Biodiversity and Agriculture

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If the Earth's population is to feed itself in the 21st century and beyond, humankind needs to preserve the biodiversity that grants us our own complex and diverse lives. But biodiversity is diminishing at unprecedented rates. Over the past few hundred years humans have increased the rate of species extinction. Human drivers of change, including habitat loss, climate change and overexploitation of resources, have increased the rate at which species are going extinct by as much as 1,000 times background rates typical of Earth's history.

Every year on the 22 May, to raise awareness of the importance of biodiversity, the world celebrates the International Day for Biological Diversity. This year's theme on "Biodiversity and Agriculture" highlights the importance of sustainable agriculture not only to preserve biodiversity, but also to feed the world, maintain sustainable agricultural livelihoods, and enhance human well-being, now and in the future. We all know that biodiversity is the basis of agriculture. Its maintenance is essential for the production of food and other agricultural goods and the benefits these provide to humanity, including food security, nutrition and livelihoods.

Agricultural biodiversity is a term that includes all components of biodiversity- at genetic, species and ecosystem levelsthat are relevant to food and agriculture and that support the ecosystems in which agriculture occurs (agro-ecosystems). This includes the crop and livestock species, and the varieties and breeds within these, and also includes those components that support agricultural production. Components at the species level that support ecosystem services include earthworms and fungi that contribute to availability and cycling of plant nutrients through the breakdown and decomposition of organic material.

According to the FAO, about 7,000 species of plants have been cultivated since humans first began farming. However, today, only 30 crops provide an estimated 90% of the world population's dietary energy requirements, with wheat, rice and maize alone providing about half the dietary energy consumed globally. Of the estimated 15,000 species of mammals and birds, only some 30 to 40 have been domesticated for food production and less than 14 species including cattle, goats, sheep, buffalo and chickens account for 90% of global livestock production. In recent decades there has been alarming genetic erosion within these species.

Biodiversity in agricultural and associated landscapes provides and maintains ecosystem services essential to agriculture. Agriculture contributes to conservation and sustainable use of biodiversity but is also a major driver of biodiversity loss. Farmers and agricultural producers are custodians of agricultural biodiversity and possess the knowledge needed to manage and sustain it. Sustainable agriculture both promotes and is enhanced by biodiversity. Sustainable agriculture uses water, land and nutrients efficiently, while producing lasting economic and social benefits. Barriers inhibiting its widespread adoption need to be reduced.

Agricultural producers respond to consumer demands and government policies. To ensure food security, adequate nutrition and stable livelihoods for all, now and in the future, we must increase food production while adopting sustainable and efficient agriculture, sustainable consumption, and landscape level planning that ensure the preservation of biodiversity. The conservation and sustainable use of biodiversity is essential for the future of agriculture and humanity. At the same time, since agricultural lands extend across such a considerable proportion of the Earth's surface and harbour significant biodiversity, the conservation of biodiversity within agricultural landscapes must play an important part in global conservation strategies.

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Some key information for Biodiversity and Agriculture is as below: (Courtesy: CBD, 2008)

- The global agricultural labor force includes approximately 1.3 billion people, about
- A fourth (22%) of the world's population and half (46%) of the total labor force.
- Over 826 million people are chronically hungry; they need 100400 calories more per day.
- Of the 27,000 species of higher plants, about 7,000 are used in agriculture.
- Worldwide, 32% of pre-school children are underweight.
- Between 1960 and 2000, the demand for ecosystem services grew significantly as the world's population doubled to 6 billion people and the global economy increased more than sixfold.
- Animals and insects pollinate approximately 80% of angiosperms, which amounts to about 300,000 flower-visiting species.
- During the second half of the 20th century the global food system was able to respond to the doubling of world population by more than

doubling food production.

- Agriculture accounts for 44% of anthropogenic methane emissions and about 70% of nitrous oxide gases, mainly from the conversion of new land to agriculture and nitrogen fertilizer use.
- 20% of CO2 emissions in the 1990s originated from land use changes, mostly deforestation.
- Deforestation in the tropics and sub-tropics leads to a reduction in regional rainfall.
- Water withdrawals from lakes and rivers doubled since 1960, with 70% worldwide used for agriculture.
- In England and Wales the damage costs of freshwater eutrophication was estimated to be $105160 million per year in the 1990s.
- Since 1960, flows of nitrogen in ecosystems have doubled and flows of phosphorus have tripled.
- Worldwide, soil is being lost at a rate of 13 to 18 times faster than it is being formed.
- A study in Costa Rica found that forest based pollinators increased coffee yields by 20% within 1 kilometer of the forest.
- Dryland systems cover about 41% of the Earth's land and more than 2 billion people inhabit them.
- Globally, there are 6,500 breeds of domesticated animals, but 20% of these are under threat of extinction.
- Roughly 80% of wheat area in developing countries and three quarters of rice area in Asia is planted with modern varieties.
- Government subsidies paid to the agricultural sectors of OECD countries between 2001 and 2003 averaged over $324 billion annually, or one third the global value of agricultural products in 2000.
- Neglected and underutilized species can become valuable commodities for the poor, who have used them to survive for centuries as subsistence crops in difficult and low-input production environments.
- Food production increased by roughly two-and-a-half times (160%) between 1961 and 2003.
- Globally, the potential of rainfed agriculture is large enough to meet present and future food demand through increased productivity.

Current Status of Biodiversity, Conservation and Utilization for Sustainable Agriculture

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Conservation and sustainable use of plant genetic resources is fundamental to ecologically sustainable development and food security of any nation. These are part of daily lives and livelihood, and constitute resources upon which families, communities, nations and future generations depend. Therefore, every nation has the responsibility to conserve, restore and sustainable use the plant genetic resources within its jurisdiction. Plant genetic resource diversity is fundamental to the fulfilment of basic human needs like food, fuel, fodder, fibre etc. Loss of plant genetic resource diversity has serious implication on economic and social development of any nation. The experience of industrial nations has shown that economic development at the cost of depletion of ecosystems has an adverse effect on environment, food production and human health. India fortunately, while following the path of development, has been sensitive to the needs of conservation and hence is still rich in biological resources. This has been because of Indian ethos of policies, because conservation and harmonious living with nature is very much part of lifestyle of Indians.

India's strategies for conservation and sustainable use of plant genetic resources have been to provide protection to areas rich in biodiversity afforest ration of degraded areas, creation of *ex-situ* conservation facilities in the form of gene bank etc. However, the challenge before India is not only to sustain the efforts of the past, but further strengthen them as per the rational and national needs to accelerate the growth and development, particularly in the area of agriculture to meet the growing needs of food for overgrowing population and alleviating the poverty to improve their buying power and living standards.

Agro-Biodiversity (Gene-Rich Indian Sub-Continent)

“Biodiversity” refers to the variability in living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part; this include diversity within plants, species and of ecosystems. “Agro-biodiversity” is an evolutionary divergent and highly interrelated component of biodiversity dealing with agro ecosystems, and variation in agriculture related plants, animals, fish, insects, microbe's avian etc. Plant genetic resources are 'keystone' components of agro-biodiversity dealing predominantly with domesticated species which directly or indirectly sustain human kind; their wild relatives used in breeding; other wild species used in agriculture, horticulture, forestry or other industries, and species of interest to a wide range of research areas. It also deals with species that are part of ecosystems and known to be, or likely to become, threatened or endangered in their habitat.

Indian subcontinent is one of the 12-mega-biodiversity centres and represents two of the eight Vavilovian centres of origin and diversity of crop plants. Two of the eighteen globally identified 'hot spots' of biological diversity occur in India, one each in the Western Ghats and the North-eastern Himalayas. India also has the greatest diversity in its environment, which has resulted in the development of a number of ecosystems and agro-ecological zones, harbouring innumerable life forms of potential value to provide food, fodder, fuel, medicine, and textile etc. for human consumption and socio and economic development. Value and potentials of a large number of species are already known and bio prospecting of certain genes and chemicals has been undertaken to some extent. Yet, there are innumerable species, the potentials of which are yet to be investigated. Therefore, it would be prudent to conserve not only those species, who's actual or potential value we know, but also those, which have not yet been investigated from economic point of view. For example, *Taxus baccata*, a tree found in the sub Himalayan region, once believed to be of little economic value is now considered to be effective in the treatment of cancer. Similarly Noni (*Morinda citrifolia*) from the coastal region and Seabuckthorn (*Hippophae* spp) from the cold dessert areas have been found rich source of phyto chemicals and are now being exploited for many human health hazards.

Indian sub-continent entails a wide spectrum of life forms. Agro-climatic situations vary from humid tropical to semi-arid, temperate, alpine, and agrarian habitat ranging from highly mechanised, near mono-specific cropping to nomadic cultivation and even food gatherers. The sub-continent is bestowed with immensely rich landrace diversity in major agriculture and horticulture crops, due to native farmers' conscious/unconscious selections, inherited and perpetuated over generations.

Agro-ecological system diversity:

Based on phyto geography, climatic and cultural features, the ICAR recognised 8 agro-climatic regions Based on further micro climatic consideration; these were classified into 20 agro-climatic zones, which have been further sub-divided into 120 zones. Planning Commission has demarcated 15 agro-climatic zones. These zones provide diversity in the environment to various crop species for specific traits or gene complexes to react in different manner to evolve them differently, thereby generating variability suited to climatic condition of that zone. Hence, these zones can be centres of diversity for various desirable traits as per the natural selection pressure. For example, arid and semi-arid zones should be significant source of variability for drought resistance.

Species diversity

India is situated at the tri-junction of three realms, namely Afro-tropical, Indo-Malayan and Paleo-arctic, and therefore, offers characteristic features of all of them, and makes the country rich and unique in biological diversity. India ranks tenth in the world and fourth in Asia in plant diversity.

The Indian sub-continent is the centre of domestication and diversification of several forest plant species, forages, grasses, shrubs, herbs, ornaments etc. The floristically very rich, India has about 141 endemic genera belonging to over 47 families of higher plants. India, which has been considered as one of the twelve mega-centres of biological diversity, as per Botanical Survey of India, has 46,214 plants species (11.9% of global flora). Of these, about 17, 500 (7, 000 species in north east region alone) represent flowering plants (7% of the world flora); 37 % of them are endemic, and roughly 1,500 species being threatened species. Of the endemic species (4,950), the largest number (about 2532) species are located in Himalayas followed by peninsular region (1,788 species) and Andaman Nicobar islands (185 species). It also holds half of the world's aquatic floral diversity. It is a treasure house of wild economic plants, particularly wild edible and medicinal plants, which are largely utilised locally or in several *Ayruvedic* preparations, which can be safely termed as commercially

Crop diversity/genetic diversity

Of the 5000 species of plants studied in detail so far, only 30 provide 95% of human nutrition and three crop species representing maize, wheat and rice give 60% of the calories and protein obtained from plant systems by human beings. In view of this, diversity both between and within few species representing crop plants and their wild relatives has been a major concern in developing programmes on crop genetic resources conservation and for sustainable use in food and agriculture both at national and international level.

About 44 major or minor crop species originated and domesticated in India is known to have more than 17,500 species of higher plants, including 168 crop species India is 7th in number of domesticated plants and animals. It has 334 wild relatives of crop species; additionally, the native tribes use another 1,532 wild edible plant, species. These include 145 species of roots and tubers, 521 of early vegetables/green, 101 of bulbs and flowers, 647 of fruits and 118 of seeds and nuts. In addition, nearly 9,500 plant species of ethno-botanical uses have been reported from the country, of which around 7,500 are for ethno-medicinal purposes and 3,900 are multipurpose/edible species.

India is centre of origin of several crop species like, rice and minor millet in cereals, pigeon pea in pulses, sugarcane in cash crops, bitter gourd, amaranths in vegetables, coconuts in plantations crops etc. Thousand of varieties of several important native or introduced staple food crops, vegetables, fruits, spices, fibre, forage and medicinal plants have developed in India under *in situ* condition making it one of the important centres of genetic diversity for these crops.

The significance of Indian flora in global economy and food security is evident from the number of species of wild relatives of crop plants found in different regions of the country. Several hundred wild relative species of a number of crop species are distributed all over the country. For example, a major centre for wild relatives of rice is the Eastern Peninsular India, i.e. West Bengal, Orissa, and Andhra Pradesh; the north-eastern Hills and the Tamil Nadu hills are rich in wild relatives of millets; while wild relatives of wheat and barley are located in the western and north-eastern Himalayas.

Table 1: Number of cultivated crop species originated in India

Crop Group	Crops
Cereals	Rice, Little millet
Grain Legumes & Oilseeds	Black gram, Green gram, Moth bean, Pigeon pea, Horse gram, Sarson
Vegetables	Egg plant, Cucumber, Ridge gourd, Pointed gourd, Snake gourd, Round gourd, Kundri, Arvi, Jamikand, Leafy mustard, Yam
Fruits	Citrus, Banana, Mango, Jamun, Kronda, Khirni, Phalsa, Aonla, Bael, Wood apple, Jack fruit
Spices & Condiments	Ginger, Turmeric, Cardamom, Areca nut, Black pepper, Betel leaf, Cinnamon, Dalchini
Others	Sugarcane, Sunhemp, Tree cotton, Jute, Bamboo, Tea, Dhaincha

Importance of Plant Genetic Resources

There are approximately 75,000 species of edible plants worldwide but over the course of human civilisation, only about 7000 plant varieties has been used for food. There is also a remarkable diversity and abundance of insects, fungi, and other organisms that are valuable to the productivity of agro-ecosystems. The concept of agro-biodiversity also includes habitats and species outside farming systems that benefit agriculture and enhance ecosystem functions, such as, sources of host plants for natural enemies and predators of agriculture pests. In order to increase production and food security some wild plant species are also used.

In addition, 95% of prescriptions of traditional systems of medicines are plant based. Similarly, lot of plant material is used in housing and construction activities. Among the indirect benefit, many habitat and species are attractive from recreation and tourism point of view, while many ecosystems or production systems are important for appropriate management of environment, because of their ability to absorb pollution, maintain soil fertility, micro-climate, recharge of water and in providing other invaluable services. PGR are also important from moral, cultural, religious, aesthetic, social and scientific point of view. Many plant, and their parts are used in rituals.

In addition, to the above direct and indirect uses of plant genetic resources, the most important use of genetic variation, particularly in domesticated species and their wild relatives is to use this genetic diversity as building blocks in further genetic improvement of crop and other economically important species to increase productivity and their use in food security and overall economic and social sustainable development for alleviation of poverty levels. Advent of biotechnology that can help carry genes beyond the sexual boundaries and use microorganism in production of bio fertilizers, bio pesticides and in mining etc. has given another flip to the importance of PGR.

Conservation

Conservation of plant genetic resources should be looked in term of gene pools. Following this approach, it is very likely that a range of methods of conservation would be applicable to satisfy the needs of a gene pool. This suggests for the need of both *in situ* and *ex situ* conservation in saving of species and genetic diversity from extinction. This can be referred as Complementary Conservation

Strategy or Complementary Comprehensive Conservation Strategy (CCCS).

For problem plant systems, if *in vitro* conservation is difficult and expensive, and then a significant part of the gene pool can initially be conserved in field gene banks, followed by research efforts for *in vitro* conservation. These approaches are complementary to each other having balance of advantages and disadvantages. *In vitro* conservation may be economic, provide improved security of germplasm, and independence from climatic variation etc; whereas, the field gene bank allows evaluation of germplasm assisting users and continued evolution in response to the climatic variation. While *in situ* conservation of wild relatives of such crop, species may help in protection of habitat, thereby the ecosystem and the environment, in addition, to continue evolution for generation of new variability for present and future use.

The basic objective in conservation of plant genetic resources is 'gene (s)'. In clonal species, all clonal gene combination may not be equally important, but overtime may become important. They are best conserved as seed (also pollen), therefore, whenever the seeds can be produced in as many as root and tuber crops, they should incorporate in conservation strategies.

Devising conservation strategies should aid efficient conservation. It can help in identification of research needs. For example, if an ideal strategy for a species is *in vitro* conservation and slow growth method, but if it is not yet available, then this means it requires research for development. In this way true needs of conservation with focus on efficiency, cost and utility can be developed in future. Therefore, because of the complementarily of these approaches a continued dialogue between environmentalists, conservationists, breeders and biotechnologists is required to ensure necessary stimulus for research and to identify best approach, its adaptation to pressing problems and realisation of new bio technological solution in agriculture.

***In-situ* conservation:** Approximately 4.2% of the total geographical area of the country has been earmarked for extensive *in-situ* conservation of habitats and ecosystems. The Indian Council of Forestry Research and Education (ICFRE) has identified 309 forest preservation plots of representative forest types for conservation of viable representative areas of biodiversity. One hundred eighty seven of these plots are natural forests and 112 in plantations, covering a total area of 8,500 h. A programme called "Eco-development" for *in-situ* conservation of biological diversity involving local communities has been initiated. This integrates the ecological and economic features for sustained conservation of ecosystems by involving local communities. .

In addition, to above conservation programmes, India has traditional refuge of natural resources called sacred grooves. These are seen throughout the country and vary in size from few plants to several acres. There are four regions important for grooves, Khsia and Janthia Hills, Western Ghats, Aravalli Hills and Sarguja, Chand and Bastar area in Central India. Maximum number of grooves is in Kerala, Maharashtra and M.P. etc.

However, the current protected area network is unevenly distributed over states and bio geographic regions. For example, many biotic states are not adequately covered, such as Ladhakh, South Deccan, Gangetic Plains, Assam Hills, and Nicobar Island have less than 1% area of their total area under protection, despite their recognition as rich centres of biodiversity. Very little attention is being paid to conservation of plants in general and crops plants and lower group of plants in particular. The *in situ* for conservation of agriculture biological diversity of economically important crop species is yet to start. This requires immediate attention, as release of high yielding varieties in most crop species is encouraging monoculture in vast areas of cultivation. This has resulted in the loss of a large number of local landraces, and old or traditional cultivars, causing severe genetic erosion, particularly for the nutritional traits and the traits related to biotic and biotic stresses, that were inbuilt components of these resources for sustained production in subsistence farming from generations. They would still be important for sustainable food production in subsistence agriculture that is on increase in India, because of population pressure and depleting farmer's holdings. To meet these challenges *in-situ* conservation efforts should be strengthened through-

Ex-situ Conservation: Central government and State Governments together run and manage 33 Botanical Gardens that maintain the diversity in the form plants or plant populations. Biodiversity has also been preserved in the form Herbarium. Botanical Survey of India has largest holding of 1,500,000. There are many more herbariums, such as Presidency College, Madras (100,000); Baltter Herbarium at St. Xavier's College, Bombay (100,000); St. Joseph's College at Tiruchinapally (60,000) etc. in other parts of the country.

Compared to the geographical size of the country, and its rich biological diversity in different biogeographically zones, *ex-situ* conservation bases are less. Many of them are small and other does not have adequate facilities. There is only one Botanical garden, while the need is to have more botanical garden in each phytogeographic region. The current efforts of conservation of genetic resources in *ex-situ* are inadequate and are restricted mainly to improve high yielding varieties. Unfortunately, similar attention is not paid for conservation of traditional varieties/ landraces and their wild relatives because of several reasons, and requires immediate attention. Following steps may help in meting these challenges.

Need for Documentation of Indigenous Knowledge on Plant Genetic Resources

Indigenous knowledge systems are both coded and non-coded and are formal and informal. Coded systems include treaties on Ayurveda, Unani and Sidha system of medicine and health care. There may be some lesser-known descriptions of other uses in ancient texts. A wealth of information is non-coded which is in the form of local knowledge systems and practices. The potential of such knowledge, particularly in product development has been proved beyond doubt. The products may be limited to a region while in some cases has even crossed the regional boundaries. In quit few cases the lead for such products has been provided by the local communities, but can not be traced back because user is not oblige to disclose the origin of source of information. However, it was limited to tribal communities and did not include vast wealth of other local uses and practices.

Nevertheless, there is a threat of extinction of such knowledge through non-use, because of substitution effect of modern products or non-transfer of such knowledge to successive generations particularly if an individual or a family holds the information. This traditional knowledge has the potential of being translated into commercial benefits. This should, however be accompanied with sharing of the benefits accruing from commercial utilisation of the local knowledge with the communities/ people individuals responsible for creating, refining and using this knowledge as being practised by TBGRI Kerela. Documentation of knowledge systems and practices and innovations has to be sensitive to the needs of protecting intellectual property rights (IPRs) of these people, even though the subject of such IPRs is not yet fully resolved.

Role of PGR in Sustainable Agriculture and Development

The component of agri biodiversity used in development of new plant varieties or hybrids is called genetic material. It is any material of plant, animals, and microbes or of other origin containing functional units of heredity. It includes seeds, semen, tissue, cells, pollen, DNA molecules etc. The use of the genetic material (genetic variation) as source of gene(s) in the genetic improvement of crop species/domesticated animals to produce high yielding varieties, hybrids, breeds etc. for sustainable increase in food production for food security and poverty alleviation is increasing, to effect ecologically sustainable economic and social development. A few examples of utilisation of Plant Genetic Resources in conventional breeding that made significant impact on food production are-

In tomato, several species have been used in breeding programmes to select varieties resistant to parasite fungi (*L hirsutum, L. peruvianum* and *L. pimpinifolium*), virus (*L. chilense* and *L. peruvianum*), nematodes (*L. peruvianum*), insects (*L. hirsutum*) for improvement of fruit quality (*L. chmielewskii*) and adoption to unfavourable condition (*L. cheesmanii*). **Two species from Peru were used in US to increase pigmentation and solid matter contents, which resulted in an annual gain of US $ 5 million to canned tomato industry in US**. The conservation of diversity within a species is indispensable to future utilisation. For example, one single population of *Oryza nivara* has been used to select rice varieties with resistance to grassy stunt virus. There re such examples in corn, rice, groundnut, rubber, alfa-alfa etc. proving that accession of genetic resources has been the basis of improving and selecting crop varieties to increase productivity either through conventional breeding, culture of plant cells, tissue and organ or gene transfer.

Advent of biotechnology that can make possible carry desired gene across the sexual boundaries i.e. from animals to plants, can modify micro-organisms for use in mining, scavenging the oil spills and other wastes and produce of bio fertilizers, bio pesticides and antibiotic and vaccines in the plant system would further increase the role of PGR in sustainable socio-economic development.

Conclusion

India is primarily an agricultural based economy. The economic growth and development of country predominantly depends on agriculture sector. Two factors i.e. consumer preference to plant derived drugs/products in pharmaceutical industry and the new development in the area of biotechnology that can provide diverse use of plant genetic resources in recent past. The raw material for both these technologies is the plant biodiversity. Thus importance of PGR in future is growing to grow and would be one of the key factors in global economy. Therefore, PGR are going to play a major role in diverse areas and would be a money-spinner.

Fortunately, the plant biodiversity wealth is concentrated in tropical countries of south. Unlike other countries of south, India is in a unique position to convert these resources into product using the intellectual power available in the country and then to money. In addition, India is also a repository of indigenous knowledge about the use of these resources that can help accelerate the process of utilisation of PGR. Besides, it also has made enormous investment in agricultural research, especially during the green revolution to generate valuable scientific human resource. Hence, India is in a unique position to take the advantage in the field of biodiversity and emerge as global player in the field of Agro-industry.

Being a gene-rich country from south, India can develop useful collaboration with other gene-rich countries to have access to large range of genetic resources. Therefore, with genetic resources at hand, skilled manpower and capabilities of using the newly developing technologies provides big opportunity to cash on this natural resource for sustainable development of agriculture in India.

Ethno-agricultural Diversity with special reference to Food and Forage Plant diversity in India

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The varied climatic conditions and topographic situations are responsible for unique and rich floristic composition of India. Out of 15,000 species of higher plants reported from India, about 4,900 species belonging to 141 genera and 47 families are endemic. The higher percentage of endemic plant species (about 2,532 species) found in Himalaya, the peninsular region (1,788 species), and the Andaman and Nicobar Islands (185 species). The endemism can provide clue to the mechanism or evolution through isolation and speciation. North- eastern region is considered as the cradle of flowering plant. It harbours the maximum floristic richness, which holds about 50 percent of India's total species diversity, i.e., more than 7,000 species (Nayar, 1989). The floristic diversity available in wild relatives and related type of cultivated plants is estimated to about 320 species, of which about 60 are endemic taxa (Arora and Nayar, 1984). India is one of the twelve centres/regions of diversity of crop plants in the world (Zeven and de Wet, 1982).

The Indian subcontinent is inhabited by over 53 million tribes and forest dwellers belonging to over 573 indigenous communities of 227 ethnic groups, covering 5000 villages in India, mostly located in the central and peninsular region and in northeast, with sporadic pockets in other part of the country. They subsist on natural resources obtained from forest and on some traditional crops. The culture and economics of various tribal communities and forest-dwellers scattered in the forests of various geographic zones in India, vary with the ecosystems. Some are dependent entirely upon hunted and gathered food and other on the agriculture for their subsistence. The ethnic diversity in sub-continent has played a major role in the diversification of crop resources in this region. Thus, rich genetic diversity occurs in several crop plants and their wild progenitors. The northeastern region of India, forming the 'Hindustani Center of Origin of Cultivated Plants' is very important for tropical and subtropical fruits, cereals, etc. (Vavilov, 1926). A rich diversity of wild herbage legumes and grasses is largely distributed in various phyto-geographical regions of India. Living with nature and natural resources, the tribal people developed their own cultures, customs, taboos, folk-tales, and they have discovered a large number of plants for multifarious uses as food, fodder, forage, medicine and other utilities for themselves and their domestic animals. Later on some of them have been selected for cultivation as crop by these primitive people for food and forage. Maize, rice and wheat are the greatest achievement of their quest, utilized as major crops during modern time. Numerous land races of low nutritive value and less productivity have also been invented by them at the same time as alternative food and forage crops. The numbers of wild relative of crops or germplasm are also present in many tribal localities which may be used to improve crop varieties. The people who have traditionally lived in forests are the key to understanding, utilizing and conserving the plant diversity. The traditional storage of ethno-botanical knowledge in memory and practice has a long history. The centres represent a storehouse of genetic diversity, being maintained by peasant and subsistence farmer- the traditional conservator of biodiversity at grass root. Several traditional practices that are sustainable and environmental friendly continue to be a regular part of the lives of people. These need to be recognized rather than replaced by more “modern” but unsustainable practices and techniques. It has been estimated that the Indian subcontinent possesses rich floristic wealth. Of this about 3,000-5000 species are of economic value which includes about 1,000 wild food plants distributed in all phyto-geographical/ agro-ecological zones in India.

It is true the industrial development has gain momentum in various parts of India and standard of living of common people has been raised in urban areas during recent years but what has been done for two third of total population of India's rural and tribal people, still they live with scarcity of basic needs. Over 200 million of India's population is underfed, and millions are undernourished. It is pity that the highest producer of food is struggling for their survival and most of them are living below the poverty level. Although some attention have been paid by Government towards the development of rural and ethnic societies but it is not so enough that they can sustain in their native places with comfort. Scrutiny of literatures reveals that large number of information on multifarious uses of wild plants such as cereals, millets, legumes, fodder, forage along with wild relative of cops and primitive cultivars are preserved in it. Nevertheless, it is unfortunate that no new food crop has been added by agricultural scientists during recent time. Large numbers of land races have already lost their existence during last centuries; however, still some indigenous crops are being cultivated by tribal and ethnic communities residing in various parts of the phytigeographic zones in India. There is still an immense wealth of plants awaiting exploration, identification and scientific research in the remaining wilderness areas. This not only opens out possibilities for expanding the rather narrow existing food plant base but also represents a vital security through genetic pool for hybrids.

This vast repository of knowledge related to plants has been cared and nourished by the tribal communities as a common property since thousands of years and it is also being freely transmitted from generation to generation by means of oral communication. Many plants used today by us were originally identified and developed through indigenous knowledge. The utility of wild plants for diverse purposes has not recognized in one day or in one century; it is a result of the progressive development of human culture. The cereals, vegetables and root crops that we have cultivates as source of food, fiber and oil for our subsistence, are all gifts of Tribal to our modern civilized society. Infect, the civilized society should be indebted to primitive people for they had during the last several thousands years, screened the wild plant life and determined its usefulness. The systematic study of traditional agro-botanical knowledge of indigenous people and other ethnic groups, and use of locally available domesticated plants and their landraces or folk varieties in food an forages has called Agro-ethnobotanty. Thus, it is endeavor of scientific community, that they study these valuable natural resources so that problem of their utilization and conservation are understood for sustainable development of the area.

Food and forage are the part of Agricultural diversity which comprises all cultivated modern and traditional varieties relevant to food and agriculture present in ago-ecosystems, which support soil security and provide a home to wildlife. Modern varieties are the outcome of scientific breeding and are characterized by high yield and high degree of genetic uniformity while traditional variety or landrace are product of selection carried out by farmers and primitive people over millennia. They represent higher levels of genetic diversity.

Agricultural biodiversity is not only the result of human activity but human life is dependent on it not just for the immediate provision of food and natural resources based goods, but for the maintenance of area of land and water that sustain production and maintain agroecosystems and the wider biological and environmental services. Agricultural biodiversity is the first link in food chain, developed and safeguarded by farmers, forest workers and indigenous people throughout the country. It contributes to food security and livelihood security. Agro-biodiversity is a vital tool in the challenge to meet the Millennium Development.

The crop diversity is being diminished under pressure of genetic and ecological uniformity imposed by the development of modern agriculture. The uniformity in gene and simplified agriculture system cause a serious loss of the wild diversity that coexists with domesticated species. The major driving forces behind the genetic erosion in crops are replacement of local variety by high yielding or exotic variety or species, land clearing, overexploitation of species, population pressure, environmental degradation, overgrazing, policy and changing agriculture systems. A large number of varieties can also often be dramatically reduced when commercial varieties are introduced into traditional faming systems. Wild diversity is directly useful providing medicine, food, fuel and building materials. Using modern biotechnological tools, our agricultural scientists have bred high yielding varieties, enabling the huge human population to sustain itself and also its domestic animals. But they are failing to increase the range of crops. Present day food production is highly vulnerable because of narrow range of crops and increasing demand of food for growing population. Over 60 percent of food energy comes from just three cops- maize, rice and wheat. According to the World Food Programme (WFP), “the scarcity of food is the biggest crisis looming in the world”.

There is need for conservation of plant in relation to the needs of agriculture, medicine and fodder to alleviate the poverty. They constitute some of the most important genetic resources for the food and other requirements of mankind. It is perhaps not sufficiently realized that the largest portion of human food comes from crop plants and land races. Many of them unfortunately are being driven out of existence by newer high yielding varieties or even wild relative of crop plants. Now it has been realized that information about biodiversity and their utility as genetic resources for improvement of food and forages crops along with oil, medicine and timber should be documented for their conservational measure.

The situation has to be saved by plant breeders discovering a source of resistance in old varieties. Thus, there is an urgent need for enhancement of crop range and other value added alternative food crops by conserving and preserving land race, germplasm and other food and forage plants, using modern biotechnological methods to meet the food requirement for ever-growing population. The research papers published during recent years reveals that thousands of wild plants, land races and germplasm are still being used, conserved and preserved by all tribal and rural communities in various phytogeographic zones of India. Realizing the importance wide a range of germplasm the of conservation of these materials is urgently needed through *ex*-situ conservation by establishing seed bank and even collection of pollen and tissues and *in-situ* method by growing plants in their native localities.

Keeping the view in mind the author has made survey in different parts of Central, Northern and Southern India and scrutiny of literatures published on this aspect from India with an aim to compile various land races, wild relatives of crop plant and forages plants for development of variety of high yielding and resistance to diseases, drought and cold. It is hoped that the observations given in this paper will be helpful for the betterment of the entire nation including that of tribal communities.

The survey of some more localities and documentation of information concerning food and forage plant, being used in many remote tribal localities of all phyto-geographic zones of India is urgently required for humankind and to alleviate poverty. Besides this, the indigenous methodology and technology involved in the production of food and forage crops should also be essentially recorded not only for the benefit of the society but also for the adaptation of suitable measures for their sustainable utilization towards the socio-economic uplift of the tribal and rural people.

On the basis of field survey and scrutiny of literatures following observation on wild edible plants, primitive cultivars, wild relative of cop plants and forage plants has been made.

1. Edible Plants

There is an incredible variety and abundance of edible plants available to us. Carbohydrates, proteins, minerals, vitamins, fats and condiments are all provided by plant foods. However, of the 18,000 known species, over the centuries, fewer than 20 species of the plants now supply about 90% of our food requirements. It is all the more necessary to relieve pressure on the traditional crops by adopting the other improved varieties of some of the wild plants which have been domesticated by the tribal people on which the tribal community subsists. Out of several hundred examples of the edible fruits, seeds, shoots, flowers, etc. some are given as follows.

A. Food Plants: Food is the primary need of all life forms as it provides energy to work and sustain life. During the quest of food, the earliest people might have experimented on various edible plants and discovered a wide variety of food as wild roots and tubers, fruits, berries, grains and seeds, flowers, foliage and stems (Anonymous, 1948-76; Jain, 1964; Jawahar, 1996; Joshi and Tewari, 2000; Nayar, et.al. 1989; Negi, 1996; Nizauddin, et.al. 1996; Rajlakshami, 1991; Verma, 1955). Nutritional evaluation of these wild food plants will be very promising by bringing them into modern food.

Grains: Many tribals and orthodox cultivators have not adopted all new or improved varieties of crops and have continued to grow the traditional (even less productive) land races or wild relatives of commonly cultivated crops, thereby maintaining their genetic material or germplasm (Arora, 1996, 1997). Specific characters of hardiness, disease resistance and adoptability to special conditions like waterlogging, extreme drought or cold, etc. in the land races. They may be utilized by the plant breeders for improvement of crop varieties. Several wild grains occurring in rain fed areas are used as staple energy foods such as *Avena sativa*, *Coix lachryma-jobi, Dactyloctenium aegyptium, Dinochloa scandens, Echinochloa colonum, Echinochloa crus-galli, Eleusine coracana, Oryza rufipogon, Panicum miliare, Avena fatua, A. ludoviciana, A. barbata, Aegilops tauschii, Digitaria sanguinalis, Hordeum spontaneum, H. Glaucum, H. Turkestanicum, Elymus dahuricus, E. Dasystachys, E. natans, Eremophyrum buonapartis, E. distorts, Panicum atrosanguineum, Panicum hippothrix, Panicum paludosum, Panicum trypheron, Panicum turgidum, Coix lacryma-jobi, C. gigantean, C. aquatica, Oryza rufipogon, Polytoca wallichiana,: Panicum psilopodium, Oryza nirvara, O. Jeyporensis, O. granulate, O. tomentosa, Paspalum scrobiculatum, Paspalum distichum, Nymphaea nauchali, Nymphaea stellata, Pennisetum alopecuroides, Paspalidium flavidum, Setaria glauca, Setaria italica* and *Sorghum halepanse.* These have excellent nutritive value with high protein content and are known as the "poor man's protein".

Seeds: Ripe seeds of several wild plants are very nutritious and rich in protein value. They are also planted with other crops specially to improve nitrogen content in the soil through root nodules. These seeds are eaten raw or cooked.

Eaten raw: *Buchanania lanzan, Euryale ferox*, *Nelumbo nucifera*, *Trapa bispinosa*, etc.

Eaten cooked: *Artocarpus heterophyllus, Bauhinia purpurea, Bauhinia variegata, B. vahlii, Cicer soongaricum, C. microphyllum, Moghania vestita, M. bracteata, Mucuna capitata, Trigonella emodi, Mucuna prurita, Vigna capensis, V. radiata var, sublobata, V. Umbellata, , V. umbellata, V. pillosa, Atylosia barbata, A. . scarabaeoides, A. villosa, A. mollisma, A. platycarpa, A. albicans, A. candollei, a. elongate, A. germinflora, A. kulnensis, A. lineate, A. mollis, A. nivea, ,A. rugosa, A. rostrata, Trigonella corniculata, T. polycerata. Vigna corymbosa, V. vexillata, V. aconitifolia, V. trilobata, Vigna pilosa.*

The seeds of above plants are very rich in protein content and very much similar to Almond. The seeds of *Bauhinia vahlii* may eventually become as popular as seeds of *Buchanania lanzan*, which were once uncared in the forest, but adopted later for human exploitation. Similarly, large numbers of seeds gowaste in the forests and can be utilized by urban population.

Made into coarse flour: *Polygonum glabrum, Fagopyrum esculentum, Fagopyrum tataricum.*

B. Fruit - Plants: Vegetables and fruits are the source of vitamins and minerals, necessary for good health and growth. Even before their intrinsic value was realized, Stone Age men were using several vegetables cultivated today. Fruits are the most delicious, naturally sweet and nutritive plant food eaten as such or after cooking. Over hundreds of the wild fruits such as *Aglaia edulis, Aporusa dioica, Baccaurea courtallensis, Eriobotrya angustifolia, Mangifera sylvestica, Musa accuminata/M.balbisiana complex, M. Manni, M. Nagensium, M. Sikkimensis, M. Superba, M. Velutina, Myrica esculenta, Ensete superba, Mikosops elengii, Crataegus oxycantha, Feronia limonia, Myrica esculenta, Docynia hookeriana, Elaegnus latifolia, Elaegnus angustifolia, Emblica officinalis, Euodia fraxinifolia, Ficus plamata, Fragaria indica, Prunus sp., Ribes graciale, R. Nigrum, Rubus ellipticus, , Zizphus vulgaris, , Morus spp., Myrica esculenta, Pyrus pashia, Dillenia aurea, Dillenia indica, Hovenia dulcis, Madhuca latifolia, Olax nana, Syzygium jambos, Eiobotrya japonica, Pinanga dicksonii, Rubus niveus, Phoenix sylvestris, Borssus flabellifer*, *Zizyphus jujube, Zizyphus xylopyrus, Zizyphus oenoplea* etc., are used in various ways by local people and tribal communities throughout the India for sweet drinks, pickles, seasoning material, jellies and jams, brewing local beer, and chutneys.

