes, which are commonly recognized as lower castes in our social structure, are denied access to nearby forest (Graner 1997). Similarly the contribution to community forest in terms of labor, money, or time is inequitable. Poor and powerless sections of the society are spending enough physical labor whereas upper section are holding control through management and paper-work though they spend little time period. Discrimination happened mainly to so-called lower caste and poor people as well as women because they lack skill on paper work and keeping account. There is also inequity in participation on decision-making process for forest management as well as other social work (Poudel 1998). There are difficulties for these deprived sections in order to participate on decision-making process, as they are not well informed about meetings and other programs. In such a way lacking of 'transparency' is aiding to create injustices.

The next problem as revealed by many studies is related to women. Women are found politically weak which hinders them to have resource ownership and domination in society (Gautam 2001). Forest guard considers them adversary since they visit forest area more frequently to fulfill daily requirement of their family. Families with women and children member have to face difficulties since committee separates short duration on cutting wood logs and fire wood as well as sparing night time to use water for irrigation (Pun 2001).

Many projects and programs hardly consider minorities to encourage for participation. For example encouraging only Gurungs in Gurung village or Brahmin-Chhetris in those communities where they dominate is unjust to minorities. Studies related to eco-tourism shows that benefits from tourism industry mainly goes to the side of urban-based entrepreneurs and few local but elite persons whereas burdens raised by tourism – say for example in the form of degradation of forest, price increase of labor as well as daily use of food items, deterioration in local cultural practice and hazards of western consumerism – come up to the side of local farmer or families with low income. Although poor people get some work opportunity as porter and like, there is also exploitation and injustice to porter not getting subsistence level of salary or medical, clothing, foot wear and similar facilities as compared with their work risk.

Park people conflict is also a form of injustice occurring around the protected areas established mainly for protection of wildlife and tourism. Depredation of crop and domestic animals by wildlife of such conservation area and not getting compensation for such destruction is the main problem (Adhikary 2000). Sometimes human casualties also happen around national parks. Displacement of local inhabitants in the name of creation or extension of protected areas without giving any appropriate alternative way for subsistence used to be common practice in the past (Baghhchand 2001). Displaced people feel uprooted from their communities and environment, and as a result face various social and health problems, which lead to various changes in their cultural patterns. Similarly, indigenous or tribal people, maintaining their long history of living around these park areas and preserving the local environment and culture from their generation to generation, are also prohibited to utilize local natural resource (Ghimire 2001). This results in their livelihood crisis.

Urban environmental justice problems are quite different from rural. In an urban setting, most of the injustice issues root in the management of solid waste, for example, dumping of waste material near the slum and marginal neighborhoods without giving adequate information regarding its hazardous consequences (Shrestha 1993). Similarly polluting rivers by disposal of sewerage, lacking access to clean drinking water, air pollution, adulteration and contamination of food items are other common issues of environmental problem in urban areas. Environmental degradation and pollution essentially produce more impacts on poor than rich since poor people are usually exposed directly to such hazards and unable to manage protection measure owing to lack of resources.

Improving environmental justice

In fact, environmental justice, in the context of Nepal, should aim at enhancing and improving livelihood of poor, less privileged, minority and affected people in sustainable way since they have depended directly on natural resources for subsistence. That also applies to urban part since air pollution affects more seriously the health of poor people, as they cannot afford for treatment. In such condition their livelihood is adversely affected.

Environmental justice is a movement which when rises from public spare, we can attain the sustainable conservation of nature and environment as well as the highest level of environmental equity. This movement is essential not only for pressing the state agencies for fair distribution of benefits and adverse impacts of the environmental conservation and deterioration, but also for sustainable development. We have already discussed about what sorts of political, social and economical preconditions are required to advance such movements.

Generally secured civil right of affected community can ensure environmental justice, which further requires participatory democratic system with enough prospects of discourse. In such political system decision-makers should be accountable to the consequences of their decision and voices from grassroots level should have easy and significant access to decision-making body. But it seems quite impossible in capitalist system with such rapid trend of globalization.

It will be a long process to achieve above-mentioned condition of justice and fair treatment. From the short-term viewpoint, different development projects should have a regard for environmental justice. Following points can be recommended for consideration and further discussion:

1. Socio-economic structure should be studied in affected or to be affected (by any projects or programs) places or communities. It will get to know how people are made happen to face health and environmental hazards.
2. Some cultural, social or economic factors enhance the discrimination and injustices created by programs or policies related to environment and resource utilization.
3. Formulation, implementation and monitoring of new plans, policies, programs and projects require active public participation. Therefore authorities and decision makers should provide enough scope for worthy participation. Public participation should be maintained right from planning stage.
4. Generally affected communities deserve more concern, which are also called environmental justice community of concern (EJCOC). It is composed predominantly of persons of lower caste, tribal or ethnic minorities or a substantial proportion of persons below the poverty line. EJCOC can be a target for policy-makers in environmental reparations or remedies to compensate or restore environmental quality and to provide environmental security.
5. Alternative means for livelihood should be investigated and planned to correct existing injustices and to protect from additional adverse impacts.
6. Adequate information should be provided to affected communities and other concerned individual. Moreover improving the awareness of public on existing legal provisions, and easy access to information are other factors that help in having improved access to environmental justice.
7. There are many indigenous communities who make their livelihood by utilizing natural resource. Therefore new policies and program should not affect them in discriminatory way.
8. During the designing phase of study of environmental impact, opinion of socio-economically less privileged sectors of a society should be well incorporated. Public hearings should be carried out in local language at the time and place favored by such people to ease their participation and access to information. ■

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Metal toxicity in plants: How to metallophytes manage to grow ?

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Some of the metals (e.g. Cu, Mg, Mn etc.) are essential micronutrients of plants but other metals (e.g. Pb, Cr, Ni etc.) are non essential. Higher concentration of both essential and non essential metals are toxic to the plants. However, some plants called metallophytes, can grow in metal rich soil. Resistance to metal may involve exclusion from protoplast or detoxification and storage of metals in relatively inert sites such as vacuole. An understanding of genetic and physiological basis of the process involved in detoxification of metals is important in agriculture, afforestation etc. Cellular mechanisms of metal detoxification are briefly discussed.

Introduction

There is a wide range of habitat in biosphere, ranging from fresh water spring to saline water in aquatic ecosystem and marshy land to arid region in terrestrial ecosystem. Due to some anthropogenic activities such as mining, disposal of industrial waste, agricultural practices etc, physico-chemical characters of soil has been changed to such an extent that it is unsuitable for growth of many plants. The rapid change in environmental condition is likely to override the adaptive potential of plants, specially that of tree species with their long reproductive life cycles. Some plants growing in such extreme conditions evolve different strategies to ameliorate the effect of environmental stress. Absorption of water for halophyte, storage of water in xerophyte, resistance to metal toxicity in metallophytes etc. are few examples of strategies used by plants growing in respective habitat. Understanding the mechanisms of these strategies and improving plants' protections against stress are important fields of research in ecophysiological study.

Heavy metals are characterized by their higher density, being greater than 5 g/ml (Lambers *et al.* 1998). Heavy metals such as copper (Cu), cobalt (Co), iron (Fe), manganese (Mn), molybdenum (Mo), and zinc (Zn) are essential micronutrients necessary for normal growth and development since they are important constituents of many enzymes (as co-factor or activator) and other proteins. However, higher concentrations of these essential and non-essential (cadmium Cd, chromium Cr, lead Pb, gold Au, mercury Hg, silver Ag, and uranium U) heavy metals in soil are toxic and inhibit growth of most plants. Toxicity in plants may results from binding of metals to proteins leading to inhibition of activity, or from displacing of essential element resulting of deficiency effect, or stimulating the formation of free radicals and reactive oxygen species resulting in oxidative stress (Lambers *et al.* 1998, Hall 2002).