C. Vegetable Plants: Large number of wild plants, of which aerial and underground parts are used as vegetable:

Aerial parts used as vegetable: The aerial parts of the number of wild plants are being used by various tribal communities and other people in the forests, rural and urban areas of the country which may be exploited for better and larger uses. Mnilal, et.al. (2000) has enumerated some wild plants, used by two tribal groups of Attappady, Palkkad district, Kerala. Some examples are given as : Young foliar buds of *Ficus infectoria, Cassia tora*; young foliages with tender stems of *Amaranthus blitum, Basella alba, Ipomoea aquatica, Celosia argentea, Chenopodium album, Chenopodium murale, Digera muricata, Fagopyrum esculanta, Lathyrus sativa, Lathyrus sphaericus, Lathyrus aphaca, Moghania macrophylla, Ophioglossum reticulatum, Tetrastigma lanceolarium, Vicia sativa, Vicia hirsuta*, etc.; fruits and seeds of *Madhuca indica, Ipomoea alba, Artocarpus heterophylla, Artocarpus lakoocha, Abelmoschus manihot (tetraphyllus forms), Cucumis hardwickii, C. trigonus, Luffa graveolens, Solanum incanum, S. indicum, Trichosanthes multiloba, T. himalensis, Neoluffa sikkimensis Cordia dichotoma*, *Xeromphis spinosa, Xeromphis uliginosa;* flowral buds of *Bauhinia variegate, Bauhinia purpurea, Crotalaria juncea, Luffa cylindrical, Luffa acutangula,* etc.

Underground Parts used as vegetable: Underground parts of a large number of plant species are known for vegetable of which roots, tubers, bulbs and rhizomes are used in various ways, and they may be eaten raw or cooked. The tubers of *Aponogeton natans, Aponogeton crispum, Potamogeton natams, Scirpus grossus, Scirpus* *tuberosus;* Rhizomes of *Nymphaea pubescens, Nelumbo nucifera and* roots of *Phaseolus adenanthus and Pueraria tuberosa* are eaten after boiling. The giant taros and *Manihot esculenta* are eaten raw or cooked after repeated washing to get rid of the bitterness and pungency. Tuberous roots and aerial bulbils of *Dioscorea alata, Dioscorea bulbifera, Dioscorea esculenta, Dioscorea hispida, Dioscorea aculeate, Dioscorea pentaphylla, Dioscorea versicolor,* etc., are eaten cooked. The fusiform roots of *Phoenix acaulis and Borassus flabellifer* are consumed raw or cooked. Likewise, hundred of plants are still left uncared in the forests of which underground parts are consumed by wild animals. They may be exploited for human use.

D. Oils and Fats: The saturated fats and the animal fats consumed today are believed to be one of the causes for heart attacks. It is usually advised by doctors to the heart patients to consume less animal fat (saturated oil) exclusively. The unsaturated fat, which occurs in oil derived form plants should be used by heart patients. We have traditional oil plants, the seeds of which are rich in oil, used widely in cooking food such as mustard, coconut, groundnut, etc. Ethno botanical studies bring to light that oils for cooking medium can be derived from forest trees and shrubs such as *Derris indica, Schleichera oleosa, Calophyllum inophyllum, Prinseppia utilis, Aleurites mollucana, Caralia brachiata,* etc. The oil extracted from seeds of wild plant- *Perilla frutescens and Ventilago maderaspatana* are largely used by Baiga tribes in the forest of Amarkantak as cooking medium. Apart

from vegetable oils, even butter as cooking medium can also be extracted from some other trees such as *Diploknima butyracea, Garcinia morella, Moringa oleifera, Mimusops elengi, Shorea robusta* (Roy, 1998). Other plants are-*Abelmoschus manihot (tetraphyllus forms), Cucumis hardwickii, C. trigonus, Luffa graveolens, Solanum incanum, S. indicum, Trichosanthes multiloba, T. himalensis, Neoluffa sikkimensis.*

Thus, the popularization of vegetable oil through establishment of cottage industry in rural and tribal areas can be beneficial for socio-economic development of ethnic communities as well as to civilized people for medical point of view. Wild plants like *Guizotia abyssinica* and *Carthamus tinctorious* have recently brought under cultivation for its oil, which is used as cooking medium. Thus, to get away from several diseases related to heart caused by animal fats, it would be good to make use of the tribal expertise for vegetable oil and butter.

E. Spices and Condiments: Spices are aromatic flavourings made from different parts of the variety of plants. Archaeologists estimate that by 50,000 B.C., primitive man had discovered certain aromatic plants, which help him to make their food in better taste. With few exceptions, the spices and condiments known today were used early in human history. Fragrant leaves of *Allium hooker, Allium wallichii, Ocimum basilicum,* wild coriander, *Trachuspermum roxburghianum, Mentha piperata* and *Eryngium foetidum*; ripe fruits and seeds of *Garcinia cambogia, Zanthoxylum rhetsa, Piper scmidtii* and *Piper mullesua*; roots of *Allium stracheyi* barks of cinnamon. Vanilla, the essence of which is drawn in ice cream, chocolates and cakes, comes from an orchid. The rhizomes of *Alpinia galanga* and flowers of*, Zinziber gerumbet and Acacia farnesiana* are used as spice for flavouring food. Other plants are *Allium rubellum, A. schoenoprasum, a. tuberosum, Carum bulbocastinum, Amomum subulatum, Curcuma zedoaria, Alpina speciosa, Amomum aromaticum, Curcuma amada, Piper peepuloides,Myrisica beddomei, M. malabarica, Piper nigrum, P. Schmidtii, Zingiber casumunar, Curcuma angustifolia, C. aromatica*

F. Non-alcoholic beverages: Tea from Asia, coffee from Africa and cocoa from South America are the world's favourite beverages. They all contain caffeine, a stimulant. Tea is the world's most popular beverage after water. China was the main source of tea, whose cultivation spread through trade to other parts of the world. *Camellia assamica*, a wild tea plant, growing in Assam, was later discovered by Brtishers. Tribal communities inhabiting in forest areas use the leaves of *Cymbopogon citratus* and *Basella alba* for preparation of tea like dink. Cooling drink is made from hairy seeds of *Lepidagathis bandraensis* and *Ocimum basilicum*. The fruits and plant of *Tricopus zeylanicus* is used by Kani tribes of Agasthyar Hill as "ginseng" for evergreen health and vitality (Pushpangadan, et.al. 1988). The juice of various fruits, vegetables and the clear water of the tender coconut are used as naturally sweet and refreshing drinks. Toddy or palm liquor obtained from *Borassus flabellifer*, *Caryota urens, Phoenix dactylifer* and *Phoenix sylvestris* is commonly used in India.

G. Alcoholic drinks: Tribal uses the fleshy petals of *Madhuca latifolia*, rhizomes of *Imperata cylindrica,* fruits of *Syzygium cumini* and rhizome of *Cissampelos pareira* in the fermentation of rice beer. The flowers of *Madhuca latifolia* are also used to prepare country liquor by all tribes.

H. Natural Dyes stuff and Mordents: There is no dearth of wild plants from which dyes have been extracted and used by the tribes to dye yarn and cloths made of both cotton and silk and colour their food items. Most of the natural dyes come from bark, berries flowers, leaves and roots of the plants. Being of natural origin, many of these colours are safe to colour food as well. It is also used in colouring and flavouring food, especially sweets. Turmeric, a yellowish powder obtained by grinding the rhizomes of *Curcuma longa* has been used for hundreds of years as a dyestuff and as a spice. '*Abir*' or '*Gulal*' is the finely powdered rhizomes of *Curcuma zedoaria* mixed with powder of *Caesalpinia sappan*.

It is suggested that a large-scale cultivation of these dye-yielding plants should be encouraged in order to obtain natural dye in place of synthetic dyes.

I. Plant for Flavouring Food:

Fragrant flowers of jasmine, lavender, frangipani, rose, lilies, vetiver, etc., have always been used for making sacred offerings, adoring hair, floral arrangements, garlands, bouquets and floral decoration industry. The leaves of *Eyngium foetidum*, *Murraya koenigii* and *Premna latifolia* are provide flavour to curries.

2. Wild forage plants

A rich diversity of wild herbage legumes occurs in different phyto-geographical regions of India About 400 species belonging to about 60 genera are known. Some of these taxa possessing large number of species This diversity, both in herbage legumes and grasses, is largely distributed in the Western Ghats, Eastern Ghats, north-eastern region and the Himalayas. Species of proven utility mainly belong to legumes and grasses (Arora and Chandel, 1972). .

Grasses: Grasses constitute another important group represented by about 245 genera and 1,256 species, of which 21 genera and 139 species are endemic. About 600 species belonging to 58 genera are referred as palatable to livestock (Arora etal.,1975). Species of proven utility mainly belong to legumes and grasses. Some of these taxa possessing large number of speciesare-*Agrostis gigantean, A. munroana, Brachypodium pinnatum, Bromus inermis, Muhlenbergia himalayensis, Phelum alpinum, Poa alpine and Dactylis glomerata, Apluda mutica, Dichanthium annulatum, D.cariosum, Panicum repens, Oplismenus compositus, Digitaria adscendens, D. cruciata, Bothriochloa intermedia, Ischaemum pilosum, I. laxum, Setaria pallide-fusca, Sehima nervosum, cenchrus ciliaris, C. setigerus, Centotheca lappacea and Themeda triandra.*

Legumes: *Cicer microphyllum, Lespedeza floribunda, Medicago falcata, M. denticulate, Trigonella gracilis, Vicia pallida, V. Tenuifolia, Lotus corniculatus, Parochetus communis, Pueraria phaseoloides, Muccuna pruriens, Clitoria ternatea, Teramnus labialis, Desmodium triflorum, D. gyroides, D.floribundum, Smithia ciliate, S. setulosa, Alysicarpus vaginalis and Zomia diphylla*.

3. Other Crop plants:

Buckwheat, prosomillet, , field peas, bluish/black grain types barely occur at high altitudes(above 3300 m), exhibiting akinness to local Tibetan types (Arora, 1975).

Pseudo-cereals- buckhweat, Chenopodiun , and soft-shelled forms in *Coix*.

Millets- finger millet, foxtainl millet;

Legumes-rice bean, winged bean,

Vegetables- cucurbits (*Cyclanthera, Cucurbita, Momordica, Cucumis, Luffa, Benineasa); Corchorus*) , tree cotton, kenaf and mesta; taro/yam, Colocasia*, Dioscorea* and *Coleus*; rhizomatous types like , *Curcuma* species

4. Wild relatives

The floristic diversity available in the wild relatives and related types of cultivated plants in India is estimated to about 320 species, of which about 60 are endemic taxa. The diversity in wild relatives is largely distributed in the warm humid tropical, sub-tropical regions, western Himalayas and the north-eastern region. The range of species strength in different genera of wild relatives of crop plants and related taxa such as *Cicer* (1), *Sesamum* (3), and *Mangifera* (3) with very small number, others like *Vigna* (10) and *Atylosia* (15) *Solanum* (32) and *Piper* (50) are well represented. (Arora and Nayar, 1984).

Oryza nivara (annual; source of rice tungro virus resistance). The wild forms of Job's tears (*Coix lacryma-jobi*) occur predomintaly in northeastern region, and in the peninsular tract. *Saccharum, Erianthus.*

Legumes- *Vigna radiata*- (*sublobata* type) provide sources of resistance to yellow-vein-mosaic virus. Wild forms of pigeonpea (arhar) i.e. bushy species of *Atylosia* (*A. sericea*, and *A.lineata*) are reported to be resistant to wilt. Other important wild relative of pigeonpea are *Atylosia cajanifolia*, *Vigna umbellate*, *Cicer microphyllum*.

Oilseeds- *Sesamum prostratum*

Vegetable- Wild okra, *Abelmoschus tuberculatus* (related to the cultivated okra, *A. esculentus*. The wild forms of bringal, *Solanum incanum* and *S. melongena* var. *insanum*. Other wild germplasm includes species of *Momordica, Trichosanthes* and *Cucumis* (wild cucumber), and *Cucumis* , wild ginger and turmeric (*Zingiber, Hedychium, Curcuma*), wild yams (*Dioscorea*) and Taros (*Alocasia, Colocasia*).

5. Miscellaneous Uses:

Besides the above, numerous minor/ miscellaneous uses of thousands of the plant species are encountered, such as *Helicteres isora* used for fire production by friction; stem of *Aeschynomene aspera* and *Aeschynomene* indica used for fishing floats and various decorative items for marriage ceremonies; several plants used for making bows for hunting; seeds of *Adansonia digitata* used to smooth earthenwares before firing and leaves of *Adhatoda zeylanica* used to wash and paint unglazed pottery before firing to give it a black colour; crushed fruits of *Xeromphis spinosa* are mixed with stored grain to protect it from insects and leaves of *Trigonella foenum-graecum, Azadirachta indica* and pieces of root of *Saussurea lappa* are put with clothes to protect them from insects; seeds of *Canna indica, Elaeocarpus sphaericus, Adenanthera pavonia, Caryota urens, Coix lachryma-jobi, Drypetes roxburghii, Abrus precatorious* are used as beads in necklaces; wood of *Buxus wallichiana, Carissa carandas, Morinda citrifolia, Premna tomentosa, Xeromphis spinosa and Xeromphis uliginosa* are used for the manufacture of combs; powedered seeds of *Annona squamosa, Annona reticulate and Annona muricata* with gram flour are used to kill lice; to wash hair the dried fruit-rind of *Sapindus mukorossi* in combination with fruits of *Emblics officinalis* and *Acacia concinna* are used; wood ash obtained form burning *Avicennia officinalis, Haloxylon recurvum* and soda ash of *Salsola maritime* is used as detergent for washing clothes; woolen clothes are washed with powdered roots of *Dioscorea deltoidea and* dried fruit-rind of *Sapindus mukorossi;* seeds of *Strychnos potatorum* are used to clean water; to increase the milk and to meet the nutritive fodder to the domestic animals large number of grass species and other plant species are used by rural and tribal people.

DISCUSSION

The scrutiny of literatures, so far available in India like books on regional flora (Duthie, 1960; Hooker, 1872-1897, forest working plans, survey of tribal by Anthropologists reports in tribal development projects, ethnographies, archaeological accounts, travelogue, district gazetteers, herbals, material-medica, various research papers on ethnobotany, germplasm, etc., reveals that enormous information on modern crops, landraces, wild relatives of crops and other utilities of wild plants have been preserved in it since ancient time. This vast repository of knowledge related to plants has been cared and nourished by the tribal communities as a common property since thousands of years. Many plants used today by us were originally identified and developed through indigenous knowledge. The utility of wild plants for diverse purposes has not recognized in one day or in one century; it is a result of the progressive development of human culture. The cereals, vegetables and root crops that we have cultivates as source of food, fiber and oil for our subsistence, are all gifts of tribal to our modern civilized society. Infact, the civilized society should be indebted to primitive people for they had during

the last several thousands years, screened the wild plant life and determined its usefulness. Though tribal communities have treasure of knowledge about multifarious uses of plants, however, many of these plants have not been adequately studied, and sometimes not even identified. Several of them of food values are sill unknown to the modern civilization and they have yet not received the due attention by agricultural scientists for yield enhancement and varietals improvement in food and forage plants, as has been accumulated since over 100 years by now. With the disappearance of the tribal culture that have developed in and around the forests, the traditional knowledge concerning useful plants are disappearing very fast. One of the most pressing and important task is to complete surveys and studies on plant resources as rapidly as possible to provide vanishing a firm factual base for conservation measures and elimination of poverty.

While we are all familiar with the common food crops like wheat, rice and maize and fruit tree like mango and guava, there are hundreds of other species that grow and utilized at a local level, either through cultivation or harvesting in many parts of India. This hidden harvest of indigenous species enables many tribal and local people to survive in periods of drought and famine. Rural families also earn cash by collecting wild fruits, seeds, flowers, tubers, barks, leaves, fibres, etc., and selling them in local markets. Many of them have great market potential for the growing urban centres. Many under-utilized plants have potential for more widespread use, and their promotion could contribute to food security, agricultural diversification, and income generation, particularly in areas where the cultivation of major crop is economically marginal.

The tribal and rural people live in environmentally degraded system, which are unproductive and the root cause of poverty. Thus 'economic' poverty in many parts of India is due to 'ecological' poverty of the area. It is the restoration of these natural systems or natural resource management practiced at the grassroots level, which will help in eliminating poverty. A massive global enterprise for ecological regeneration and for building up the natural resources base that would help the poor in all tribal and rural communities throughout the county needs to be undertaken. Poverty alleviation by removing ecological poverty should be the major goal. Lively hoods, based on local natural resources base would lead to self-reliance and sustainability. These local livelihood systems would not be drastically affected by market trends and mechanisms, and would be largely self-sufficient.

In the scenario of shrinking land and depleting plant resources along with ecology, the challenge of the new millennium is to increase agricultural yield to feed the ever-growing population without destroying the ecological foundation.

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Change in Agricultural Patterns vis-à-vis Biodiversity Concerns

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The Biodiversity:

Biological diversity, or biodiversity, is the term given to describe the variety of life on Earth. It reflects the number, variety and variability of living organisms and how these change from one location to another and over time. Biodiversity includes diversity within species **(genetic diversity)**, between species **(species diversity)**, and between ecosystems **(ecosystem diversity)**. As per the estimates, total biodiversity of all life on earth is as under:

Monera bacteria	4760	Fungi	46983
Algae	26900	Plantae	248428
Protozoa	30800	Porifera Sponges	5000
Coelenterates Jellyfish	9000	Platythelmines Flatworms	12200
Nematodes Roundworms	12000	Annelida	12000
Molluscs	50000	Echinoderms	6100
Insects	751000	Other Arthropods	123161
Fish	19056	Amphibians	4184
Reptiles	6300	Birds	9040
Mammals	4000		

It is estimated that some 270,000 - 425,000 species of vascular plant are already known with perhaps a further 10- 20% still to be discovered and described. Some of these species have been described twice or more, giving several names for one plant. Estimates differ widely as to the number of useful plant species. Heywood (1991) estimated that about 100,000 species are useful to humans in some way or other (e.g. as food, forage, fuel, building materials, medicines, or as wild relatives with potentially useful genes). FAO (1998) suggested that 30,000 plant species are edible, and that about 7,000 have been cultivated by humans for food at one time or another. In contrast, it is currently estimated that only 103 crops provide 90% of plant based food supplies.

India is one of the 12-mega diverse countries of the world. With only 2.5% of the land area, India already accounts for 7.8% of the global recorded species. India is also rich in traditional and indigenous knowledge, both coded and informal.

The Concern for Diversity:

Ecosystems, whose functioning depends on biodiversity, provide the basic necessities of life (e.g., food, clean water and air), offer protection from natural disasters and disease (e.g., by regulating climate, floods and pests), and shape human cultures and spiritual beliefs. Besides those provisioning, regulating and cultural services they provide, ecosystems also support and maintain life processes such as biomass production and nutrient cycling (supporting services) which are essential to

human well-being.

It has been reported that out of the 24 ecosystem services that make direct contributions to human well-being, 15 are in decline. The impact of humans on the natural environment is significant and growing, causing changes in biodiversity that have been more rapid in the past 50 years than at any time before in human history. As demographic pressures and consumption levels increase, biodiversity decreases, and the ability of the natural world to continue delivering the goods and services on which humanity ultimately depends may be undermined.

Biodiversity loss disrupts the functioning of ecosystems, making them more vulnerable to perturbations and less able to supply humans with needed services. The consequences are often harshest on the rural poor, who depend most immediately upon local ecosystem services for their livelihoods, and biodiversity loss poses a significant barrier to meeting the Millennium Development Goals.

"Caring for the Earth: a Strategy for Sustainable Living" declared that "some 10% of the area of each of the main ecological regions should be safeguarded in one or other of the various categories of protected area" (IUCN 1991). The figure of "at least 10% of the world's landmass to be set aside for conservation" was declared as a target at the IV World Congress of Protected Areas in 1992. The 10% figure is just short of 9%, which is the current total coverage of terrestrial protected areas on the planet, embracing a total of 44,000 sites (Phillips 2000). The total coverage for all *forest* protected areas (IUCN Categories I-VI) is 10.4% (WCMC 2002).

The Value of Biodiversity:

The Value of Biodiversity's Components from both wild and domesticated components of biodiversity humanity derives all of its food and many medicines and industrial products. For Example, economic benefits from wild species alone make up an estimated 4.5 percent of the Gross Domestic Product of the United States-worth $87 billion annually in the late 1970s. Fisheries, largely based on wild species, contributed about 100 million tons of food worldwide in 1989. Indeed, wild species are dietary mainstays in much of the world. In Ghana, three out of four people look to wildlife for most of their protein. Timber, ornamental plants, oils, gums, and many fibers also come from the wild.

The economic value of domesticated species is even greater. Agriculture accounts for 32 percent of GDP in low-income developing countries and 12 percent in middle-income countries. The components of biodiversity are also important to human health. Once, nearly all medicines came from plants and animals, and even today they remain vital. Traditional medicine forms the basis of primary health care for about 80 percent of people in developing countries, more than 3 billion people in all. For example, more than 5,100 species are used in Chinese traditional medicine alone. Biotic resources also serve recreation and tourism. Worldwide, nature tourism generates more than $12 billion in revenues each year.

The Objectives of Biodiversity Conservation:

1. The ultimate and long-term objective of the Biodiversity Conservation is to halt the current and continuing loss of plant diversity.
2. The conservation strategy should provide a framework to facilitate harmony between existing initiatives aimed at plant conservation, to identify gaps where new initiatives are required, and to promote mobilization of the necessary resources.
3. The conservation strategy should be a tool to enhance the ecosystem approach to the conservation and sustainable use of biodiversity and focus on the vital role of plants in the structure and functioning of ecological systems and assure provision of the goods and services such systems provide.

Facets of Biodiversity Conservation and Use:

India is a Party to the Convention on Biological Diversity (1992).Recognizing the sovereign rights of States to use their own biological resources, the Convention expects the parties to facilitate access to genetic resources by other Parties subject to national legislation and on mutually agreed upon terms (Article 3 and 15 of CBD). Article 8(j) of the Convention on Biological Diversity recognizes contributions of local and indigenous communities to the conservation and sustainable utilization of biological resources through traditional knowledge, practices and innovations and provides for equitable sharing of benefits with such people arising from the utilization of their knowledge, practices and innovations.

After an extensive and intensive consultation process involving the stakeholders, the Central Government has brought Biological Diversity Act, 2002 with the following salient features:

i. to regulate access to biological resources of the country with the purpose of securing equitable share in benefits arising out of the use of biological resources; and associated knowledge relating to biological resources;

ii. to conserve and sustainably use biological diversity;

iii. to respect and protect knowledge of local communities related to biodiversity;

iv. to secure sharing of benefits with local people as conservers of biological resources and holders of knowledge and information relating to the use of biological resources;

v. conservation and development of areas of importance from the standpoint of biological diversity by declaring them as biological diversity heritage sites;

vi. protection and rehabilitation of threatened species;

vii. involvement of institutions of state governments in the broad scheme of the implementation of the Biological Diversity Act through constitution of committees.

As per this Act:

- "biological diversity" means the variability among living organisms from all sources and the ecological complexes of which they are part, and includes diversity within species or between species and of eco systems;
- "biological resources" means plants, animals and micro organisms or parts thereof, their genetic material and by products (excluding value added products) with actual or potential use or value, but does not include human genetic material;
- "commercial utilization" means end uses of biological resources for commercial utilization such as drugs, industrial enzymes, food flavours, fragrance, cosmetics, emulsifiers, oleoresins, colours, extracts and genes used

for improving crops and livestock through genetic intervention, but does not include conventional breeding or traditional practices in use in any agriculture, horticulture, poultry, dairy farming, animal husbandry or bee keeping;

- "sustainable use" means the use of components of biological diversity in such manner and at such rate that does not lead to the long term decline of the biological diversity thereby maintaining its potential to meet the needs and aspirations of present and future generations.

Obstacles to the implementation of the Convention on Biological Diversity:

The obstacles may be grouped into following categories:

Political/societal obstacles

a. Lack of political will and support to implement the Convention on Biological Diversity

b. Limited public participation and stakeholder involvement

c. Lack of mainstreaming and integration of biodiversity issues into other sectors, including use of tools such as environmental impact assessments

d. Political instability

e. Lack of precautionary and proactive measures, causing reactive policies.

Institutional, technical and capacity-related obstacles

a. Inadequate capacity to act, caused by institutional weaknesses

b. Lack of human resources

c. Lack of transfer of technology and expertise

d. Loss of traditional knowledge

e. Lack of adequate scientific research capacities to support all the objectives.

Lack of accessible knowledge/information

a. Loss of biodiversity and the corresponding goods and services it provides not properly understood and documented

b. Existing scientific and traditional knowledge not fully utilized

c. Dissemination of information on international and national level not efficient

d. Lack of public education and awareness at all levels.

Economic policy and financial resources

a. Lack of financial and human resources

b. Fragmentation of GEF financing

c. Lack of economic incentive measures

d. Lack of benefit-sharing.

Collaboration/cooperation

a. Lack of synergies at the national and international levels

b. Lack of horizontal cooperation among stakeholders

c. Lack of effective partnerships

d. Lack of engagement of scientific community.

Legal/judicial impediments

a. Lack of appropriate policies and laws

Socio-economic factors

a. Poverty

b. Population pressure

c. Unsustainable consumption and production patterns

d. Lack of capacities for local communities.

Natural phenomena and environmental change

a. Climate change

b. Natural disasters.

Fundamental causes of biodiversity loss:

- The unsustainably high rate of human population growth and natural resource consumption
- **The steadily narrowing spectrum of traded products from agriculture, forestry and fisheries**
- Economic systems and policies that fail to value the environment and its resources
- Inequity in the ownership, management and flow of benefits from both the use and conservation of biological resources
- Deficiencies in knowledge and its application
- Illegal and institutional systems that promote unsustainable exploitation

The Agricultural Patterns relates to point number 02 that is **'the steadily narrowing spectrum of traded products from agriculture, forestry, and fisheries'** and are becoming a concern for the loss of Agri-biodiversity. Almost all commercially important crops have now occupied a well carved niche in the global market, consumer preference and the resulting trade. The ever increasing area under improved and high yielding varieties erodes the existing variability from the traditional cultivation areas. Although a lot of exercise is in full swing at national level to collect, evaluate, document and conserve the existing variability of the important crops, but, it is a time consuming, labour intensive and expensive preposition. Further, several minor crops which are important locally or are used in a limited way are still to be brought under the umbrella of conservation. Moreover, there are several other aspects which need immediate attention. These are:

a. Identification and conservation of hither to unidentified but locally used plants.

b. Mapping of rhizospheric microbial population along with the collections.

c. Conservation of agriculturally important microorganisms.

d. Documentation of indigenous knowledge about plants and its scientific verification.

e. Popularization of Conservation Agriculture in biodiversity rich areas.

f. Promotion of Land Races and Farmers' Varieties in national and international trade.

g. Cataloguing of the available information regarding agri-biodiversity

A Case Study:

To assess the impact of shifting agricultural patterns on the steadily narrowing agri-biodiversity a case study of sugarcane cultivation can be the best example.

The cultivated sugarcanes of today are mainly complex interspecific hybrids primarily between *Saccharum officinarum*, known as the noble cane, and *Saccharum spontaneum* with contributions from *S. robustum*, *S. sinense*, *S. barberi*, and related genera such as *Miscanthus*, *Narenga*, and *Erianthus*. *S. sinense* and *S. barberi* have been cultivated for sugar production in China and India for centuries. Following the rediscovery of *S. officinarum* in the 18th century, the sugar industry rapidly spread throughout the tropics and subtropical areas. The widespread appearance of new sugarcane diseases caused great damage to the noble varieties and led to the search for new noble canes. The discovery of sexual fertility in sugarcane in the 19th century in the Bahamas and Java opened the door for establishing breeding programmes.

The proposed origin of *S. officinarum* from a domesticated thick-stalked, high sugar, low fiber form of *S. robustum* in New Guinea is accepted by most sugarcane breeders. From New Guinea, *S. officinarum* spread to Indonesia, Malay, China, India, Micronesia and Polynesia during prehistoric times. An officer of Alexander- the Great was the first to mention sugarcane in India, in 325 B.C. Its distribution from Polynesia to Hawaii took place with native migrations around 500-10000 A.D. and from Indonesia to southern Arabia and East Africa probably before 500 A.D. The Dutch breeders in Java called *S. officinarum* the “noble” cane, and “nobilization” the process of backcrossing of *S. spontaneum* hybrids to *S. officinarum*.

S. sinense cultivated in China and Pansahi in India was used for chewing as well as for sugar production, whereas the thinner, harder stalks of *S. barberi* cultivated in northern India were used only for crushing. The two cultivated sugarcane were probably the result of natural hybrids of *S. officinarum* and *S. spontaneum* that occurred about 1000 B.C. *S. barberi* subsequently spread from India to the Middle East, Mediterranean, and to the New World beginning with the second voyage of Columbus in 1493. The most important Indian cultivar had many names: Creole in French, Criola in Spanish, or Crioula in Portuguese. Today, *S. sinense* and *S. barberi* exist only in germplasm collections.

Creole was quickly replaced in cultivation by the noble cultivar 'Otaheite' when it was brought to Jamaica from Tahiti by Bligh in 1793. From there it was distributed throughout the Caribbean and the Americas. Original noble canes collected from the Pacific Islands were the only source of cultivars for plantations for the world's sugar production for over a hundred years. Before sugarcane breeding programmes were started, the most important noble cultivars were the “Otaheite' (Bourbon, Lahaina) of Tahiti, Cheribon' (Louisiana Purple) of Java, and 'Caledonia' of new Hebrids. 'Bourbon' was extremely susceptible to root rot, mosaic and gumming diseases; 'Cheribon' to sereh, mosaic and root rot; and 'Caledonia' to mosaic. These initial cultivars were replaced by new ones selected from the breeding programs established during 1880s. Today, clones of *S. officinarum* are in breeding collections and/or cultivated as garden canes for chewing.

The first sugarcane breeding program began in Java and Barbados in 1888, following the observations independently in Java (1858) and Barbados (1859) that sugarcane was capable of producing viable seed. Other countries soon followed Java's lead. With the start of sugarcane breeding programme in India during early twentieth century at Sugarcane Breeding Institute, Coimbatore and the release of Co 213, Co 281 and Co 290 varieties by the year 1930, there was a paradigm shift in the cultivation practices and within a short period all cultivated area under sugarcane was replaced by high yielding interspecific hybrids. By 1970s, the sugarcane breeder's started facing the problems of narrow genetic base, reflected through the wide appearance major diseases and pests. This led to the initialization of the process for genetic base broadening. But, still at present only a few varieties numbering less than 50 occupy the major area under cultivation. All other variability existing before the release of high yielding varieties was either lost or a portion of it is maintained in the Germplasm Collection at Sugarcane Breeding Institute and its Regional Centre at Kannur, Kerala. The numbers of accessions maintained are *S. officinarum* 764, *S. barberi* 43, *S. sinense* 29, *S. robustum* 145, *S. spontaneum* 1063, Related Genera 464, Foreign Hybrids 585, Indian hybrids 1158, IA clones 130; totaling to just 4381. The importance of this collection increases with the fact that it is an international collection and represents the major existing variability related to sugarcane.

These details are an indicator of just one such crop where the scientific innovations and developments have actually shown their impact on the production front. But then, the toll in terms of genetic erosion is unaccounted but large. Similar is the case with other cropping systems which are based on rice, wheat, maize and so on. Thus, the significance of biodiversity concerns vis-à-vis production and productivity have to live together on and on, it is the scientific community to devise innovative means and approaches to sustain the ecosystem for our generations to come.

Biodiversity of Under-utilized Vegetable Crops: an Indian Perspective

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India is the second largest producer of vegetables in the world with a total production of 109.0 million tonnes from an area of 7.1 million hectares with a productivity of 15.2 tonnes per hectare (Indian Horticulture Data Base, NHB-2006). However, per capita availability of vegetables in India is only 190 g per day which is far below the ICMR recommendations of 300 g per day. The vast diversity of land, soil and agro climatic conditions in the country provides an opportunity to produce all kinds of vegetables to meet the present inadequate supply and to keep pace with ever increasing population for nutritional security. However, present nutritional situation is alarming in the country because according to a recent survey 36% of children affected with malnutrition in the world are Indians. Anemia is prevalent in 60% of our children and one-third children are born underweight in the country which is highest in the world. Nearly 20,000 children become blind every year due to vitamin A deficiency. Malnutrition problem is more acute in poor segment of our population which resides mostly in arid, hilly and tribal regions. Furthermore, these regions are characterized with illiteracy and inaccessibility meaning thereby that the residents are unaware about the importance of balanced diet, and fruits and vegetables are not available all over the year.

Being rich in bio-diversity, there are several lesser known under-exploited and under-utilized plant species available in India which have tremendous potential to be used as vegetables and can be exploited to solve the problem of malnutrition and under nutrition. The important under-utilized vegetables commonly found in India are amaranth, *Chenopodium* (*Bathua*), leaf mustard (*sarson sag*), broad bean, rice bean, hyacinth bean, yam bean, elephant foot yam, basella, cassava, taro, drum stick, *Ipomea* (kalmi sag) etc. Most of these vegetables are cheaper source of protective nutrients such as vitamins and minerals. Some of these vegetables have the potential to produce significantly high amount of food per unit area and are also rich in protein and carbohydrates. These vegetables are easy to cultivate, do not require high input and can thrive well on marginal and sub-marginal land and therefore could be exploited for meeting the nutrient requirement of predominantly vegetarian population of the country. Besides, there are a number of under-utilized vegetables which grow in extreme environmental conditions and can be considered as species of emergency utility. Most of these vegetables are cultivated and consumed by local people and their popularity vary from locality to locality. These vegetables have long history of consumption by the local people and they are aware of their nutritional importance and medicinal properties. Moreover, these vegetables have tremendous capacity for acclimatization and they not only contribute towards food but also act as genetic reservoir of several important traits. With drastic increase in country's population and fast depletion of natural resources there is an urgent need to explore new sources of vegetable and to diversify the vegetable cultivation to meet out the present day demand. The adaptation of these vegetables to marginal environment, their contribution to household food security and their flexibility in mixed farming system emphasize their significance in the welfare of rural masses.

Rapid increase in the urban population and greater health awareness has contributed to a rise in domestic consumption of vegetables. Our traditional vegetables are used mostly after cooking and in the process of cooking there is a great loss in the nutritional content. Moreover, by daily use of the same kinds of vegetable there is a state of unlikeness among the users. As the dietary patterns are changing in India day by day, everybody wants a change in food habit (nutrition) along with change in their way of living. In such circumstances a new range of unusual exotic vegetables like asparagus, broccoli, Brussels sprout and lettuce have gained popularity in some parts of the country and have caught the attention of growers, retailers and consumers These vegetables fetch more remunerative return in relatively reduced time frame. Besides providing nutritional security to the urban population, these vegetables can increase the income of the farmers of peri urban areas as they can sell these vegetables at a very high price in cosmopolitan markets, star hotels and places of tourist interest. Such vegetables are available under minor brassicas, minor root crops, and minor leafy and salad vegetables. The more common vegetables under these groups are Chinese cabbage, chicory, kale, Brussels sprouts, broccoli, lettuce, endive, savoy cabbage, Swisschard, celery, parsley, sorrel, sweet marjoram, calabrese, chervil, parsnip etc. Majority of the aforesaid vegetables are grown only on hilly terrains thereby limiting its availability to elite kitchen and multi star hotels only. The cultivation of these vegetables can be extended to other regions with proper agro-climatic conditions.

Agro-climatic and other regions suitable for growing under-utilized vegetables

Arid region

Both hot and cold arid regions exist in India but hot arid region is predominant. Hot arid region is characterized with high day temperature during summer (40-48^{0}C) and low night temperature during winter (3-10^{0}C), strong hot wind (*loo*), scarce rainfall, low fertile sandy soil and soil salinity. In such a situation, agriculture is uncertain and uneconomical and occurrence of famine is quite common. The cultivation of underutilized vegetables not only provides nutritional security but also provide fuel, fodder, fencing material and raw materials for medicines. The vegetables which can be exploited in such region are guar, amaranth, *Portulaca*, *Prosopis* (Khejri), buffalo gourd and *Kachri* (*Cucumis calosus*).

Hill region

Hill region mainly comprises of north-west and north-east Himalayan hills and south Indian hills having 2 types of agro climatic conditions, i.e. cold arid zone, and humid high and mid-hills. The cold arid zone consists of Ladakh in Kashmir, Lahaul, Spiti, Chini and Kinnur in Himachal Pradesh and Gangotri, Mana, Niti and Milan valley in Uttaranchal. The zone has typical harsh agro ecological conditions, namely high altitude (3,000-3,500 m above sea level), heavy snowfall, low temperature (-9 to -14^{0}C), scanty rains (100-200mm), infertile soils and short growing season. The entire zone is a tribal region which remains inaccessible for a period of more than 6 months in a year. High humid and mid-hills have got high rainfall, good soil and large forest area. This is the main hill region of the country. Non-traditional vegetables are generally found growing in wild condition. The local people collect them from forest for their consumption and sometimes sale in the market. The important under-utilized and rare vegetables grown in this region are chow-chow, chicory, buckwheat, celery, parsley, broccoli and lettuce.

Tribal of other region

Most of the tribal areas are located in Orissa, Jharkhand, Bastar in Madhya Pradesh while small pockets in various other parts of the country. These areas have both semi-arid and humid climatic conditions. Most of the traditional fruits are found in wild and semi-wild state. The important under-utilized vegetables which can be exploited for this region are portulaca, colocasia, alocasia, guar, winged bean, hyacinth bean, chenopods and cassava.

The detailed information on important underutilized and rare vegetables suitable for cultivation under different agro-climatic conditions of India, their plant parts used as vegetables and their habitat has been outlined in this paper and the nutritional composition of some of the important under-utilized and rare vegetables is given in Table-1.

1. Under-utilized plants whose leaves, shoots

and flower-buds are used as vegetables

Most leafy vegetables are rich in carotene, riboflavin and minerals. It has been estimated that 100 g of tropical leafy vegetables can provide 60-140 mg of ascorbic acid, 100 ug of folic acid, 4-7 mg of iron and 200-400 mg of calcium. Consumption of 100 g of leafy vegetables per day can supply 15% or more of the total intake. Only 30 g of the leaves will be sufficient to meet the requirements of vitamin-A and C. The B vitamins (thiamin, riboflavin and niacin) will increase by 15-30%, and the entire requirement of folic acid will be met.

Amaranthus spp. [Syn. Amaranth, Chaulai]

It is a pseudocereal and has tremendous potential for vegetable as well as grain crop. It is grown during summer and rainy seasons in India. The fresh tender leaves and stem which are rich in protein, minerals, vitamin A and C are delicious and cooked like other fresh leafy vegetables. Among the leaf type, *Amaranthus tricolour* occupies a predominant position in India with different morphological forms in colour and shape of leaves. Apart from this, *A. blitum, A. tristis* and *A. cruentus* are the other species which are under cultivation in India. A few other important weeds viz., *A. spinosus, A. virdis* and *A. graecitaus* are used as pot-herbs and widely distributed in road sides and uncultivated fellow land. Leaves are rich source of β-carotene, riboflavin, vitamin C, calcium and iron.

Basella (_Basella alba_ Linn.) [Syn. _B. rubra_ Linn.]

Indian Spinach is a perennial herb, common in eastern and southern India and in the islands. The tender stems and leaves are consumed as pot-herb. Leaves are rich source of β-carotene, vitamin C, calcium and iron.

Begonia spp.

This is a fleshy herb, chiefly found in humid tropical regions extending to northern hills. The succulent stems are used as pot-herb. The leaves possessing a pleasant acidic taste are eaten as vegetable.

Chenopodium (_Chenopodium album_ Linn.) [Syn. Lamb's Quarters, Bathua-Sag]

A herb common as a winter weed all over except in southern most areas particularly. The leaves and twigs are used as vegetable; also cultivated. *C. ambrosioides* L. - a herb of north-eastern and peninsular India is used like wise. Leaves are rich source of β-carotene, vitamin C and calcium.

Chicory (_Cichorium intybus_ Linn.) [Syn. Kasni]

A herb found as weed in Punjab, Haryana and adjacent region extending to colder parts of Western Himalayas. The young shoots are used as salad and the leaves are eaten as vegetable. It is cultivated in Jammu and Kashmir. The roots are dried, roasted and ground for use as coffee substitute or in blends with coffee. Leaves are rich source of β-carotene, and calcium.

Kalmi sag (_Ipomoea aquatica_ Forsk.) [Syn. Swamp Cabbage, Kalmi, Patua-sag]

An aquatic trailing herb found widely in wet lands. The leaves and shoots are eaten cooked as vegetable, also used as salad.

Lettuce (_Lactuca sativa Linn._) [Syn. L. brevirostris Champ.]

An annual herb found in Central India, Assam and Khasi hills. The leaves of selected races are used as vegetable. Leaves are rich source of β-carotene and calcium.

Lotus (_Nelumbo nucifera Gaertn._) [Syn. _Nelumbium speciosum_ Willd.]

It is a common aquatic herb. The young leaves, stalks and rhizomes, often called lotus roots are eaten cooked.

Portulaca (_Portulaca oleracea Linn._) [Syn. Purslane, Kulfa]

An herb, common as weed found throughout India. The fleshy leaves are eaten as vegetable. It is also cultivated. Leaves are rich source of β-carotene, and calcium.

Portulaca (_P. quadrifida Linn._)

A tiny-leaved herb, a common warm season weed found throughout India. The plant is used as pot-herb.

Makoi (_S. nigrum_ Linn.) [Syn. Black Nightshade]

A herb found all over India. The leaves and tender shoots are boiled like spinach and eaten particularly in north-eastern India.

Broccoli (*Brassica oleracea* L. var. *italica*)

Morphologically, broccoli resembles cauliflower. The plant forms a kind of head, consisting of green buds and thick fleshy flower stalks. The terminal head is rather loose, green in colour. The sprouts in the axils of leaves develop strongly, specially after the removal of the terminal head. Both terminal head and the sprouts with bud clusters are consumed as human food. It can be grown in winters in northern plains and also in hills. Leaves are rich source of β-carotene, vitamin C and calcium.

Kale (*Brassica oleracea* var. *acephala*)

Kale is mainly winter vegetable. Most forms of kale bear a rosette of leaves at the top of the stem, which is harvested and used as food. For fresh market, the whole top rosette is frequently harvested while in tall cultivars the lower leaves, if adequately curled are also harvested. Leaves are very rich source of β-carotene, vitamin C and calcium.

Brussels sprouts (*Brassica oleracea* L. var. *gemmifera*)

Brussels sprouts is mostly grown in northern hills. The edible portions of this plant are buds or small heads called 'sprouts' which appear in the axils of the leaves. The sprouts when fully developed are 3-5 cm in diameter. They are cooked as other vegetables and also used as popular frozen products. Leaves are very rich source of riboflavin, calcium, vitamin C and iron.

Celery (*Apium graveolens* L.)

Celery is one of the important salad crop grown for its long fleshy leaf stalk and looks like leafy onion. The leaf stalks and petioles of celery are eaten raw as salad or used for the preparation of sauces, soups, vegetable juices etc. Its seed is used as condiment and spice. Celery has important medicinal values and used as a flavouring material. Leaves are rich source of β-carotene.

Parsley (*Petroselinum crispum* Millan Nyman ex. A.W. Hise)

Parsley is one of the most popular garden herbs grown mainly as a salad crop. The leaves are used for flavouring, garnishing and also for salad purposes. It is a cool season crop grown during winter months in northern India. Leaves are rich source of β-carotene, vitamin C and calcium.

Leek (*Allium porrum* L.)

Leek is a non-bulbous crop related to onion family. The economic parts are blanched stem and green tender leaves which are chopped and cooked. It is also used as green onion for making salads and green vegetable curry. Leek has milder and more delicate flavour than onion and garlic. This is cooked with other vegetables as a flavouring ingredient in soups. It can be a great substitute for onions and can be relished even by those who are scared or allergic to onions due to one reason or the other. Leaves are rich source of calcium and iron.

Asparagus (*Asparagus officinalis* L.)

The commercial part of asparagus is tender shoot called as 'spear'. These spears are used for preparation of soup, vegetable products like pickles, canned and other frozen products. It is also eaten raw. It is a perennial vegetable and starts economic yield after three years and continues to give economic yield for 10-15 years.

2. Under-utilized plants whose tender fruits and pods are used as vegetables

Winged bean (***Psophocarpus tetragonolobus*** **L.)**

It is rich in protein (30-39%) and oil (15-18%) and offers good promise as a multipurpose crop. Its pods, seeds and roots are edible and the plant is also used as fodder. The young, tender pods are made into a delicious vegetable. In India, it is largely cultivated in the humid sub-tropical parts of North-eastern region, sporadically in western ghats and Central/eastern peninsular region.

Cluster bean (*Cyamopsis tetragonoloba* L.)

It is grown for green pods for use as vegetable and for dry seeds. It is also grown as a forage and green manure crop. Some of the varieties are used for extraction of gum (Gaur gum). It is suitable for arid regions. Pods are rich source of protein, carbohydrate and calcium.

Faba bean *(Vicia faba*) [Syn broad bean, winter bean]

It is a temperate crop and requires cool climate and a long season. In India, it is grown mostly as a minor crop in Himalayan hills, Bihar, Uttar Pradesh, Punjab, Haryana, Rajasthan and Gujarat both as a source of vegetable and fodder. Young pods and seeds are cooked as vegetable. It has certain unique qualities such as fruiting on main stem from base of the plant, responsiveness to irrigation and relatively high protein content (25%). Planting of faba bean in high moisture conditions particularly in rice fallows has been tried and found successful at Jabalpur.

Adzuki bean (*Vigna angularis* Willd.)

This crop is cultivated in some remote areas of Himachal Pradesh in the name of Chitra mah and its young pods and ripe seeds are eaten; seeds are also used for cakes and confectionary. It is also grown locally in Shillong and Garhwal region. Pods are rich source of protein and carbohydrate.

Hyacinth bean (*Lablab purpureus* L.) [Syn. Butter bean, helmet bean, Dolichos bean]

It is commercially grown as vegetable crop in M.P., Maharashtra, West Bengal, Andhra Pradesh and Tamil Nadu. Its green pods are used as vegetables and dry seed as pulses. It is under-exploited tropical legume that is valued for its nutritional and sensory attributes. It contains 30% protein on dry weight basis. Pods are rich source of protein and calcium.

Coccinia (*Coccinia cordifolia* Cogn.) [Syn. *C. grandis* (L.) Voigt, *C. indica* W. & A. Ivy Gourd, Kundru]

It is a climbing herb occurring throughout India. The tender shoots are used as pot-herb mainly in peninsular India. Immature fruits are very popular as vegetables in Madhya Pradesh, Orissa, Bihar and West Bengal. Pods are rich source of calcium.

Gul karela (*Momordica cochinchinensis Spreng)* [Syn. Gulkakra, Yangerua]

A perennial climber found in north-eastern and peninsular tracts mainly in humid parts of north-eastern and western India and in Andaman Islands. The young leafy shoots are cooked and eaten. Fruits are rich source of calcium and iron.

Balsam apple (*Momordica balsamina* Linn.) [Syn. Mokha]

A twiner found in hotter parts of north-western India. The unripe, round, tender and non-bitter fruits are eaten as vegetable, and also pickled. Some people call it midget karela. Pods are rich source of β-carotene, calcium and iron.

Drumstick Tree (*Moringa oleifera Lam.*)

A small tree found in the sub-Himalayan tract. It is also cultivated. The tender leaves and fruits are eaten as pot-herb. Fruits are rich source of vitamin C and calcium and the leaves are rich source of β-carotene, thiamin, vitamin C, calcium and iron.

Chow-Chow *(Sechium edule (Jacq.) Sw.)* [Syn. *Chayote, Prickly Pear*]

A cucurbit now naturalized in sub-tropical/sub-temperate Eastern Himalayas. The buds and flowers and unripe fruits are eaten as vegetable. Fruits are rich source of calcium.

Buffalo gourd (*Cucurbita foetidissima*)

It is also known as Missouri-gourd, chilli-coyota is well adapted to desert environment of arid and semi-arid region of India. Its seeds are rich in oil and protein and roots are rich source of starch. Its stems and leaves are used as fuel.

3. Under-utilized plants whose tubers and roots are used as vegetables

Several root and tuber vegetables like sweet potato, cassava, taro and yam are rich in starch and serve as staple food and source of energy in many tribal regions of our country.

Yams (*Dioscorea* species)

Dioscorea species commonly known as yam, belong to the family Dioscoreaceae under monocotyledons. The genus consists of about 600 species mostly tropical in distribution. They produce tubers, bulbils or rhizomes that are of economic importance. In India, about 50 species occur which are distributed throughout the country except in the dry north-west region. They are also found to occur up to and elevation of 10,000 feet in the Himalayas. Two Asiatic yams, viz. *Dioscorea alata* (greater yam) and *Dioscorea esculenta* (lesser yam) are the major food yams of India. These two species are cultivated in almost all States of India. *Dioscorea rotundata* (white yam) which is extensively cultivated in the African continent is a recent introduction to India. Apart from the three food yams of the world, about 50-60 other species of Dioscorea are also either cultivated to a limited degree or gathered as famine food. Some of them are *D. bulbifera*, *D.hispida*, *D. trifida, D. dumetorum, D. opposita* and *D. japonica*. The yams exploited for pharmaceutical purposes are non-edible. Important among them are *D. composite, D. floribunda, D. spiculiflora, D. friedrichsthalii* and *D. deltoidea*. The tubers of the major species are rich in carbohydrate content and are better sources of protein than other tuber crops.

Yam tuber is consumed after roasting, boiling or with other vegetables. It is also used as chips, flakes, and flour. Yam chips are a stabilized product, made from small peeled, pre-cooked and sub-dried tubers. They are mainly consumed in the form of a paste (amla or telubo) prepared from the flour obtained by grinding the chips (Bricas *et al*., 1997). Some poisonous types like *Dioscorea dumetrorum* and *D. hispida* are eaten during scarcity after clarification or as such used as an aid in hunting, fishing, arrow poisoning and for insecticidal purpose. Many species of yam contain small amounts of sapogenins and alkaloids for various uses. The main sapogenins present in diosgenin which is starting point of several corticosteroid drugs.

Taro (*Colocasia esculenta* Schott), Tannia [Syn. Arbi], (*Xanthosoma* spp.) and Giant taro (*Alocasia* spp.)

Among these crops, taro and tannia are cultivated to a larger extent in the wet lands of eastern India, while giant taro is not so common as commercial crop like the other two. In general, these are crops of third world countries, particularly grown in Africa and Asia. The leaves, petioles, corms and cormels are edible. The leaves and shoots particularly the small leaves (Chamkora) are eaten cooked as vegetable and leaves are rich source of β-carotene, riboflavin, calcium and iron. Root/rhizome is a popular vegetable of northern and eastern India.

Taro, a tall semi-fleshy shrub occurring wild mainly in wet land of eastern India, is recommended for gastric patients and taro flour is a good baby food. In Hawaii and Polynesia, a fermented product prepared from taro is very popular. The pressure cooked taro corms after being passed through strainer are allowed to ferment giving an acidic product called 'poi'. In Africa, the corm paste prepared from the cooked taro is taken in the name 'fufu'. In India, it is used as vegetable and for the preparation of slices and chips. Giant taro (*Alocassia* sp.) occurs wild in humid tracts of eastern, north-eastern and southern India. Taro is popular in Asia while tannia is popular in Africa.

In Assam, North Bengal and neighboring states, it is grown in courtyards as a multi-purpose plant, for its ornamental appearance and edible leaves and tubers. The young shoots, leaves and tubers all are edible and much consumed locally as leafy boiled vegetables. Tubers need prolonged boiling/cooking depending on the variety to get rid of acridity due to more rapid content.

***Amorphophallus* (*Amorphophallus paeoniifolius* [Syn. *A. campanulatus* or elephant foot-yam]**

It is grown as vegetable in tropical and subtropical regions in many countries particularly in south east Asia. It is commercially grown in India, Sri Lanka, China, Malaysia, Thailand, Indonesia, and Philippines and in tropical regions of Africa. In India, elephant-food-yam is cultivated on large scale in Andhra Pradesh, Bihar, Gujarat, Maharashtra and West Bengal. The corm is used as vegetable. Corms are rich source of carbohydrate and calcium and serve as a staple food in our country.

Yam bean *(Pachyrrhizus erosus)* [Syn. jicama or jacatupe bean (*P. tuberosus*) and Andean yam bean (*P. ahipa*)]

It is a leguminous tuber crop of commercial importance. All the three cultivated species are often termed as yam bean. The edible pachyrrhizus is a unique combination of the general qualities present in most cultivated legumes, which makes them attractive to the consumers, the producers. The young tubers have a crisp, juicy and refreshing flesh and can be eaten raw or cooked. They can also be sliced and made into chips. The tubers contain adenine, arginine, choline and phytin. The juicy flesh is rich in ascorbic acid and has an antiscorbutic action on rats.

Cassava (*Manihot esculenta* Crantz)

It is also known as Yuca, tapioca or manioc, is a perennial shrub cultivated in the tropical parts of India for its starchy tuberous root. High carbohydrate yield per unit land and labour, adaptation to poor soil/stress and tolerance of various insect pests, influence its role in tropical farming system. In general, tuber contains 30-40% carbohydrate and 1-2% crude protein, the carbohydrate fraction is primarily composed of starch. Amongst tuber crops, it is richest in vitamin C and calcium.

Conclusion:

1. Considering the rich biodiversity of under utilized vegetable available in India and their nutritional importance, efforts should be made to increase the area and productivity of these vegetables to overcome the problem of under-nutrition and malnutrition of the people living in arid, hilly and tribal areas.
2. Most of the under-utilized vegetables are hardy in nature, thus, they can be exploited by growing in vast area of uncultivable wasteland, undulating upland, gullied ravines, waterlogged and marshy land, degraded pastures, sandy and saline soil of the country to increase production of these vegetables.
3. Efficient production technology and post-harvest management system of under-utilized vegetables/rare exotic vegetables should have developed to make commercial cultivation of these vegetables feasible and attractive to the farmers.
4. An untapped potential of different under-utilized vegetables exists in the forests, grasslands, swamp, rivers, seas and even deserts of India. These vegetables have tremendous scope of acclimatization and they not only contributed towards food but also act as wild gene pool for several important traits.
5. Genetic erosion is a very serious problem in under-utilized vegetables and many important local germplasm/land races will become extinct if these are not conserved soon. There is an urgent need for conservation and sustainable management of biodiversity of these vegetables.
6. Since enormous diversity, semi-domesticated and wild type of under-utilized vegetables is found in local pockets of tribal dominated tracts, the incentives should be given to native people who are still the custodian of such germplasm and select them as part of their routine vegetable requirement.
7. Till now, in most of the under-utilized vegetables, only local varieties/land races are available, which besides very low yielding, are also susceptible to various insect-pest and diseases. Efforts should be made for evaluation, maintenance and effective utilization of these germplasm and species having desirable gene for agronomical/horticultural traits can be exploited in the crop improvement programmes through conventional breeding and biotechnological tools.

Table 1: Nutrient composition of under-utilized and rare vegetables per 100 g edible portion

S. No.	Name of the vegetable	Calories (k cal)	Moisture content (g)	Carbohydrates (g)	Protein (g)	Fat (g)	â carotene (µg)	Thiamine (mg)	Riboflavin (mg)	Vitamin C (mg)	Calcium (mg)	Iron (mg)
1	Amaranthus tender	45	85.7	6.1	4.0	0.5	5520	0.03	0.30	99	395	25.5
2	Basela	32	90.8	4.2	2.8	0.4	7366	0.03	0.16	87	200	10.0
3	Bathua leaves	30	89.6	2.9	3.7	0.4	1740	0.01	0.14	35	150	4.2
4	Brussels sprout	45	85.2	8.3	4.9	0.4	330	0.10	0.16	102	36	1.5
5	Broad bean	48	85.4	7.2	4.5	0.1	9	0.08	-	12	50	1.4
6	Cassava (Tapoica)	157	59.4	38.1	0.7	0.2	0	0.05	0.10	25	50	0.9
7	Celery	17	94.1	3.9	0.9	0.1	3990	0.03	0.03	9	39	0.3
8	Chicory leaf	13	92.0	1.1	1.7	0.3	2400	0.06	0.10	24	100	0.9
9	Chinese cabbage	14	95.0	3.0	1.2	0.1	90	0.1	0.04	25	43	0.6
10	Cho-cho (immature fruit)	27	92.5	5.7	0.7	0.1	30	0.00	0.04	4	140	0.6
11	Cluster bean	16	81.0	10.8	3.2	0.4	198	0.09	0.03	49	130	4.5
12	Colocasia stems	18	94.0	3.6	0.3	0.3	104	0.07	0.07	3	60	0.5
13	Coriander leaves	44	86.3	6.3	3.3	0.6	6918	0.05	0.06	135	184	18.5
14	Colocasia	97	73.1	21.1	3.1	0.1	24	0.09	0.03	0	40	1.7
15	Colocassia leaves (green)	56	82.7	6.8	3.9	1.5	10278	0.22	0.26	12	227	10.0
16	Dolichos bean	48	86.1	6.7	3.8	0.7	187	0.10	0.06	9	210	1.7
17	Drumstick	26	86.9	3.7	2.5	0.1	110	0.05	0.07	120	30	5.3
18	Drumstick leaves	92	75.9	12.5	6.7	1.7	6780	0.06	0.05	220	440	7.0
19	Elephant-foot yam	79	78.7	18.4	1.2	0.1	258	0.06	0.07	0	50	0.6
20	Endive	11	95.0	1.2	1.3	0.2	1500	0.07	0.08	8	42	2.0
21	Hyacinth bean	48	86.1	6.7	3.8	0.7	185	0.10	0.06	9	210	1.7

Bamboo Scenario in India

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Bamboos are distinct and fascinating plants, with a wide range of values and uses. It has more than 1,575 species in 75 genera in the world, occurring in a great variety of soil and climatic conditions. India is well endowed with resources of bamboo, the second largest in the world. Bamboo grows on millions of hectares of forest land, in homesteads and on private plantations. One hundred and thirteen species both wild and cultivated are at present known to grow in India. According to the Forest Survey of India report, about 12.8 percent of total forest area is under bamboo cultivation, with the northeast region accounting for 66 percent of the country's bamboo resources in terms of value and 28 percent in terms of area.

There are almost 130 species in India, spread across 18 genera. There are 16 genera and 58 species of bamboos in Eastern Himalayas and other parts of Eastern India; 5 genera and 14 species in Western Himalaya including foothills; 4 genera and 8 species in Indo-Gangetic Plain, 8 genera and 24 species in peninsular India and 7species in Andaman and Nicobar Islands. Amongst the important bamboos *Dendrocalamus strictus* is found throughout North West India up to 1000 m. in the hills. *Bambusa balcooa* is found in Bihar and Eastern U.P. *Arundinaria* species are found mostly in Eastern Himalayas while only four species occur in Western Himalayas. In Western India most commonly planted species are *Bambusa arundinacea, B. nutans, B. vulgaris, Dendrocalamus hamiltonii, D. hookeri* and *D. strictus*. In Central India and in the Deccan Planteau *Dendrocalamus strictus* and *Bambusa arundinacea* are the commonest, the former occurs on drier slopes while the latter in moist valley, the other species found sometimes are *Bambusa tulda, Cephalostachyum pergracile* and *Oxytenanthera nigrociliata*. In the Western Ghats and on coasts where mostly evergreen and semi-evergreen forests occur 5 spcies of *Oxytenanthera* and 8 species of *Ochlandra* are met with. On the higher hills of Nilgiris and Pulneys 4 species of *Arundinaria sensulato* occur and out of this *Indocalamus walkerianus* is the commonest. In Bengal, Assam and North East Himalayas the Principal bamboos are *Dendrocalamus hamiltonii* in the North, *Bambusa tulda* in the middle and *Melocanna baccifera* in the South. The commonest bamboos of Andamans and Nicobar Islands are *Oxytenanthera nigrociliata, Dinochloa andamanica* and *Bambusa schizostachyoides*.

Estimated current world market of bamboo is US$ 10 billion that is expected to increase to US$ 20 billion by 2015. India is looking to not only develop a bamboo-based economy in the country but also tap the growing global demand for bamboo. As against an estimated demand for 26.9 million tons of bamboo, India is currently able to supply only 13.47 million tons. The country today exploits just a tenth of its bamboo-producing potential. India's share in the global market is estimated to be $1 billion and is expected to increase to $5.7 billion by 2015. China's share in the world bamboo market is currently the highest at $5 billion. So vary is bamboo's application that one finds its utilization on a massive environment protection as nutrient food, high-value construction material and 1,500 other listed applications. There is a growing realization that the potential of bamboo in the country has not been tapped to its fullest. Bamboo is being rediscovered in India as its attributes and potential are increasingly recognized.

Bamboo belongs to family Poaceae Tribe Bambuseae. They are woody grasses, often gregarious, rarely climbing. Rhizomes are stout, and either twisted or knotted, sometimes exposed and producing distinct culms. They have prominent nodes, having sheaths, and having usually two rings of which the more indistinct and upper marks the node and the lower is the scar of the culms sheath and often has a ring of rootlets. Amongst all plant life bamboos grow fastest in height. Bamboos may be clump forming or runner. Bamboos differ significantly from other vegetation in the mechanism of flowering. Most bamboos species have a more or less sharply defined flowering cycle of

1,3,7,11,15,30,48,60 or 120 years at the end of which all plants of a given seedling generations flower gregariously. This is like setting genetic clock when all population of given species raised from the same seed source no matter where they are situated would start flowering at the same time. Certain species are however physiologically stable and are not known to have flowered at all. Bamboos produce culms each year from the rhizomes of the previous years. Culms dry up and after certain age they keep producing new culms till flowering. Clumps get congested if older culms are not removed in time. The best management practice is to harvest culms each year. Bamboos grow best under light shade. There is no terminal bud in culms. The height growth is caused by the successive elongation of the internodes. Bamboos are primarily surface rooters. A new bamboo culms sprouts with full diameter and does not subsequently in crease in girth. The productivity in bamboos is judged by the number of new culms produced.

They play a significant role in biodiversity conservation and contribute to soil and water management. They are important for biomass production and play an increasing role in local and world economies. In UNEP-WCMC Biodiversity Series 14, it has been reported that more than 400 bamboo species are potentially threatened by the destruction of natural forest cover. Conservation and sustainable management of wild populations of bamboo should be high priority, especially where diversity is high or deforestation is a significant threat. Studies on the flora of Indian Himalaya reveal that as many as 350 species are rare and endangered. These species have been listed in the Red Data Book prepared by Botanical Survey of India under the guidelines of IUCN. Bamboos of the Himalayan region, to be considered endemic, are threatened through their restricted distribution. Twelve species of bamboos have been marked as rare and endangered due to biotic pressure coupled with biological phenomena such as periodic flowering, poor seed setting and indiscriminate exploitation. N.E. India represents a high proportion of Indo-Malayan species of bamboo. Elements such as *Phyllostachys, Pleioblastus, Semiarundinaria, Sinobambusa, Thamnocalamus, Chimonobambusa* occurring in Himalaya are Sino-Japanese in origin. Himalaya has served primarily as a route of emigration and colonization from the east and north-west, secondarily of endemic development. Topographical features particularly the hilly terrain; deep valleys, slopes and river systems have restricted the distribution of several species of bamboos in the region. Phenological studies carried out in the case of *Dendrocalamus longispathus, D. strictus* var. *argentea, D. somdevae* and *Schizostachyum polymorphum* show insufficiency or non-availability of pollen for crossing and poor seed production. As a consequence of synchronous senescence of clumps following flowering and due to poor regeneration, the distribution of the species may become disjunct, isolated or narrowly confined.

Till recently, Bamboo remained confined mostly to the forests. The plantation of bamboo on private land has been quite insignificant. It is only in the last few years that bamboo sector has been witnessing substantial growth in terms of awareness and uses, and bamboo's wealth-generation potential .With its increasing demand, the importance of this crop as a source of raw material, particularly for industrial and domestic uses has made it imperative for its cultivation on farm lands. Agriculture scientists have so far identified around a dozen varieties of high-value commercial bamboo for cultivation by farmers that could be used as an alternative to wood for construction, furniture making and even weaving cloth using bamboo fibres. In fact, bamboo fibre clothes and saris are fast catching the fancy in some parts of the country. Efforts are also on to promote cultivation of edible bamboo varieties. Outside the northeast, efforts are also on to promote awareness of bamboo shoots as a food delicacy. It is considered to be a suitable species for practicing agro-forestry on degraded lands. Ecological benefits of bamboo are numerous. Studies have shown that bamboo develop the fastest growing canopy for the re-greening of degraded areas. Bamboo generates plenty of oxygen, low light intensity and protects against ultraviolet rays and is an atmospheric and soil purifier. It also conserves water and greatly reduces soil erosion. The increased permeability of the soil reduces water runoff, with the result that more water penetrates the soil. The impact of bamboo on water resources is highly positive. Thus, bamboo plantations lessen evaporation, allow better water penetration into the soil and increase the drainage capacity of the soil. It conserves soil moisture and mitigates adverse drought effects on flora and fauna. Thus, development of bamboo-based agro-forestry systems in this context holds great promise in augmenting the supply of bamboo products in our country without adversely affecting the ecology of the area.

Keeping in view the importance of bamboos, the Government of India has implemented a Centrally Sponsored Scheme under the National Bamboo Mission for addressing the issue relating to the development of bamboos in the country. The main objectives of the Mission are:-

- To promote the growth of the bamboo sector through an area based regionally differentiated strategy
- To increase the coverage of area under bamboo in potential area under bamboo in potential areas with suitable species to enhance yield
- To promote marketing of bamboo and bamboo-based handicrafts
- To establish convergence and synergy among stake holders for the development of bamboos
- To promotes, develop and disseminate technologies through a seamless blend of traditional wisdom and modern scientific knowledge
- To generate employment opportunities for skilled and unskilled persons, especially unemployed youths.

To achieve the objectives, the Mission has decided to adopt the following strategies:-

- Adopt a coordinated approach covering production and marketing to assure appropriate return to growers/producers;
- Promote Research and Development (R&D) of genetic superior clones of suitable species and technologies for enhanced production;
- Enhance acreage (in forest and non-forest areas) and productivity of bamboo through species change and improved cultural practices;
- Promote partnership, convergence and synergy among R&D and marketing agencies in public as well as private sectors, at all levels;
- Promote where appropriate, cooperatives and self help groups to ensure support and adequate returns to farmers;
- Facilitate capacity building and Human Resource Development;
- Set up National, State and sub-State level structure to ensure adequate return for the produce of the farmers and eliminate middlemen to the extent possible.

The key elements of the National Bamboo Mission are:-

- Research and Development for sustainable development and new Bamboo Agri-forestry technique for technology generation.
- Establishment Nurseries to raise bamboo seedlings.
- Raising high-yielding bamboo plantations on commercial basis in Forest and Non-Forest areas.
- Rejuvenation of senile neglected bamboo plantations.
- Pest and Disease Management of bamboo.
- Handicrafts, bamboo marketing and exports,
- Capacity building and Human Resource Development of farmers, field functionaries and others.
- New Marketing Strategy for Bamboo and establishment of Bamboo Markets, Bamboo Bazaar and retail outlets.
- Meticulous monitoring, evaluation and reporting, Database generation, compilation and analysis.
- Bamboo should become a tool not only in poverty elimination but also in prosperity accumulation.

The species selected by National Bamboo Mission are *Bambusa tulda, Bambusa balcooa, Dendrocalamus hamiltoni, Melocanna baccifera, Dendrocalamus giganteus, Dendrocalamus asper, Bambusa nutans, Bambusa bambos, Dendrocalamus strictus, Ochlandra travancoria, Bambusa pallida, Bambusa balgaris, Oxytenanthera parviflora*.

The scheme provides subsidies to private individuals for plantation, kishan nurseries, mahila nurseries, micro-irrigation, bamboo bazar etc. The programme will definitely enhance the bamboo plantation and other bamboo related activities in the country.

Conservation of Forest Genetic Biodiversity

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Biodiversity, also called Biological Diversity encompasses all life forms on this earth. This is described by the number, variety and variability of all living organisms. The concept and importance of biodiversity finds a prominent mention in *Vedas* where it is mentioned that human life is the most precious one and if not utilized in the realization of god, then one has to go though 8.4 million different life forms (*yonis*) like insects, animals and plants etc.. Surprisingly the present scientific estimation of the species is very close to that. The precision with which our ancient saints have estimated the biodiversity is highly appreciable.

Biodiversity can be categorically described at there levels: genetic, taxonomic and ecological one. Genetic biodiversity describes populations, individuals, genetic material and even genes. All other types of biodiversity are the consequence of genetic makeup. There are very few species where genetic diversity has been property described and understood. We are still a long way from making scientific assessment of genetic biodiversity of most of the species.

Taxonomic biodiversity describes various taxonomic classes like phyla, orders, family, genera, species and subspecies. The most commonly used parameter of taxonomic biodiversity is the species diversity, also called alpha diversity. Alpha diversity describes the species richness and is simply the number of species in a given area. Species are the discrete and recognizable entities to which the populations can be easily divided and are the most commonly used indicator of biodiversity. This type of biodiversity is relatively better understood for economically important species. Still much needs to be done about the alpha diversity of bacteria, fungi and other invertebrates.

Ecological biodiversity describes the diversity of habitats; in which individuals of species occupy their unique niches within the ecosystem. Each ecosystem has structural and/ or functional diversity. For example, we have forest ecosystem, a grassland ecosystem or even a wet-land ecosystem. Here structural diversity can be vertical or horizontal distribution of flora and fauna. Functional diversity can describe nutrient cycling, trophic level relations and biomass production etc. There can be spatial diversity of the same ecosystem as it happens with different seral stages of succession at different points in time.

Genetic Bio diversity

All forms of life on earth, whether plants, animals or microbes have genes. Sum total of all the genetic information contained in the genes of individual plants, animals or micro-organisms constitutes the genetic diversity. Each species contains a large amount of genetic information in the form of traits or characteristics etc. The number of genes present in an individual vary form a few thousands (as in case of bacteria) to few millions (as in case of higher plants and animals). Within one species there can be variation in one or few characters controlled by the gene or gene complexes. It is this diversity which is very important for the natural and/ or artificial selection to operate. Genetic differentiation within species arises as a result of random mutation of the genetic material and is amplified by the process of sexual reproduction by which these genetic differences get recombined in all permutations and combinations. Thus each offspring is the outcome of new combinations of genes or gene complexes and therefore differs from each other.

Conservation of Genetic Biodiversity

The need for conservation of genetic diversity is quite evident and is beyond any dispute. The points of debate are purpose and the methodologies of conservation. The concept of gene or gene complex conservation leads to the suggestion that wild stocks need to be preserved. It must be clear that the gene or gene complex do not mean the genotype of the individual but the gene action that leads to the expression of a specific trait.

Conservation of Gene and Gene Complex in forests

Foresters endeavour is to conserve genes or gene complex that make the tree economically desirable, disease free and adapted to a particular environment. Conservation, control and recombination of gene complex is the basic concept by which tree improvement can be achieved. But there are some differences of opinion as to what kind of gene complex should be conserved and how this can be achieved. Some are in favors of saving all possible genes or gene complexes within species or races while others suggest that only those that will be most useful in a long run should be conserved. The argument put forth by the former ones is *"who knows when a given gene or gene complex may become useful."* Others say that it is highly impractical because this puts huge demand on space, time and money.

The priority or the need can be other criteria of conserving gene or gene complex. Sometimes it is important to conserve genes dealing with adaptability to a particular condition or resistance to a disease. Very often one has to conserve the characteristics that are endangered in the population. Genes responsible for enhancing economic value of the products and services are generally given top priority of conservation.

Threats to forest Genetic Diversity

Any activity that destroys forests can lead to the loss of genetic diversity. The agent of destruction can be clearance of forests through any anthropogenic activity. Natural disasters like fire, storms, diseases, floods or even insets etc may be other potential threats to genetic diversity.

Preferential removal of some, so called economically inferior species can also lead to a dangerous situation. In the hills of Uttrakhand, there used to be working plan prescription to mark broad leaved heartwood species growing in the high altitude Deodar, Fir and Spruce forests. This resulted in marked decrease in the density of Oak, Acer and Maple trees which are so essential in the maintenance of natural ecosystem of high altitude micro catchments. This mistake was realized after about 30 years when such preferential logging of broad leaved trees was put to an end.

Planting exotics without proper care and consideration can also threaten the native genetic resources. Few examples of such activities are planting/ sowing of *Prosopis* in Tarai as well as southern part of Uttar Pradesh, where it has drastically encroached upon the native vegetations by offering tough competition. Unfortunately this practice is still prevalent in most part of Uttar Pradesh. Similarly planting Teak in the Tarai region of U P has posed a great problem to sal regeneration. Recently Govt. of India has banned the planting of Teak in sal Forests in U P.

Another activity that drastically reduces the frequency of desirable genes or gene complexes is the illicit cutting of the trees. The illicit feller is interested only in the healthy, full grown and better trees of desirable species. This leaves forest impoverished with inferior trees of inferior species composition. Example of this type of loss can be found in and around Kanpur where Shesham and Babool, both economically rewarding species have been preferentially removed by the illicit fellers leaving the remaining forests full of bushy and thorny *Prosopis* and at some places with stunted *Eucalyptus.*

Importance of forest genetic Biodiversity

Nature as well as tree improver manipulate the genetic diversity present in the forest trees to produce trees with desirable combination of characters like growth, form or adaptability. No further improvement is possible unless steps are taken to ensure maintenance and enhancement of sufficient genetic diversity. Therefore it is essential to have a broad genetic base by using the programs that will conserve the genetic potential of the populations. Conversely loss of genetic diversity results in narrowing of the genetic base leading to inbreeding depression. In most cases loss of genetic diversity results close related matings which lead to inbreeding depression and this leads to the loss of genes or gene complexes. In extreme case the whole taxonomic category of species may get extinct this way.

Methodology of conservation

Broadly speaking genetic biodiversity conservation strategy follows the approaches of *in situ* and *ex situ* conservation. *In situ* conservation means preservation of trees and forests as such in natural condition, where as *ex situ* means conservation of genes or gene complexes under artificial conditions out side their natural place of occurrence.

In situ conservation

This is exercised by setting aside and preserving stands of the desired species with descried traits. This does not mean that in such cases every thing is left to nature and no human intervention is allowed. Some management is necessary to maintain the gene and gene complex diversity otherwise their distribution will change as the preservation areas pass through one stage of succession to another. Further more areas or stands need to be protected against possible damages of fire, flood, disease or even illicit cutting, lest there can be even complete loss of genes and gene complexes.

The most important issue of *in situ* conservation is as to how much area is to be put under preservation. General attitude is that bigger the area, better it is. Though large sized *in situ* conservation areas are not undesirable from genetic diversity conservation point of view still lager area impose great strain on land and monetary resources. It is not necessary to conserve thousands of hectare of area containing the desired genes or gene complexes, conservation of few thousands of such trees is generally sufficient.

There was a concept of establishment and maintaining the preservation plots in Uttar Pradesh Forest Department. For want of financial resources these areas are no longer managed properly since long. There is an urgent need to realize the purpose and importance of establishment and maintains of preservation plots so that the desired genes and complexes are not lost for ever.

Ex situ conservation

The most traditional method of *ex situ* conservation is through storage of seed that contains the desired genes or gene complexes. Though this is the most convenient method of *ex situ* conservation still it poses certain limitations. This is very good method for those species whose seed viability is very high. When the seed viability is very low, long time storage will not be possible. Though through improved storage condition, their viability can be enhanced still with the loss of viability frequent replacements are needed.