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Metallophyte is a group of plants, which can grow in soil rich in certain metals. They can grow in such soil not because they need higher concentration of metal but because they can resist higher concentration. Resistance to heavy metal involves avoidance and tolerance. In avoidance plant avoid the absorption while in tolerance they detoxify and sometimes accumulate the metals on or inside the cell. Hyper-accumulation raises important biological questions such as the mechanisms by which toxicity is avoided and the possible adaptive significance of such high level of heavy metals (Psaras *et al.* 2000). An understanding of genetic and physiological basis of the process involved in detoxification of heavy metals is an essential pre-requisite in the development of crop for phyto-remediation of heavy metals, in selecting appropriate species and breeding suitable varieties for re-vegetation of highly contaminated soil and for selecting bio-indicator plants (Larcher 1995, Salt *et al.* 1998).

Sources of heavy metals

Environment of plant receives heavy metals from geological (natural) or anthropogenic sources. Serpentine soil naturally have high levels of Ni, Cr, Co and Mg. Higher level of metals is also found in soil covering ore bearing rock. Anthropogenic sources involve slag from metal extraction plants (e.g., As, Cd, Co, Cr, Cu, Mn, Pb, Zn), waste water from factories (e.g., Cd, Cr, Cu, Fe, Hg, Pb, Zn, etc.), heavy vehicular traffic (e.g., Pb), garbage and sewage slug (e.g., Cd, Cr, Cu, Fe, Hg, Ni, Zn), strongly acidic soil (e.g., Al) etc. (Larcher 1995). The metals enter into the plant from soil through root. But mercury in leaves of red pine (*Pinus resinosa* Ait.) is directly derived from atmosphere (Fleck *et al.* 1999). Atmospheric mercury may enter through stomata or it may be deposited on leaf surface as particulate mater, which ultimately reaches to internal tissue.

Nature of metal toxicity

The toxicity of heavy metal ions is due chiefly to inactivation of vital enzymes and their interference with electron transport

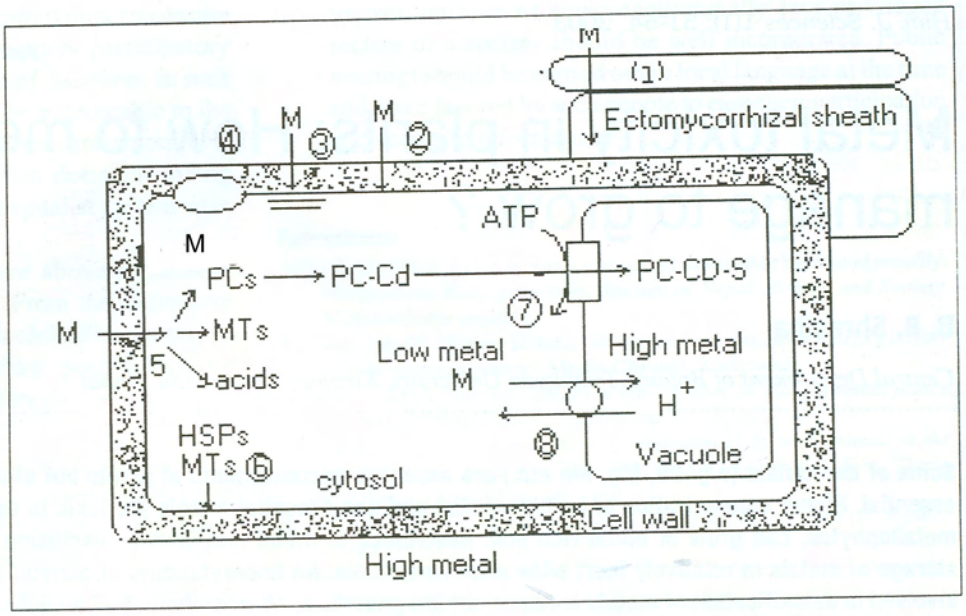

Figure 1. Summary of potential mechanisms available for metal detoxification and tolerance in higher plants. 1. Restriction of metal movement to roots by mycorrhizas. 2. Binding to cell wall and root exudates. 3. Reduced influx across plasma membrane. 4. Active efflux into apoplast. 5. Chelations in cytosol by various ligands. 6. Repair and protection of plasma membrane under stress conditions. 7. Transport of PC-Cd complex into the vacuole. 8. Transport and accumulation of metals in vacuole. (After Hall 2002).

in respiration and photosynthesis. (Larcher 1995). Heavy metals create long-term problem because they not only accumulate in organism and circulate in food chain but also remain in ecosystem in dangerous concentration for longer period in sediment. Some of the heavy metals are necessary for plants at very lower concentration but most of the plants cannot prevent the entry of heavy metals in excess amount. Other non-essential toxic heavy metals also enter the plant by similar mechanisms.

Mechanisms of metal toxicity have not been known in detail. Based on their chemical and physical properties three different molecular mechanisms of heavy metal toxicity can be distinguished: a) production of reactive oxygen species, b) blocking of essential functional groups in bio-molecules, and c) displacement of essential metal ions from bio-molecules (Schutzendubel and Polle 2002). There are direct evidences for nature of toxicity of few metals like Cu and Al but for other metals like Zn, Cd, etc this has been inferred from indirect evidences. Cd reduces ATPase activity of plasma membrane while Cu toxicity leads to increased efflux of K^+ from root by changing cell permeability, damage to cell membrane by oxidation of proteins, inhibition of key membrane protein such as H^+-ATPase or changes in the composition and fluidity of membrane lipid (Hall 2002). Cu has also been found to reduce the amount of chlorophyll-a and total chlorophyll in lichens (Chettri *et al.* 1998) and thereby hampers photosynthesis. Ni is known to suppress photosynthetic electron flow and to impair photosynthetic activity by substituting Mg in chlorophyll molecules (Psaras *et al.* 2000). Zn may replace Mg in Rubisco, reducing the activity of this enzyme and hence the photosynthetic capacity. Zn toxicity may also be due to binding of this metal with water channel protein of plasma membrane leading to reduced water up take (Lambers *et al.* 1998 and references therein).

Al is the most abundant and toxic light metal, and is available to plants as the free Al^{3+} ions under acidic condition. Al accumulates predominantly in the cells located within the apical elongation zone in plant roots and inhibits cell elongation rapidly. Al accumulated on the outer plasma membrane may effect mitochondria functions by an unknown signal transduction pathway while a small amount of Al transported across the plasma membrane may directly interfere with mitochondrial functions (Yamamoto *et al.* 2002). Production of reactive oxygen species (presumably O^{2-}), respiration inhibition and ATP depletion seem to be critical events of Al toxicity in cultured plant cell and whole root. Al triggered hindrance of an electron flow leads to the inhibition of normal oxygen consumption by cytochrome oxidase (respiration inhibition), but to the enhancement of O^{2-} production by the leakage of electrons directly to oxygen. So it is likely that O^{2-} production is a key critical event leading to the loss of growth capability.

Resistance to toxic metals

Plants growing in contaminated soil, which develop the ability to resist higher level of heavy metals, are the chemo-ecotype. The ability to resist heavy metals is genetically determined and can also be modified by adaptation. Chemo-ecotypes develop the ability to resist higher concentration of heavy metal in their tissue when they grow on contaminated soil. This ability increases with greater exposure to such elements. Some species have higher degree of genetic plasticity and can resist many heavy metals (Larcher 1995). For example *Agrostis tenuis* and *Plantago lanceolata* are resistant to Zn, Cu, Cd, and Ni.

Although in many plants resistances is due to exclusion of the metal from the protoplast, some plants actively take up metals leading to accumulation at extremely higher level, exceeding those in the soil. Such plants are called hyper accumulators. In Ni-hyper-accumulators (*Alyssum* spp, *Bornmuellera* spp and *Thlaspi pindicun*) it is deposited in leaf epidermis. However it is excluded from guard cells and trichomes, and is sequestered in physiologically more inert, yet living cells (Psaras *et al.* 2000.) The absence of Ni from mesophyll and guard cells can be correlated with its deleterious effect in photosynthesis. In seeds of hyper-accumulating species *Thaspi pindicum* Hausskn (Brassicaceae), Ni preferentially accumulates in micropylar area opposite the radicle and in the

Table - 1. Summary of potential mechanisms involved in the detoxification of and tolerance to specific metals.