There is a special advantage with the forest tree species that most of them can be propagated vegetatively. Thus the individuals with desired genes or gene complexes can be stored for much longer period by vegetative propagules planted in the gene banks or arboreta. Few vegetative propagules of desired trees can be used in establishment and further breeding programs rather than preserving large chunk of areas. By controlled pollination, these genetic qualities can be combined and packaged into a few individuals which can be subsequently multiplied. This is precisely what is achieved during tree improvement program.

These are some latest, technology intensive methods of *ex situ* conservation like tissue culture and pollen storage etc. Tissue culture has become quit operational for many forest tree species as more and more protocols for tissue culture are developed. Through tissue culture it is possible to conserve the desired genes or gene complexes in very small areas.

Cryo-preservation of plant parts including gemmules is another possibility which the scientists are exploring for storing the desired genes or gene complexes for long time. This technique has yet to be used on operational scale.

Biodiversity Destruction and Illegal Trade in Wildlife Agra Case

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All the flora and fauna have evolved in to a stage where only the fittest survives. Each species is unique in its own way. In a given ecosystem plants and animals coexist and interact each other. They also interact with the non living things in the system. In an ecosystem, flora and fauna always try to maintain their population at optimal level. The rapid rise and fall in population of any species disturbs the equilibrium. The ever increasing human population is fast exploiting the other natural resources, resulting in extinction of many species from our planet. Many species of flora and fauna have become either threatened or endangered and are on the brink of extinction. After receiving information about a dead baby cobra found in a consignment at a Courier Office of Agra the Forest department raided the place and conducted a detailed examination of the consignment and discovered 97 baby cobras, 5 adult cobras and 97 baby Olive Ridley Turtles in dead condition on ***September 13, 2006.*** No transit permit or any document from wildlife authority was available. The consignment was sent by a Chennai based firm and the receiver was an industry of Agra.

A search was conducted with the help of Police department and WILDLIFE SOS at the residence cum office of a scientific lab and large quantity of banned wildlife material was recovered from the premises.

Agra: The firm was involved in the trade of zoological specimens, chemicals, lab equipments for a long period of time without any permission under Wildlife (Protection) Act, 1972. Accused father was an employee in a scientific firm in Agra where he learnt about the trade of biological products and scientific equipments. He established his own business in the late 1970's (there are evidence such as quotations, price lists of 1977) and the accused took over the business after his post graduation in Zoology from Agra University.

The firm was involved in the purchase, stock & sales of protected wildlife materials as a part of their business for a long period of time.

As per the collected evidences such as sales documents, bank books and transportation documents the purchase of the wildlife goods were mostly from Chennai and the sales was happening all over the country. All the documentation evidences show the main purchasers were various schools, colleges and other institutions. But there is a huge mismatch between the procurements and actual documented sales. This indicates there could be an offline trade route setup between other firms or people involved in trade across the country.

The wide variety and huge quantity of the materials are the most shocking facts of the case. The dead and well preserved specimens included Olive Ridley Turtles, Gharials, Cobra, Rat snake, Tree snakes, Saw scaled Viper, Russell's Viper, Python, Monitor Lizard, Butterflies, Various species of Birds, Dog faced water snakes, Water snakes, Sea horses, Corals, Sponges, Wide variety of Marine species including sharks, rays, Shells etc.

Members of Wildlife SOS were closely associated in identification of various wildlife specimens, their inventorization and intelligence gathering.

More than 29,700 number of dead wildlife specimens were collected from the premises and some specimens were found abandoned at a couple of places making it probably one of the largest seizure of its kind in the history of wildlife crime in India. Most of the above listed materials are protected under various schedules of the Wildlife (Protection) Act, 1972. All the species were traded in large quantities (in dozens & hundreds).

Agra being the trade hub of Preserved wildlife:

The Scientific equipment industry in Agra is well established and Agra is the place from which most of the preserved biological materials are send to various destinations across the country. The history of the trade date back to the 1940s, when a single unit was established in Agra, to make plastic models of specimens for studies. Later, in the 1960s the persevered materials were brought from USA and UK as most of the text books used in the colleges was non Indian.

The technology of preserving materials in Formalin was not known to them at that point of time and later they acquired the technical know-how and the business in the preserved materials grass rooted in Agra. The Glass industry in Firozabad, a town close to Agra, played a major role in boosting the trade in Agra. The cylindrical glass containers which were initially used to store the specimens were manufactured here and the proximity, cheap rate and customization facility supported the trade. Later the glass containers were replaced by much cheaper, safer and durable acrylic and plastic containers, which are also made in and around Agra. Basically, the technical knowledge and the pool of technically qualified people who were able to prepare the specimens helped to establish the trade in Agra.

The infamous 'formalin, which is banned in many countries due to its chemical nature was the preservative used to preserve the materials. The introduction of acrylic containers boosted the industry as the material was durable and cheaper than glass.

The Volume of Trade:

As per the intelligence collected by the office of DFO- Agra, there are more than fifty scientific material suppliers operational in Agra. The office conducted inquiry about their involvement in the trade but were not able to collect material evidence to prove their involvement. This happened due to the wide publicity about the seizure of the consignment on 13th of September, 2006. By the time the investigation team gathered information about the labs they could have destroyed or abandoned any materials in their possession.

How the trade syndicate works?

Most of the zoological materials are coming from Chennai to Agra by transport companies and only a fraction of the materials are coming by courier. The consignments come in large non transparent drums which are usually labeled 'Scientific/ Educational materials'. The banned materials are hidden in the bottom of the containers which are covered with materials such as fishes, sea urchins, sting rays which are preserved in diluted formalin. The stench of formalin and the nature of the materials prevent any kind of detailed checking of the containers by authorities when they are transported to the destination.

Orders are placed via telephonic conservations/ faxes/ letters by the purchasers and also the sellers inform them about the availability of the materials as many of them are seasonal (The hatchling of turtles, baby cobras etc...). Once the order is placed the materials are dispatched through regular channels with the declaration as "educational materials".

As per the documents examined, the trade was bi-directional too. The supplier of banned wildlife goods at Chennai used to buy chemicals, slides and scientific equipments from the Agra counter part and the amounts were adjusted on mutual understanding. This method helped them not to show the actual transactions on records.

Details and follow-up of the case:

Two Chennai based and one Agra based Firms are mainly involved in the case. There is information about other dealers/ sub dealers and purchasers across various states whose names are referred in the documents seized from Agra based lab. This lab was procuring banned wildlife materials from

Chennai based labs and supplying it the other traders / end users across the country.

On January 14, 2007 a raid was conducted at godown of Agra based firm and 52 articles/dead wildlife including Horns of Black buck, Baby python, Turtle, Scorpions, Octopus, Callodis, King Crab, Sea snail, Star fish etc were seized. The accused was arrested and sent to jail.

On the basis of information gathered from this accused another raid was conducted on January 15, 2007 at Agra and a total of 174 dead wildlife/specimens were recovered. This catch included snakes, crocodiles, gharials and scorpions.

Based on tip off from the same accused a raid was conducted at another company of Agra and a total of 125 Pitcher plant, 37 dead frogs and one Cabbage Butterfly (mounted) were seized. The owner of the company was arrested and sent to the jail.

Huge abandoned specimens of wildlife (dead) were recovered in a road side ditch on Agra-Delhi highway on January 17, 2007. This seizure included 72 Baby gharials, 2 baby crocodiles, 2 monitor lizards, 18 Baby Olive Ridley Turtles, 5 Russels Viper, 2 Saw scaled Vipers, 1 Rat snake, 18 Dog Faced Water snakes etc. Feeling the pressure of Forest Department and due to fear of raid these materials were thrown by some unknown persons.

After absconding about one year the main accused was arrested by Special Task Force and his wife by U.P. Police in the month of November, 2007. Police Department is fighting the case in the court. Bail has been refused to both the accused by the court

Recommendations:

The trade in restricted/banned wildlife is taking place because there is market available for it. Syllabus of many boards and universities include dissection of banned wildlife. Clear cut direction is needed for universities, boards and labs for not using any restricted wildlife specimens without proper permission from competent authority under Wildlife (Protection) Act, 1972. A massive awareness campaign/drive needs to be organized for policy makers, officials, teachers, students, traders and people.

Gender Issues in Biodiversity Conservation

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Shri S.K. Pande, former Director General of Forests once said: "Rural India has a women centric agriculture system. Nothing can happen without them. Women are a great repository of biodiversity knowledge, as they intimately understand it. If animals are sick, they know what medicinal plants have to be administered. Women have the greatest concern as far as protecting biodiversity is concerned and they have to be brought in if we are serious about conservation." The Food and Agriculture Organization in one of its publications, "Gender-Key to Sustainability and Food Security", underlines that rural women in developing countries hold the key to many of the earth's agricultural systems for food production, seed selection and protection of agro biodiversity.

Which variety of mango will be used for making pickles and which ones for chutneys? Which locally available vegetable should be given during a particular illness? What variations in the spices are to be done with different varieties of a vegetable? How to differentiate between different varieties of rice at the time of cooking? While performing their day to day routine jobs, several such questions are regularly answered by rural women. The answers to these simple but specific questions are the inherited property of women and some times these answers end up in legacies of a particular family or area. For example Guava Jelly of Allahabad, Aonla products of Pratapgarh, Pickles of Varanasi etc became famous only because women of those areas identified the best varieties for their production.

It is a fact that the knowledge of growing conditions and nutritional traits of plants not only gives rural women a unique, crucial edge in seed selection and breeding, it also helps them maintain the genetic diversity required for adaptation to fluctuating weather. Despite this, the role of women in protecting biodiversity is largely unrecognized. For many women, biodiversity is the cornerstone of their work, their belief systems and their basic survival. Apart from the ecological services that biodiversity provides, there is the collection and use of natural resources. For indigenous and local communities in particular, direct links with the land are fundamental, and obligations to maintain these form the core of individual and group identity. These relationships extend far back into human history, when division of responsibilities by gender began. Scientists have discovered that already in the early Stone Age (15,000-9,000 B.C.), women's roles and tasks in hunter-gatherer communities were explicitly linked to biodiversity, with the natural environment in essence determining their status and wellbeing. For example, Owen (1998) describes women collecting and conserving edible plants that contributed 50 to 70 per cent of dietary requirements.

The link between the physical and metaphysical is common in many cultures. In parts of India, traditional practices specifically emphasize the close ties between biodiversity conservation and spirituality. Auspicious days are chosen to start preparing the fields, sowing the seeds or harvesting. When heads of grain arrive at the threshing yard, women welcome the first cartload with a puja, or ceremonial offering. As the seeds are carried away for storage, women invoke the forces essential for a good crop in the next growing season. And before the seeds are sown, the women take them to the local deity and worship them. They make seed offerings to the village goddesses, which are later collected by the poor. Women also worship the draft animals and the farming implements that will be used for sowing.

Both men and women acquire traditional environmental knowledge, which stems from generations living in close contact with nature. It is generally socially differentiated, however, according to gender, age, occupation, socio-economic status and religion. Gender related differences in terms of labour, property rights and decision-making processes and perceptions also shape knowledge systems, so men and women end up with varying forms of expertise. Men may know a great deal about trees used for timber, for example, while women are authorities on those providing fruits, medicines and fodder. In general women's understanding of local biodiversity tends to be broad, containing many unique insights into local species and ecosystems gained from centuries of practical experience. In a sample participatory study, women hill farmers in Dehra Dun, India provided the researchers with no less than 145 species of forest plants that they knew and used (Shiva and Dankelman, 1992). Highly sophisticated and dynamic, this kind of knowledge is traditionally shared between generations. It encompasses information about locations, movements and other factors, explaining spatial patterns and timings of ecosystems. As women farmers and resource users constantly experiment with plants and animals in order to improve their quality, they adapt their knowledge to multiple uses. Home gardens become small laboratories where women try out diverse wild plants and indigenous species. Experience and innovation result in sustainable

practices to protect the soil, water and natural vegetation, such as natural pest controls as an alternative to agricultural chemicals.

Despite its value, researchers often fail to study local women's knowledge, automatically regarding it as insignificant. There are several possibilities for enhancing women's position in biodiversity conservation, including through policy-making, research, programmes and projects, and women's organizations and networks. Apart from national initiatives, international policy frameworks also offer specific entry points. In terms of policies, one of the objectives of Agenda 21 (UNCED, 1992) is the recognition and promotion of “the traditional methods and the knowledge of indigenous people and their communities, emphasizing the particular role of women, relevant to the conservation of biological diversity”. In its preamble, the Convention on Biological Diversity (1992) recognizes “the vital role that women play in the conservation and sustainable use of biological diversity” and affirms “the need for the full participation of women at all levels of policymaking and implementation for biological diversity conservation”. In its article 1, the Convention has as its objective the “… fair and equitable sharing of benefits arising out of the utilization of genetic resources, including by access to genetic resources …”.

An older and now widely known national case is the Chipko movement in India, made up primarily of village women who stopped commercial logging in the 1970s by embracing trees in their community forests. Chipko led to a re-evaluation of the country's forest policy and a ban by the Supreme Court of India on green felling in the Himalayas. If large numbers of women participated in mass movements like *Chipko* in the upper reaches of Himachal and Uttar Pradesh, it was with good reason. They had a stake in protecting local biodiversity and natural resources like wood and water as additional burdens fell on them when these resources dried up. In community conservation efforts, they have played a major role especially in areas of seed selection and preservation. At a temple in Along, Arunachal Pradesh, women are respected for domesticating rice.

In states like Uttaranchal, Himachal Pradesh and Andhra Pradesh, women have a large share of jobs on the farm in addition to the household work and tending of children and the family. Though their responsibilities have soared, they still have no rights to the land they work in. They rarely hold land titles. Women who work on the family farm feel that they are not working on their own farm, as they have no legal rights to the land. They toil in the fields all year long, but once the crop is harvested, it is the men who take it to the market. Usually, work on a farm is divided on gender lines. Men usually plough, though nowadays, women also do it, even in conservative rural Andhra Pradesh. Women are generally responsible for sowing, hoeing, crop maintenance, harvesting, food processing, storage and finally, the intricate expertise of seed selection for future planting. The Save Our Seeds Movement, or Beej Bachao Andolan, subsequently sprang up among local farmers in the central Himalayan region of Garhwal (Uttaranchal). It has preserved in situ a rich variety of traditional seeds, ensuring food security and the well-being of both the people and the land. The Mahila Samakhya, an umbrella organization of women, works on these and other development issues through women's welfare groups in several villages.

The ways in which men and women have traditionally managed their seeds, plants and animals are fast changing in rural India. Agricultural policies often end up changing dietary habits. This often ends up in tribal and rural families abandoning their traditional foods. For example, studies in Gujarat where India's white revolution took off have shown that rural families stopped drinking milk and consuming milk products as much as they did before, as milk became a source of immediate cash with milk cooperatives buying it from them. Likewise, as economic pressures push more women into marginal lands, they may be pressured into abandoning sustainable practices. After all, immediate needs must be met.

Instead of improving the lives of the rural poor, modern agricultural development strategies like higher yields have contributed to environmental degradation and biodiversity loss. This, in turn, has ended up increasing the workload of women and cutting down on their innate strength of catering to their families' needs.

The real worth of women's role in preserving biodiversity can only come about with some concrete steps. Some of them could be:

- Document the knowledge of rural women on biodiversity in different parts of India.
- Recording oral history listing the perceptions, knowledge and skills of both men and women could give a fillip to further research.
- Gender sensitive biodiversity laws on biodiversity.
- Gender analysis in policies and project plans.
- Integrate gender sensitivity into Intellectual Property Rights issues.
- Gender specific databases and information systems and gender oriented participatory action research.
- Women must have access and control of land and other ecological resources.
- Integrate women into local institutions that deal with biodiversity management.
- Sensitize grassroots level democratic institutions like gram panchayats in their biodiversity conservation.
- Highlight women's organizational and managerial skills to help traditional societies give women broader responsibilities and not box them into traditionally gender specific jobs.
- Prevent traditionally existing and newly imposed social and cultural constraints on women.

Thus, it can be concluded that the knowledge of the necessary growing conditions and nutritional characters of various species gives women a unique, crucial repository of experiences in seed selection and plant breeding. It is this knowledge that helps women to maintain the genetic diversity required to adapt to fluctuating weather patterns to ensure the survival of traditional crops. Such a role assumes great importance in an era of increasing hybridization and monoculture. Rural women in particular have an intense interaction with natural resources, given their heavy involvement in collecting and producing food, fuel, medicinal remedies and necessary raw materials. With knowledge passed down through many generations, women frequently acquire a profound understanding of their environment and of biodiversity in particular, yet their contributions to conservation go unrecognized. Biodiversity loss and bio-piracy now endanger their knowledge and resources, including through the erosion of their diverse resource base. Lack of ownership and control over land and resources along with limited access to education and services, impose major constraints.

Collection of dhaincha (*Sesbania* spp.) variability in Uttar Pradesh

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Rice wheat cropping system is the most important crop sequence in India. It is followed in about 12 million hectare in the Indo-Gangetic plains and contributes about 73 % of total food grain requirement. It is also a well known fact that intensive cultivation of rice and wheat and application of inputs has created many harmful and adverse effects on natural resources, water quality and quantity, decline in soil health, deficiency of major and micro nutrients, energy crisis, stagnation of yield and ecological concern.

Rice wheat cropping system can not be sustained unless the declining trend in soil fertility, resulting from extensive uptake by crops, is replenished adequately and properly. Under this situation, green manuring plays a central and important role in minimizing the adverse effects of intensive farming and high input use on soil health.

Leguminous crops like cowpea, moong bean, urd bean, pigeon pea, chickpea, lentil, field pea, lathyrus, rajmash, *Temphrosia*, groundnut, soybean, woody legumes (e.g. *Leucaena*, *Gliricidia*, *Pongamia* and *Delonix*), dhaincha (*Sesbania* sp.) and sunhemp (*Crotalaria* sp.) have ability to fix nitrogen in their root nodules. Among green manuring crops, dhaincha is the most important crop and its incorporation at succulent stage in the soil adds 60- 90 Kg of nitrogen per ha and helps to improve the physical and biochemical structure of soil, prevents leaching losses of nutrients, enhancing water holding capacity, preventing weed growth, reducing residual effect of chemicals and also helps in minimizing occurrence of diseases and pests. Besides soil improvement purpose, dhaincha is used as stakes, feed and fodder, making fibre and fuel wood in Uttar Pradesh. Most *Sesbania* species are small plants of 12 years longevity although a few, such as *S. sesban*, are woody perennials.

Recognizing the great significance of green manuring, study was undertaken under umbrella of National Agricultural Technology Project (NATP) entitled "Network project on Genetic Evaluation and Improvement of *Sesbania* and *Crotalaria* for green manuring" of Indian Council of Agricultural Research (ICAR), New Delhi. Effort was made on exploration, collection, evaluation and ex situ conservation of germplasm of *Sebania* and *Crotalaria* from Uttar Pradesh and adjoining areas, which is considered as centre of diversity for some species of *Sesbania.*

In parallel with the above exploration, collections were made of two endemic perennial *Sesbania* taxa viz. *Sesbania sesban* and *Sesbania rostrata* (stem nodulating species). Populations of these species are under threat from urban expansion.

The collections accorded an excellent opportunity to consider pertinent germplasm collection issues such as (a) the need for systematic inclusion of urban areas in the vicinity of intense farming like Garh Muktaswar, Gajraula in J P Nagar, Bhanera and Rabri Road in Ghaziabad and Chinhat in Lucknow districts of Uttar Pradesh in exploration strategies, and (b) development of strategies for the maintenance of active, base and core *ex situ*

germplasm conservation of *Sesbania spp. in* National Gene bank at National Bureau of Plant Genetic Resources, New Delhi for posterity.

Rationale for the collections

The following two issues prompted germplasm collections of *Sesbania* in Uttar Predesh:

1. Conservation of land/ local races of *Sebania* from farmers' fields and banks of the rivers like Ganga, Gomati, Ghagara etc: Uttar Pradesh has a unique habitat, dissected by numerous rivers and streams which ultimately flow into the Ganga River. It has a great diversity of local ecological conditions of topography, rainfall, cropping systems viz., mixed farming, intercropping, sequence cropping, relay cropping and soil types within a relatively small area. In recent times the habitat in rural and urban districts of Uttar Pradesh has changed dramatically with increased urban pressure. The riverside areas typically inhabited by *Sesbania* are endangered by urban development, and peri-urban agriculture, horticulture and dairy farming. The river systems around the city have been altered in recent times. It is common for declared green belt areas to be suddenly resumed for development. For all these reasons a strong case exists for *ex situ* conservation (rather than *in situ*) of the wild native and local /land race populations of *Sesbania* around and within urban and rural areas as part of an overall strategy for the conservation of genetic resources of *Sesbania* species.

2. Issues related with species distribution: In botanical terminology, "the type is that element of a tax on to which the name of the tax on is permanently attached" (Davis and Heywood 1963). The principal type is the holotype which is that single specimen chosen to best represent the species. The holotype must be from one individual plant. Duplicates of the holotypes are called isotypes. This is to understand diversity between different species of *Sesbania* (species diversity) and diversity within species (genetic diversity) which could be utilized for the improvement of *Sesbania* through hybridization and selection. Details of characteristics and distribution of these species are presented below.

Distribution of *Sesbania* species

It has large genus of herbs, shrubs and soft wooded but short lived trees. It is mainly grown for green manuring, fodder, temporary shades and wind breaks. However, it is popularly known as green manure crop. Genus *Sesbania belongs* to family Fabaceae tribe Robineae. It is a versatile leguminous crop, distributed in tropical and subtropical areas of Indian sub- continent and also distributed in tropical areas of Africa, South Asia, China and West Indies. It is a large genus comprise of 32 species in Africa, 10 in Australia, 10-11 in tropical Asia and 8 in New World (Montero, 1984). Sesbania has basic chromosome number, x = 6. In India, only seven species namely, *S. aculeata*, *S. grandiflora*, *S. rostrata*, *S. sesban*, *S. speciosa*, *S. bipinosa* and *S. procumbens* are found in different agro climatic regions.

Sesbania aculeata is shrubby annual and native to Australia. It is cultivated during rainy swamps. Stem is green, sparingly prickly branching from the base. Leaves are abruptly pinnate with linear oblong shape and glabrous leaflets. The inflorescence is raceme in 3-4 flowers and flowers are 1.25 cm long, pale yellow, unspotted or spotted red to black.

Sesbania sesban is a soft wooded, quick growing short lived shrub, 1.8- 6.0 m in height. It is cultivated through out the plains of India to an altitude of 1200 msl. The inflorescence is axillary raceme, 2.5 -14.0 cm long with 8-10 flowers. The flowers are yellow or with red or purple spots. Pods are 12.5 -22.5 cm long, pendulous, weak, twisted, sharply beaked, septate with 20-30 seeds. On the

basis of flower colour, this species has been classified into three types: *S. sesban* var. typical with uniformly yellow flowers; *S. sesban* var. pictal with standard petal externally spotted purple and *S. sesban* var bicolour having standard petal dark maroon or purple outside.

Sesbania bispinosa (Wight) is an erect herb or a low annual with red prickly stems. It is found as a weed in the rice field or comes up gregariously in wasteland. It is also used as green manure and for production of fibre.

Sesbania procumbence (Wight and Arn.) is diffuse, obscurely muricate and annual. It has 5.0 - 7.0 cm long leaves with 31-41 linear oblong, glabrous leaflets. The inflorescence is solitary or 2-4 flowered racemes. Pods are straight with 15-20 seeds. It is found in plains of western region of India.

Sebania rostrata is annual herb and is commonly grown under water logging area in tropical region of India. It has green stem with heavy nodulation on it. It shows poor to no root nodulation. Flowers are yellow with purple streak.

Survey and Collection

Several exploration trips were carried out in different districts of Uttar Pradesh (table 1) by the scientists of Project Directorate of Cropping System Research, Modipuram, Meerut and NDUA&T, Kumarganj, Faizabad and National Bureau of Plant Genetic Resources, New Delhi. Most stands of *Sesbania* found in the fields were small and grown as intercropping with sugarcane or mixed cropping with pigeon pea for fodder and fuel purposes. Single plant collections were made. Sample seed were also collected from threshing yard of the farmer in rural areas. A total of 76 accessions were collected through crop specific explorations from various cropping system and farming system regions of Uttar Pradesh. Accessions were also collected from

water logged areas in the vicinity of rivers like Ganges and Gomti. Wide variability was observed during survey trip for cropping systems, soil types, irrigation system, cultural practices, and method of planting. Wide variability was also recorded for plant vigour, biomass, leaf size, pod length, pod shape, seed shape, colour, size and number of seeds per pod and flower colour.

All seed was divided and stored in either base or active collections. Base collections are stored (at -20°C) at the National Gene Bank of National Bureau of Plant Genetic Resources, New Delhi and active collections are stored (at 5°C) at the Project Directorate of Cropping System Research , Modipuram , Meerut and NDUA&T, Kumar Ganj, Faizabad.

Germplasm Evaluation:

In order to have better understanding on variability exhibited by different collections, the data of various traits viz., Green biomass, Dry matter, at 45 and 60 days after sowing plant height, Fresh & dry weight of root nodules, Number of root nodules were recorded and documented. Pandey *et al* (2003) and Sardana *et al* (2004)observed high variability for these traits which could be utilized in future breeding programme.

A large number of collections have been made from different districts Uttar Pradesh. Still some important areas from districts of Bundelkhand region remained unexplored. A good deal of information can further is generated from available genetic material having greater diversity for the improvement of dhaincha for green manuring as well as other purposes.

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Table 1: Areas surveyed and collection of germplasm in Uttar Pradesh

Village/Block	Districts	Accessions collected
Modipuram	Meerut	IC402226, IC402226-1, IC402228, IC402229, IC402230, IC402230-1, IC402231, IC402232, IC402232-1
Sumenagara	Mainpuri	IC402226-2, IC402226-3, IC402226-4
Rabri Road	Ghaziabad	IC402217
Ladyata	Kannauj	IC402218
Tigayi, Khatauli	Muzafarnagar	IC402233, IC402234, IC402235, IC402236
Raipura, Jat, Jamunavata,	Mathura	IC381749, IC381749, IC381750, IC381751, IC381752,
Jait, Nagaria, Mahaur,		IC402214, IC402215, IC402216
Palso, Farah		
Nanau, Katra Maur, Balvant Nagalia, Bheekampur	Aligarh	IC381742, IC402203, IC402204, IC402205
Baryishahpur Gerka Nagala, Shahi,	Hathrus	IC 381743
Shijvaripura, Kokthala	Agra	IC381745, IC381746, IC381747, IC402209, IC402211,
Naglabishe, Thabi,		IC402212, IC402213, IC402270, IC402273
Sadabad		
Amanganj, Kumarganj, Khandasa, Shinath	Faizabad	IC410985, IC410988, IC402271, IC402272, IC402274
Chillalla	Pratapgarh	IC402268, IC402268-1, IC410994
Kinora	Sultanpur	IC402269

Microbial Biodiversity for Human Welfare

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Abstract

The recent intensification of agricultural productivity, overgrazing and conversion of land into domestic and industrial uses due to population pressure, has resulted in several undesirable changes in the environment with adverse effects on agriculture. The over-exploitation of the natural resources has almost destroyed the natural harmony among many of its components and has adversely affected soil health. The impact of such un-natural efforts is being manifested in the form of imbalance in the beneficial microbial pool of the soil, degraded soils ecosystems, polluted ground water, emergence of disease/pest problems, and the loss of nature's wealth. In present day's agriculture, therefore, care should be taken to improve the microbial biodiversity in the soil which is the only obvious key for maintaining soil health, improved crop productivity and sustainable management of agro-ecosystem.

The concept of sustainable increase in the pace of agricultural productivity to provide food to rapidly growing human community has remained one of the dreams of the human endeavor. During the last few decades the modern technological developments have led to the increase in the agricultural productivity to the top but at the same time, it failed to generate sustainability, both in terms of the crop production as well as the ecological restoration. The need and greed for maximizing crop yields has resulted in over-exploitation of the natural resources and soil ecosystem. The impacts of such un-natural efforts are being manifested in the form of degraded soils ecosystem, polluted ground water, emergence of disease/pest problems, and the loss of nature's wealth.

In the Indian context, the seriousness of the problem can be understood by the following facts. Crop losses due to diseases and pests by the end of 2007, as assessed by ASSOCHAM report, will score a figure of Rs. 1,40,000 crores while annual pesticide use figures at 20% of the agricultural land in India. Most of these toxic chemicals, while controlling targeted pests/diseases, cause threat to the beneficial bacteria, fungi, nematodes, insects etc. as well as accumulate in the ecosystem and food chain as residues causing ecological imbalances and problems to human health. Similar is the fate of the nutrient fertilizers being put into the soil. About one-fourth of the nitrogen, more than half of phosphate and total potash are being imported either in the form of raw material or finished products. However, only a considerable of these nutrients put in to the soil remains available to the plant roots and therefore helps in the agricultural productivity. A major part of these nutrients are lost due to the physico-chemical properties, biological activities or leaching and ultimately create ecological problems. Therefore, alternative methods for increasing crop productivity and for controlling plant pests/diseases with its roots lying in the natural resource management, community development in harmony with the nature and respectful attitude towards the soil-based microbial wealth are the first and foremost demand of the present day agriculture.

Beneficial microbes improve plant health

Microbes are the integral parts of any soil ecosystem. Their presence and abundance provide soils richness in terms of making available slow-release nutrients, continuous breaking down of complex macro-molecules and natural products into simpler ones to enrich beneficial substances, maintaining physico-chemical properties of the soil and perhaps most essentially, providing supports to the plants in terms of growth enhancement and protection against diseases/pests through their metabolic activities that goes on in the soil day and night. The metabolic activities of the microbes such as rhizosphere bacteria, beneficial mycorrhizal fungi, biological control agents e.g. species and strains of *Aspergillus niger*, *Bacillus* spp., *Burkholderia cepacia, Candida oleophila* I-182, *Coniothyrium minitans, Coniothyrium sclerotiorum, Fusarium oxysporum* (Nonpathogenic), *Gliocladium* spp., *Phlebia gigantean, Pseundomonas cepacia, Pythium oligandrum, Streptomyces griseoviridis* and *Trichoderma* spp., the biological nitrogen fixers e.g. cyanobacteria (blue green algae), *Azolla-Anabaena* symbiont and soil fauna like nematodes, worms, protozoans etc. continuously add to the soil health and promote crop productivity through diverse mechanisms. The organisms such as *Rhizobium, Azotobacter, Azospirillum, phosphate solubilizing micro-organisms* etc. that are currently being used as the formulations of biofertilizers have been put under the schedule of Fertilized Control Order (FCO), 1985 amended vide S.O. 391 (E) dated 24.03.2006 wherein, the state governments are asked to enforce quality control of these biofertilizers and organic fertilizers as per the specifications of the FPO act.

There is growing interest in the presence of certain naturally occurring, beneficial microorganisms in agricultural wastes (e.g. processing wastes, composts and anaerobic slurries) that have considerable potential to enhance the growth, health and protection of crops. The numbers of these organisms can be increased through incubation procedures and they can be applied as mixed or pure culture inoculants to soils and plants in waste materials or as sprays and suspensions. The various mechanisms of disease control and plant protection imparted by these beneficial microorganisms may be related to (a) microbe-microbe interactions, (b) plant-microbe interactions, (c) metabolites produced and/or, (d) induced systemic-acquired resistance. Research is being carried out in many premier institutions to elucidate exact mechanisms or modes-of-action to determine the optimum time, rate and frequency of application for improving plant health and protection.

Microbial biodiversity and biological farming

The rhizosphere or the zone of influence around roots harbors a multitude of microorganisms that are affected by both abiotic and biotic stresses. Among these are the dominant rhizobacteria that prefer living in close vicinity to the root or on its surface and play a crucial role in soil health and plant growth. Both free-living and symbiotic bacteria are involved in such specific ecological niches and help in plant matter degradation, nutrient mobilization and biocontrol of plant disease. These are the real players in a defined ecosystem whose beneficial effects boosts and detrimental effects diminish soil health and crop production. Overall, the population of all these inhabitants is directly dependent on the organic matter content of the agro-ecosystem. Within the plant roots, the loss of carbon sources provides the desired energy for the development of active microbial populations in the rhizosphere around the root. Generally, saproptrophs or biotrophs such as mycorrhizal fungi grow in the rhizosphere in response to this carbon loss, but plant pathogens may also develop and infect a susceptible host, resulting in a diseased condition.

Microbial interactions that can take place in the rhizosphere and are involved in biological disease control are very important from the view of sustainable crop productivity. The interactions of bacteria used as biocontrol agents of bacterial and fungal plant pathogens, and fungi used as biocontrol agents of protozoan, bacterial and fungal plant pathogens are equally important. Whenever possible, modes of action involved in each type of interaction were assessed with particular emphasis on antibiosis, competition, parasitism, and induced resistance. It has been found that, such interactions not only provide plants the needed resistance against pathogenic attacks or environmental stress but at the same time metabolites constituted due to such interactions either in plants or in microbes or beneficial to each other. Production of a vast range of secondary metabolites with diverse biological properties in plants and production and excretion into the medium, plant growth harmones e.g. indole acetic acid, siderophores, amino acids and proteins, enzymes and other nutrients etc. by the microbes interacting the plant roots are some beautiful examples of such a highly complex interactive system needed for the survival of each other. The significance of plant growth promotion and rhizosphere competence in biocontrol is much considered research theme in present days. Multiple microbial interactions involving bacteria and fungi in the rhizosphere are shown to provide enhanced biocontrol in many cases in comparison with single biocontrol agents.

Microbial biodiversity regulates soil ecosystem

With the first estimation of prokaryotic abundance in the soil, researchers have attempted to assess the abundance and distribution of species and relate this information on community structure to ecosystem function. One of the major difficulties that plant biologists and microbiologists face when studying these interactions is that many groups of microbes that inhabit this zone are not cultivable in the laboratory. Recent developments in molecular biology methods are shedding some light on rhizospheric microbial diversity. Culture-based methods were found to be inadequate to the task, and as a consequence a number of culture-independent approaches have been applied to the study of microbial diversity in soil. Applications of various culture-independent methods to descriptions of soil and rhizosphere microbial communities are being worked out with great success. Culture-independent analyses have been used to catalog the species present in various environmental samples and also to assess the impact of human activity and interactions with plants or other microbes on natural microbial communities. Recently the linkage of specific organisms to ecosystem function has been investigated carefully and prospects for increased understanding of the ecological significance of particular populations in the soil remains an open field for the investigators in near future.

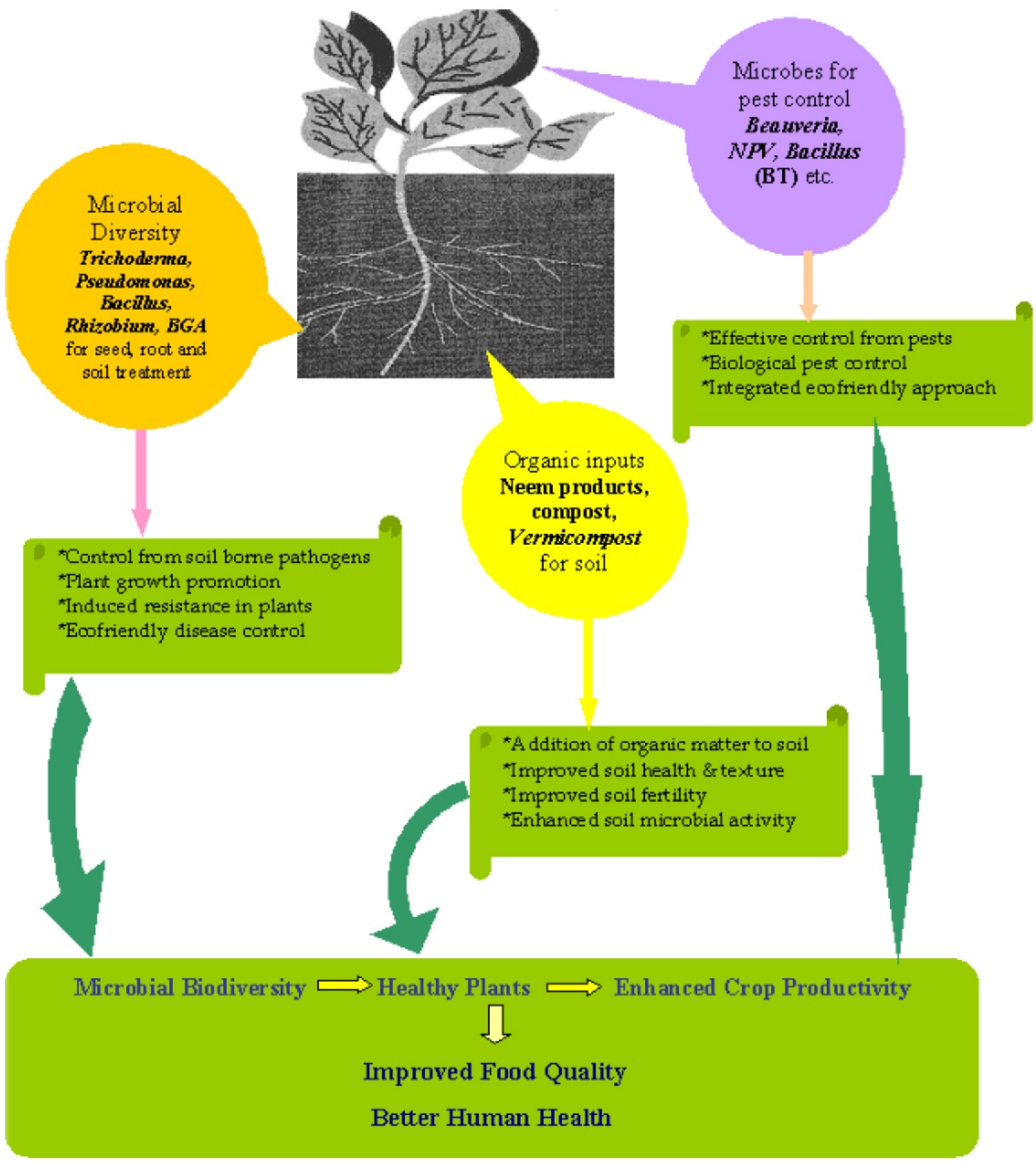
While the rhizosphere as a domain of fierce microbial activity has been studied for over a century, the availability of modern tools in microbial ecology has now permitted the study of microbial communities associated with plant growth and development, in situ localization of important forms, as well as the monitoring of introduced bacteria as they spread in the soil and root environment. This interest is linked to environmental concerns for reduced use of chemicals for disease control as well as an appreciation for utilization of biologicals and organics in agriculture. Indian researchers have studied the diversity of rhizobacteria in a variety of plants, cereals, legumes and others along with assessment of their functionality based on the release of enzymes (soil dehydrogenase, phosphatase, nitrogenase, etc.), metabolites (siderophores, antifungals, HCN, etc.), growth promoters (IAA, ethylene) and as inducers of systemic disease resistance (ISR). Based on such primary screening protocols, effective rhizobacteria have been field tested with success stories from various agroecological zones of the country, as reflected in the control of root- and soil-borne diseases, improved soil health and increased crop yields. Several commercial formulations, mostly based on dry powder (charcoal, lignite, farmyard manure, etc.) have been prepared and field tested, however, problems of appropriate shelf-life and cell viability are still to be solved. Also, inherent in such low cost technologies are the problems of variability in field performance and successful establishment of introduced inoculants in the root zone. In addition, most products available in the market are not properly monitored for quality before they reach the farmer. As a consequence, the acceptance of rhizobacterial formulations in the country is limited. However, several laboratories have now developed protocols for the rapid characterization of effective isolates based on molecular fingerprinting and other similar tools. Also, the use of molecular markers (gus, lux, gfp, etc.) makes it easy to monitor introduced inoculants in situ in soil and rhizosphere environments. The government initiative in integrated nutrient management and pest management systems has provided additional incentives to relate rhizobacterial science to other ongoing activities so that the benefit of this research leads to technologies that are environmentally and socially acceptable.