Mechanism	Metals
Plant-mycorrhizal association	Zn, Cu, Cd
Cell wall, root exudates	various metals including Ni, Al
Plasma membrane	
-Reduced uptake	Arsenate, Ni
-Active efflux	various including Zn
Phytochelatin	Cd
Metallothioneins	Cu
Heat shock proteins	various including Cd
Vacuolar campartmentation	Zn

epidermis of cotyledon (Psaras and Manetas 2001). Micropyle is the point of entry of radical-consuming frugivores. Accumulation of Ni at micropylar region may be an elemental chemical defense. This is in compatible to the antiherbivore role ascribed to metal hyper-accumulation (Boyd 1998).

A successful detoxification of heavy metals requires the formation of a stable organo-metallic complex (e.g. complex of Ni with citrate and malate) and physiologically inert cell compartment for permanent storage (Brooks 1998). Strategy adopted by the plant is to avoid metal accumulation in cytosol which may involve reduced uptake into the cytosol, chelation of metal in cytosol or efflux from cytosol, either into apoplast or into vacuole (Hall 2002). It is possible that more than one mechanisms may be involved in reducing the toxicity of a particular metal. A summary of potential cellular mechanisms for metal detoxification and tolerance in higher plants is presented in Figure 1. Different mechanisms are briefly described below.

Mycorrhizas

Mycorrhizas are characteristics of many trees and shrubs. Particularly the ectomycorrhizas are effective in reducing the toxic effect of heavy metals such as Zn, Cu and Cd to the host plant. Most mechanisms that have been proposed to explain the role of ectomycorrhizas in metal resistance involve the exclusion process that restrict metal movement to host roots. It includes adsorption of hyphal sheath, reduced access to the apoplast due to the hydrophobicity of fungal sheath, chelating by fungal exudates and adsorption onto the external mycelium. Schutzendubel and Polle (2002) showed that mychorrhizal symbiosis buffered the typical Cd-induced stress but it not known whether mychorrhization protects root from Cd-induced injury by preventing access of Cd to sensitive extra- or intracellular sites, or by excreted or intrinsic metal-chelators, or by other defense system.

Binding to cell wall and root exudates

The binding property of the cell wall and its role as a mechanism of metal tolerance has been a controversial one. However, accumulation of a range of metals in the epidermal cell walls (of root) of heavy metal resistant *Silene vulgaris* ssp. *humilis* has been reported (Bringezu *et al* 1999). Similarly, transmission electron microscopic study in lichens have revealed that most of the bioaccumulation of metals takes place in cell wall and high concentration of Cu may damage cell wall (Chettri *et al.* 2000).

Root exudates contains a range of organic compounds including organic acids (e.g. oxalic acids). They may form chelating product with heavy metal like Ni and non-toxic derivatives of high metals like Al (Al-oxalate) (Ma *et al.* 2001).

Role of plasma membrane

Plasma membrane is the first living structure of cell that is a target for heavy metal toxicity. Damage to the plasma membrane is the main event of toxicity of heavy metals such as Cu and Cd. So tolerance involves the protection of plasma membrane against heavy metal damage. Another factor may be the efficient membrane repair system after damage. Beside these, the cell membrane may play an important role in metal homeostasis, either by preventing or reducing entry into the cell or through active efflux mechanisms. The tolerance mechanism to arsenic toxicity in *Holcus lanatus* is genetically determined reduced uptake of ions (Meharg and Macnair 1992). Energy dependent efflux of toxic ions through plasma membrane is another important strategy for controlling intracellular metal level. This efflux pumping system has been identified for Cu, Cd, Co, Ni and Zn (Silver 1996). Though there is no direct evidence, recent researches show the possibility of presence of metal transporter for active efflux of toxic metal ions across plasma membrane.

Heat shock proteins (HSPs), which show increased concentration in response to higher temperature, are also expressed in response to heavy metal stress and function in the protection and repair of proteins under stress condition. Cu and Cd are known to induce greater expression of HSPs. It may have important role in tolerance mechanism involving a more resistant plasma membrane or improved repair mechanism (Hall 2002).

Chelation

Chelating of metals in the cytosol by high affinity legends is potentially a very important mechanism of heavy metal detoxification and tolerance. Potential legends involve amino acids, organic acids, phytochelatins and metallothioneins. Phytochelatins (PCs) have been most widely studied in plants in relation to Cd tolerance. PCs appear to be important in the detoxification of Cd and arsenate but play no role in the detoxification of Zn, Ni and selenite ions (Ha *et al.* 1999). A possible role of PCs in Cu tolerance has also been proposed but it is yet to be resolved.

Phytochelatins are metal complexing peptides, which are rapidly induced in plants by heavy metal treatment. A clear role of PCs in Cd detoxification has been supported by biochemical and genetic evidences. In *Brassica juncea* it has been shown that Cd accumulation is accompanied by rapid induction of PCs biosynthesis which was sufficient to chelate all Cd taken up and this protects photosynthesis (Haag-Kerwer *et al.* 1999). The

final step in Cd detoxification involves the accumulation of Cd-PCs in vacuoles. In vacuole it is stabilized by the formation of Cd-PCs-sulphide complex (Ortiz *et al.* 1992).

Metallothioneins (MTs) are cytosine-rich, metal binding peptides. There are evidences for the role of MTs in heavy metal tolerance in fungi and animals and its role in Cu, Zn and Cd tolerance in higher plants has been suggested but it remains to be established (Hall 2002). They may functions as anti-oxidant and may have some role in plasma membrane repair.

Vacuolar compartmentation

Transport of ions to vacuole to reduce the level of toxic metals in cytosol is potentially another important mechanism for heavy metal tolerance. In fact, vacuoles are the site for accumulation of a number of heavy metals including Zn and Cd (De 2000).

Zn indices increased vacuolation in meristematic cell and rapid sequestration of Zn into the vacuoles. At higher concentration Zn transport across the membrane of isolated toneless vesicle is 2.5 times higher in Zn tolerant than that in Zn sensitive ecotype of *Silene vulgaris* (Verkleij *et al.* 1998). Zn tolerance may be genetically controlled and specific Zn transporter may be involved in sequestration of Zn in vacuoles (Chardonnens *et al.* 1999).

Though the mechanisms of metal toxicity and resistance have been extensively studied it is not precisely known. It is important to understand these mechanisms to improve plant's protection against metal toxicity. Toxic metal induced production of reactive oxygen species and role of mychorrhiza in detoxification of heavy metals are promising fields of research. The development of heavy metal tolerant plant-mycorrhizal associations may be a new strategy for pytoremediation of metal from contaminated soil. The primary screening of Nepalese flora has not been done to assess the potentiality to resist heavy metal toxicity. Since the behavior of Himalayan plants is different from both temperate and tropics, generalization made from research of other region may not be applicable for these plants. There is urgent need to identify potential plant species to be used for phytoremediation from Nepalese Himalayan flora that has not been explored yet for this purpose. ■

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Domesticating Lapsi, *Choerospondias axillaris* Roxb. (B. L. Burtt & A. W. Hill) for fruit production in the middle mountain agroforestry systems in Nepal

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Cherospondias axillaris **is a potential agroforestry tree species for income generation and nutrient supplementation in the middle mountains of rural Nepal. The occurrence and distribution of *C. axillaris* (locally known as Lapsi in Nepal) has been surveyed and documented. Status of indigenous knowledge about cultivation, management and utilisation has been studied and documented; indigenous indicators for early sex determination and criteria for fruit quality assessment has been established. Based on farmers selection and fruit quality assessment, elite trees for quality fruit production has been selected and methods for their successful propagation has been developed. Lapsi was reported growing in 301 Village Development Committees of 29 hill districts. Over 40000 trees has been producing fruits and additional 500,000 new trees has been planted. Interest on lapsi cultivation and marketing is increasing. Farmers have wealth of indigenous knowledge on lapsi ecology, husbandry practices and variation in different lapsi types. This knowledge combined with scientific methods has offered better opportunities for lapsi domestication. Bud grafting, side grafting, hardwood and softwood cutting propagation were successful methods for lapsi propagation, while research in tissue culture is still underway. Bud grafting during the first three weeks in February is recommended for lower cost and effectiveness (90% success). Selected trees are recommended for mass propagation and planting for quality fruit production.**

What is domestication?