Rhizospheric bacterial community in service of plants

Plant growth results from the interaction of roots and shoots with their environment. The environment for roots is the soil or planting medium which provide structural support as well as water and nutrients to the plant. Roots also support the growth and functions of a complex of microorganisms that in lieu can have a profound effect on the growth and survival of plants. These microorganisms constitute rhizosphere microflora and can be categorized as deleterious, beneficial, or neutral with respect to root/plant health. Beneficial interactions between roots and microbes do occur in rhizosphere and can be enhanced. Increased plant growth and crop yield can be obtained upon inoculating seeds or roots with certain specific root-colonizing bacteria- 'plant growth promoting rhizobacteria'. Various mechanisms by which these plant growth promoting rhizobacteria such as species and strains of *Pseudomonas, Bacillus* etc. may stimulate plant growth has well been documented and based on such research, commercialization of these products is underway.

Co-existence of the plants and their rhizosphere microbes and the chemical communications that exists within the system helps greatly the biological processes to sustain. Primarily it is the loss of carbon compounds from roots that drives the development of enhanced microbial populations in the rhizosphere when compared with the bulk soil, or that sustains specific mycorrhizal or legume associations. The benefits to the plant from this carbon loss are enormous. Overall the general rhizosphere effect could help the plant by maintaining the recycling of nutrients, through the production of hormones, helping to provide resistance to microbial diseases and to aid tolerance to toxic compounds. When plants lack essential mineral elements such as P or N, symbiotic relationships can be beneficial and promote plant growth. However, this benefit may be lost in well-fertilized (agricultural) and organic matter rich soils where nutrients are readily available to plants and symbionts reduce

Model: Microbial biodiversity relates to improved soil health, crop production, crop quality, safer environment and human health



Plant-microbe interactions Biological cost-benefits

growth. Since these rhizosphere associations offer key benefits to plants, these interactions would appear to be essential to the overall sustainability and success of the ecosystem.

Societal concerns about pesticide and chemical farm-input residues in the food and the adverse effects of chemical intensive agriculture on the environment, combined with the increasing cost of petro-product derived agri-inputs and continuously declining food quality are the prominent factors influencing the development of alternative disease control strategies as well as sustainable ways of soil fertility promotion. Prior to 19th century, agriculture was labour (human and animal) intensive and largely depended on diverse land-races, poly-cropping systems (poly varietal cultivation, inter cropping and alley cropping), and crop rotation practices for control of diseases and pests. Soil fertility was maintained or enhanced by cultivation nitrogen-fixing crops or by collection of biological material from the wild, where available. Such traditional systems if practiced in integrated manner, will again become sustainable, resulted from the co-evolution of local social and environmental systems and may exhibit a high level of ecological rationale expressed through the intensive use of local knowledge and natural resource management.

Conclusion

The microbial entities, individually or in combination, helping in maintaining the optimum level of minerals in the soil, and the plants tissues even at low level of fertilizer inputs and at the same time, offering protection to crop plants from various soil borne diseases and pest infestations in the most sophisticated way almost competitive to the natural processes need special care and proper attention in order to conserve and proliferate them. These microorganisms in the form of bio-fertilizers or bio-pesticides are the essential agricultural commodities and inputs for maintaining good soil fertility, better soil conditions and sustainable agricultural productivity.

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Measuring biodiversity: a case of wild lentil

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The living world around us is disappearing before our eyes. Losses of biological diversity are being driven, primarily, by human population growth and by unsustainable patterns of resource consumption, reinforced by inappropriate economic structures and activities that maximize short term gain, without considering long-term consequences. 270 000 plant species are known to science, out of which 7 000 have ever been used for food. About 120 plant species are cultivated today; of which 90 cultivated plant species provide 5% of human food. About 21 species provide 20% of human food and only 9 species provide 75% of human food. The information regarding the loss of biodiversity is in the public domain but a systematic framework for assimilating data, and assessing its impact on society, does not exist. It is essential to clarify the scientific basis for measuring biodiversity in order to contribute to universal consensus on how biodiversity can be monitored.

Structuring the Framework

The framework can be regarded as a conceptual process that can be applied to all levels of biodiversity. It is also relevant to long-term monitoring programmes and in emergency situations. Equally, in situations where a potential disaster can be anticipated, the framework can be used to develop a damage limitation programme.

The framework consists of a series of linked activities that comprises the assessment of some aspect of biodiversity or ecosystem function. The framework process can be divided into three main stages: the scoping stage, the design stage and the implementation and reporting stage. A case study on diversity in wild lentil is discussed in following section.

Scoping stage

The process of identifying interested parties and their valued attributes, assessing existing knowledge and developing a conceptual model of the system, comprises the Scoping Stage. This should lead to the identification of a clear set of aims and objectives for the assessment.

Interested Parties

Interested parties may be evolutionary biologists, people who have interest in nature, local people whose livelihood depend on local diversity, farmers, commercial foresters, conservationists, marine eco-tourists etc The potential effects of decisions about management of biodiversity within a system may vary among stakeholder (interested parties) groups. For example the health, welfare, intellectual, recreational, spiritual and financial interests of different groups of stakeholders may be affected in different kinds of ways. Scientific assessments of biodiversity occur because some subset of stakeholders wishes to have certain information.

Identifying valued attributes

The valued attributes of the biodiversity that to be assessed, need to be defined in the interest of stakeholders. Differences in timescales that are inherent in the stakeholders' values will also be identified at this stage. The examples of valued attributes are global species richness and the location, abundance and range of species as resources for documenting and understanding the evolutionary process. It is essential that interested parties should clear about what the assessment can and cannot provide. A scientific assessment is only likely to satisfy the requirements of interested parties if it first establishes that what are their interests and values.

Assessing existing knowledge

Existing knowledge may come from a variety of sources, such as previous studies, from the interested parties itself and from those carrying out the assessment. Where the knowledge comes from previous scientific studies of the system or from studies of other systems, if the similarities are sufficiently strong, judgments have to be made about the extent to which it can be relied upon as a guide to the present assessment and close to its minimum viable population size, The initial stages of an assessment of biodiversity may involve formal review and critical testing of existing knowledge alternating with discussion with interested parties of the conclusions drawn from it. During this process of rigorous examination, interested parties may change their priorities about which attributes of a system they value.

Modeling the system

Consideration of existing knowledge, together with values and requirements of interested parties, provides a background to prepare a conceptual model of the system. The nature of an appropriate model will depend upon the system and the attributes to be measured. For example, suppose the object of the assessment is a measure of species diversity and the attributes to be measured concern the effects of habitat fragmentation at a global or continental scale. The model includes known latitudinal trends in species numbers, range sizes and levels of endemism. The knowledge, in turn, would influence the choice of study sites and the scale of analysis required in different regions. If the assessment aims to measure aspects of the pressures and drivers that are thought to affect the biodiversity attributes of interest, it is important that the model of the system includes the relationships among them. These relationships can be expressed using a Driver-Pressure-State-Impact-Response (DPSIR) framework, even if this is only possible in conceptual form.

The design stage

The designing stage consists of choosing measures of biodiversity, deciding among alternative measures and devising the sample strategy.

Biodiversity measures

There are four categories of biodiversity measures i.e. extent of habitat, ecosystem processes and changes in its functioning, listing and distribution mapping of taxa (especially species and sub-species) and population size of selected species. Extent of habitat establishes the extent of large-scale ecosystems or habitats. Large-scale habitat measurements have been aided greatly by advances in remote sensing and GIS software.

Ecosystem processes and changes in its function are approached by the use of proxies. For example, key aquatic plants can be valuable indicators of eutrophication of freshwater bodies. Surveying these aquatic macrophytes may be more rapid and cheaper than full-scale monitoring of water quality and biological composition. For the lists and distribution mapping of taxa, counts of species (species richness) are probably the most commonly used surrogate for overall biodiversity at both local and broader scales. The species level is an accepted standard, because species are the most familiar taxonomic unit for scientists, the public, and the policy makers. A fourth group of measurements i.e. population size of selected species, concerns the abundance of individuals and changes in population numbers of organisms. These measurements are often aggregated across species to produce composite indicators of changes in particular regions or habitats. Population surveys can provide sensitive indicators of the status of particular species under study, but they may also be expensive to acquire.

Selection of measures

Selecting appropriate measures depends first and foremost on the object of the assessment and the attributes of interest. Some attributes can be measured directly, but others cannot and in these cases reliance may have to be placed on indirect (proxy or surrogate) measurements that are in some way correlated with those of direct interest.

Devising the sampling strategy

The next step is to use the model to develop a sampling strategy that specifies what to measure, when, where and how. A fundamental decision is whether to make estimates of attributes of interest by extrapolating from measurements made upon a sample, or whether to survey or measure them in their entirety. Assessment of populations routinely use counts made from surveys in sample areas, such as quadrates or line transects, which are then extrapolated to estimate the total population size. If characteristics of surveyed and non surveyed areas that are correlates of population density, such as vegetation type or topography, can be obtained and then these can be used to improve the precision of the estimates and to model the distribution and abundance of the species outside the surveyed areas.

The implementation and reporting stage

This stage comprises of data gathering, checking, storage, analysis and reporting to the interested parties.

Data gathering, checking and storage

Several principles of data collection apply to a wide variety of biodiversity assessments are listed below.

- Ensure that people collecting data are adequately trained and follow a common protocol for collecting and recording the information.
- Keep raw data for checking and re-interpretation.
- Store data in its most disaggregated form.
- Record precise locations of field study areas.
- Record both presence and apparent absence in distribution and abundance assessments.
- Ensure that checks are carried out to keep errors in recording and data storage at an acceptable level.
- Where possible, collect any additional, low cost data that may be useful later.
- Review progress regularly to check that the data being collected will address the questions originally posed.

Analysis, assessment and reporting

The details of the analysis and reporting of the assessment will be specific to each particular case, but some points on the issues of great significance.

- The results of the assessment should be used to update and improve the model of the system as a basis for future research. Defects in the model underlying the assessment should be identified clearly and remedies suggested.
- The survey design, the procedures used in sample area selection, and the fieldwork and analysis protocols should all be described in sufficient detail to allow the survey to be repeated. This is especially important for complex, semi-automated techniques such as the mapping of habitats.
- Where possible, the raw data from the assessment should be available to other researchers for alternative analyses.
- Precise survey localities should be archived so that the study could be repeated at the same localities if necessary.
- The results of the assessment should, wherever possible, be published in the peer-reviewed literature. Where this is not possible, an attempt should be made to subject the outputs to other forms of external review.

Reporting to interested parties

Scientific assessments of biodiversity should be reported to interested parties in ways that minimize the scope for misinterpretation of the results. Reporting results in a form accessible to scientific colleagues is important, but is unlikely to be effective in communicating to interested parties without further effort. Reporting of the results of an assessment to interested parties will often lead to proposals to repeat the assessment or to undertake some connected piece of research.

A Case Study of Wild Lentil

In 30 years time, the world's human population will have grown significantly to 8.5 billion according to some estimates and substantial, sustainable increases in food supply will be needed. Conservation and sustainable use of plant genetic resources should form a foundation upon which improvements in sustainable agricultural productivity can be built.

Valued attributes

Wild species are an important component of agricultural biodiversity. Species that are relatives of crop plants contain valuable genes for crop improvement, and wild species of plants may be important nutritionally and culturally to people in many parts of the world, where they serve as food in times of famine, provide vitamins, minerals and nutrients, and provide income for cash-poor households. In the case of wild species of lentils, it will be necessary to breed better adapted crop varieties in the future. Natural populations of lentil species conserved in regions of greatest diversity will be particularly valuable when their genetic diversity results from adaptation to changing abiotic factors. Wild species of lentil form an important component of ecosystems that are vulnerable to climate change and to reduced rainfall in particular. Wild lentil germplasm is represented in *ex situ* seed bank collections but the diversity conserved does not accurately reflect the genetic diversity found in nature.

Knowledge

The genus *Lens* consists of 6 wild taxa that are relatives of the cultivated lentil *L. culinaris* Medik.. Their distribution is the Mediterranean basin, with one species spreading into Central Asia. All species exist in small, disjunctive populations, predominantly in undisturbed rocky or pine forest habitats. These factors make these species vulnerable to genetic erosion unless effective conservation in protected areas can be achieved. Approximately 800 seed accessions are conserved in gene banks the majority at the International Center for Agricultural Research in the Dry Areas, where 'passport data' are maintained. Other data are available from herbarium specimens. Together these data sets are sufficient to determine accurate geographical distributions and ecological preferences for all species. Each species is highly inbreeding; heterozygotes are extremely rare. On average, 89% of genetic diversity within the species occurs among (as opposed to within) populations, but within-population variation is significantly different for different populations, and is therefore an important consideration for conservation.

Model

The model assumes that there is genetic variation within the wild species of lentils and that it may vary within and among populations in different parts of the geographical range. It further assumes that measures of genetic distance obtained from a sample of molecular markers can represent this variation in a quantitative and reliable way.

Relevant questions identified by the scoping stage

The main aim is to map the geographical distribution of *Lens* species and the genetic variation within these species. It is feasible to do this for four of the six wild taxa of lentils (*L. culinaris* subspecies *orientalis*, subspecies *odemensis, L. ervoides, L. nigricans*). From the map it should be possible to identify the most important wild populations for the conservation of genetic resources.

Sampling strategy, data gathering and analysis

An assessment of the distribution of the genetic diversity of each species both within and among populations was made using molecular markers (RAPD). This approach was chosen because RAPD markers are easily applicable to species where little or no genomic information is available, and they are relatively simple and inexpensive. Geographical distribution of the genetic variation in the four taxa was assessed by calculating genetic distance between population samples, cluster analysis, then calculating gene diversity as well as 'number of clusters per sub-region' (NCSR). Further analysis was undertaken to determine whether diversity was directly associated with ecological and geographic range, so that areas where further sampling or collection should be undertaken, in a recurrent biodiversity assessment, could be identified. Exploration and seed collection activities provided a dataset and material for assessing the correlation between genetic diversity and eco-geographic range to highlight future conservation priorities. While seed collection from each population was randomized, the locations of these populations was not, but was guided by eco-geographic information from various sources. Sampling (by ICARDA) was concentrated in the Fertile Crescent of the Middle East, but samples were also collected throughout the total geographical range of wild lentils from Portugal to Uzbekistan. It was not possible to determine the likely total number of populations in existence for each species, although previous pilot studies gave indications that the Fertile Crescent had the highest numbers of populations. For every sample, geographical co-ordinates of the collection site were available. Both assessments of diversity were undertaken on all samples. The two measures of diversity (gene diversity and NCSR) sometimes gave conflicting results. To meet the objective of maximizing conserved variation, the use of NCSR was used. Some areas of high diversity coincide with high plant population densities and are therefore good targets for reserve establishment and *in situ* conservation .In one case (*L. culinaris* subspecies *odemensis*) however, genetic diversity is distributed widely and will be more problematic to conserve *in situ*.

- *Lens culinaris* subspecies *orientalis*: two centres of diversity are identified (west and north Jordan and southern Syria; southeast Turkey and northwest Syria) and should be prioritised for *in situ* conservation.
- *Lens culinaris* subspecies *odemensis*: genetic diversity is localized in small pockets of distinct germplasm, and six of the eight sub-regions studied exhibited unique germplasm. For adequate conservation, many small reserves throughout the distributional range would need to be established.
- *Lens ervoides*: a centre of diversity associated with high population numbers (density) is found on the coast of Syria and is a good target for reserve establishment.
- *Lens nigricans*: a clear centre of diversity with a high population density exists in western Turkey that should be a target for *in situ* conservation.

Areas of high and unique genetic diversity are located for each taxon in Turkey, Syria and Jordan; outside of these countries, much less genetic diversity, total and unique, is found. This indicates that although the majority of existing *ex situ* conserved material has been sampled from Turkey, Syria and Jordan, it still under-represents the genetic diversity from these countries. Conversely the diversity found in peripheral countries is already well represented in existing collections.

Science gaps

- New data are needed for two taxa i.e *Lens culinaris* subspecies *tomentosus* that only recently separated taxonomically from subspecies *orientalis*, so populations and samples with definitive identification were not included. *Lens lamottei* is regarded as a cytotype of *L. nigricans*, and insufficient populations/material could be identified for the particular study.
- Although the majority of existing *ex situ* conserved material has been sampled from Turkey, Syria and Jordan, it still under-represents the genetic diversity from these countries.
- *In situ* genetic reserves have recently been established for wild lentils in Turkey, Syria, Lebanon, Palestine and Jordan, but even these multiple reserves cannot represent the total genetic diversity found in nature. ICARDA continues to routinely sample genetic diversity for wild lentils at the geographical centre of their diversity.
- Other molecular markers such as SSRs, AFLPs or SNPs could provide much more transferable information, and could be developed as specific indicators of biodiversity loss for future assessments in this group of species.

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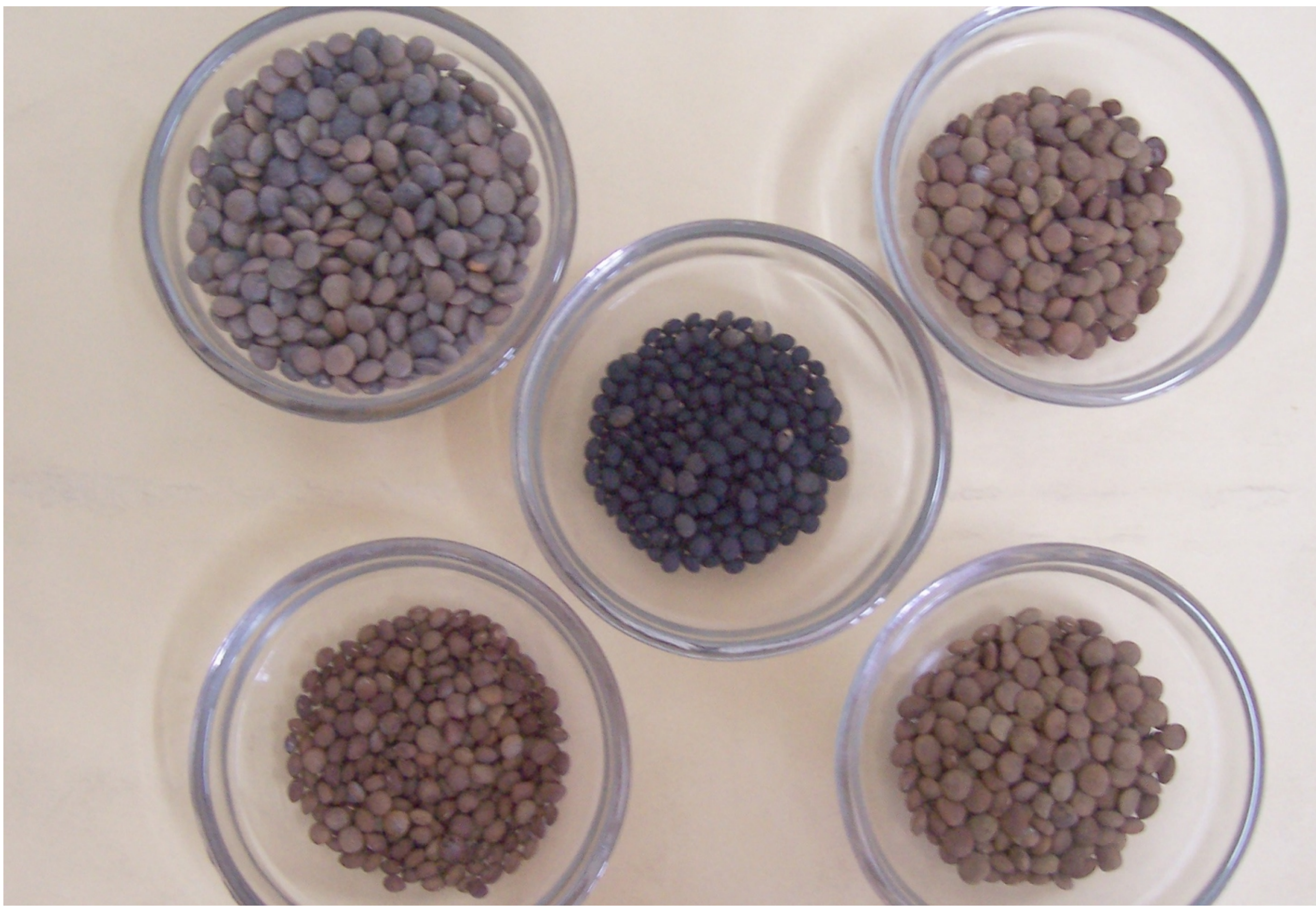

Pomegranate (*Punica granatum* L.) Biodiversity and Conservation

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Pomegranate (*Punica granatum*. L.) is an important fruit crop of tropical and sub tropical regions (Jalikop 2003). It is capable of growing in a great variety of climates ranging from the tropical to temperate and as a result a large number of diverse forms have evolved over the years in nature (Levin 1995). Pomegranate is becoming export oriented crop for the last one decade and its area and production is increasing with a faster pace in India. Its demand for internal consumption and export is a driving force for promotion of its cultivation in the country. Consequently, Maharashtra is a leading state for production of pomegranate which is contributing more than 80% of the total production. At present, major produce is consumed as fresh fruit in India and hardly 2% of the produce is processed and 1% exported which is very low as compared to other pomegranate growing countries like Spain, Israel, Iran, Egypt etc. (NRCP. 2007b). Hostile agro-climate of arid ecosystem makes fruit culture a difficult enterprise, but even under such environment, pomegranate has proved to be a successful fruit crop. The built in capacity to withstand heat, drought and salinity, besides high profitability has made its cultivation increasingly attractive. The unique plasticity of this fruit crop is evident from the threshold limits it exhibits for higher (44^0 C) and lower (-12 ^{0}C) temperatures (Westwood 1978). The plant habit, fruiting and flowering physiology are, however, altered with the habitat (Pareek and Sharma 1993). In the sub-temperate regions of the country (Western Himalaya), seedling types of trees locally known as *Daru* come up naturally in abundance. *Daru* genotype is very common and gregarious in gravel and boulder deposit of dry ravines in the outer Himalaya. These hardy deciduous seedling trees growing since long time possess better climatic adaptability and resistance to pests and diseases owing to natural selection (Sharma and Sharma 1990). The tropical varieties are evergreen and produce sweet fruits that are mainly consumed fresh, but the fruits of *Daru,* though highly acidic, are also commercially important as they are extensively used in the preparation of *anardana,* an acidulant condiment product (Jalikop *et al.* 2005).

The pomegranate has been cultivated around the Mediterranean region for several millennia. In Georgia, to the east of the Black Sea, there are wild pomegranate groves outside of ancient abandoned settlements. The ancient city of Granada in Spain was renamed after the fruit during the Moorish period. It is also extensively grown in South China and in Southeast Asia, whether originally spread along the route of the Silk Road or brought by sea traders. The pomegranate was introduced by Spanish colonists into the Caribbean and Latin America.

The fruit has wide consumer preference for its attractive juicy, sweet-acidic and refreshing arils and there is a growing demand for good quality fruits both for fresh use and processing into juice, syrup and wine. Since time immemorial, it is being used as a symbol of fertility because of innumerable seeds. It is a nutraceuticals of great importance. All parts of the tree, roots, bark, leaves, flower, rind and seeds are used for medicine. Even since ancient time, it has been used in folk medicine in the Middle East, Iran and India as medication for antiviral, antifungal, antibacterial activity. The Charka, the great physician of ancient India, has prescribed a large number of formulations using different parts of pomegranate in the treatment of diseases like dyspepsia, stomach ache, dysentery, diarrhea, tapeworm, inflammations, bronchitis, cardiac disorders *etc*.

Origin and distribution

This fruit crop is known to have been domesticated in the Middle East more than 5000 years ago (Adsule and Patil 2005). It is one of the species mentioned in the Bible and the Koran and is often associated to fertility. It is native to Iran (Persia) and perhaps some surrounding areas. It was cultivated in ancient Egypt and early in Greece

and Italy. The fruit was very popular in Iraq. In time, it spread into Asia (Turkmenistan, Afghanistan, India, China, etc.), North Africa and Mediterranean Europe. The domestication process took place independently in various regions (Evreinoff 1949, Zukovskij 1950, Melgarejo and Martínez 1992). The Romans first called this species "malum punicum" (Punic apple or apple of Carthage) that evolved to "punicum granatum" and C. Von Linne, finally, gave the name *Punica granatum*. It is now widely cultivated in Mediterranean, in tropical and subtropical areas. It can be encountered as regular plantations in Cyprus, Egypt, Morocco, Spain, Tunisia and Turkey. A high number of scattered trees on the borders or within other fruit orchards are reported in many Mediterranean countries where the fruit is very popular in local markets. It is cultivated in Central Asia and to some extent in the USA (California), Russia, China and Japan for fruit production and is also developed as an ornamental tree in East Asia (Mars 1996, Tous and Ferguson

1996). Earlier pomegranate was considered as a minor fruit in India and its regular cultivation started after 1986 on commercial scale. Now, Maharashtra has become the main pomegranate producing state in India followed by Karnataka and Andhra Pradesh. However, some other states like Rajasthan, Gujarat, Tamil Nadu, Haryana, Punjab, UP, Bihar and Madhaya Pradesh have also cultivation potential for which systematic approach has to be made in popularizing of pomegranate.

Biodiversity

Like other fruit crops, genetic biodiversity in pomegranate is also available in the world. Not much efforts have been made to collect and conserve the biodiversity of this crop. Some parts of the Mediterranean area are considered as native lands of pomegranate. Almost all of the

varieties in the region are of local type selected by unknown persons and maintained by vegetative propagation. Authors from different countries listed many local cultivars/varieties (Levin 1995a, Ozguven 1996, Mars 1996, Mars and Marrakchi 1998a). The grown local material may be considered as the pomegranate primary gene pool. It grows wild in the near east, Transcaucasia, Dagestan and also in Asia Minor. In these regions, hybridization between cultivated and wild forms is, probably, still taking place (Zukovskij 1950). Wild forms (populations) would be the secondary gene pool. The tertiary pomegranate gene pool would consist of forms of the pomegranate wild relative (*P. protopunica*). It is presumed that *P. protopunica* played a part in the origin of the cultivated pomegranate. But Zukovskij (1950) affirmed that the Socotran pomegranate has not played any part in the origin of the cultivated one.

Genetic studies are rare or lacking entirely because pomegranate has not been subject of much scientific investigation in the past. Some studies based on morphometric criteria have recently been performed to determine the degree of polymorphism within local material (Mars and Marrakchi 1998b). Results show a considerable phenotypic (presumably genetic) diversity among accessions. High degree of cross pollination exists in pomegranate. This leads to heterozygosisty among the cultivars. At present over 70 cultivars, both from indigenous or exotic sources, are available in India. Mars and Marrakchi (1998b) have reported morphometric studies on 63 pomegranate accessions in Tunisia as part of the variety evaluation process. Since majority of them are of seedling origin, they provide wide variability with respect to shape and size of fruit, mellowness of seeds, aril colour, rind colour, sweetness and sensitivity of fruits to bursting or cracking (Keskar *et al.* 1993, Mars and Marrakchi, 1998b). Presence of a wide variation for organic acids content in pomegranate juice has been recently reported from Portugal, Spain and Turkey and Melgarejo and Artes (2000) reviewed the differences in acidity levels reported by different workers in Egypt, Israel, Saudi Arabia, Yugoslavia, India, Russia and USA. Similarly, a great diversity in organic acid composition has been detected in pomegranate juice. Citric and malic are the major acids in the pomegranate juice (Melgarejo and Artes 2000, Poyrazoglu *et al.* 2002, Miguel *et al.*2004). However, oxalic and tartaric acids dominated in pomegranate varieties analyzed by Melgarejo *et al.* (2004). Presence of small amounts of acetic, fumaric, lactic, quinic and succinic acids have also been identified by Melgarejo and Artes (2000) and Poyrazoglu *et al.* (2002). Further, according to Melgarejo and Artes (2000), sweet varieties sometimes contain more of malic than citric acid but sour varieties on the other hand citric acid is always the major acid. In India, wild pomegranate found growing in Western Himalaya (Jammu and Kashmir, Himachal Pradesh and Uttarakhand). Recently, diversity in wild pomegranate has also been reported from Himachal Pradesh by Singh and Singh (2006). Remarkable variability was observed among clones collected from the forest. High variability was found in respect to number of fruits per tree (215-769), weight (54.28-85.12 g), number of arils per fruit (48-165.7), TSS (17.5-20.5 ^{0}brix) and acidity (2.46-6.60%). Similarly, variability in plant height, leaf and fruit size, stem, rind and aril colour, number of thorns and their size, TSS, acidity etc. has been recorded in accessions collected from Uttarakhand (NRCP, 2007a). Under net work programmes with various organizations, *in-situ* conservation strategies could be finalized and implemented for systematic conservation. In western Himalaya, at least one or two gene sanctuary of pomegranate needs to be established involving NBPGR, forest Department and NRC on Pomegranate to check further genetic erosion of pomegranate.

Taxonomy and Cytogenetics

The genus *Punica* belongs to the family Lythraceae, which was previously placed in family Punicaceae. Recent phylogenic studies have shown that Punica belongs to the family Lythraceae and is classified in that family by the Angiosperm phylogeny group (Graham *et al.*1998).Its better known species is the pomegranate (*Punica granatum* L.). The only other species in the genus, the Socotra pomegranate (*Punica protopunica*), is endemic on the island of Socotra (Yemen). It differs in having pink flowers and smaller and less sweet fruit. The species *granatum* has two subspecies viz. Chlorocarpa and Prophyrocarpa. Dwarf pomegranate (*P. granatum* L. var. nana) is a miniature variety of the pomegranate most suitable for pot plant production. In out door plantation, it may reach a maximum height of 2 m (Beach 1980). Further, Levin (1985) has also reported dwarf fruiting form of pomegranate. Some authors classified the ornamental dwarf pomegranate as a distinct species, *Punica nana (*Melgarejo and Martínez 1992). According to Smith (1976), *P. granatum* has 2n = 2x =16, 18 chromosomes. The somatic chromosome number of cvs. Dholka, Ganesh, Kandhari, Muscat White and Patiala was found to be 2n= 16, while the cultivar Double Flower has 2n =18 (Nath and Randhawa 1959). The chromosome number in Vellodu and Kashmiri varieties was found to be 2n = 18 with 1 or 2 quadrivalent associations at meiosis (Raman *et al.* 1963).

Propagation

Pomegranate seeds germinate easily. In general, 60-75% seed germination has been observed in most of the cultivated varieties. In dwarf pomegranate (*P. granatum* L. cv. nana), seed germination reported to be very low (Cervelli and Belleth 1994, Jalikop 2007) and poor germination was due to presence of a water soluble inhibitor in seeds. However, seedlings show high degree of variability. Among vegetative methods, hardwood, semi-hardwood and softwood stem cuttings were reported to be used for propagation of pomegranate. In "Ganesh", IBA (5000ppm) with quick dip method (one minute dip) found optimum for better rooting (73.3%), field survival and growth (Panwar *et al.* 2001). As far as rooting is concerned, hardwood cuttings were better than semi-hard and soft wood cuttings. It was observed that cutting thickness also influenced the rooting success. Dhillon and Sharma (2002) found that cutting thickness of 0.8 1.2 cm was most appropriate for getting high rooting success. However, they recorded November as most suitable time for raising cuttings under Punjab condition. Position of cuttings (basal, sub-apical and apical) responded differently when used for raising of stem cuttings. Basal cuttings (1.0 1.25 cm thickness) treated with 5000ppm IBA gave higher rooting success than other types of cuttings taken. It was recorded that high C: N ratio and carbohydrate reserves of the cuttings were responsible for higher rooting success in basal cuttings (Purohit and Shekharappa 1985). Rooting media also play vital role in enhancing the rooting success of stem cuttings. Hardwood cuttings gave better rooting success when planted in river silt (Baghel and Saraswat 1989, Deol and Uppal, 1990).

In Maharashtra, mostly layered plants are used for pomegranate cultivation. Very high rooting success (94%) with layering method using 1500ppm IBA was recorded when layering done between June and August (Hegde and Sulikeri 1989, Hore and Sen, 1994). Propagation of pomegranate is also possible by root cuttings. It was reported that root cuttings taken from young trees (<4 yrs old) gave better result particularly when planted in February (Mendilcioglu 1968).

For regeneration of pomegranate through tissue culture techniques, some works were initiated in India and aboard. Omura *et al.* (1987a) could achieve organogenesis using leaf explants. They have also tried to induce tetraploidy with colchicine treatment during the course of *in vitro* culture of dwarf pomegranate cultivars (Omura *et al.* 1987b). Later on, Mahishni *et al.* (1991) were successful in culturing shoot-tip explants on supplemented MS medium and then transferring them to Lloyd and Mc Crown woody plant medium. They achieved 80% success in establishment of plantlets in 1:1:1(v/v) peat, perlite and sand mixture. Kanatharajah *et al.* (1998) have tried to standardize tissue culture techniques. However, little attempt appears to have been made on using isozymes or molecular (genetic) markers to identify or measure genetic variability among existing genotypes or hybrids resulted due to innumerable crosses. Further, somatic embryos were induced from petal explants on MS medium supplemented with various plant growth regulators and nutrients (Nataraja and Neelambika 1996).

Conservation

Conservation strategy is an important approach for maintenance of germplasm and their further utilization in future. Both *in situ* and *ex situ* methods can work in pomegranate conservation. The plant diversity could be observed in land races, local selections, elite cultivars, wild relatives, obsolete farmer's named and old varieties, commercial and modern bred cultivars, special genetic stock as parental lines and genetic stock with known attributes. The genetic base in pomegranate in low, but still variability is available in the form of seedlings, landraces, primitive cultivars etc. in nature owing to cross pollination and their high adaptability in diverse situations ranging from the tropical to temperate climates as reported by Jalikop and Kumar (1990) and Levin (1995b. For the preservation of local pomegranate germplasm, prospections are realized and collections are already established in several Mediterranean countries like Spain, Morocco, Tunisia, Greece, Turkey, Egypt, etc.(Mars 1996). Levin (1995b) reported that 8 countries of the former USSR have collections of pomegranate germplasm. Azerbaijan, The Ukraine, Uzbekistan and Tajikistan have relatively large collections of 200-300 accessions. The collection of the Turkmenistan Experimental Station (TES) of Plant Genetic Resources was established in 1934 and is the largest in the world containing 1117 accessions and recently, it was enhanced to 1157 (Levin 1995b). Samples are from 26 countries on 4 continents, consisting of cultivars received from commercial firms and through interchange with other scientific

Table 1: Status of germplasm of pomegranate in India

S. N	Centers	Number of collections
1	PAU, Abohar, Punjab	19
2	ANGRAU, Anantpur, Andhra Pradesh	29
3	TNAU, Arrupukottai, Tamil Nadu	24
4	CCSHAU, Bawal, Haryana	09
5	CIAH, Bikaner, Rajasthan	152
6	IIHR, Bangalore, Karnataka	64
7	RAU, Jobner, Rajasthan	09
8	CAZRI, Jodhpur, Rajasthan	34
9	MPKV, Rahuri, Maharashtra	52
10	S.K. Nagar, Gujarat	52

institutions and material collected from wild populations and landraces (Levin 1994, 1995a). However, TES has a core collection which is 10% of the size of the main collection (Levin 1996). For the unique wild relative of the pomegranate (*P. protopunica*), an expedition during 1989 located the species at 5 sites in the Socotra island (Yemen) and seeds were collected and successfully germinated (Guarino *et al.* 1990). Collected material is maintained as living plants. According to Levin (1994) experiments have shown that Crayopreservation is suitable for storage of seed and pollen of pomegranate cultivars. Also, natural reserves are used in Transcaucasus and Central Asia for *in situ* conservation of wild pomegranate population. However, interchange of plant material is not frequent. Guidelines for its safe movement are not available. But it seems not to be problematic and it depends on the general policies for genetic resources for each country. Pathological constraints that may impede the movement of germplasm are not reported. Nevertheless, Levin (1994) reported that since 1964, material from the collection of the TES has been sent to scientific institutes to form working collections. However, in India, at present 7 SAU's and 4 ICAR Institutes are maintaining germplasm of pomegranate in their repositories (Table 1).

Utilization

At present, the main objective in pomegranate breeding are aimed at to obtain types which produce small soft seeds with attractive reddish (pink) arils and fruit skin. Priority is given to a variety having thicker, sweet juicy aril and large number of seeds with an easily manageable upright growth having semi tall and dwarf habit of the tree. Thornlessness of the twigs is also a desirable character as it helps in cultural management of the tree. The demand of ornamental forms of pomegranate is also increasing that also needs attention in future. Recently, bacterial blight of pomegranate caused by *Xanthomonas axonopodis* pv. punicae has been reported to cause enormous yield losses (60-80%) in Maharashtra, Karnataka and Andhra Pradesh (Sharma *et al.* 2006). Therefore, the most priority area would be to develop bacterial blight resistant varieties in India. Besides, wilt is also an emerging problem for which resistant rootstocks and tolerant varieties are to be identified. Among the insect pests and physiological disorders, fruit borer (*Virachola isocrates*), fruit cracking and internal breakdown of arils are also important problems to be solved. Sources of resistance to these problems need to be identified for further breeding programme.

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Biodiversity in Sugarcane

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It is widely accepted that India is the original home of sugarcane and the cane species *Saccharum barberi* was indigenous to the country. The earliest reference to the crop has been traced to a verse in Atharva Veda composed by the Aryans between 3000 and 7000 years ago. The verse says **"I have crowned thee with shooting sugarcane so that thou shall not be averse to me"**. Sugarcane has, thus, been known in India long ago. Historical evidence shows that Indian canes were taken to Babylon by the Arab traders, where from them were taken to Syria, Cyprus, Malta and Sicily Islands in the Mediterranean. Alexander and Columbus took canes from India and introduced them into West Indies.

There are several exhaustive narrations about the origin of sugarcane. They abound in controversies that were gradually cleared by way of experience and knowledge gained through expeditions for collection of sugarcane germplasm. Several historic anecdotes about the crop are available through notes of Deerr (Deerr, Noel 1921 *Cane Sugar*., Norman Roger, London) and Earle (Earle, F.S. 1928 *Sugarcane and its culture*, Chapman and Hall, London). References in Hindu mythology are available in Brahmanda purana and people talk of Trishanku Swarga. Parthasarathy

(Parthasarathy, N. 1946 The probable origin of North Indian Sugarcane, *Jour. Int. Bot. Soc.* 133-150) referred to Tamil classics of the Sangam period (200 AD) in Pattirrup- pattu where references were made to growth, arrowing and cultivation. Charaka reported in 100 BC about existence of two sugarcane types viz. *Ikshu* and *Paundra*. In 200 BC Patanjali mentioned that by about 400 BC sugarcane was familiar at Takshasila. There were citations on sugarcane during 800 BC in Atharva Veda and Manu in 1000 BC. Sugarcane was first mentioned in China during 286 BC and it was reported to be known in the period of Ssu-ma-Siang Ju. It is also opined that after the times of Budha, Indian Sailors possibly had contacts with Burma, Indonesia and Malaya and would have brought *Saccharum officinarum* to India from Indonesia.

Saccharum is the Latin name proposed by Linne' in 1753 by derivation from *Karkara* and *Sakkara* from Sanskrit and Prakrit. It conveyed the shape of black gravel possibly meant to refer to sugar crystals developed from dark syrup. It is the opinion of many explorers that sugarcane had its origin in *Saccharum barberi* Jeswiet of north India and that *Saccharum officinarum* had Polynesian origin. Jeswiet in his revised publication described sugarcane under *S. officinarum* L., *S. sinense* Roxb. and *S. barberi* Jesw. *S. officinarum* is the thick stalked noble cane, rich in sucrose and was therefore used for chewing in South East Asia, Indonesia and the Pacific islands. The rest two were considered harder, thinner and less sweet canes mainly confined to China, Japan and India. Barber and also Jesweit indicated that *Saccharum officinarum* was evolved in Malaysia- Indonesia- Papua- New Guinea region or in the islands of Polynesia or Melanesia groups. Brandes and co-workers have mentioned in their records of expedition during 1928 that maximum diversity was noted in New Guinea where from *S. officinarum* might have evolved and since *S. robustum* was endemic to this area, the latter may be the ancestor of the former. It is now accepted also as both the species had a chromosome number of 2n= 80. Warner and Grassl also confirmed it after the expedition in 1957. *S. spontaneum* group originated possibly in the India-Burma-China outskirts before it was transported to Pacific. Daniels and co workers proposed three centers of origin for different cane species:

Indonesia/Papua New Guinea- *Saccharum officinarum* evolved from *S. robustum* present in this area. There might have been some introgression here between *S. spontaneum* of South East Asia and non- *Saccharum* genera of this zone.

India-Burma-China border region- Here, genus *Saccharum, Saccharum* complex and *S.*

barberi might have their origin.

China-Japan area- Here, *Miscanthus* is suggested to have been involved in origin of *S. officinarum* and *S. sinense*.

Sugarcane Breeding- Origin and Expansion:

The ancient sugarcane cultivars were of two kinds i) thick, soft rinded, sweet, colourful but pest and disease susceptible 'Noble' canes belonging to the group *S. officinarum* and ii) thin, hardy, vigorous growing types belonging to *S. barberi* and *S. sinense*. Being a vegetatively propagated crop, sugarcane improvement in the early years was only through 'variety substitution'. Naturally occurring promising types called 'Sports' (vegetative mutants) were spotted in larger plantations and from there they were isolated, multiplied and grown as a new variety. 'Green Sport' and 'Gillmans Sport' were such selections.

Sexual reproduction in sugarcane commenced with the chance discovery of naturally germinated sugarcane seedlings from 'true seeds', almost

simultaneously from Java and Barbados in 1887-88. That triggered sugarcane breeding in many countries.

In India, sugarcane breeding for better varieties commenced with the establishment of a Breeding Station at Coimbatore in 1912. The free flowering environment at Coimbatore was the most favourable factor for locating the breeding centre there. The primary objective to start with, was to produce improved varieties for replacing the indigenous canes, with low productivity, which were occupying the vast subtropical cane belt. The initial efforts to improve them through hybridization with the thick, tropical canes were disappointing, owing to the erratic and defective flowering behaviour of the original canes, even under Coimbatore conditions. Faced with this dilemma, Dr. Barber, the pioneer Sugarcane Breeder at Coimbatore took an unorthodox but bold step to rope in the wild species *S. spontaneum* (*Kans, Therbai, Rellugadda*) as a parent in the breeding programme. This paid immediate dividends in the production of the first



famous sugarcane hybrid- Co 205, which effectively combined the hardiness, remarkable growth vigour, resistance to pests and diseases from the wild parent and the commercial needs of yield and sugar from the tropical cane parent (Vellai- *S. officinarum).* This variety released from Coimbatore in 1918 became an immediate success and replaced the old cultivars especially *Katha*, because of its superior yield of both cane and sugar.

Breeding for tropical India started in 1926. The long chain of superior varieties from Coimbatore viz. Co 213, Co 312, Co 313, Co 419, Co 453 and so on became popular all over the country. This ushered in the 'Sugar Revolution' much earlier than the well known 'Green Revolution'. Some of the Coimbatore varieties like Co 213, Co 281, Co 290, Co 331, Co 419 and Co 421 even crossed the shores to become important commercial varieties in many outside countries.

Genetic diversity:

The genus *Saccharum* falls under the family *Gramineae* and has the following species:

Cultivated species: *S. officinarum, S. edule, S. barberi, S. sinense*

Wild species: *S. robustum, S. spontaneum*

Related Genera: *Erianthus* spp., *Narenga sclerostachya, Sclerostachya fusca, Miscanthus* spp.

Indian collection of wild species

The *Spontaneum* Expedition Scheme began in India in 1948 with the objective of collecting and studying the *Saccharum spontaneum* and allied grasses (Mukherjee, 1950). Collection of *S. spontaneum* and related genera became organized when breeders realized the importance of *S. spontaneum* in interspecific hybridization in sugarcane breeding in India. The objective of the collection Scheme was “a thorough exploration, collection and botanical study of the characters of the various types of *S. spontaneum* and allied genera.... for utilizing them in breeding” (Panje, 1956). The Indian effort was considered to parallel the contribution of American and Australian organizations made to collect *S. officinarum* and *S. robustum* (Warner, 1964). In fact it far surpassed it (Berding and Roach, 1987). The *Spontaneum* Expedition Scheme also sought to expand the knowledge of biosystematics of the elements of the *Saccharum* complex. The complexity of genera and species of *Saccharum* complex present in India and in the *'terai'* region in particular are highlighted by Panje (1954). Collections were made in the Southeast India in 1948 and in 1949. Panje covered the remainder of the sub continent and Nepal in the period 1950-1952. Additional collections in Asia (Burma, Thailand, and Malaysia) and Africa (Egypt, Sudan, east Africa, Congo, the Gold Coast, and Nigeria) were reported by Panje (1957). During the 80s and 90s, Sreenivasan and Palanichami in 1981, 1982, 1984, Sreenivasan and Vijayan Nair in 1983 and Vijayan Nair and Jebadhas in 1984 have collected several clones of *S. spontaneum, Erianthus, Miscanthus* and related grasses from the Bihar, Nepal and the North Eastern Region.

International sugarcane germplasm collections

Starting from the year 1875, a number of international collection expeditions have been made with a view to *inter alia* strengthen the available array of cultivated varieties and to act as a source of resistance to abiotic and biotic stresses. The sugarcane gene bank has about 800 such collections in the cultivated group and more than 1000 in the related genera and species.

World Repository

The Sugarcane Breeding Institute, Coimbatore (SBI) is one of the two world repositories of sugarcane germplasm collection, in addition to being a pioneer institute in the task of collection of cultivated and wild relatives of Sugarcane. The other such repository is, the Sub-tropical Horticulture Research Station of USDA at Miami, Florida, USA. Bulk of the Indian Sugarcane

Germplasm collection is maintained at the Kannur Research Centre and the *S. spontaneum, Erianthus spp*. and the working germplasm collection are maintained at Coimbatore. The status of sugarcane germplasm collection is presented in Table 1.

The concept of 'Precision Farming', which involves the use of right inputs at right time in the right manner, has broadened the use of PGR database in searching the right genotype for the right environment. This thought holds more importance in sugarcane crop, which remains in field through out the year. The modern day sugarcane varieties, which are outcome of inter-varietal hybridization programmes, lack the required broad genetic base (Table 2 and 3). This makes them extremely vulnerable to diseases and pests, thereby drastically reducing their field life.

Table 1: Sugarcane germplasm collection – present strength

Group	**Species**	**No. available at SBI, RC, Kannur**	**No. available at SBI, Coimbatore**	**Working germplasm at Agali Centre**
Cultivated Species				
	S.officinarum	764		243
	S.barberi	43		19
	S.sinense	29		
Wild Species	*S.robustum*	145		9
	S. spontaneum	79	654	104
Related Genera and other grasses	*Narenga porphyrocoma*	1	1	
	Sclerostachya fusca	1	1	
	Erianthus spp. and other grasses	152	226	11
	Recent Indian Collection	393	56	
Man Made Hybrids				
	Indian hybrids	1020	1800	354
	Exotic hybrids	585	64	47
	Intra, Interspecific and intergeneric hybrids	-	-	400
	Indo-American hybrids	130	12	
	Total	3342	2814	1187

The sugarcane has enormous genetic potential, which is still locked in the form of variability being expressed by the huge number of germplasm lines being maintained at different Institutes and Stations working on the sugarcane research and development. **Although sufficient data has been generated on the field performance of the**

Table 2: Extent of utilization of wild species in sugarcane varietal improvement

Species	Gamete Source	Extent of Utilization
S. spontaneum	Kassoer (Java)	Extensive
	Local (India)	Extensive
	Uba Marot (Phillipines)	Limited
S. sinense	Chunee (Saretha Group)	Extensive
	Saretha (Saretha Group)	Limited
	Uba (Pansahi Group)	Limited
	Tekcha (Pansahi Group)	Limited
S. robustum	Mol 1231 (Port Moresby)	Limited
	NG 28-251 (Port Moresby)	Very Limited
Erianthus arundinaceus	Local	Limited

Table 3: Desirable traits in various *Saccharum* sp. and related genera

S.No.	Genera & Species	Desirable Traits Found
1.	*S. officinarum*	Sugar content, Stalk thickness, Low fibre
2.	*S. spontaneum*	Resistance to biotic, abiotic and nutritional stresses, higher fibre content, higher biomass
3.	*S. robustum*	High yielding capacity, resistance to water-logging and diseases, Response to irrigation and fertilizers
4.	*Narenga sp.*	Resistance to diseases and pests especially to root parasites and drought tolerance
5.	*Miscanthus sp*.	Disease resistance, yielding ability and cold tolerance
6.	*Erianthus sp.*	Resistance to soil borne nematodes, root parasites and insects, higher biomass, higher fibre, lower nutritional requirements, better ratooning ability

available sugarcane germplasm lines, the following areas of research need due consideration in the future:

1. Evaluation and characterization of germplasm available at SBIRC, Kannur for performance under sub-tropical conditions
2. Development of electronic database management system capable of expansion with time and filter the required data within no time as per the need.
3. Identification of specific molecular markers for Sucrose Accumulation, Red Rot Resistance, Abiotic Stresses etc
4. Standardization of technique for Protoplast Fusion, which can open up new avenues for utilization of non-flowering *S. officinarum* genotypes
5. Utilization of Phytotron Facilities to stimulate and synchronize flowering in genetically diverse germplasm lines
6. Extensive survey, collection and characterization of existing natural variability of *S. spontaneum, Erianthus*, etc especially for sub-tropical India is urgently required under the present IPR regime.
7. Standardization of techniques for long term conservation of germplasm lines.

Genetic diversity and germplasm enhancement in wheat

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Assessment of genetic diversity within a cultivated crop has important consequences in plant breeding and conservation of genetic resources. The global mandate for wheat genetic diversity and germplasm enhancement includes: long-term safe conservation of genetic resources for future generations, understanding the rich genetic diversity, mining the untapped value of genetic resources through discovery of specific, strategically important traits required for current and future generations of target beneficiaries, and development of strategic germplasm through innovative genetic enhancement. In this regard, India is a major source of wheat seed-embedded technology to reduce vulnerability and alleviate poverty, helping farmers move from subsistence to income-generating production systems in the whole of South Asia. Over 80 autonomous germplasm collections holding in excess of an estimated 800,000 accessions have been established globally. The major germplasm collection centre in India is at National Bureau of Plant Genetic Resources, N. Delhi. Apart from collection and maintenance of valuable germplasm that includes, cultivars, land races and alien specie, wheat researchers have also enhance genetic variability by developing synthetic wheat lines. The current focus of use of genetic diversity is to address yield potential under global warming, biofortification and the stem rust super race Ug99.

Wheat is the foremost staple crop for millions and is produced in a wide range of climatic environments and geographic regions. It is the most traded food crop and is a single largest food import into developing countries. It provides 500-1400 kcal of food energy per capita per day in different countries. Presently, the global annual harvested area of "bread wheat" and "durum wheat" averages around 217 million ha, producing 621 million t of grain equivalent to approximately US$ 150 billion. Developing countries constitute half of the wheat area i.e., around 116 million ha producing 308 million tons of grain (FAO 2007). In developed countries around 90% of the wheat area is rainfed while in developing countries more than half of the wheat area is irrigated.

India, one of the greatest success stories of Green Revolution, is the second largest producer of wheat in the world with production hovering around 70-75 million tons in the past few years (Joshi et al., 2007a). It accounts for approximately 12 percent of world's wheat production and is the second largest wheat consumer after China (FAO, 2007). Although India's population grew by around 650 million between 1965 and 2000, the severe wheat crises of the early 1960s gave way to wheat surpluses in late 1990s (Evenson et al., 1999). Wheat production of 6.5 million tons in 1950, was dwarfed by the 72 million tons produced in 2005, a tenfold increase. This national production increase is reflected in increased yields per hectare that went from around 660 kg/ha in 1950 to 2,710 kg/ha in 2004. Alongside increased yields came an increase in area planted from nearly 9.8 million hectares in 1950 to 24 million hectares in 1990, to about 27 million hectares in 2004. Although increased wheat area played its role in increased wheat production in the initial years of the Green Revolution (Evenson et al., 1999), it appears to have stabilized at 27 million hectares in the last decade (FAO, 2007), and it is thought that wheat area will remain around this figure in the coming decades.

In India, three species of wheat are cultivated: *Triticum aestivum, Triticum durum,* and *Triticum dicoccum* (Gupta, 2004). Bread wheat accounts for approximately 95% of the wheat grown, while 4% is durum wheat and 1% is dicoccum wheat (Gupta, 2004). At present, major wheat growing states are Uttar Pradesh, Punjab, Haryana, Rajasthan, Madhya Pradesh, Gujarat, and Bihar. Three of the wheat producing states (Uttar Pradesh, Punjab, and

Haryana) account for nearly 80% of the total wheat production. Around 312 wheat varieties were released during past 40 years in India's six wheat zones and played a major role in enhancing productivity. Although around 60 varieties are grown by farmers in the various zones, only a few varieties occupy substantial area (Nagarajan, 2005). Presently, the most dominant variety in India is PBW 343, which occupies around 7 million hectares (Joshi et al., 2007a). In the other large zone (North Eastern Plains Zone), an old wheat variety, HUW 234, remains the most dominant variety, covering around 2-3 million hectares (Joshi et al., 2007a). Similarly, an old variety, LOK 1 (released in the year 1982), is the dominant variety in central India. The dwarf wheat varieties were first introduced from CIMMYT, Mexico and later improved to suit the Indian consumers.

India's population of more than a billion people is growing at approximately 1.8% annually, almost parallel with the annual growth rate of cereals. To maintain self-sufficiency, annual production of wheat needs to increase by 2 million tons every year. For wheat, the estimated demand will be about 87.5 million tons in 2020, or around 13 million tons more than the record production of 75 million tons harvested in the 1999-2000 crop season (Joshi et al., 2007a). Notably, this estimate is around 105-109 million tons projected in other reports (Sharma et al., 2002; Nagarajan, 2005). Since 1999-2000, India has struggled to equal its impressive record production and now must confront the task of increasing production at a rate sufficient to feed its growing population. Availability and use of appropriate genetic diversity shall play an important role in enabling wheat breeders varieties develop superior wheat cultivars, especially those against resistance to diseases (Singh and Huerta-Espino 2004).

The wheat genetic resources endowment

In the beginning of 20^{th} century it was acknowledged that wheat cultigens of the genus *Triticum* belonged to three ploidy groups with chromosomes number of $2n = 2x = 14$ (*T. monococcum*), 28 (*T. turgidum* and *T. timopheevi*), and 42 (*T. aestivum* and *T. zhukovskyi)*. Genetic resources in wheat can be categorized into six broad groups, namely modern cultivars in current use, obsolete cultivars often the elite cultivars of the past and often present in the pedigrees of modern cultivars, landraces, wild relatives of crop species in the Triticeae tribe, genetic and cytogenetic stocks, and breeding lines. These genetic resources represent the gene pool potentially available to breeders and other users of collections. This broad pool can be further subdivided into primary, secondary and tertiary gene pools (Harlan and de Wet 1971). The primary pool consists of the biological species, including cultivated, wild and weedy forms of the crop and gene transfer in this group is considered to be easy. In the secondary gene pool are the species from which gene transfer is possible but difficult, while the tertiary gene pool is composed of species from which gene transfer is possible only with great difficulty.

The cultivated species of *Triticum* and their genomic constitution are given in Table 1. There are two valid biological species at each ploidy level. The diploid *T. monococcum* has both cultivated and wild forms, while *T. urartu* only exists in the wild. Both tetraploid forms exist in both cultivation and the wild, while both hexaploid species only exist in cultivation. *Aegilops* is the most closely related genus to *Triticum* and has been widely used in wheat improvement. All *Aegilops* are annuals. The genus consists of 11 diploid species and 12 polyploid species, including tetraploids and hexaploids (Table 2). *Dasypyrum [Haynaldia] villosum* is among the Triticeae species a genetic resources for wheat breeding. It is an annual with V genome and is easily hybridized to durum or bread wheat.

In addition to *Aegilops* a host of more distantly related annual and perennial members of related genera in the Triticeae have potential as a source of germplasm in wheat breeding including cultivated rye and barley and their near relatives as well as a host of perennial grasses. The bulk of the perennial Triticeae species have been difficult to exploit in wheat improvement primarily because their genomes are non-homologous to those of wheat, and genetic transfers cannot be made by homologous recombination. However gene transfer is possible via complex cytogenetic protocols. The perennial genera of the tribe Triticeae of interest in wheat improvement are given in Table 3 along with their genome designations and ploidy levels. All the genomes of the perennial Triticeae have been combined with the A, B, and D genomes of bread wheat.

Conservation of genetic diversity in whet: *ex situ* strategy

Due to the strategic importance of wheat in food security and trade in many countries, and the critical importance of breeding in ensuring national industries remain competitive, over 80 autonomous germplasm collections holding in excess of an estimated 800,000 accessions have been established globally. Wheat germplasm collection is major countries/institutions are listed in Table 4. These collections vary in size and coverage; the largest have over 100,000 accessions and the smallest a few hundred. Most collections evolved from breeders working collections and carry predominantly local or regional cultivars-advanced, obsolete or landrace-as well as introduced cultivars of interest to national or regional breeders. However, there are also numerous small specialist collections of wild wheat relatives and genetic stocks.

An important issue in developing a global strategy for the conservation of wheat genetic resources is the diversity of accessions to be included in the strategy. One extreme view would be to limit the network to the primary gene pool the cultivated species and the closely related species with which they can be readily hybridized. The other extreme is that in the modern world of transgenics all biological species are potential genetic resources for wheat breeding and the concepts of primary, secondary and tertiary genepools are outmoded. The growing size and sophistication of genetic and molecular stock collections is testimony to their increasing contributions to enable the effective utilization of the variation conserved in "traditional" germplasm collections. The role of genetic stock collections in the global conservation effort of wheat germplasm should be re-evaluated and they should be afforded a higher priority in a rationalised system than they have been accorded in the past.

The Global Wheat, Rye and Triticale Conservation Strategy (Global Crop Diversity Trust 2007) suggested that the following criteria were essential for an efficient and effective global system for the conservation of wheat genetic resource: globally or regionally important, accessible under the internationally agreed terms of access and benefit sharing provided for in the multilateral system as set out in the ITPGRFA, committed to the long-term conservation of the unique resources it holds, well-managed and in conformity with agreed scientific and technical standards of management, maintaining effective links to users of plant genetic resources, and indicated willingness to act in partnership with others to achieve a rational system for conserving wheat genetic resources. Twenty-three private, national and global collections that fulfilled these criteria where identified as key components for a global wheat conservation network.

The wheat conservation strategy focuses on the conservation and use of the full spectrum of the genetic resources of wheat with the exception of the perennial wild relatives. Modern and obsolete improved cultivars are generally well conserved in global wheat germplasm collections because many such collections either were derived from breeders working collections or were primarily established to service local or regional breeding programs, and these were the accessions most sought by breeders. In fact many important cultivars are conserved in the majority of national and international collections. The major focus of a global strategy for this category of genetic resource would be to reduce redundancy in the global set of collections to free up resources for other priorities. Landraces have received priority for collection, conservation and documentation in recent years because of the increasing threat to their continued existence by the spread of improved modern cultivars. Nevertheless, such cultivars are poorly represented in world collections compared to modern and obsolete cultivars and should remain a priority for the global strategy both to ensure the collection of material that still exists in the field but is not in collections and the long-term conservation of collected material in line with agreed international standards. The wild relatives of wheat are also generally poorly represented in global wheat germplasm collections. There are several reasons for this viz., wild relatives are seldom use in conventional breeding programs than cultivars of the same species and usually require an extensive period of germplasm enhancement; they are more difficult to seed increase and maintain because of their tendency to shatter their seed than crop cultivars; thirdly wild species, because of their capacity to self-reproduce in nature, were seen as under less threat of extinction than the cultivated landraces.

Unfortunately many populations of the annual wild relatives of wheat, particularly those at the extremes of their distribution that are of special interest for breeding purposes, are under threat because of changing patterns of land use and global warming. At the same time, new technologies have made the use of the annual wild relatives as a germplasm source easier, which has generated an interest and need for representative collections of annual wild relatives to be maintained in accessible collections. For these reasons the annual wild relatives should clearly be afforded a greater priority in the global wheat germplasm collections than they have had in the past.

The perennial wild relatives of wheat were not seen as a priority for conservation in the collective global wheat germplasm system. Again there are several reasons for this. The most important reason is that collections of many of these species are maintained in perennial grass collections for use in breeding programs as grazing species or for other uses. Second, despite the number of perennial wild relatives of wheat that exist, their extensive global spread, and the extensive research that has taken place, the number of examples of commercially successful gene transfer from perennial wild relatives to wheat remain modest. Third, the perennial wild relatives like their annual counterparts require specialized seed increase knowledge and facilities which is only likely to be available in specialized collections.

Synthetic wheat: man made genetic diversity

Apart from natural variability, wheat researchers have also attempted diverse crosses in control to create new genetic diversity in wheat. One of the most successful examples were, the re-synthesized wheat lines developed by crossing modern durum wheat with *Ae. tauschii*, the probable donor of the D-genome in hexaploid wheat. These crosses have introduced new genetic variation into the wheat gene pool for many characters. Not surprisingly, re-synthesized wheat lines have also been a source of variation for drought and heat tolerance. Some advanced materials derived from re-synthesized wheat lines have improved adaptation worldwide, especially in drought-stressed environments.

Broadening the genetic base wheat with wild and landrace genetic resources

Various tool and techniques viz., Interspecific hybrization, embryo rescue, plant regeneration, cytological diagnostic, breeding methods and stress screening, and assessment of the stability of the advanced derivatives had been used to utilize the wealth of the wheat genetic endowment beyond the cultigen pool (Mujeeb-Kazi and Rajaram 2002). “Capturing” wild grass diversity requires more time and effort for a sequential production from F_1s, amphiploids and addition lines to translocation lines. Only translocation lines would be useful for wheat breeding, but intermediate products (amphiploids and addition lines) are useful to evaluate the presence of useful genes or traits. Also, certain amphiploids may be propagated as new man-made crop, e.g. triticale (amphiploid between wheat and rye). Alien species sometimes possess high levels of host plant resistance to biotic stresses, but the most used species for the genetic enhancement of wheat belong to the primary gene pool due to the easy gene transfer; i.e., the species of the A and D genomes are sources of alleles that can recombine directly with their respective genome partners in the cultigen pool.

CIMMYT has produced F_1 hybrids with many of genus in Triticeae including *Aegilops*, *Thinopyrum*, *Secal*, *Agropyron*, *Elymus*, *Leymus*, *Hordeum* and *Psathyrostachys*. Amphiploids involving *Aegilops* and *Thinopyrum* have been used in wheat improvement and those of *Secale* as new sources in triticale breeding. Addition lines have been also produced from the above materials. Currently, the work focuses on producing translocation lines to supply them to wheat breeders. CIMMYT has been working on the capturing genetic sources of the D genome of *Ae. tauschii* via re-synthesizing hexaploid wheat since 1980s, because of the wide adaptation of the species in many geographical and climate regions. The most widely approach for re-synthesizing hexaploid wheat includes the use of tetraploid durum and diploid *Ae. tauschii* (Fig. 1). These synthesized lines have shown significant and useful diversity that provides better host plant resistance to biotic stresses and for traits that enhanced adaptation to abiotic stress-prone environments. The re-synthesized wheat lines were used in CIMMYT and other countries including India as new sources to breed host plant resistance to Karnal bunt (*Tilletia indica*) and *Helminthosporium* leaf blight (*Cochliobolus sativus*).

Information management on genetic diversity of wheat

Recently, a new initiative the *Wheat Phenome Atlas* was initiated through the association of CIMMYT, Cornell Univ (Ithaca, N.Y., USA), and the Univ. of Queensland (Brisbane, Australia) for the development of enabling technologies to link genotype to phenotype across a wide range of agronomic traits of high priority to wheat farmers across the world. This *Wheat Phenome Atlas* is expected to will facilitate more rapid development of molecular breeding tools, increased understanding of genotype-by-environment interaction leading to increased precision and scope of targeted breeding impacts. The initiative is based on a unique database (amongst crop plants) developed by CIMMYT and national partners over the past half century, based on the field evaluation of more than 15,000 elite breeding lines in more than 100 locations across the world at a cost of about US$ 0.5 billion. All seed from these breeding lines has been preserved in the CIMMYT genebank and can now be subjected to whole genome genotyping.

Establishing the analytical tools to deal with data sets of over 15,000 lines x 40 years x 80 traits x 100 locations x 2,000 DNA data points (approximately 10 billion data points) will involve the development of new and powerful bioinformatics tools and webpage visualization software. The *Phenome Atlas Toolbox* will facilitate the identification of gene blocks having beneficial effects on high priority agronomic traits such as rust resistance, drought tolerance and yield. From these outputs it will be possible to develop molecular tools for rapidly introgressing these elite gene blocks into new cultivars. The *Wheat Phenome Atlas* database will also be used for modeling and simulation studies to predict cultivar performance in a range of global environments, including future environments predicted by climate change models. It is envisaged that the *Phenome Atlas Toolbox* will develop dynamically with input from wheat researchers worldwide. The *Phenome Atlas Toolbox* will be generic and applicable to all biological systems, whether plant or animal.

Genetic diversity to address human nutrition through wheat biofortification

The health of undernourished people may be enhanced by breeding staple food crops that are rich in micronutrients, a process referred to as biofortification. The importance of nutrient rich crops is widely accepted to the extent that improving livelihoods through increased levels of micronutrients in food is considered second only to controlling HIV/AIDS. Zinc and iron are the two well known nutrients having significant importance to human health. In developing countries, where there is high child and adult mortality, Zn and Fe deficiencies ranked fifth and sixth, respectively, among the top ten risk factors contributing to the burden of disease (WHO, 2002). The CGIAR launched in 2003 the Challenge Program HarvestPlus with the aim of breeding and disseminating crops for better nutrition. Within this global alliance undertaking, CIMMYT is developing high-yielding wheat cultivar whose grain contains 30 to 50% more iron and zinc. The potential impact is dramatic given that wheat cultivars bred by CIMMYT and its partners cover 80% of the global spring wheat area.

The best sources of these micronutrients are wild species that do not cross easily with modern wheats. Researchers have therefore developed a "bridge" line by crossing one such grass (*Ae. tauschii*) with high-micronutrient primitive wheat (*Triticum dicoccon*). The resulting “bridge” lines combine readily with modern wheat cultivars, producing lines whose grain contains more iron and zinc than modern wheat. Partners in India and Pakistan are using this approach to develop high yielding, disease-resistant, biofortified wheat for South Asia. In Turkey, home to pioneering research on zinc deficiency and wheat, wheat landraces and cultivars that take up and use zinc more efficiently are being combined with wheat cultivars that have resistance to yellow rust and root diseases. CIMMYT researchers with partners from labs elsewhere are identifying molecular markers for genes that control grain iron and zinc levels, to facilitate their transfer to new cultivars.

Genetic diversity for the new threat - Ug 99 stem rust

In 1998, severe stem rust infections were observed on wheat in Uganda, and a race, commonly known as Ug99 (TTKSK on North American nomenclature system) with virulence on resistance gene *Sr31*, which was initially transferred from rye to wheat, was identified. Race Ug99 was subsequently detected in Kenya and Ethiopia in 2005, in Sudan and Yemen in 2006, and in Iran in 2007. It is predicted that Ug99 will continue to migrate to North Africa, the Middle East, South Asia and beyond through winds or other means. The most striking feature of Ug99 is that it not only carries virulence to gene *Sr31* but also this unique virulence is present together with virulence to most of the genes of wheat origin, and virulence to gene *Sr38* introduced into wheat from *Triticum ventricosum* and bred in several European and Australian cultivars and a small portion of new CIMMYT germplasm (Singh et al. 2006). It is estimated that between 90 and 95% of the global wheat area is planted with wheat cultivars that are susceptible to Ug99 or its new variants.

A high frequency of the highly resistant wheat materials from South America, Australia, USA and CIMMYT were identified through 2005 and 2006 screenings with Ug99 in Kenya. They possess *Sr24*, located on the *Thinopyrum elongatum* translocation on chromosome 3DL together with leaf rust resistance gene *Lr24*. Detection of race TTKST with *Sr24* virulence in Ug99 lineage during 2006 in low frequency resulted in rapid buildup sufficient to cause an epidemic on *Sr24* carrying cultivar 'Kenya Mwamba' in 2007, which occupied about 30% of the Kenyan wheat area. The situations described above have once again questioned and reminded us of the consequence of dependence on narrow genetic base for disease resistance.

Diverse sources of effective race-specific resistance genes, mostly derived from wheat relatives, are available for breeding. Genes *Sr25* and *Sr26*, derived from *Th. elongatum*, have been used successfully previously in developing cultivars. Other genes, practically not used in wheat improvement but may have good chances of succeeding are *Sr27* of rye origin, *Sr22* and *Sr35* derived from *T. monococcum*. The undesignated resistance genes *SrTmp* (wheat origin), *SrR* and *Sr1A.1R* (rye origin), and a few other uncharacterized sources originating from re-synthesized hexaploid lines or bread wheat offer further diversity.