Domestication means bringing in to human use. To domesticate is to naturalise to human conditions and it involves human-induced change in the genetics of a plant (Harlan 1975; in Leakey and Neuton 1994). The domestication of agroforestry trees, as in other species, involves accelerated and human induced evolution to bring species into wider cultivation through a farmer-driven and often market-led process (ICRAF 1997). Domestication is an iterative procedure involving the identification, production, management and adoption of desirable germplasm, and it can occur at any point along the continuum from the wild to the genetically-transformed state (Leakey and Tomich 1999). Basically, domestication of agroforestry trees is targeted towards the benefit of small holders. There is a close linkage between domestication and commercialisation.

Introduction of lapsi

Lapsi [*Choerospondias axillaris* Roxb. (B. L. Burtt & A. W. Hill)] is a wild, large, deciduous and dioecious fruit tree under the family Anacardiaceae. The tree is largely known for its delicious fruit in Nepal, for timber in China and for medicinal value in Vietnam. The tree is native to Nepal (Roxburgh 1832) and is distributed from north-east India to south-east China and Japan including Nepal, Assam and Sikkim in India; central and south China; Vietnam, Thailand, Japan and Happy valley in Hong Kong.

The trees producing pistillate flowers are locally called as '*pothi lapsi*'(female trees) and others producing staminate flowers are called '*bhale lapsi*' (male trees). Study on the flowers of *C. axillaris* (both in glass house and field conditions) confirms this to be a cross-pollinated tree. Pistillate flowers have empty anthers and the staminate flowers lack gynoecium. The pollens are transported by insects, honey bees and wind. Study on pollen grains derived from the anthers of staminate flowers, under a scanning electron microscope shows them to be tricolporate, tagillate, subprolate and medium in size. More description about the species is available in various flora and other publications (Roxburgh 1832, Ohwi 1953, Paudel 2001, Blackman *et al.* 1937).

Importance of lapsi in Nepal

Lapsi is a wild, edible, indigenous fruit tree of multiple benefits. The tree has social, cultural, ecological and economic value in Nepal. Existence of lapsi as pre-historic vegetation types of '*Sleshmantak Ban*' (meaning lapsi forest) around 'Pashupatinath' in Kathmandu has been quoted in the '*Swasthani Bratakatha.*'

Nepal is unique for processing and use of lapsi fruits. Lapsi fruits are consumed fresh or pickled, and processed for preparing

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varieties of sweet and sour, tasty food products locally called as '*Mada*' (dried lapsi mat prepared form the pulpo/peel of ripen/ raw fruits) and candy. Recent study shows that the fruits are very rich in essential amino acids, especially arginine (106 mg/ 100gm), glutamic acid (36 mg/100gm) glutamine (32 mg/ 100gm); vitamin **C** and minerals such as potassium (355 mg/ 100gm), calcium (57 mg/100gm) and magnesium (34 mg/ 100gm) (Paudel *et al.* 2002a). This property in lapsi fruit signifies its importance in human health. The candy products are popular among women, children, trekkers, and tourists. Most of these fruit products are at present consumed within the country but there is a potential international market for export promotion. Lapsi wood is used as light construction timber and fuelwood; seed stones are used as fuel in brick kilns and the bark has a medicinal value for treating secondary burns (Quang 1994, Nguyen *et al.* 1996).

Only very recently, lapsi has been recognised as one of the potential agroforestry tree species for income generation to hill farming communities in Nepal (Paudel and Parajuli 1999, Gautam 1997, LARC 1997). The Agricultural Perspective Plan of Nepal (APP 1995) has clearly identified the research needs in the area of agroforestry in general and that of multipurpose trees and non-timber forest products in particular.

Farmers collect lapsi fruits from forest and farm grown trees and sell between October and January. The price of fresh fruit in Kathmandu in 1999 varied from NRs.10/kg in October to NRs.40/kg in February/March, equal to the price of the mandarin orange. The annual transactions based on fruit in Kathmandu alone was estimated at around US $ 1m worth, i.e. over 50m Nepalese Rupees (BM 1999). Because lapsi is often grown in uncultivated lands, it makes an indirect but substantial contribution to providing wood and food crops through the utilisation of marginal lands (e.g. community and leased forestlands) and also contribute to soil conservation and environmental protection.

Problems

Current production and supply of lapsi fruit do not meet the market demand for quality products on the one hand, and the production from remote areas has not been able to fill this gap on the other. Expansion of lapsi cultivation for quality fruit production is limited mainly due to the associated risk of non-bearingness, as only female trees produce fruits, normally after 7-10 years of planting. Neither appropriate techniques for early sex determination nor simple and reliable vegetative propagation methods were developed and disseminated. Because of this problem, farmers are worried whether the trees they have already grown, will produce fruits.

Although lapsi is reported to be growing sporadically in various hill districts of Nepal, detailed information about the occurrence and distribution of lapsi in Nepal is not available. Available information on existing forest types does not inform adequately about the existence of lapsi as a natural vegetation; neither does the agricultural sector address its abundance and importance in the farming systems. Identification, selection, evaluation, and propagation of selected germplasm of lapsi are still in its infancy in Nepal. Farmers are planting lapsi trees without information about their origin, quality, or yield potential,

Plate 1 : Lapsi fruits in 3 year old vegetatively propagated plant

which in the long run may not be paying as expected. A systematic approach to selection, evaluation, multiplication and conservation of available best trees/stands is required before they are extinct. Examples on extinction of superior trees are already realised. Since lapsi is a relatively new crop for scientific research and often an ignored crop both from agricultural and forestry sector, there exists very little and inadequate information in the form of published literature.

Occurrence and distribution of lapsi in Nepal

A total of 301 village development committees (VDCs) in 29 hill districts have reported cultivation and protection of lapsi trees for some socio-economic purpose. Lapsi was grown from east to west Nepal from 850 masl to 1900masl. Distribution of Lapsi has been found in a much wider areas in the country than reported earlier. Over 40,000 trees are at fruit bearing stage and more than 450,000 new trees are planted in these districts. There is a tremendous opportunity for income and employment generation through proper management and use of Lapsi tree. (Paudel 2001)

A distribution map of lapsi at national and VDC level has been produced for the first time in Nepal. Accordingly, high intensity Lapsi production areas can now be selected and be used as potential seed production areas. Major Lapsi production areas, fruit processing locations and market centres for fresh and processed fruit products have been identified and

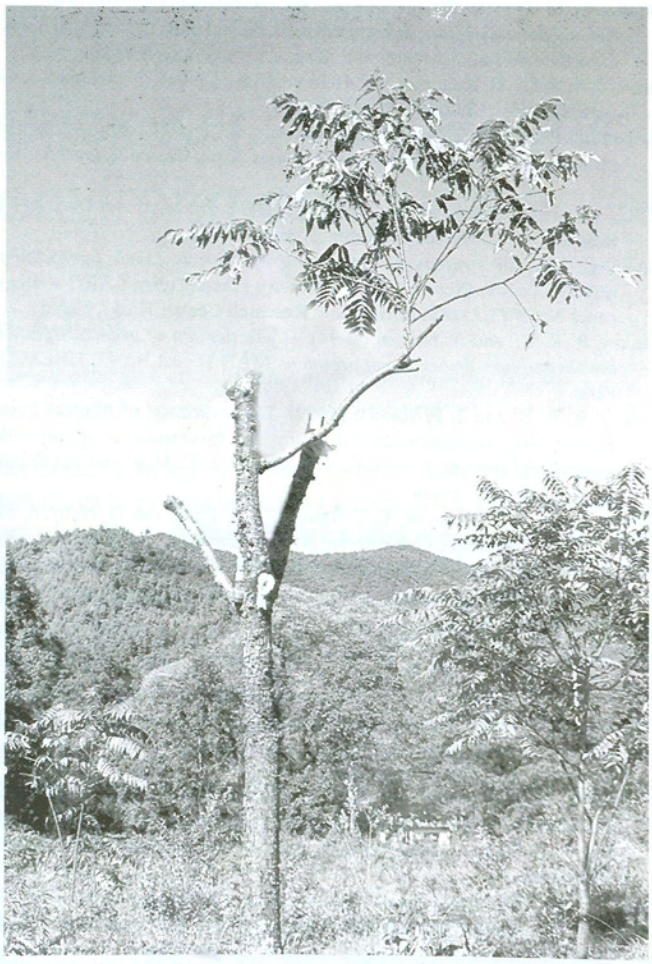

Plate 2 : Successful grafting of female branch on male plant

documented (Paudel 2001). Major limitations to expansion of Lapsi cultivation as identified included lack of technical know-how, extension support, uncertainty of fruiting, unavailability of planting material, long gestation period and lack of market.

Information collection about distribution of a high value agroforestry tree at national level using participatory approach through existing government forestry network and their staff has been proven to be a time and cost effective way of starting domestication efforts in a resource-poor country like Nepal.

Indigenous knowledge about cultivation, management and use of lapsi

Local farmers have wealth of indigenous knowledge about Lapsi cultivation, management and utilisation. Almost all Lapsi fruit coming to markets to date was produced from wild grown trees. Farmers have been protecting and growing naturally regenerated Lapsi plants in forest and farmland. They have increased cultivation of this tree for the last 10-20 years, especially when forest nurseries have begun to produce and distribute Lapsi seedlings. No evidence on the use of improved technologies/ varieties for quality fruit production was found in Nepal and no improved horticultural practices such as irrigation, fertilisation, and pruning were applied.

Lapsi was considered as one of the best agroforestry tree species to be grown in farmlands due to several reasons such as – thinner crown density, tall and deciduous in nature that causes low level of shading effect on cereal crops. However, the disadvantage of growing Lapsi in farmland was also realised by farmers as crop damage occurs while Lapsi harvesting. It was also evident from interaction with Lapsi growers that they are quite aware about the crop impact of Lapsi trees in their bari (un-irrigated farms) lands and they try to minimise this effect by locating trees in the margins of farmland, corners and pasture lands.

Lapsi cultivation has been much influenced by marketing facilities such as access to motorable road and market centres; processing companies and traders activity (Paudel 2000). The extensive cultivation of Lapsi around the districts of Kathmandu valley, and its catchment area provide an absolute evidence on positive influence of market facility on Lapsi production.

Farmers have categorized Lapsi into different types according to their indigenous indicators that are based on fruit size, time of maturity and fruit quality (Table 1). Although these indicators did not hold uniformity across sites, they are of good value for studying genetic diversity of lapsi trees.

Table 1: Types of lapsi fruits according to criteria used by farmers

Criteria	Type
Fruit size: small and large	*Sano* and *Thulo* lapsi
Fruit maturity: early and late	*Aghaute* and *Pachaute* lapsi
Taste of fruit: sweet and sour	*Guliyo* and *Amilo* lapsi
Pulp content: high and low	*Bose* and *Hade* lapsi

Early sex determination of Lapsi at seedling stage was realised as a big problem for increased fruit production by the farmers in all the study sites. Exploration about indigenous technical knowledge has indicated some morphological differences between two sexes (Table 2). This knowledge needs to be further tested and verified.

Table 2: Morphological differences observed between bearing and non-bearing trees

Criteria	Female lapsi	Male lapsi
Leaf emergence	Later	earlier
New leaf color	yellowish	purple/reddish
Leaf margin	entire	mostly serrated
Color of latex	milky, thick	watery, thin

Selection of superior mother trees and their conservation

Criteria for the selection of elite mother plants were based on farmers perception of fruits and trees, but also processors' preferences including size, appearance, pulp content, color, sugar content and health status. Farmers' criteria for selecting superior trees were mainly based on the quantity of Lapsi production per tree as this means value in monetary term. This criterion was a combined criterion associated with the fruit size, fruit retaining quality until maturity, insect and disease tolerance.

They were also aware of the quality criteria such as the taste of the fruit, appearance, seasonality of fruit ripe etc.

Farmers preferred *bose lapsi* (fruits with high proportion of pulp) for fruit production. Early varieties were preferred by most of the farmers as it fits to the time of main festival in Nepal when they can harvest and sell to meet their household needs. Analyses of sample fruits from selected trees have shown a great variation in fruit size, weight (8-18 gm), pulp, and acid/ sugar content. (Paudel 2001, Paudel *et al.* 2002b).

Conclusions

Lapsi has been identified as a potential agroforestry tree species for domestication for rural income generation and human nutrient supplementation. Lapsi fruits are rich in essential amino acids, minerals and vitamin C. The participatory approach used in the occurrence and distribution of Lapsi in Nepal has been effective to draw a distribution map of a single species of farmers' interest. Lapsi has been growing in 301 VDCs in 29 hill districts of Nepal and is further expanding. Information on distribution of lapsi would help to identify better stands, individual trees for tree improvement. It is clearly evident that farmers are rich in indigenous knowledge about lapsi ecology, husbandry practices and utilisation of lapsi fruits. Indigenous knowledge combined with collection and evaluation of lapsi fruits has strongly contributed to select elite mother trees in the middle mountains of Nepal. As a result, over 60 superior trees with consumer preferred fruit quality has been selected and propagated. Analysis of fruit quality from among selected trees showed significant difference between the trees of different location and among the trees within locations.

Research scientists are suggested for the continuity of ongoing research and contribute on starting new research in breeding, developing morphological markers for early sex determination and study on tree crop interaction for better quality fruit production to meet growing demand of lapsi fruits. ■

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Brick Kilns in Kathmandu Valley: Current status, environmental impacts and future options

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'Kathmandu Valley' is vulnerable to air pollution problem due to its topography, which restricts the wind movement and allows pollutants to remain within the valley. Brick kilns, operating in the Valley, are known to be a prime cause of air pollution. There are currently more than 125 brick kilns operating in Kathmandu valley deteriorating its air quality and degrading the health of the people living near the kilns. Recent studies have found that the concentration of particulate matter in the air in an area with brick kilns is three times higher when the kilns are operating than during the off-season. Similarly, the health of students studying at a school situated near a brick kiln was found to be significantly worse than that of students studying in a similar school but located in an area without brick kilns. Other environmental costs of the brick kilns are the reduction in the soil fertility, reduced visibility, drying ground water sources. The use of an old and inefficient technology called Bull's Trench kilns and low quality fuel are the main causes of the problem. Recently the government has decided to ban Bulls Trench brick kilns in Kathmandu in a year and a half. As a result, entrepreneurs are searching for environment friendly and cost effective alternative technologies. There are some technologies currently in practice in India like Vertical Shaft Brick Kiln, Fixed Chimney Kilns which are environment friendly and economically sound. Introduction to these technologies in Nepal can save both ecology and economy.

Introduction

Kathmandu Valley is the main economic as well as cultural centre of the country. Situated at an altitude of about 1300 masl, the valley occupies an area of about 351 km^2. The cross section of valley is about 20 km North to South and 30 km East to West. Kathmandu valley, which includes three districts namely Kathmandu, Bhaktapur, and Lalitpur, has five municipalities and almost a hundred village development committees. Approximately 1.5 million people currently live in Kathmandu valley. Among these, about a million live in the urban areas in the Valley. Overall, Kathmandu valley's population is growing at a rate of 4.83% per year, which is high compared to the country's population growth rate of 2.27% per annum (CBS 2001). This is the result of centralization of development activities and migration of the rural people to the capital for different opportunities. This rapid and haphazard growth of Kathmandu is putting tremendous pressure on the valley's natural resources, including air, water and soil.

The Valley is especially vulnerable to air pollution due to an exploding population inflow, rapid urbanization, valley centric industrialization and significant increase of vehicular transport in narrow streets. Furthermore, the bowl like topography of the valley restricts wind movement and retains the pollutants in the atmosphere. This is especially bad during the winter season when thermal inversion – cold air flowing down from the mountains being trapped under a layer of warmer air – creates a lid, which keeps the pollutants sealing within the valley.

Kathmandu's brick kilns, most of which are situated at the southern part of the Valley, are largely responsible for the degrading air quality of the valley. The growth of Kathmandu's brick industry has brought with it significant environmental and health problems because the industry is using poor quality fuel and very inefficient technology. According to an emission inventory conducted under the URBAIR program by The World Bank, the main contributing sources for total suspend particles (TSP) in the valley are cement factory (36%), brick kilns (31%), domestic fuel combustion (14%), road resuspension (9%) and vehicle exhaust (3.5%). However, for the particulate matters less than 10 microns in size (PM_{10}) concentration, which is more of a concern because these are particles that can enter the respiratory system, contribution of brick kilns was found to be more than any other sources. The share of brick kilns was 28%, domestic fuel combustion 25%, cement factory 17%, vehicle exhaust 12% and road resuspension 9%. The study further estimated that dust particles in Kathmandu valley cause almost 18,863 cases of asthma and about 4,847 cases of bronchitis in children every year (URBAIR 1997).