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Table 1. Different species of genus *Triticum* and their genomic constitution

Species	Genomic constitution Nuclear	Organellar
Triticum aestivum L.	ABD	B (rel. to S)*
Triticum aestivum subsp. *aestivum* (common or bread wheat)		
Triticum aestivum subsp. *compactum* (Host) Mackey (club wheat)		
Triticum aestivum subsp. *macha* (Dekapr. & A. M. Menabde) Mackey		
Triticum aestivum subsp. *Spelta* (L.) Thell. (large spelt or dinkel wheat)		
Triticum aestivum subsp. *sphaerococcum* (Percival) Mackey (Indian dwarf wheat)		
Triticum turgidum L.	AB	B (rel. to S)
Triticum turgidum subsp. *carthlicum* (Nevski) A. Love & D. Love (Persian wheat)		
Triticum turgidum subsp. *dicoccoides* (Korn. Ex Asch. & Graebn.) Thell. (wild emmer)		
Triticum turgidum subsp. *dicoccum* (Schrank ex Schubl.) Thell. (emmer wheat)		
Triticum turgidum subsp. *Durum* (Desf.) Husn. (macaroni or durum wheat)		
Triticum turgidum subsp. *paleocolchicum* A. Love & D. Love		
Triticum turgidum subsp. *polonicum* (L.) Thell. (Polish wheat)		
Triticum turgidum subsp. *turanicum* (Jakubz.) A. Love & D. Love (Khorassan wheat)		
Triticum turgidum subsp. *turgidum* (pollard wheat)		
Triticum zhukovskyi Menabde & Ericz.	A^tA^mG	A (rel. to S)
Triticum timopheevii (Zhuk.) Zhuk.	A^tG	G (rel. to S)
Triticum timopheevii subsp. *armeniacum* (Jakubz.) Slageren (wild form)		
Triticum timopheevii subsp. *timopheevii* (cultivated form)		
Triticum monococcum L.	A^m	A^m
Triticum monococcum subsp. *aegilopoides* (Link) Thell. (wild form)		
Triticum monococcum subsp. *monococcum* (einkorn or small spelt wheat)		
Triticum urartu Tumanian ex Gandilyan (wild form)	A	A

* Related to S-genome species

Table 2. *Aegilops* species and their genomic constitution

Species	Genomic Nuclear	constitution Organellar
Aegilops bicornis (Forssk.) Jaub. & Spach	S^{b}	S^{b}
Aegilops biuncialis Vis.	$U\underline{M}$ (UM^{o})	U
Aegilops caudata L.	C	C
Aegilops columnaris Zhuk.	$U\underline{M}$ (UX^{co})	U^{2}
Aegilops comosa Sm. in Sibth. & Sm. *var. heldreichii*	M	M
Aegilops crassa Boiss.	$\underline{D^{c1}}\underline{M^{c}}(D^{c1}X^{c})$	D^{2}
var. glumiaristata	$\underline{D^{c1}}\underline{D^{c2}}\underline{M^{c}}$	-
	$(D^{c1}D^{c2}X^{c})$	
Aegilops cylindrica Host	$D^{c}C^{c}$	D
Aegilops geniculata Roth (syn. *Ae. ovata*)	$U\underline{M}$ (UM^{o})	M^{o}
Aegilops juvenalis (Thell.) Eig	$\underline{DMU}$ $(D^{c}X^{c}U^{j})$	D^{2}
Aegilops kotschyi Boiss.	$U\underline{S}$ (US^{1})	S^{v}
Aegilops longissima Schweinf. & Muschl.	S^{1}	S^{12}
Aegilops mutica Boiss.	T	T,T^{2}
Aegilops neglecta Req. ex Bertol. (syn. *Ae. triaristata*)	$U\underline{M}$ (UX^{n})	U
var. recta (Zhuk.) Hammer	$\underline{UMN}$ $(UX^{t}N)$	U
Aegilops peregrina (Hack. in J. Fraser) Maire & Weiller (syn. *Ae. variabilis*)	$U\underline{S}$ (US^{1})	S^{v}
Aegilops searsii Feldman & Kislev ex Hammer	S^{s}	S^{v}
Aegilops sharonensis Eig	S^{sh}	S^{1}
Aegilops speltoides Tausch	S	S,G,G^{2}
Aegilops tauschii Coss. *var. tauschii, var. strangulata*	D	D
Aegilops triuncialis L.	$U\underline{C^{t}}$	U,C^{2}
Aegilops umbellulata Zhuk.	U	U
Aegilops uniaristata Vis.	N	N
Aegilops vavilovii (Zhuk.) Chennav.	$\underline{DMS}$ $(D^{c}X^{c}S^{v})$	D^{2}
Aegilops ventricosa Tausch	$D^{v}N^{v}$	D

Table 3. The nuclear genome of the perennial species of the tribe Triticeae

Species	Genome	Species	Genome
Agropyron cristatum	PP	*Leymus angustus*	NNNNNNXXXXXX
Agropyron cristatum	PPPPPP	*Leymus arenarius*	NNNNXXXX
Agropyron desertorum	PPPP	*Leymus chinensis*	NNXX
Agropyron fragile	PP	*Leymus cinereus*	NNXX
Agropyron michnoi	PPPP	*Leymus innovatus*	NNXX
Agropyron mongolicum	PP	*Leymus mollis*	NNXX
Australopyrum pectinatum	WW	*Leymus racemosus*	NNNNXXXX
Elymus abolinii	SSYY	*Leymus salinas*	NNXX
Elymus alvatavicus	SSYYPP	*Leymus tritcoides*	NNXX
Elymus arizonicus	SSHH	*Pascopyrum smithii*	SSHHNNXX
Elymus batalinii	SSYYPP	*Psathyrostachys alatavicus*	NN
Elymus canadensis	SSHH	*Psathyrostachys fragilis*	NN
Elymus caninus	SSHH	*Psathyrostachys huashanica*	NN
Elymus ciliaris	SSYY	*Psathyrostachys juncea*	NN
Elymus dahuricus	SSHHYY	*Psathyrostachys kronenburgii*	NN
Elymus drobovii	SSHHYY	*Pseudopyron deweyii*	SSPP
Elymus gmelinii	SSYY	*Pseudopyron tauri*	SSPP
Elymus grandiglumis	SSYYPP	*Pseudoroegneria libanotica*	SS, SSSS
Elymus kamoji	SSHHYY	*Pseudoroegneria spicata*	SS, SSSS
Elymus kengii	SSYYPP	*Pseudoroegneria stipifolia*	SS, SSSS
Elymus longearistatus	SSYY	*Pseudoroegneria strigosa*	SS, SSSS
Elymus panormitanus	SSYY	*Secale montanum*	RR
Elymus parviglume	SSYY	*Thinopyrum bessarabicum*	JJ
Elymus pendulinus	SSYY	*Thinopyrum caesitosum*	EESS
Elymus shandongensis	SSYY	*Thinopyrum curvifolium*	JJJJ
Elymus sibiricum	SSHH	*Thinopyrum distichum*	JJEE
Elymus strictus	SSYY	*Thinopyrum elongatum*	EE
Elymus tsukushiensis EEEESS *junceiforme*	SSHHYY *Elymus ugamicus* JJEE	*Thinopyrum intermedium* SSYY	JJJJSS, JJEESS, *Thinopyrum*
Elymus vaillantianus	SSHH	*Thinopyrum junceum*	JJJJEE
Elytrigia repens	SSSSHH	*Thinopyrum nodosum*	EESS
Hordeum bogdanii	HH to HHHHHH	*Thinopyrum ponticum*	JJJJEEEEEE
Hordeum brevisubulatum	HH to HHHHHH	*Thinopyrum sartorii*	JJEE
Hordeum iranicum	HH to HHHHHH	*Thinopyrum scirpeum*	EEEE
Hordeum jubatum	HH to HHHHHH	*Thinopyrum scythicum*	EESS
Hordeum violaceum	HH to HHHHHH	*Thinopyrum turcicum*	JJJJEEEE

Table 4. Collections of a Global Network of Wheat Genetic Resources

Country	Institute	No. of accessions
Global	CIMMYT, El Batan, Mexico	111,681
USA	USDA-ARS, National Small Grains Facility, Aberdeen, Idaho	56,218
Russia	N.I. Vavilov Research Institute of Plant Industry (VIR), St. Petersburg	39,880
Global	ICARDA, Aleppo, Syria	37,830
India	National Bureau of Plant Genetic Resources (NBPGR), New Delhi	32,880
Australia	Australian Winter Cereals Collection, Tamworth	23,917
France	INRA Station d'Amelioration des Plantes, Clermont-Ferrand	15,850
Iran	National Genebank of Iran, Genetic Resources Division, Karaj	12,169
Czech Republic	Research Institute of Crop Production, Prague	11,018
Ethiopia	Plant Genetic Resources Centre, Institute of Biodiversity Conservation and Research, Addis Ababa	10,745
Bulgaria	Institute for Plant Genetic Resources "K. Malkov", Sadovo	9,747
Germany	Genebank, Institute for Plant Genetics and Crop Plant Research (IPK), Gatersleben	9,633
United Kingdom	Department of Applied Genetics, John Innes Centre, Norwich	9,584
Cyprus	National Genebank (CYPARI), Agricultural Research Institute, Nicosia	7,696
Japan	Genetic Resources Management Section, NIAR (MAFF), Tsukuba	7,148
Switzerland	Station Federale de Recherches en Production Vegetale de Changins, Nyon	6,996
Turkey	Plant Genetic Resources Department, Aegean Agricultural Research Institute, Izmir	6,381
Netherlands	Centre for Genetic Resources, Wageningen	5,529
Canada	Plant Gene Resources of Canada, Winnipeg	5,052
USA	Wheat Genetics Resource Center, Kansas State University, Manhattan	5,000
Japan	Plant Germplasm Institute, Graduate School of Agriculture, Kyoto University	4,378
Spain	Centro de Recursos Fitogeneticos, INIA, Madrid	3,183
Sweden	Nordic Gene Bank, Alnarp	1,843
Total	23Institutes	434,358

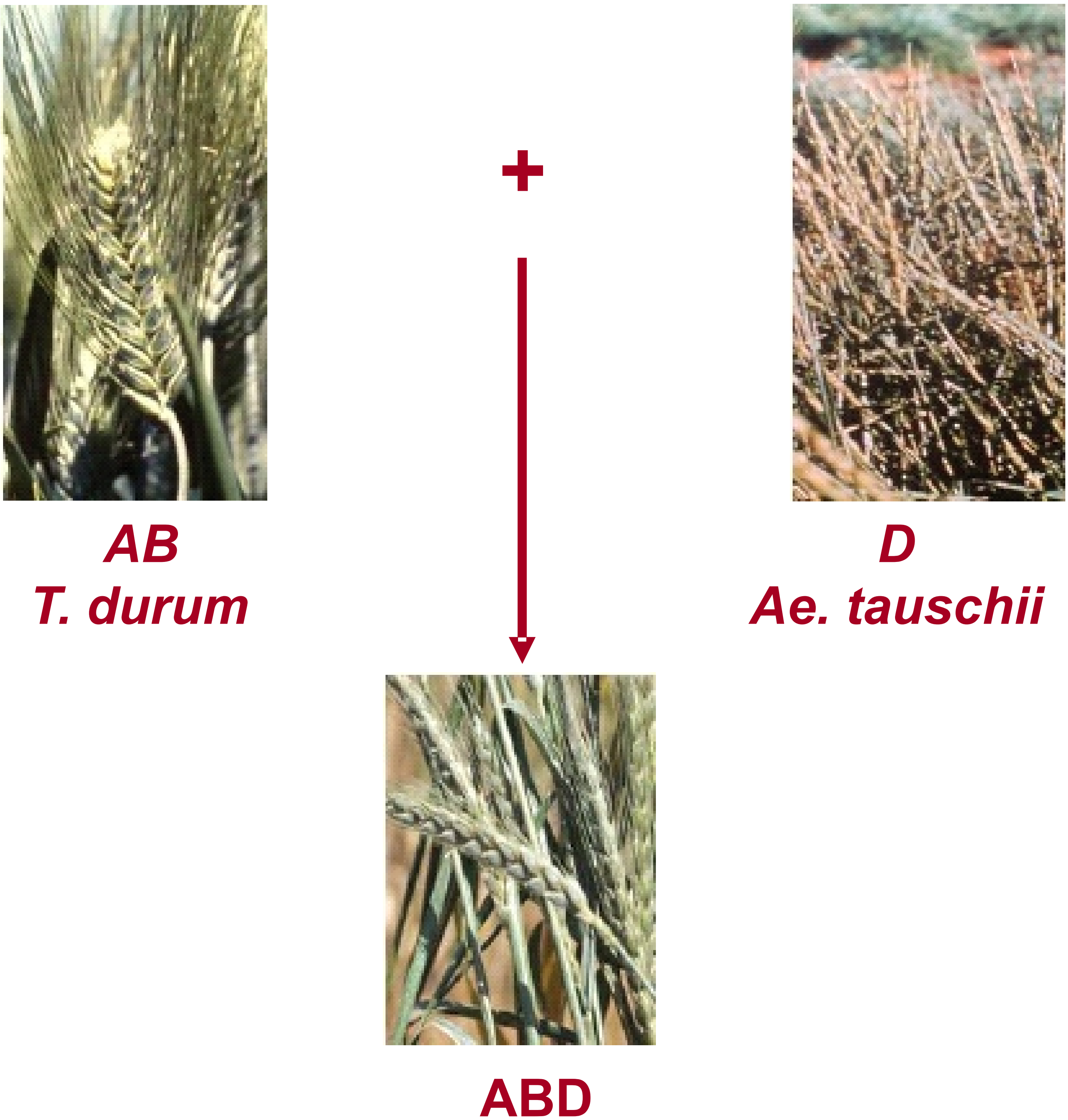

Fig. 1. A model of re-synthesis of hexaploid wheat (ABD) by wheat researchers using crossing between durum wheat (AB) and *Ae. tauschii* (D)

Exploitation of Cucurbit Biodiversity and Poverty Alleviation

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Status of Cucurbits among Vegetables

There are 117 genera and 825 species of cucurbits reported in the world. About 30 species of cucurbits are cultivated world over. In India 22 cucurbit species are grown for commercial purposes. About half of these 22 species originated in India itself. Cucurbits constitute about 1/3 of the total number of vegetables grown in the country. Great biodiversity is encountered among the cucurbits that originated in India/ Indian subcontinent. The variability is found with respect to fruit shape, colour, size, quality, earliness, fruit yield, seasonal specificity, disease and insect-pest resistance etc. The classical example of richness of genetic diversity was the transfer of powdery mildew resistance in PMR-45 from Indian muskmelon by Jagger and Scott (1937). Release of PMR-45 led to major revolution in Cantaloupe industry in USA. The flesh of PMR-45 was thick, well coloured, and firm with good flavour and sugar content.

Importance of Cucurbits

Food and nutrition: Majority of cucurbits viz. bottle gourd, bitter gourd, sponge gourd, snake gourd, round melon, summer squash, pumpkin, pointed gourd, ivy gourd, sweet gourd, spine gourd etc. are used as cooked vegetable. The tender leaves of bottle gourd and pumpkin are also cooked as vegetable. Cucumber and long melon are eaten as salad. The ripe fruits of water melon, muskmelon and snap melon are used as dessert. The fruits of ash gourd, pumpkin, bottle and pointed gourd are used to prepare different kinds of sweets and candies. Cucurbits are rich source of Vitamin A, C and E along with minerals. The seeds of cucumber, long melon, pumpkin, bottle gourd, ash gourd are rich in proteins and fats. They are used in different kinds of delicious preparations. The seed oil of different cucurbits is used in cooking food and for other purposes.

Awareness about medicinal value: Cucurbits are of immense importance from medicinal point of

view. Among the cultivated cucurbits with medicinal quality bitter gourd, bottle gourd, ivy gourd, pumpkin, pointed gourd, wax or ash gourd, ridge gourd, sponge gourd and chow-chow (*Sechium elude*) are noteworthy (Ng, 1993; Chaudhary, 2001). The putative medicinal properties include purgative actions, treatment of physical ailments and diseases, wormicidal, aphrodisiac, and abortifacient (Ng, 1993). A detailed account of the traditional Ayurvedic medicinal uses of a few cultivated cucurbits are described by Chaudhary (2001) in his Hindi book '*Ahaar Hee Aushadhi Hai*'. A review of medicinal value of cucurbits is also reported by Singh *et al.* (2007).

Plant parts of some the cucurbits are used as antidote to poisonous insects, scorpion, and snakes (Chaudhary, 2001). Leaf juice of bitter ivy gourd (Kundru) is beneficial on scorpion sting. The tuber extract of male plants of Khekhsa (*Momordica cochinchinensis*) is used as antidote to snake poison. The rubbing of its tuber paste is found useful in all kinds of poisonous insect stings. The rubbed paste of pumpkin fruit peduncle alleviates scorpion sting pain. Bottle gourd flowers are reported as an antidote to poison but the elaborations are not available (Duke and Ayensu, 1985). It is reported that bottle gourd fruit poultice at the site of scorpion sting and drinking its fruit juice relieves off pain and

poison of scorpion (Chauhan, 2007). Research work at NDUAT, Faizabad has conferred that bottle gourd leaf juice has antidotal property against insect sting (Singh, 2006). It cures the pain within less than a minute and there is no inflammation there after.

The fresh green fruits of bottle gourd contain 96% water, but a diet solely based on it can keep the human life going for years, particularly of the serious chronic patients under naturopathic treatments of over weight, asthma and renal problems. Currently the use of bottle gourd fruit juice has become a boon for patients of coronary heart disease, which avoids by-pass surgery of heart. It is cautioned that bitter type fruits must not be used for such purposes. By utilizing traditional, herbal, medicine, extra economic burden can be avoided for health maintenance.

Other uses: Hard shells of bottle gourd are used to make utensils, pots, measurements, floats of fishnets, musical instruments, amusement, fancy caps and meditation hats-a rare thing among vegetables. Ash gourd fruit is used in certain Hindu rituals. Pumpkin produces largest fruit in the world. Several competitions are organized world over for fascinating fruit size of pumpkin. The largest fruit weight of pumpkin was recorded 606.12 kg in the year 2004.

Commercial value: Cucurbit cultivation is the blessing for small and medium holding farmers. By adopting suitable crop, improved cultivar, time of cultivation and proper crop care, cucurbits can produce 200 2000 q/ha fruit yield. They also fetch remunerative price in the market. Thus they can play a role in poverty alleviation.

Role of Biodiversity in Improvement of Cucurbits

Various issues related to biodiversity science, development and its implications have been elaborated by Castri and Younes (1996). The existent biodiversity in India has been moderately to extensively exploited in some of the major cucurbits, whereas, it has been very little exploited in minor and underutilized cucurbits that originated in the country itself. The use of biodiversity in the development of new varieties and promising isolates of some of the cucurbits at Narendra Deva University of Agriculture & Technology (NDUAT), Kumarganj, Faizabad is described in offing pages.

BOTTLE GOURD

Although bottle gourd originated in Africa, the greatest variability is encountered in its fruit shape, size and colour in India. Variability is also recorded with respect to earliness, seasonal specificity, disease and insect pest resistance etc. The details of bottle gourd breeding using biodiversity of bottle gourd are described by Singh (2004). The NDUAT, Faizabad has developed following improved varieties utilizing local land races of Uttar Pradesh:

Narendra Rashmi: Narendra Rashmi is a summer/rainy season type variety. Fruits are bottle shaped with medium length. It is suitable for cultivation in summer, rainy season, and November sown early summer crop. Its average fruit yield is 400 q/ha. It is popular among farmers because of its yield and short attractive fruits.

Narendra Jyoti (NDBG-104): Narendra Jyoti is summer/rainy season type, high yielding and early maturing variety of bottle gourd released and notified for cultivation in Uttar Pradesh. It bears slender, long attractive fruits. During summer its average yield is about 400 q/ha. In July August sown rainy season crop the variety has given a fruit yield of about 700 q/ha on trellis.

Narendra Dharidar: Narendra Dharidar is a mark of quality in bottle gourd. It is an early variety that bears bottle shaped striped green short fruits. Fruits produce highly palatable cooked vegetable. Fresh fruits also produce tastier fruit juice, and

quality *Halwa (Sweet meat)*. It is suitable for cultivation during summer as weel as rainy season and gives an average yield of about 400 q/ha.

Narendra Sankar Lauki-4 (NDBGH-4): NDBGH-4 is an early prolific bearer hybrid, with highly attractive near cylindrical fruits. It has an yield potential of 700 q/ha during summer and 1000 q/ha in July-August sown rainy season/ early winter crop on trellis. The variety is released and notified for the cultivation in Uttar Pradesh, Bihar, Punjab, Rajasthan and Haryana.

Andromon-6 (A near seedless genotype of bottle gourd): Andromone-6 is an unique contribution of NDUAT, Faizabad to the bottle gourd world. It is an andromonoecious genotype of bottle gourd in contrast to the commonly found monoceious sex form in bottle gourd. Andromecious sex is monogenic recessive to monoceious sex form (Singh *et al*., 1996). The fruits are drum shaped and bear no seeds or 1-20 seeds per fruit near the blossom end. In a sense Andromon-6 is a near seedless genotype. The green fruits produce highly palatable cooked vegetable. Andromon-6 has been registered with National Bureau of Plant Genetic Resources, New Delhi with Registration number - INGR-99009.

Narendra Shishir: Narendra Shishir is a round-fruited winter type variety of bottle gourd with its sowing time only from mid-July to mid-August in Uttar Pradesh. It has peculiar pedate leaves. Fruits produce highly palatable fried vegetable and are especially fit for delicious preparation of *Lauki-do-pyaaza.* Variety is good for kitchen garden purposes and it remains in fruiting for about six months if given good crop care. Two plants per pit trained on trellis of size 20 sqm produce about 200 fruits, with an estimated yield of 1000 q/ha. It has shown multiple disease resistance against anthracnose, downy mildew, powdery mildew and viral disease complex.

Narendra Madhuri: Narendra Madhuri is a mark of quality in round fruit bottle gourd with it suitable sowing time similar to Narendra Shishir. It is a winter type variety, which can also be successfully cultivated during summer, if sown in early February. July-August sown winter crop produces on an average fruit yield of 1000 q/ha or 200 fruits per two plants trained on trellis of size 20 sqm. Fruits are attractive round and produce highly palatable cooked vegetable. The ovaries of pistillate flowers are striped in early stages of fruit set. It is good for kitchen garden as well as commercial purposes.

Narendra Shivani: Narendra Shivani is a bottle gourd genotype for fascination. It is a very long fruited winter type prolific bearer variety with its suitable time of sowing from mid-July to mid-August like Narendra Shishir. It is fit for kitchen garden purpose. The full-grown fruits cross the length of 2.0 meters. It remains in fruiting for 5-6 months with proper crop care. Two plants per hill trained on trellis size of 20 sqm produce more than 200 fruits. It has estimated yield potential of more than 1300 q/ha. The genotype has become highly popular among growers/consumers. It was recommended for release in Uttar Pradesh in the year 2007.

Narendra Madhushree (NDBGH- 58): Narendra Madhushree is a round fruited, winter type hybrid of bottle gourd with its suitable time of planting from mid-July to mid-August only. It gives first fruit in about 70 days after sowing. In evaluation trials at NDUAT the hybrid has exhibited estimated yield potential of 1900 q/ha in mid-July sown winter crop, where fruiting period extends from September to April provided. The hybrid is endowed with dominant genetic marker of pedate leaf shape which ensures purity of F_1 plants in early stages of germination. The hybrid is in pipe line for release.

PUMPKIN

Because of rich content of beta-carotene

(Vitamin A) in fruits as well as leaves pumpkin has special place among cucurbits. In many reputed hospitals and medical colleges pumpkin vegetable is preferably served to all kinds of patients. It is mere myth that pumpkin causes constipation. Pumpkin seeds are great vitalizer, particularly for men. They contain essential fatty acids viz. omega-3 and omega-6 which are required for mental health. Tender leaves and flowers are also used to prepare vegetable. Fascinating biodiversity is met in India for yield and yield contributing characters such as fruit shape, size and colour, disease and insect pest resistance etc. The characteristic features of pumpkin varieties developed by NDUAT, Faizabad, utilizing indigenous genetic variability are described below:

Narendra Agrim (NDPK-24): Narendra Agrim is a short vined, very early variety of pumpkin, suitable for February-March sown summer crop. First picking is done within 55-60 days after sowing. Pistillate flowers appear 3-4 days earlier than staminate flowers in same plant. The tender fruits weigh small 1.5-2.0 kg and are round and stripe-less dark green. Mature fruits weigh 3.0-4.0 kg. The fruit yield ranges from 300-400 q/ha. Narendra Agrim exhibits tolerance to pumpkin mosaic virus in February sown summer crop.

Narednra Abhooshan (Narendra Pumpkin Hybrid -1, NDPKH-1): Narendra Abhooshan bears near round, dark green striped and highly attractive fruits. It is an early prolific bearer with an yield potential of about 700 q/ha in mid-February sown summer crop. Suitable planting time is from mid-February to mid-March. The tender fruits weigh 3.0-4.0 kg while mature fruits weigh about 5.0-6.0 kg. Mature fruits have thick flesh and deep orange colour. The fruits produce highly palatable cooked vegetable.

Narendra Amrit (NKPK-130): Narendra Amrit is a mark of quality in pumpkin. It is a medium maturing variety, which gives its first picking in about 65 days in summer. Pistillate flowers appear earlier than staminate flowers in same plant. The green

fruits are near-round in shape and light-green-mottled in colour and weigh about 3.0 kg. Full grown fruits weigh 6.0-7.0 kg and have papery skin, 6-7 cm. thick flesh and small seed cavity. Its average yield is 330 q/ha. Green and mature fruits posses negligible level of peculiar odour of common pumpkin varieties, therefore, they are good for highly palatable vegetable preparations. Fruits can be used to prepare quality *Halwa* and *Barfi*. Narendra Amrit is tolerant to pumpkin mosaic disease in February- March sown summer crop.

Narendra Upcar: A variety for all seasons, Narendra Upcar is an early round and small fruited genotype of pumpkin. The fruit skin is dark-green striped. It exhibits high degree of field resistance against pumpkin mosaic disease. Therefore, it can successfully be grown during summer as well as rainy seasons. The average fruit yield is about 400 q/ha. Narendra Upcar has brought hope to farmers for rainy season cultivation of pumpkin.

POINTED GOURD (PARWAL)

Pointed gourd remains in fruiting for about eight months from March to October in many parts of the country, where it is largely cultivated. It is an import source of income to poor and small land holding farmers. It is cultivated in plains as well as in river-beds. In river-beds the crop withers with the rising water-level of the river in the rainy season. Pointed gourd is diocious vegetable. It is vegetatively propagated through mature vine cuttings of 1.0 m length. Female and male clones are planted in 10:1 ratio, respectively, from mid August to mid September in the plains and from mid October to mid November in the river beds, when water level recedes in the rivers. There exists great variability in the fruits size, shape, colour and yield potential of female clones. By using improved female clones of desirable yield potential and fruit attributes pointed gourd cultivation can be made remunerative. The description of pointed gourd varieties developed at NDUAT, Faizabad is as follows:

Narendra Parwal-260: Narendra Parwal-260 is a big fruited variety of pointed gourd measuring 13-15 cm in length and 40 to 60 g in weight. Fruits are long, spindle shaped, striped-light-green and have thick flesh. Fruits are suitable both for vegetable and sweet making. The average fruit yield is 225 q/ha when planted is single stake system at 1.25m x 1.25m spacing on bamboo stakes. It is tolerant to vine borer and wilt disease complex.

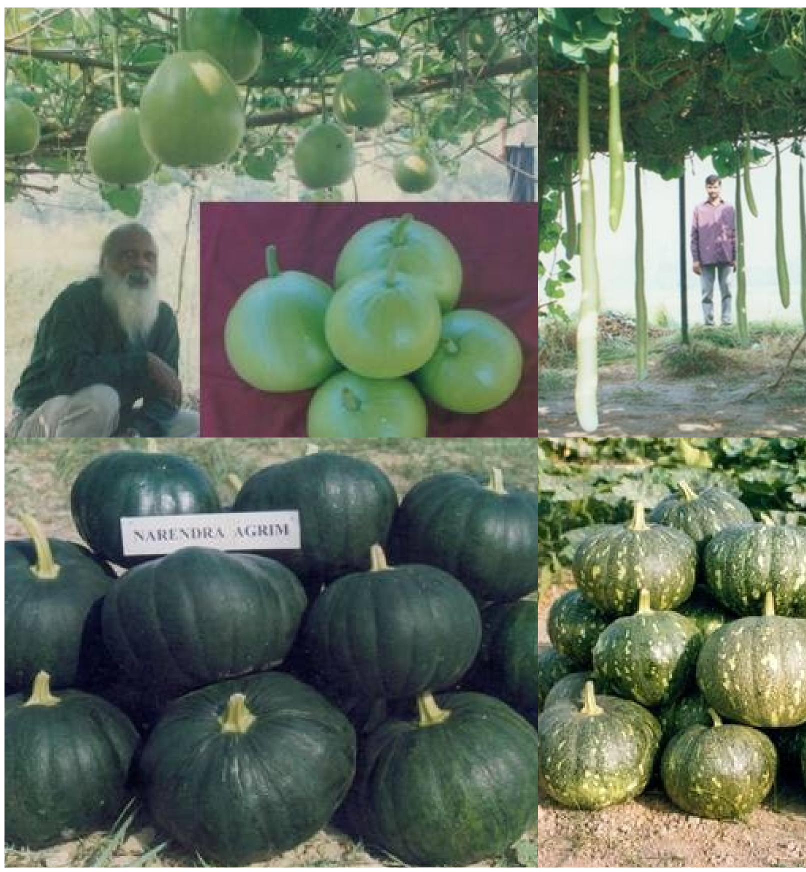
Narendra Parwal-307: Fruits are small, round, striped dark green. It has thin short vines, dark green leaves and short internodes. The average weight of fruits is 15g. It gives an average yield of 230 q/ha when planted in single stake system on bamboo stakes at 1.25 m. x 1.25 m. spacing.

Narendra Parwal-604: It bears stripless, light green, medium size fruits. Fruits have medium thick flesh. Its average fruit yield is 225 q/ha, if planted at 1.25 m x 1.25 m spacing on bamboo stakes.

MUSKMELON

Muskmelon is a delicious dessert. The variability of this crop has not been fully exploited. The characteristics of two muskmelon varieties developed at NDUAT, Faizabad are as follows:

Narendra Muskmelon -1: It is big fruited variety of muskmelon with an average fruit weight of



1.0 kg. TSS value is about 13.0 % and the fruit yield varies from 100-125 q/ha.

Narendra Muskmelon -2: It is small fruited variety of muskmelon with an average fruit weight of 500 g. The TSS value is above 13.0 % and the average yield is more than 100 q/ha. It is tolerant to powdery mildew.

Lucknow Batti and Mau Local are the popular land races of muskmelon widely grown in the local areas.

BITTER GOURD

Large variability is found in fruit shape, size, colour and skin surface ridges. The genotypes also differ with respect to seasonal specificity. Accordingly summer type and rainy season type cultivars are distinguished. The characteristics of some promising bitter gourd variety/genotypes developed at NDUAT, Faizabad are as follows:

Narendra Karela Barahmasi-1: Narendra-Karela Barahmasi-1 is a variety suitable for cultivation in mid-June to mid-July sown rainy season/early winter season crop. The full grown fruits measure 45-50 cm. The fruits are green and bear well developed broken ridges on the fruit surface along the length. It is prolific bearer with a fruit yield level of 250 q/ha.

Narendra Karela Barahmasi-2: Narendra-Karela Barahmasi-2 is a variety suitable for cultivation in mid-June to mid-July sown rainy season/early winter season crop. The full grown fruits measure about 50 cm. The fruits are dark green and bear continuous ridges on the fruit surface along the length. It is prolific bearer with a fruit yield level of 250 q/ha. This genotype is in advanced stage of release.

Narendra Kantedar: It is a summer type genotype which bears medium size fruits with dark green skin colour. It is high yielder and is in advance stage of evaluation for release.

Narendra Kareli-1: This bitter gourd genotype suitable for summer as well as rainy season cultivation. The fruit are short, oval and light green. It is prolific bearer. The cooked vegetable is relatively less bitter as compared to common varieties.

Exploitation of Biodiversity of Underutilized Cucurbits

The underutilized cucurbits such as ash gourd, snake gourd, satputia, sweet gourd, spine gourd and ivy gourd require attention for their popularization crop improvement and popularization among the growers. The university with its limited resources cautiously maintains a humble number of promising genotypes in each of these crops. A few high yielding genotypes of these crops viz. Narendra Kundru-1, Narendra Satputia-1 and Narendra Upcar Chichinda-1 hold promise and are pipe line for release.

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Environmental and Ecological Security through Conservation of Biodiversity

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Natural resources, which are vital for food, livelihood and environmental security, are under intense pressure. In fact development activities must not be allowed to result in severe depletion of natural resources and degradation of our environment. The rapid increase in green house gasses in the atmosphere, land degradation, increasing floods and droughts, advancing deserts and deteriorating conditions of fragile ecosystems, deforestation, loss of biodiversity and environmental pollution have become subjects of serious global concern. The overall impact of these phenomena is likely to result in depletion of ozone layer, change of climate, rise in sea-level, loss of natural resources, reduction in their productivity ultimately leading to an ecological crisis affecting livelihood options for development and overall deterioration in quality of life (Anonymous 2001).

Available Global Biological Productivity:

Various uses of nature are competing for space, for example land used for wheat production cannot be used for roads, forests or grazing and vice versa. These mutually exclusive uses of nature are all added up to assess the total six (6) main categories of ecologically productive areas on global basis.

These categories are:

1- Arable land

2- Pasture

3- Forest

4- Sea space

5- Built-up land

6- Fossil energy land

1. **Arable land:** is ecologically speaking the most productive land, it can grow the largest amount of plant biomass. According to FAO, nearly all of the best arable land or about 1.35 billion hectares is already under cultivation. Out of this about 10 million hectares of it are abandoned annually because of serious degradation. To-day, there exist less than 0.25 hectares per capita world wide of such highly productive land.

2. **Pasture:** is grazing land of dairy and cattle farming. Most of the 3.35 billion hectares of pasture or 0.6 hectares per person are less productive than arable land.

3. **Forest:** refers to farmed or natural forests that can yield timber products. Of course, they secure many other functions too, such as erosion prevention, climate stability, maintenance of hydrological cycles and biodiversity protection. With 3.44 billion hectares covering our planet, there are 0.6 hectares per capita world wide.

4. **Sea space:** Cover 36.6 billion hectares of the planet or a little over 6 hectares per person. Roughly 0.5 hectares out of these 6 hectares harbor over 95 percent of the seas' ecological production.

5. **Built-up land:** host human settlements and roads and extended approximately 0.03 hectares per capita world wide. As most of human settlements are located in the most fertile areas of the world, built up land often leads to the irrevocable loss of prime arable land.

6. **Fossil energy land:** is the land that is reserved for CO_2 absorption. But today we do not have little area set aside to absorb CO_2. Also using fossil fuel based products or burning fossil fuels can release toxic pollutants.

The biologically productive areas on our planet

The earth has a surface area of 51 billion hectares, of which 36.3 billion are sea and 14.7 billion are land. Only 8.3 billion hectares of the land are biologically productive. The remaining 6.4 billion hectares are marginally productive or unproductive for human use, as they are covered by ice, find themselves with unsuitable soil condition or lack water.

Agricultural productivity and ecological subsidies

Many people hope that augmented agricultural productivity will be able to save humanity from the ecological squeeze. What they often forget is that high agricultural productivity is mainly possible due to massive ecological subsidies such as loss of ground water loss of top soil and input of fossil fuel consuming fertilizers and other agro-chemicals.

Indian Scenario of Environmental and Ecological security:

(A) Status of Biodiversity:

The following table reflects the India's status of biodiversity, which shows that we stand 10th out of twelve mega diverse countries in the world:-

Table – I. Ranking of twelve countries with highest Mega diversity based on scores of species richness and endemism.

Country	Species richness	Endemism	Total
Brazil	30	18	48
Indonesia	18	22	40
Colombia	26	10	36
Australia	5	16	21
Mexico	8	7	15
Madagascar	2	12	14
Peru	9	3	12
China	7	2	9
Philippines	0	8	8
India	4	4	8
Ecuador	5	0	5
Venezuela	3	0	3

Source: Mittermeier et al. (1997).

(B) Strategies for conservation and enhancing the productivity for ecological security:

India is a leading country to recognize the contribution of forestry and tree resources to ecological stability. Natural resources particularly land; water and forest (including biodiversity) occupy centre stage for the welfare and development of people. For conservation and enhancing the productivity following efforts were made:

(i) Adoption of National Forest Policy 1988

(ii) Amendment of the Indian constitution to include forestry under concurrent list (Article 48-A, Article 51-A (G).

(iii) Adoption of National Agriculture Policy 2000.

(iv) Creation of National Wasteland Development Board to afforest 5 million hectares of wasteland every year. Later on National Afforestation and Eco-development Board (NAEB) was also established in the MoEF to regenerate degraded forest land.

(v) Formulation of Social Forestry Projects and their implementation by states.

(vi) Joint Forest Management (JFM) was started for regenerating, protecting and equity sharing of forest resources.

(vii) Promoting agroforestry on farmlands for meeting the requirements of wood based industries.

(viii) Legal and policy supports for private forestry development for increasing production and improving ecological status and economy of the region.

Around 300 mha is the available productive land out of 328.27 mha of total geographical area of the country. Actual forest cover is 63.73 mha of which only 37.73 mha are good forests. About 20 mha is covered under tree plantations (agroforestry, farm forestry, social forestry and other plantations). Thus, in order to achieve one third area under forest/ tree cover, 43 mha of area is proposed to be covered in 10 year period according to the norms of NFP (1988), which envisages that 33% of land area should be under forest / tree cover (Anonymous 2001). The details for afforestation are as under :-

i) 15 mha of degraded forest land to be covered under JFM.

ii) 10 mha of irrigated area to be brought under commercial agroforestry.

iii) 18 mha of rain fed area to be brought under subsistence agroforestry.

(C) Present Scenario of Uttar Pradesh:

After creation of Uttaranchal state, Uttar Pradesh has total geographical area of 2, 40,928 sq.km or 7.33% of the land area of the country. It is the fifth largest state of India, lies between latitude 23^{0}52' 30^{0}24'N and longitude 77^{0}5' 84^{0}38'E. The human population of the state is 166.05 million (2001 census). It is one of the most densely populated states of India with population density of 689 per square km. More than 87.39% of the total geographical area of the state is under agriculture followed by 8.84% under forest/ Tree cover (FSI 2002). The forest / tree cover and productivity of India forests is very low (0.68m^3/ha/yr) as compared to world average of 2.1m^3/ha/yr and for U.P. it is even less than half of the countries productivity.

Hence, to overcome the grim situation of Uttar Pradesh, various technological inputs were given to enhance the productivity and to conserve the biodiversity for environmental and ecological security by the forest departments of U.P.

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Genetic Resources of Vegetable Crops

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In India, vegetables are grown from dry temperate to humid tropics between the altitudes from sea level to snow line. Its plays a vital role in nutritional security of the Indian population and financial economy of majority of small and marginal farmers. Further, vegetables are becoming more transparent considering their medicinal value and protective attributes. In the light of crop diversification, vegetables play a significant role by providing an opportunity for employment generation, through export trade and in the development of industry based on post harvest management and value addition. Total vegetable production of our country before independence was merely 15 million tonnes. It increased from 23.45 million tonnes in 1961-65 to 28.36 million tonnes in 1967-71 and to 39.99 million tonnes in 1986. According to the latest report, vegetables are grown on more than 7 million ha with a total production of more than 94 million tonnes. Thus, in past three decades, India has made a quantum jump in vegetable production, securing second position in the world. However, this amount is much lesser than our total requirement serves per caput intake of vegetables of 210 g against/caput/day requirement for balanced diet. There is a challenge to achieve the target of 250 million tonnes of vegetable production to fulfil the per day requirement of 250 g/capita by 2020.

A Russian plant explorer and geneticist, Nikolai I. Vavilov, was one of the first scientists to recognize the importance of plant genetic diversity. On the basis of geographical survey he summarized that the cultivated plants have originated from the eight basic geographical centers of origin and two subcentres viz; Chinese-Japanese, Indo- Chinese, Hindustani centre, Central Asia, Near East, Mediterranean, African, European- Siberian, Central America and Mexican region, South American region and North American.

1-North Western and Eastern Himalayan region

Under Western and Eastern Himalayan region, only temperate vegetables are predominantly found. Enormous diversity occurs in Allium species-leek, shallot and other introductions of Allium sativum and Allium cepa. Sporadic diversity also occurs in asparagus, spinach, chenopods, amaranthus, and Beta vulgaris. Other vegetables like Brassicas, squash, Cucurbita spp., Cucumis, chillies, bell pepper, peas, faba bean, cowpea, horse radish, artichoke, potato, Colocasia, tomato, parsley, coriander, ginger, Sechium edule and Cyclanthera pedata do expresses a lot of variability.

2-North Eastern region including Assam

In this region also, most of the temperate vegetable crops predominate. Maximum diversity occurs in leafy vegetable crops like amaranth and Brassica species. Other vegetables like chillies, tomato, brinjal, okra, taros, yams and cucurbits are grown in this tract. Several kinds of beans like winged bean, French bean and lima bean are specialized due to edaphic and climatic factors. In the lower tract, rich diversity occurs in cucuimber, pointed gourd chayote, bitter gourd, spine gourd (Momordica dioica Roxb) and meetha karela (Cyclanthera pedata). Among the wild species Abelmoschus manihot (pungens form), Alocasia macrorrhiza, Amorphaphallus bulbifera, Colocasia esculenta, Cucumis hystrix, Cucumis trigonus, Dioscorea alata, Luffa graveolens, Moghania vestita, Momordica cochinchinensis, Momordica macrophylla, Momordica subangulata, Trichosanthes cucumerina, Trichosanthes dioica, Trichosanthes dicaelosperma, Trichosanthes khasiana, Trichosanthes ovata, Trichosanthes truncata and Solanum indicum are prevalent.

3-The Northern Plains/ Gangetic Plains including Tarai Region

The Northern Plains/ Gangetic Plains including Tarai Region is one of the richest pocket of diversity in major vegetable crops. Due to year round cultivation, more diversity emerges and it is well fitted into the cropping patterns. Rich diversity can be observed in Cucumis species, Luffa specie, Cucurbita species, Benincasa hispida, Lagenaria siceraria, Momordica species, Trichosanthes species,, Solanum species, Capsicum species, Abelmoschus species, Brassicas and tuber crops.