There are around 125 brick kilns in Kathmandu valley (ENPHO 2001). Of these, over 90% are Bull's Trench kilns, which supply 87% of the total brick demand of the valley. As the Bull's Trench kiln runs seasonally and many of the kilns are operating illegally, the actual number of kilns under operation at a given time is variable. There are other brick making technologies in practice as well like 'Clamp Kiln' and

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'Hoffmann Kiln'. Hoffmann kiln uses cleaner technology and produces good quality bricks.

Environmental impacts

The Bulls Trench kiln is an old and inefficient technology, which has been banned in India, the place of its origin. The main problem associated with this technology is the excessive air pollution it causes which degrades the local environment. A study conducted by Clean Energy Nepal (CEN) before and during brick kiln operating season at Tikathali VDC of Lalitpur district shows that the air pollutants were three times higher during the brick kiln operating time than during the off-season (Tuladhar and Raut 2002). Total suspended particulate (TSP), PM_{10}, sulfur dioxide (SO_2) and nitrogen oxides (NOx) were the criteria pollutants measured at the area for eight hours. Average value of PM_{10} during the off-season was 217.95 $\mu g/m^3$ whereas it reached 602.16 $\mu g/m^3$ at the same location when the brick kilns were operating. Similarly, TSP value was 265.49 $\mu g/m^3$ during off-season and 633.78 $\mu g/m^3$ during operation time. In Jhaukhel VDC of Bhaktapur district, PM_{10} concentration in an area with brick kilns was found to be 568.78 $\mu g/m^3$ while it was only 158.33 $\mu g/m^3$ in Sipadol, an area which is south of Jhaukhel but does not have brick kilns (Tuladhar and Raut 2002).

Loss of soil fertility is another environmental cost of these kilns. According to ENPHO (2001), brick kilns in Kathmandu valley occupy about 509.1 ha of land. For the brick manufacturing process, a large plot of land ranging from 2 – 10 ha, or 40 – 200 *ropani* (~ 20 *ropani* = 1 ha) is taken on rent from farmers during the dry season (December to May). Farmers take one crop of paddy during the summer and then lease the land for brick making and soil excavation and get paid between NRs 1200 – 2400 per *ropani* of the land. On an average 4 ha land is used by each kiln and this area includes land on which the kiln is constructed.

Studies have shown that concentrations of essential nutrients like nitrogen (N), phosphorus (P) and potassium (K) are very low in the fields that have been used by the brick industry as the kilns use fertile topsoil (Tuladhar and Raut 2002). A soil fertility test conducted by CEN along with ENPHO and Environmental Camps for Conservation Awareness (ECCA) at the Tikathali VDC, Lalitpur district have found that the use of top soil by brick kilns is making a significant negative impact on soil fertility and agricultural production. The tests indicated that areas without brick kilns showed high concentration of all these nutrients, whereas in areas, which had been used by brick kilns, these essential nutrients were very low. Discussion with local farmers also indicated that the production of crops went down after an area was used by brick kilns. Many farmers add large amount of chemical fertilizer to improve soil quality, but this causes additional environmental problems (Tuladhar and Raut 2002).

Areas that have been used by brick kilns also suffer from other problems such as drying of water wells, lower yield of crops, small landslides and poor visibility. According to the local residents in Tikathali, previously they could easily get water from 4-5 feet below the ground surface. But these days, at the same place there is no sign of water even below 70 feet and most of the water wells are dry. Similarly, impact on agriculture can be seen from the declining crop yield which has decreased by 50 percent. Local residents also reported that after extracting the topsoil for brick making, there are possibilities of landslide along the road, which is now at a higher elevation compared to the surrounding fields (Tuladhar and Raut 2002). Due to the poor visibility, some pilots have complained about problems faced during landing of airplanes from the southern part of the valley (Rai 2002).

Health impacts

Air pollution caused by brick kilns has adverse impact on the health of local people. The PM_{10}, emitted from these brick kilns has direct relation to the human health, as these particulates are small enough to pass through the nose and enter the respiratory system causing problems such as asthma and bronchitis. A health check-up conducted by Clean Energy Nepal and Pro-Public showed that young children studying at High View School, located next to the kilns in Tikathali, suffer more from respiratory problems than students at Valley Public School in Lamatar, which does not have brick kilns in its immediate vicinity. When a doctor examined over 100 children under the age of five in these schools, only 3.85% of the examined children at Valley Public School showed signs of abnormality in lower respiratory tract, whereas in High View School, the figure was 50.85%. Similarly, absence rate at these two schools were very different. On an average, a student was absent 3.6 days per month at the school located near brick kilns whereas 1.9 days per month at the school located away from the kilns. As ill-health is normally the main cause of children being absent in school, this also indicates that the kilns are having an adverse impact on the health of local people, particularly young children (Tuladhar and Raut 2002).

The way ahead

Recently, HMG Nepal has taken few steps to address the problems caused by brick kilns. In March 2002, Industrial Promotion Board decided that after a year and half the government will ban brick kilns that use outdated Bulls Trench kiln technology in Kathmandu valley. The Board has also decided to start the legal and administrative work to change existing polluting industries towards the cleaner options. The Board further ordered the Department of Small and Cottage Industries (DSCI) to close down the brick kilns which are operating without registration (illegal kilns). In the fiscal year 2000/2001, DCSI conducted action against 33 illegally operating brick kilns in Kathmandu valley and fined them a total of NRs. 3.65 million (DCSI, 2002). At the same time, government had announced to stop registration for new Bull's Trench brick kilns in Kathmandu valley.

After the government's decision to shift towards cleaner technologies, brick kiln entrepreneurs are searching for environment friendly and cost effective technologies. Some international organisations like Swiss Agency for Development Co-operation (SDC) and Environment Sector Programme Support (ESPS) supported by DANIDA are providing assistance in demonstrating clean brick manufacturing technologies. Some of the cleaner technologies being considered are as follows:

Vertical Shaft Brick Kiln (VSBK)

VSBK technology was developed in China. In these kilns, the bricks are stacked in a shaft measuring 1 x 1 m and have a height of 6 m. Green bricks are loaded from the top in batches. At the bottom of the shaft, bricks are taken out at the same rate with a special unloading device. Combustion takes place in the middle of the vertical shaft. The combustion air enters at the bottom of the shaft and moves up through the already burnt bricks. So when the air reaches the combustion zone it is preheated to about 7500^0C. After combustion the hot flue gas moves up through the unfired bricks. The transfer of heat to the bricks so very efficient that the temperature of the exhaust gas is low enough to hold a hand over it.

Previously, GTZ/Ceramics Promotion Project set up a VSBK in Nepal in 1992 and after some time the project did not grow up with the expectation and it finally failed. However, the then erectors claimed that the kiln had a fuel saving efficiency of at least 50% and a corresponding reduction of flue gas emission. The combustion in VSBK was much more thorough compared to Bull's Trench kilns and during firing, no black smoke was seen from the chimneys. Lack of initiative for promoting this technology coupled with low production capacity of the demonstration kiln (4000 bricks in 24 hours) and higher rejection rate due to brick breakage are the major reasons for brick entrepreneurs' non-adoption of VSBK in the valley (ENPHO 2001).

The advantages of VSBK technology are energy efficiency and the possibility of operating throughout the year. Unlike other traditional kilns, VSBK has a roof, which affords protection from rain. In India, the emission from VSBK kilns is found to be within the country's standards (VSBK India website).

Forced Draft Zig Zag Brick Kiln

ESPS is to build at least three Forced Draft Zig Zag Firing type brick kilns in Kathmandu, Jhapa and Bhairahawa for demonstration. This type of kiln will have a blower instead of a high chimney to create a horizontal draft through the kiln and the bricks will be arranged in a zig-zag pattern so that the fire and warm air does not go through a straight line. This results in a very compact and efficient kiln design. According to experts, this type of kiln will be cheaper to construct and operate than the Bulls Trench kilns and will result in significantly lower pollution loads.

Fixed Chimney Brick Kiln

Fixed Chimney type of brick kilns are used in India because they are more environment friendly than Bull's Trench kilns. This technology uses a properly designed chimney of about 130 feet height along with an internal gravitational setting chamber (Priya Bricks website). To supplement the chimney, flue ducts are designed so as to provide the least amount of resistance to the flue gases. However, tall fixed chimney may not be appropriate for Kathmandu because the brick industry is located in the southern belt which has soil with low bearing capacity and high seismic risk. This means that setting up a tall chimney could be structurally challenging and expensive. Therefore, kilns with forced horizontal draft or a vertical shaft kiln would be more appropriate.

Conclusion and recommendations

For last few years, Kathmandu valley has been facing serious air pollution problem. Ambient level of TSP and PM_{10} is 4 or 5 times higher than World Health Organisation (WHO) guideline values. Due to this increasing air pollution, many people are facing respiratory diseases and it is increasing annually.

One of the main sources of pollution in the valley is the brick industry, which uses outdated Bulls Trench kilns that are inefficient and polluting. Health check up of children under the age of five in areas with and without kilns revealed that the children in an area with brick kilns are more vulnerable to the respiratory infections. Besides causing pollution and health problems, these kilns also cause problems such as loss of soil fertility, drying of wells and visibility reduction.

Despite its environmental problems, there is need of bricks as construction material in Kathmandu. Therefore, although it may not be possible to close down all kilns the problems of poor quality fuel and inefficient technology must be addressed immediately. A study conducted by Tata Energy Research Institute (TERI) in India indicated that improvements in this Bull's Trench Kilns could save energy consumption by 20% and reduce dust particle by 10 times (TERI website). Similarly, technologies such as Vertical Shaft Kilns and Fixed Chimney Kilns are also available which are more efficient and environment friendly. Introduction of these technologies in Nepal can also save both economy and ecology.

Although, there is no emission standard for brick kilns in Nepal, a recent move of the government to ban Bull's Trench technology is a positive move towards the improvement in brick kilns technology. The need now is to implement this policy and demonstrate the use of environment friendly technology. ■

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Community forestry in Nepal

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Establishment of community forestry in Nepal is a successful step in conservation of forest. Community forestry programme through the local forest users group has shown its positive impacts in the society. This paper discusses an overview of the present scenario of the community forestry in Nepal. It describes the brief historical background, some important forest legislations, and organization of forest. The paper also describes the internal conflicts between forest users and district forest offices, and possible resolution. It also suggests some of the aspects of community forestry in which the research needs to be focused for the better management of the forests in Nepal.

Background

Nepal is one of the first countries to introduce people-focused forest policy. Community Forestry Developmemnt Program (CFDP) is a major program in the forestry sector of the country. The main objective of the community forestry is to meet basic needs of the local people, particularly fuelwood and timber, through a sustainable forest management and utilisation. Before the Rana regime, the forest cover was good, and no special efforts were made for forest protection. During that time, in addition, under the provisions of Jagir, Kipat and Birta, forests were given to army officers and high ranking palace officials. These forest areas were used for their own interests, which increased encroachment. But during the Rana Regime encroachment on forests increased due to conflicts among the Rana brothers over power. A number of rules were drawn up to regulate access to forest and for removal of forest products (Mahat *et al.* 1987). The promulgation of these rules coincided with increased removal of forest products of sale to India. After the dawn of democracy different political movements caused deforestation, particularly the political change of 1950/51 and the political movements of 1979/80 and 1989/90. An estimated 4% of the total forest land was cleared during 1979/80 (Thapa *et al.* 1995).

It was in 1957, the nationalization of forest led most of the forest of the country toward deforestation due to its improper management and increase demand of forest products by increased population of man and livestock (Shrestha 1995). As a result of nationalization of forests in 1957, people gradually lost all benefits and deprived their right to manage and benefits from forests. Similarly afforestration programs on a wide scale could help to close the gap of energy crisis and to meet the increased demand of the fodder, timber and other forest products. Prior to 1957 the state exercised little control over the forests. On the contrary, individuals were encouraged to convert forestland into agriculture land as means of extending state control over territory and increasing state revenue (Wallace 1987). Having failed to manage the forest resources through bureaucratic machinery, the government in 1976 recognized that management of forests by local villagers who had used the forests in the past was the only practical way to ensure protection and sustainable supply of forest products for subsistence needs. By law, resource was entrusted to the community through the local political body called the *panchayat*. This policy was continued over a decade, which finally proved to be ineffective because of lack of requisite infrastructure. Finally the government has came with the new Forestry Act, Rules and Regulations by implementing the Forest Act 1993 to meet the growing needs of various forest products and to restore the ecological balance as well as to make economic use of the forest.

Evolution of community forestry and forest legislation

In recognition of the people's intimate involvement in local forest management and of failure of previous government efforts to control forest protection and management, His Majesty's Government of Nepal (HMGN) moved towards the adoption of community forestry in the late 1970s. The government has introduced a scheme of community forest development project to improve and restablish forest so as to increase the supply of fuel wood, fodder and timber for construction. Subsidiary aims will be to check land erosion, ensure village spring-water supplies and foster the sprit of self-help among villages.

Community forestry through forest users groups is the major policy initiative for the forestry sector in Nepal. Under this programme the user group accepts the responsibility for forest protection, management and sustained use of their community forest. Rural people of Nepal, because of their dependency on a variety of forest products to maintain their subsistence agricultural lifestyle, have for a long time played an important role in the use and management of the forests of the Middle Hills (Bartelett and Malla 1991). The major use of forests by the people shown by Mahat *et al.* (1987) were gathering of leaf material for fodder and for animal bedding, collection of fuel wood and the extraction of timber for building and agriculture implementation.

The first legislative measure initiated by promulgation of

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the Private Forest Nationalization Act 1957 abrogated private ownership of forests and transferred it to the government. No compensation was given to private forest holders for the loss of their forest land (Shrestha 1995). Immediately in 1961 the second legislative measure was brought under the Forest Act 1961 which was provided for regulation of sales of forest products, and it also empowered the government to classify the forests under different categories according to use. The amendment in Forest Act was made in 1976 which classified the national forests into four different categories. In 1978, the panchayat forest rules were promulgated. The legislation provided for handing over parts of accessible governmened-managed forests to village development committees (VDCs), formerly a village panchayat, as a panchayat forest. The VDC is the lowest level political body and not a user group (Kanel 1993). In the subsequent years, amendments were made by emphasizing community participation in the management, conservation, and use of forest resources.

Plate 1: A typical community forest has features of luxuriant growth and regeneration due to protection

In 1988 the Master Plan of Forestry was finalized with the help of national and international experts. The document gives a policy and planning strategy to forestry sector, which stretches into the 21st century, setting medium and long-term objectives. The high priority objectives are: 1) to meet the basic needs for fuel wood, timber, fodder and other forest products on a sustained basis, 2) to promote people's participation in forestry resources' development, management and conservation.

Following the changes in the political system in 1990, the community forestry regulations were revised consequently and the revision in definition of user group (community) was done (Forest Act, 1993). The Forest Act of 1993 is the latest forestry legislation, promulgated by royal decree on the 18th January 1993. This new Act follows the recommendations of the Master Plan for the Forestry Sector (MPFS 1988), of which most important are: 1) community forests should have priority over other uses of government-owned forests, and 2) the protection and management of community forests should be entrusted to the actual users. The Forest Act 1993 categorizes the forest into two broad classes: National Forest and Privet Forest. The National Forests are further divided in to five sub-categories: 1) Protected Forests, 2) Community Forests, 3) Leasehold Forests, 4) Religious Forests, and 5) Government Forests.

Some of the features of the Forest Act are as follows:

- Users' group should be registered in the district forest office;
- The district forest officer is empowered to hand-over a part of national forest to users' group;
- An operational plan should be prepared and submitted along with the application to the district office;
- The users' groups can price the forest products independetly;
- The users' group can also raise funds from various sources, including the collection of fines;
- A users' group formed under this Act will be an autonomous and corporate body.

Organisation of forest

In Nepal, the forests are under the Ministry of Forest and Soil Conservation. The territorial set-up consists of Regional Forestry Directorates in the five development regions (established in 1981), 74 District Forest Offices, 222 Ranges Offices, and 888 Forest Guards (Palit 1996). A Community Forestry Division has been established to deal with community and private forestry programmes, although its main task is to coordination the community forestry development. The main tasks of five Regional Directorates include monitoring and clearance of technical matters with the districts. Each district is subdivided into 2-5 Ilaka Foest Offices (Ranges). All 23 districts (covering all the terai and some parts of the siwaliks and middle mountains) have been provided with armed guards to control encroachment and illegal felling (Bhatta 1989).

Non-government organisations

Among the strategies adopted for the implementation of the Master Plan for the Forestry Sector (MPFS), one is 'active encouragement to NGOs to participate in implementing the programmes under the leadership of the Social Services' National Coordination Council'. This enhances a number of NGOs working under various categories in Nepal. Due to their ability to reach disadvantaged people and promote self reliant development, the NGOs are used to promote community

forestry, particularly at the grassroots level. Some NGOs are at national level while some of them are locally based. These NGOs play a very important role by activating a grassroot level process of needs, identification, project formulation, and implementation of development activities (Bhatta 1989). The United Mission to Nepal (UMN) has been involved in community forestry in Nepal since 1981. Its programme focusses on general education, raising awareness, and capacity building for general community development (Kinsely 1993). The strategies adopted by UMN envisage an integrated and coordinated approach between different government line agencies as well as NGOs working in the same area. The ultimate objective is training communities in skill and capacity development, not only for community forestry but also for improved, overall community development.

Present status of community forestry

For the management of proper utilization of the forests, in earlier days, field staff attempted to motivate the local villagers towards the management and sustainable utilization of the forests. They tried to encourage the villagers towards community forestry eventhough the staffs were not well trained for that purpose. Initially, community forestry, which was viewed as a solution to deforestation problem, depended mainly on tree planting. It was thought that this would solve the fuel and fodder crisis. Attention and funds were diverted to plantation programs in the 1970s and 1980s. The formation of users' groups and handing over of the community forests was very slow. Field-level training programs were planned and carried out extensively in districts and other areas for field staffs as well as the user groups and local leaders. Various types of short-term training programs workshops, study tour programs were organized to discuss the management, utilization and protection of the community forestry. INGO, NGO and local NGO were highly involved in such programs mainly focusing on women involvement in community forestry. By this women are quite liberated socially and take an active part in community forestry.

Since forestry was basically funded by different donor agencies through projects, a reappraisal of projects, which took place in the mid-1980s, led to a change at policy level. The emphasis shifted from plantation on *panchayat* lands to government- owned natural forests. One factor (in present days), which shifted the emphasis, is the realization that natural forests can be renewed at much lower cost than plantations, and the flow of subsistence goods from natural forests is usually much higher. The non-governmental organizations are actively involved in convincing local villager in this direction. Non-governmental organizations provided opportunities to the user groups to discuss ways and means of proper management of community forestry through various participatory activities in districts, regional and national level. The local level forestry staffs are encouraged to plan community forestry level planning, by a method of Participatory Rural Appraisal (Shrestha 1995). As a result of these activities the formation of users groups and handing over of forest is accelerating, where 9,10,370 ha of forest were handed to 11,586 users groups including 1,276,433 households (Table 1). This rapid growth in community forestry was due to enactment of the New Forest Act 1993.

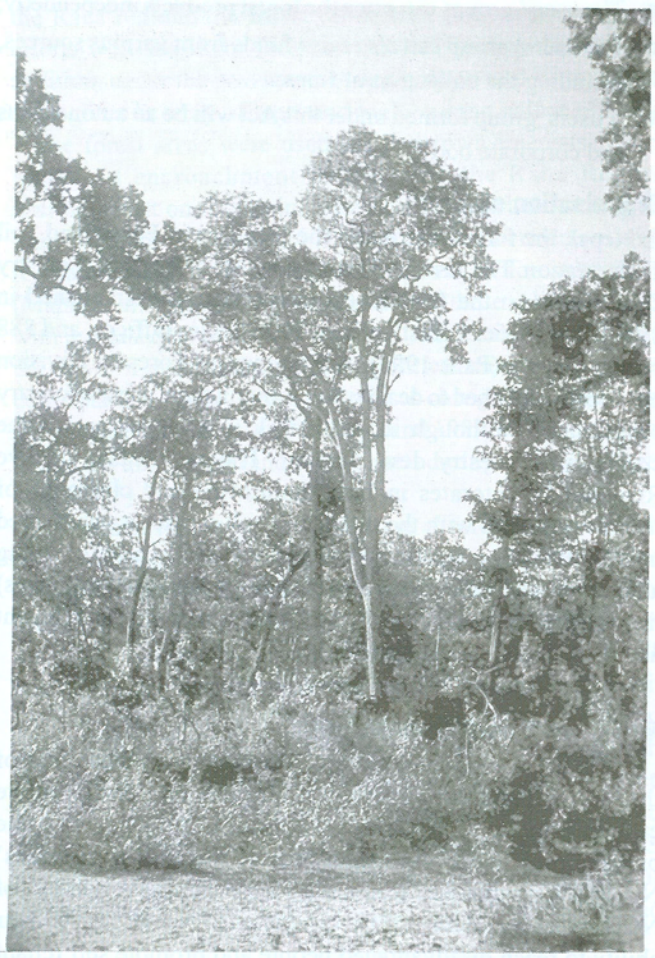

Plate 2: Several community forests exist in riverine areas

Table 1: Community managed forests (2001/'02)

Regions	FUG Nos.	CF Handover in ha.	No. of Households
Eastern	2,144	2,41,067	2,50,780
Central	2,584	1,93,783	3,00,990
Western	3,178	1,48,895	3,47,126
Mid-western	2,078	2,19,183	2,24,707
Far-western	1,602	1,07,442	1,52,902
Total	11,586	9,10,370	12,76,433

(Source: Community and Private Forestry Division, Department of Forest 2001/2002)

Conclusion

Initiated only in the late 70s, the implementation of community forestry programme through forest users groups has started showing its positive impacts in the society (Bartlett *et al.* 1992). Such impacts are revealed in the form of income generation, construction works and above all a distinctive awareness of people on the need for conservation of natural resources.

Establishment of community forestry in past 24 years (1978-2000) is a successful step in conservation of forest and it is gaining popularity not only in country but also throughout the world. This is because the users groups are also interested in such conservation activities since the fruit of such activities comes to themselves. They also get their livelihood requirement of fodder, firewood, and leaf litter. They prepare operational plan of their forest by themselves with the help of DFO for management and manage according to it. When innovative foresters have built upon community initiatives, the results have been excellent (Singh and Singh 1993). In Nepal, it is now recognized that "an important element for being successful with community forestry implementation is the field staff's ability to identify and incorporate existing local systems of forest management into their recognized system of community forests" (Barlett and Malla 1992). It is seen that many forests are managed quite well while others have conflict within them, or between user group or between user group and DFO's. In some user groups, internal conflicts that occur primarily due to the violation of rules and regulations by members have been reported. Such conflicts are usually settled by the Executive Committees of these user groups through the imposition of penalties or fines. Some of the workers pointed out the immediate research in community forestry. The socioeconomic aspect of community forestry is an important area of research. Prajapati *et al.* (1990) identified the three areas of research in the community forestry as they occupy the top three spots. These are natural forest silviculture, agroforestry, and fodder trees. The forests of Nepal have never been managed systematically. Even though the forests were nationalized in 1957, effective management of forests could not be introduced for various reasons. Even in the terai, where commercially valuable trees occur over extensive areas, efforts to introduce management plans were unsuccessful due to encroachment and sociopolitical reasons (Kayastha 1991). Very little information is available on these areas. In general the community forests were being managed under protection-oriented management systems, allowing the utilization of dry forest products but not providing additional green forest products. This management system of forest through the initiation of community forest project will give the positive result in the conservation of natural resource of the country. This will ultimately increase the socio-economic status of the local people and the whole country. ■

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