4-North Western/ Indus Plains

In this region variability exists in Cucumis species, Momordica species, Citrullus species, Solanum species, Amaranth, Chenopodium, Abelmoschus species, Capsicum species and Allium species. There are certain sporadic pockets, which are rich in indigenous germplasm like Cucurbits, okra, eggplant and garlic. Specific adoptable diversity of Caralluma species may be spotted in this region. The wild species of Momordica balsamina, Citrullus colocynthis and Cucumis prophetarum are prevalent.

5-The Central region/ plateau

More diversity occurs in Cucurbita species, ash gourd, round gourd, bitter gourd, pointed gourd, ridge gourd, okra, eggplant, chillies, tomato, root and bulbous crops and sporadically in leafy vegetables. As indigenous vegetables, more diversity exists in cucurbits, eggplant, okra and chillies. The wild species like Cucumis setosus, Cucumis trigonus, Luffa acutangula var. amara, Momordica cymbalaria etc. are more commonly prevail in this region.

6-The Western and Eastern Peninsular Region

The Western and Eastern Peninsular Region is an extremely rich region for cucurbits (cucumber, bitter gourd, bottle gourd and squashes), eggplant, okra and chillies (both annual and perennial types). More landrace diversity occurs in snake gourd in the western and for Luffa species and eggplant in eastern region. Sporadic diversity can be spotted for leafy vegetables like Amaranth, Brassicas, chenopods, Spinach, Beta vulgaris, Basella rubra and Basella alba. Several wild species like-Abelmoschus angulosus, A. moschatus, A.manihot, A. ficuleneous, Amorphophallus campanulatus, Colocasia antiquorum, Cucumis hystrix, C. setosus, C. trigonus, Luffa acutangula var amara, Luffa graveolens, Luffa umberrata, Momordica cymbalaria, Momordica denticulate, Momordica dioica, Momordica cochinchinensis, Momordica subangulata, Solanum indicum, Solanum melongena, Trichosanthes anamalaiensis, Trichosanthes bracteata, Trichosanthes cordata, Trichosanthes cuspidate, Trichosanthes horsfieldii, Trichosanthespiniana, Trichosanthesperottitiana, Trichosanthes nerifolia, Trichosanthes himalensis, Trichosanthes multiloba and Trichosanthes villosa are quite prevalent in this region.

Wild genetic resources in the Indian gene center

Wild plantshave often played an important role in many diets due to their higher nutritional value than cultivated species. Wild species and putative ancestral forms of vegetable crops contain valuable genes that are of immense need in vegetable breeding programme using conventional methods or modern biotechnology. These genetic resources can be utilized in the development of new cultivars, strains and hybrids and also in restructuring of the existing ones that lack one or the other attribute. The distributional pattern of the wild plant genetic resources in different botanical/ phyto geographical regions and the areas of their concentration where rich diversity of wild species still continues to perpetuate, are of special significance for undertaking programmes on collection as well as for in situ conservation of biodiversity. The important families possessing wild genetic diversity are Brassicaceae (Brassica), Malvaceae (Abelmoschus), Leguminoceae (Canavalia, Lablab, Trigonella, Vigna), Cucurbitaceae (Citrullus, Coccinia, Luffa, Momordica, Neoluffa, Trichosanthes), Solanaceae (Solanum), Amaranthaceae (Amaranthus), Dioscoreaceae (Dioscorea), Amaryllidaceae (Allium), Araceae (Alocasia, Amorphophallus, Colocasia). The bulb of greater galangal (Alpinia galangal family Zingiberaceae) can also be eaten raw. In the Garwhal areas, Cornus capitata and Cornus controversa (family Cornaceae) are eaten raw. In Rajasthana, the whole plant of Gisekia pharnaceoide (family Mulluginaceae) is widely consumed during food shortage but in the South and West (Deccan Region) the leaves are used as greens, as are the leaves of Glinus trianthemoides.

Loss of genetic diversity

The valuable genetic resources of vegetable crops are vanishing rapidly. Three main processes that caused loss of genetic diversity of cultivated crop species are genetic erosion, genetic vulnerability and genetic wipe out. Several other factors like shrinking of natural resources, population pressure, urbanization; deforestation, monoculture and changing cropping pattern including use of hybrids/improved varieties are responsible for loss of genetic diversity. These are not mutually exclusive but are, in fact inter-locked by the demand of increasing population and the rising expectations. This genetic erosion is taking place at a time when new tools of biological research enable scientist to focus as much on the diversity of genes as on the diversity of genotypes. There has been considerable success in protecting and preserving the agro-biodiversity albeit under ex situ conditions during the past one quarter century but much remains to be accomplished.

Conservation of genetic resources

The rich heritage and ethinic culture has favoured to preserve the richest diversity including rare landraces/ primitive types of useful vegetables like eggplant, cucumber, ridge and sponge gourd and a number of root and tuber crop species. A number of vegetable crops were brought to India from other regions by travelers, invaders like Persian, Turkey, Moughals, Portugese, Dutch, French and British which acclimatized and developed good amount of diversity. Wild relatives/species of some of the important vegetable crops having commercial importance to a great extent. Most of these wild species grown in the natural habitats possess genes resistant to biotic and abiotic stress. Howecer, diversity for valuable genetic resources is threatened in recent times. Therefore, conservation of the vegetable genetic wealth particularly their wild relatives are thus essentially required for future utilization.

National Active Germplasm Sites

The 40 National Active Germplasm Sites (NAGS) are holding active collections of relevant crop species. Eleven of them have the medium term seed storage facilities in the form of cold storage modules maintained at 4^0C and 35-40% relative humidity. Active collections are basically for sustainable use in various crop improvement programmes. The NAGS are based at premier crop or crop group-based institutes. The crop-based institutes have multi-disciplinary team of scientists, better equipped for evaluation of germplasm for agronomic potential and various yield reducing factors to identify accessions with desirable traits. This helps to generate information on potential value of various accessions to provide the needed support for their utilization in breeding programmes. The National Active Germplasm Site (NAGS) for vegetable crops is Indian Institute Of Vegetable Research, Varanasi (U.P.).

Gaps and opportunities in exploration

More important crops for which native diversity would still need more emphasis for collection include Cucumis and other Cucumis species, pointed gourd, yam, taro, sweet potato, chillies muskmelon, lablab bean, Trigonella and winged bean. Priority areas for cucurbits include Indo-Gangetic plasins, foothills of Himalayas, peninsular tract, Kachchh areas in Gujrat, eastern Ghats, Kodur and adjoining areas in Andhra Pradesh and particularly for Cucumis melo Barabanki, Unnao, Lucknow, Baghpat, Tarai, tarai, western Uttar Pradesh, Chhotanagpur, West Bengal, Assam, Karnataka and Andhra Pradesh, Cucumis melo var.utlissimus (tar kakri) diversity is available throughout India, parval (Trichosanthes dioica Roxb.) in Bengal plains and Assam valley; ivy gourd (Coccinia species)in North-eastern hill region; Luffa and Lagenaria fromIndo-Gangetic Plains, NW plains; snake gourd (Trichosanthes anguina) is southern peninsular tract and Kerala, Karnataka and adjoining pockets; lablab bean in eastern peninsular tract, Orissa, Goa and southwards; cassava in Kerala, Assam, Tripura, Andhra Pradesh, Tamil Nadu and Madhya Pradesh (tribal tract of Bastar); sweet potato in Bihar, Orissa, Uttar Pradesh and West Bengal; Dioscorea species from Andaman and Nicobar islands, Bihar, North-eastern hill region; Amorphophallus species from Andaman and Nicobar islands, Andhra Pradesh and West Bengal; carrot (purple deshi types) need to be collected from South-East of Gujrat and adjoining Rajasthan.

Future Thrust

In order to meet the needs of vegetable breeders in the country and elsewhere, some more elite germplasm will be introduced and indigenous variability will have to be collected. Considering the introductions already made and supplied to different centers in the last 40-45 years and crop diversity build-up since 1940, following priorities need emphasis:

a) To assemble and inventories all the existing germplasm with different centers in various crops and characterization of the same at multi-location using standard descriptors (already developed by the NBPGR in collaboration with crop specialists) including disease/pests resistance, quality attributes. Thus, status of field gene bank can be assessed.

b) Multiplication, seed increase and conservation of germplasm in the National Gene Bank at NBPGR with necessary passport and evaluation data.

c) To collect germplasm material in different crops as per identified gaps and areas of germplasm availability including hot spot locations. Under NATP, collection of vegetable germplasm has been given top priority. A massive programme through NBPGR Headquarters and 10 Regional Stations (acting as Zonal centers) in collaboration with several CCPIs under NATP on Plant Biodiversity project is under operation. In this task, IIVR, Varanasi, IIHR, Bangalore, other ICAR institutes, SAUs, NGOs etc. are helping a great deal.

d) The NBPGR imparts training in Exploration/ collection of germplasm. It has planned to conduct training on wild relatives of crop plants, and pant identification, Taxonomy/ biosystematics etc.

e) The wild germplasm assumes high priority for collection. It should be handled carefully for maintenance as these are the source of biotic/abiotic stresses, diseases/ pest resistance etc.

f) Accessioning of all existing germplasm with different partners and registration of elite germplasm has become a necessary in the light of recent global development after signing of CBD and WTO.

g) Re-survey/ collection in those areas from where useful genotypes have already been identified based on evaluation studies and biochemical/ molecular linked desirable traits

Prospects of conservation and commercialization of under-utilized fruit crops for nutritional security

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India is the home of world's most useful plants thriving in her diverse agro-ecological zones and altitudes. Almost all types of fruit crops can be grown in the country. Total fruit production of 58.7 million tons was recorded from 5.5 million hectares in India which accounts for 10.9% of the world fruit production. The fruit production in India is no more a means of diversification in agriculture, but it has now become an integral part of food, nutritional and economic security for the country. The several less known minor fruit species which have the potential for commercial exploitation are yet to be utilized to their full potential. Several less known fruit species like bael, aonla, lasora, ambar (amra), carambola (kamarakh), barhal (monkey jack), mulberry, phalsa, jamun, wood apple, tamarind, custard apple, jackfruit, khirni, chironji and karonda are occurring naturally. These crops have immense potential for commercial exploitation in form of fresh consumption, processing into value added products and medicinal formulations in suitable agro-ecological regions. The extent of diversity available in naturally occurring population offers unique scope for crop improvement and selection of new varieties for commercialization. The nutritious fruits come handy when there is famine.

Diversification and value addition are the key areas for strengthening fruit industry during the current century. It is high time to take adequate steps for diversifying present day horticulture with nutritious, hardy, therapeutically valuable, anti-oxidant rich under-utilized fruits for giving fillip to fruit production in degraded lands and also to catch the world market. Many of these fruit species are suitable for growing in the disaster and drought prone areas and tribal heartlands plagued with rampant poverty owing to recurrent failure of traditional agriculture and horticulture. The tribals are often, to a great extent, dependent for their income from such minor fruits growing wild in forests. The deficiency of vitamin A in Indian diet poses a serious threat particularly to children with the curse of blindness. Vitamin C deficiency is also widespread. Ostomalacia and bone deformation

due to calcium deficiency and protein deficiency common in a large Indian population are causes of national concern. The underutilized fruits are rich in vitamins, minerals and proteins. The importance, uses, extent of variability in natural population, improved varieties and propagation methods of some of the under-utilized fruit species are given below for commercialization in the years to come :

1. Bael (*Aegle marmelos* Correa); Family : Rutaceae

Bael is highly valued for its carbohydrate (31.8 %) and riboflavin (1.19 mg/100 g) rich fruits used for preparing various ayurvedic medicines and processed products such as preserve, pulp, squash, slab, toffee, powder and flakes, etc.. Every part of bael tree is used in one or the other form in ayurvedic pharmaceutical industry. The ripe bael fruit is a tonic, restorative, an astringent, digestive and stomachic and is usually prescribed for diarrhoea and dysentery. Bael is an integral component of Bruhat-Panchmul, a well known herbal drug. Various chemical constituents, viz. alkalaoids, coumarin, essential oils and steroids have been isolated from different parts of bael tree. The oil extracted from bael leaves is of great value. Anti-viral activity of bael has also been reported by various workers. Bael leaf extract and oil have been found effective in arresting fungal growth affecting various plants/crops. Pesticidal, nematicidal and herbicidal properties of bael have also been reported by various workers. These fruits are great

source of raw material for various industries like tanning, dyeing, gum, and cosmetic industries. Improved Cultivars of bael, viz. Narendra Bael-5 and Narendra Bael-9, Pant Shivani, Pant Aparna, Pant Sujata, Pant Urvashi, CISH Bael-1 and CISH Bael-2 have been developed and advocated for cultivation. Bael is naturally available in the forests/community lands of Uttar Pradesh, Orissa, Bihar, Jharkhand, West Bengal and Madhya Pradesh. Naturally occurring trees of bael have immense variability in terms of tree and fruit characters, which offers scope for further selection of improved genotypes from the population. Efforts were made at CISH, Lucknow to identify the promising genotypes of bael from natural population. High pulp content, high Total Soluble Solids (TSS), thin shell, less seed and fibre contents, medium size, uniform shape, heavy bearing potential and yield were taken as criteria for identification of promising genotypes. A total number of 83 bael genotypes collected from UP, M.P., Bihar, Jharkhand and Orissa were analysed for physico-chemical traits. Eighteen bael genotypes were found promising with respect to fruit size, colour on ripening, appeal, pulp, mucilage, seed and fibre contents, shell thickness and other characters, etc. These eighteen genotypes have been multiplied and maintained in field gene bank at the institute for further evaluation and use in breeding programmes. Bael is easily propagated vegetatively by patch budding and soft wood/cleft grafting. One year old seedling rootstocks raised from locally available trees are commonly used as rootstocks.

2. Aonla (*Emblica officinalis Gaertn*); Family-Euphorbiaceae

Aonla is medicinally and economically important fruit crop, which has immense potential for extending cultivation in semi-arid, degraded lands of India. Aonla is well known for its vitamin C and anti-oxidant rich fruits used for manufacturing various ayurvedic medicines and processed products such as Trifala, Chyavanprash, Amla Plex, Trilax, Amrit Kalash, gutka, preserve, candy, pickle and brined aonla fruits, etc. Aonla is valued as an anti-scorbutic, diuretic, laxative, alterative and antibiotic. It is used to treat respiratory, cardiac troubles, diabetes, rheumatism, scurvy, diarrhoea, dysentery and aging ailments. Improved varieties of aonla, viz. Kanchan, Krishna, NA-6, NA-7 and NA-10 have been developed and advocated for cultivation, replacing old varieties like Banarasi, Chakaiya and Francis. Naturally occurring population of aonla trees in Panna forests of Madhya Pradesh was studied for selection of new aonla genotypes rich in vitamin C and phenol contents. Great variability existed in natural population in terms of fruit size, colour, pulp, fibre, vitamin C and phenol contents. A total number of thirty five genotypes were collected and evaluated for fruit characters. Fruit weight from 10.27-48.90g; TSS from 8.67to 17.0^0Brix; acidity from 1.38 to 3.33%; vitamin C content from 292.72 to 750.12 mg/100g pulp; tannin contents from 2.59 to 6.76%; reducing sugars from 2.29 to 4.62%; total sugars from 4.06 to 6.94%; TSS : acid ratio 3.22 to 7.35 and sugar : acid ratio from 1.51 to 4.17were recorded. Out of thirty five genotypes six genotypes, namely Panna Aonla-14, PA-15, PA-16, PA-33, PA-34, PA-35 were found promising with respect to fruit size, vitamin C and phenol content. These genotypes have been multiplied and maintained in field gene bank for further evaluation and selection. Aonla is easily multiplied by patch budding and cleft grafting.

3. Carambola/kamarakh (*Averrhoa carambola L.*); Family - Oxalidaceae

Carambola fruits are eaten fresh, used in salads, desserts and cooked as star-shaped slices. Carambola fruits are utilized for making preserve, candy, jam, chutney, pickle and ready to serve beverage (Singh, 2001). Fruits can also be dried, canned and frozen. The leaves have also been eaten as a substitute for sorrel. The fruit is a rich source of reducing sugars, ascorbic acid and minerals such as K, Ca, Mg and P. Ripe fruits of sweet carambola contain both oxalic acid (0.16 %) and malic acid in quantities ranging from 1.0 per cent in unripe fruits to 0.51 per cent in ripe ones. Sugars present in both types consist largely of glucose with moderate quantities of fructose and traces of sucrose. The vitamin C content is also high

(50 mg/100 g) when compared with orange. Efforts were made to collect large fruited, sweet/sour carambola genotypes through explorations from different parts of Uttar Pradesh. Nine genotypes have been collected and maintained in the field gene bank at CISH, Lucknow. Analysis of fruit samples revealed fruit weight from 79.4 to 81 g, fruit length from 8.25 to 12.17 cm, TSS 5.9 to 8.2^{0}B, acidity 0.53 to 1.24 %, ascorbic acid 11 to 16 mg/100g and total sugars 4.91 to 5.71%. Two genotypes, one sweet type and another sour type have been selected as most promising ones.

4. Barhal/monkey jack (*Artocarpus lakoocha* Roxb) ; Family Moraceae

Barhal occurs sporadically in Bihar, Orissa, Uttar Pradesh and Madhya Pradesh. The tree is grown for its edible fruits. Fruits are roundish (2-4" diameter), ill shaped and of dirty yellow colour and sweetish sour taste. Barhal fruits are rich in vitamins and essential nutrients and have high total carotenoids (501.41 mg/100 g). Several value added products can be prepared from *barhal* (Singh, 2001). Explorations were conducted to identify superior genotypes of barhal. A total number of ten genotypes were identified and their fruits were analyzed for physico-chemical traits. The fruits of different genotypes showed considerable variation with respect to their physico-chemical attributes. As regards physical attributes, average fruit weight from 97.0 to 460 g/fruit, fruit length from 5.48 to 9.45 cm, fruit breadth from 6.49 to 10.04 cm, number of seeds from 26.0 to 127.5 per fruit were recorded. The bio-chemical parameters of fruits revealed TSS from 18.87 to 27.78 ^{0}brix, acidity from 0.74 to 2.37 per cent, ascorbic acid from 13.67 to 24.54 mg/100g and total sugars 12.60 to 17.82 per cent in various genotypes. Out of ten genotypes evaluated, four accessions, viz., CISH Barhal-7, CISH Barhal-3, CISH Barhal-10 and CISH Barhal-6 were found most promising on the basis of physico-chemical evaluation of fruits. The extent of variability available in naturally existing barhal population offers unique scope for improvement of this minor fruit through selection and commercialization.

4. Mulberry (*Morus* spp.); Family Moraceae

Morus alba (White mulberry), *Morus rubra* (Red mulberry) and *Morus nigra* (Black mulberry) are commonly cultivated species of Morus. Mulberry fruits are rich source of anti-oxidant compounds. Shivashankara *et al*., (2006) recorded higher antioxidant values of dark red and purple fruit mulberry as compared to white type. Dark red fruited mulberry fruits were found rich in phenols, anthocyanin, ascorbic acid and flavonoids. Mulberry fruit juice is used for curing throat infection, controlling fever and also for blood purification. Bark is used for making nerve tonic. Mulberry leaves are considered diaphoretic and emollient. A decoction of leaves is used as a gargle in inflammations of the throat. The fruit is cooling and laxative and it is used for sore throat, dyspepsia and melancholia. The fruit juice forms a grateful drink during convalescence after febrile diseases. The root is reported to possess anthelmintic and astringent properties. The bark is used as a purgative and vermifuge.

Ripe mulberry fruits are known to have 85-88% water, 7.8-9.2% carbohydrates, 0.4-1.5% protein, 0.4-0.5% fat, 1.1-1.9% free acids, 0.9-1.4% fibre, 0.7-0.9 percent minerals. The ripe fruit of mulberry is highly appreciated for its delicious taste which is consumed fresh or after extraction of juice. The dominant taste of the ripe fruit is sweet but usually with sub-acidic blend due to the high water content and low level of other flavouring ingredients. The fruit is very delicious and used for chutney preparation at immature stage and for table purpose on ripening. The ripe fruits of mulberry contain about 9% sugar with mallic and citric acid

The fruits of *M. alba* are eaten fresh or made into juice, stews and tarts. They may also be squashed and fermented to yield spirituous liquors. Ripe fruits of *M. nigra* are well flavoured and are eaten fresh or made into jam, jelly and sherbet. In recent years, mulberry fruit juice has been promoted as a health beverage, and it has become very popular in China, Japan, and Korea. Without adding preservatives, the original juice of mulberry fruit remains fresh under cold storage for 3 months, while the bottled beverage remains fresh for 12 months at room temperature.

The most important use of white mulberry is use of its leaves for rearing of silk worm. They are also useful as cattle fodder. Being nutritious and palatable, they are improve milk yield when fed to dairy animals. The mulberry wood is used for making agricultural implements, table, chair, boat and sport items like hockey sticks and tennis rackets. Pruned twigs are used for basket making in the Indian Subcontinent. Bark is used for making good quality paper. The stem bark of *M. alba* is fibrous and has been employed in China and

Europe for paper making. The bark may be stripped from waste branches, after separating the leaves for silkworm feeding, and worked into paper pulp. Mulberry trees are utilized for landscaping in Asia, Europe and Southern U.S.A. (Tipton, 1994). Because of low water requirements and amenability to pruning mulberry trees are suitable plants for urban conditions, house gardens, street shade and city embellishment.

Fifteen genotypes of mulberry have been identified in different parts of the country. Ten genotypes have been collected, planted and maintained in the field gene bank. Fruit characters were analyzed. Fruit weight ranged from 0.58 to 2.66 g/fruit, length from 16.92 to 69.00mm, fruit breadth from 7.8 mm to 10.8 mm, TSS from from 13 to 20.9^{0}B, acidity 0.19 to 0.69%, ascorbic acid 9.8 to 15.68mg/100g, reducing sugars from 7.98 to14.09% and total sugars from 10.71 to 17.53 % were recorded among different genotypes. Out of ten genotypes, two were found most promising.

5. Wood apple (*Feronia limonia* L.); Family - Rutaceae

The importance of wood apple fruit lies in its curative properties, which make the tree one of the useful medicinal plants of India (Kirtikar *et al.,* 1993). Fruit is used as stomachic and stimulant while leaves are carminative. Bark is prescribed for biliousness. Pulp is applied externally as a remedy for bites of venomous insects and reptiles.

This fruit can be exploited for regular cultivation in dry areas. It makes excellent *chutney,* and can be used as adjunct in jelly and made into squash. Being rich in pectin, it makes good jelly. Pulp contains 2.66% pectin on fruit weight basis (Roy and Mazumdar, 1988). The pulp is sweetened with *gur* or sugar and eaten fresh. The hard dry shells of the fruits arc made into snuff boxes (Bhasin *et al.,* 1958). The leaves arc eaten by sheep and goat. The leaves have an aroma of aniseed and yield 0.73 per cent essential oil. The ripe fruits contain sour-sweet, aromatic pulp which is about 70 per cent of total weight. Wood apple pulp contains significant amount of protein. The fruit is a rich source of riboflavin, acidity is about 2.3 per cent and sugars 7.2 per cent. Wood apple fruits available during winter contain 40-50 % pulp with 14 to 18 % total soluble solids (TSS), 3-4 % acidity, 1.6 to 2% pectin and they are very rich in calcium, phosphorus and riboflavin (Singh, 2001) and they may be utilized for making an excellent quality of the jelly, chutney, ready to serve beverage and squash. Wood apple fruits had higher content of both acidity and pectin, hence most suited for jelly making (Singh *et al.,* 1999). The wood is yellow-gray or whitish, hard, heavy, durable, and valued for construction, pattern-making, agricultural implements, naves of wheels, oil crushers, house building, rollers for mills, carving, rulers, and other products. It also serves as fuel.

Bundelkhand region has good amount of variability in wood apple trees and fruit characters. Twenty genotypes were collected from different parts of U.P. and Madhya Pradesh and analyzed for various physico-chemical traits. Fruit weight varied from 231.6 g to 641.66 g per fruit, shell weight from 77.5 to 161.66 g and shell thickness from 0.3 to 0.6 cm. The TSS ranged from 9.4 ^{o}Brix to 16.3 ^{o}Brix, acidity from 0.86 % to 2.76% and total sugars from 3.61% to 5.64%. Six genotypes were found promising and they have been collected and planted in field gene bank for further evaluation.

6. Custard apple (*Annona squamosa L.*) Family : Annonaceae

Custard apple is mostly consumed as table fruit. It is also used in ice creams and preserved as jam, jelly or other products on limited scale. Directly baked fruits are commonly eaten in Andhra Pradesh (Rao, 1974). The edible portion of fruit or pulp is creamy or custard like, granular with a good blend of sweetness and acidity. The pleasant flavour and mild aroma have a universal liking. The leaves are known to have insecticidal properties.

Carbohydrates mainly constitute of sugar and glucose. The fruits are composed of peel, pulp and seed in varying proportions. The immature fruits, seeds, leaves and roots are of considerable medicinal value both in Ayurvedic and Unani Systems of medicine. The seeds are abortifacient and roots are drastic purgative. The seeds contain about 30 per cent oil which can be used in soap and paint industry. The seed cake containing about 4 per cent nitrogen is beneficial as manure. Its insecticidal properties, when mixed with neem oil have been demonstrated against *Nephotettix virescens* and its transmission of rice turgo virus (Mariappan and Saxena, 1984). In India, the fruits are very poplar in the Deccan Plateau and also grown commercially on a smaller scale in Assam, Andhra Pradesh, Bihar, Karnataka, M.P., Maharashtra, Orissa, Rajasthan, Gujarat and UP. Andhra Pradesh appears to be a leading state in custard apple production in India. The important cultivars of custard apple are

Balanagar, Washington 98797, Washington 107005, Red Sitaphal, Local Sitaphal, Mammoth, Barbados, British Guinea, Brandy and Islander. The cultivar Balanagar has the better fruit quality as compared to others. Custard apple is easily propagated by cleft/wedge grafting on one year old seedling rootstocks.

7. Lasora (*Cordia myxa L.*) ; Family - Boraginaceae

It is a medium-sized, broad leaf deciduous tree. Lasoda trees are also known for its cool and comfortable shade during hot summer and hence it can be planted around the field or orchards as windbreaks to protect orchards from -hot and cold winds and also provides additional income to growers. Lasoda is a fairly fast growing tree. Branches spread in all the directions by virtue of which its crown can be trained into a beautiful inverted dome, like an umbrella. When fully grown up, total height comes to nearly 10-15 m. In less favourable climate or unfavorable environments, it can even remain stunted like a shrub. Bark of lasora is greyish-brown in colour with longitudinal and vertical fissures. Lac insect can also be reared on lasoda plants. Twigs are used as firewood, Fiber obtained from bark is used for caulking boats. The lasoda kernels are used for curing ring worm.

The tender lasora fruits are mostly used as vegetable. They are also dried for consumption as vegetable in off season. Mucilage obtained from half ripe fruit can even be used as an alternative to paper glue. Fruits make an excellent pickle. Ripe fruits are eaten fresh and used for preparing liquor. Ripe fruits are full of vitamins and regular use supplements hair growth and prevents baldness. Fruits have profound medicinal value and considered as anthelmentic, diuretic, demulcent and expectorant. Two types of lasora, one with small fruits and another with large size fruits are commonly found. Large fruited types is preferred. Lasora is easily propagated by patch budding and cleft grafting.

8. Jamun (*Syzygium cumini* Skeels) ; Family - Myrtaceae

Jamun is a good source of minerals, vitamins, sugars, protein and others. Fruit contains 50-65% juice, 9-11.5 % TSS, 2-2.3 % acidity, 2.3 to 3.7 % pectin, 30-40 mg vitamin C and 74 to 100 IU vitamin A/100g pulp (Singh, 2001). The tasty and pleasantly flavoured jamun fruit is mostly used for dessert purpose and much liked by the people. The fruit is usually shaken with salt before eating. The jamun fruit has sub-acid spicy flavour. Apart from eating fresh, it can also be used for making delicious beverages, jellies, jam, squash, wine, vinegar and pickles (Ochse, 1961). Jamun squash is a very refreshing drink in the summer season. A little quantity of fruit syrup is useful for curing diarrhoea. A mixture of jamun and mango juices in equal quantity is very good for quenching thirst for diabetic patient. Jamun fruit is used for preparation of wine, particularly in Goa. The vinegar prepared from juice extracted from slightly unripe fruit is stomachic, carminative and diuretic, apart from having cooling and digestive properties. The pomace after extraction of juice contains considerable amount of anthocyanin, sugars and tannin and it can be further utilized in beverage industry. Jamun seed can be used as a concentrate for animals because it is rich in protein, carbohydrates and calcium.

The jamun has received far more recognition in folk medicine and in the pharmaceutical trade than in any other field. Medicinally, the fruit is stated to be astringent, stomachic, carminative, antiscorbutic and diuretic. Cooked to a thick jam, it is eaten to allay acute diarrhea. The juice of the ripe fruit, or a decoction of the fruit, or jamun vinegar, may be administered in India in cases of enlargement of the spleen, chronic diarrhea and urine retention. Water-diluted juice is used as a gargle for sore throat and as a lotion for ringworm of the scalp.

The seeds, marketed in 1/4 inch (7 mm) lengths, and the bark are much used in tropical medicine and are shipped from India, Malaya and Polynesia, and, to a small extent, from the West Indies, to pharmaceutical supply houses in Europe and England. Extracts of both, but especially the seeds, in liquid or powdered form, are freely given orally, 2 to 3 times a day, to patients with diabetes mellitus or glycosuiria. In many cases, the blood sugar level reportedly is quickly reduced and there are no ill effects. However, in some quarters, the hypoglycemic value of jamun extracts is disclaimed. In experiments at the Central Drug Research Institute, Lucknow, the dried alcoholic extract of jamun seeds, given orally, reduced blood sugar and glycosuria in patients.

Considerable variation exists in fruit shape (round, oval, oblong, pyriform), fruit base (flat, necked), fruit apex (flat, pointed), skin colour (deep purple, purple-pink, bluish-black, black), flesh colour (purple; purple-pink, white) and other physical traits of jamun fruits (Singh and Srivastava, 2000). The common jamun cultivar grown under north Indian condition is Ra Jamun. It produces big-sized (length 2.5-3.5 cm and diameter 1.5-2.0 cm) oblong fruits with deep purple or bluish black colour at full ripe stage. The pulp colour of ripe fruit is purple pink and the fruit is juicy and sweet. The stone is small in size. A selection known as Narendra Jamun-6 has been identified with desirable traits at Faizabad (Pareek and Sharma, 1993). A seedling selection 'Paras' has been reported from Gujarat with sweet fruits. Some promising lines No. 15, 4, 14 and 13 have been identified from Pune and Ahmednagar in Maharashtra. A promising jamun accession KKV/VGL/SC-3 has been released in the name of 'Konkan Bahdoli' which has bold fruits, small seeds, heavy and cluster bearing habit, high pulp to seed ratio, better table and processing qualities and marketability (Salvi *et al*., 2006). Study of jamun variability in different areas of U.P. and Jharkhand revealed RNC-26, RNC-11, V-8, V-6 and V-7 as promising genotypes on the basis of fruit weight, pulp content and seed size (Patel *et al*., 2005). Jamun is easily propagated by patch budding and cleft grafting on one year old seedling rootstocks.Thirty eight accessions of jamun were collected at CISH, Lucknow from different parts of the country and analyzed for different traits. Fruit weight from 4.8 to 24.05 g/fruit, fruit length from 2.22 to 4.2 cm, fruit breadth from 1.66 to 3.72 cm, seed weight from 1.3 to 2.36g, pulp content from 68.36 to 92.26%, TSS from 10.2 to 18.4 0B, titrable acidity from 0.51 to 1.31 % and total sugar from 5.7 to 10.81% were recorded. CISH Jamun-37 was found to be the most promising genotype.

9. Chironji (*Buchanania lanzan (L)* Spreng) ; Family Anacardiaceae

Chironji, a slow growing tree, is naturally available in dry deciduous forests in the states of Uttar Pradesh, Madhya Pradesh, Bihar, Jharkhand, Maharashtra, Gujarat, Karnataka and Andhra Padesh. Tribals to a great extent depend on this tree for their income and livelihood in these areas. Chironji is highly valued for its nutritious kernels. Kernels have a pleasant, sub-acidic flavour and are eaten raw or roasted. They form a common substitute for almonds in flavoring sweetmeats, confectionery and betelnut powder. The kernels are often used by tribals in Gujarat as brain tonic. An ointment made from the kernels is used to cure itch of the skin and to remove blemishes from the face. It is a rich source of fat and contains 35-47.2 per cent light yellow coloured sweet oil with a mild pleasant aroma. Chironji oil is a substitute for almond and olive oil in indigenous medicine. The oil contains 0.14 % myristic, 28.9 palmitic, 8.1 stearic, 57.4 oleic and 5.5 % linoleic acids. The oil on direct inter-esterification yields a product which may be suitable as a coating material for delayed action tablets. The oil also appears to be a commercial source of palmitic and oleic acids. It is applied to glandular swellings of the neck. Chironji paste is an excellent skin conditioner. Besides fruit, its bark furnishes a natural varnish and is used in tanning in Kerala. Gum exudate from tree trunk is suitable for dressing textile. It is also used in curing diarrhoea, intercostal and rheumatic pains. The leaves are valued for their cardiotonic properties. Leaf powder is a common cure for wounds. Leaves constitute a good feed for cattle. Fruits do not have much variability with respect to fruit and kernel size. It can be propagated by veneer and cleft/wedge grafting on 1-2 year old rootstocks.

10. Khirni (*Manilkara hexandra* Roxb) ; Family - Sapotaceae

Khirni is commonly used as rootstock for propagating sapota or cheeku. But, there is good demand for its sweet fruits available during hot summer. Best quality khirni is produced in Ashok Nagar district of Madhya Pradesh. Small yellow olive like fruits of khirni are sweet when fully ripe. They are eaten fresh or dried. The seeds, fried or roasted, taste like peanuts but contain an alkaloid and are not to be used in excess. The fruits weighing 1.76g-4.44g each, contain pulp (82.12 to 90.33%) and TSS (21.8 -29.3°Brix). The seed contains 24.6 % oil (42.7 % kernels) of edible oil known as Ryan oil. The oil contains palmitic acid (18.9%), stearic acid (14.1%), oleic acid (63.2%), linoleic acid (2.7%). The seed contains a bitter saponin, which is left in the cake after extraction of oil, a sapogenin bassic acid. The tree yields a gum, the bark contains 10% tannins and may be used for tanning purposes. It is used as a rootstock for sapota/cheeku. Leaves are used as cattle fodder. The tree yields a gum. The bark contains 10 % tannin and may be used for tanning purposes. It is used in fevers and as general tonic. The bark retards the fermentation of toddy. The seed oil is considered demulcent and emollient. Twenty five genotypes of khirni were collected from Lucknow, Jhansi, Lalitpur areas of UP, Chanderi (Ashok Nagar), Guna and Neemach areas of MP and Sirohi area of Rajasthan and analysed for various traits. The fruit weight ranged from 1.76 to 4.44g, length from 1.86 to 2.90 cm, diameter from 1.20 to 2.46 cm, pulp content from 82.12 to 90.33 %, Total soluble solids varies from 21.83 to 29.80^{0}Brix, Acidity from 0.108 to 0.256%, vitamin C content from 14.2 to 21.6 mg/100g, total sugar from 10.81 to 19.36% and tannin from 1.95 to 3.24%. A genotype CISH K-10 was found most promising. Khirni is vegetatively propagated by veneer or cleft grafting.

Future lines of work

- Collecting indigenous types and related species of the underutilized fruit crops
- Establishing and maintaining a national repository of underutilized fruit crops
- Documenting and conserving the collection of underutilized fruit crops
- Standardizing rapid multiplication techniques for vegetative propagation of these fruit crops
- Evaluating the performance of underutilized fruit crops under different agro-climatic conditions of India
- Standardizing the agro-techniques for promising types under different agro-climatic conditions of the country
- Popularising the cultivation of high value underutilized fruits in suitable areas of the country
- Processing and preparation of value added products for domestic and world market.

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Fruit size variability in wood apple collected from Bundelkhand region

Biodiversity in Silkworm Species

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Sericulture is a unique farm enterprise, which combines two sequential, on-farm biological processes- mulberry cultivation and silkworm rearing. A third component Post cocoon technology is includes the aspects *viz*. stifling, drying and storage, cooking and boiling, deflossing, riddling, reeling, rereeling, finishing and raw silk testing. Sericulture, incorporating the characteristics of both agriculture and industry, is rightly called an agro-based cottage industry.

Historical

Silk is considered to be the fabric of affluent class. Raw silk is a non-perishable and highly valued commodity. Its elegance sheen and appeal is remarkably dominant over man made fibres. Sericulture is an ancient industry in India dating back at least to the second century B.C. There is recorded evidence of export of silk fabrics to Rome during Kanishkas reign. Some believe that the art of raising silkworms was introduced to India from China via Tibet (silkworm cocoon were brought in a noble way- spies disguised as saints kept it in their hollow walking sticks) others hold the view that the mulberry insect originated from the slopes of Himalayas of Mt. Everest and later due to domestication by Aryans and other ancient tribes, the insect spread to the other parts of the world.

Silk Production: Past and Present

Silk is produced in over 30 countries of the world, of which 10 are situated in Asia, contributing more than 90% to the global silk production. India is the second largest silk producing country in the world with a production of around 17000 MT of raw silk ranking next to the Peoples Republic of China with a total production of around 94,600 MT. China occupies number one position in terms of both production and export of silk, sharing approx. 75% of global production. Third position is occupied by Brazil and the next positions by Thailand, Vietnam, Japan and South Korea, respectively.

Traditionally, India, China, Japan, USSR, South Korea, Brazil, Vietnam and Thailand have been doing sericulture since thousands of years but in the past four decades some more countries of the tropical belt e.g. Iran, Sri Lanka, Bangladesh, Afghanistan, Papua New Guinea, Malaysia, Indonesia, Madagascar, Pakistan etc. have taken it up. India has grown from a tardy 1000 MT during the first plan period (1951-56) to the current position during the past 50 years, with a productivity of 698.00 kg of cocoon production per ha, raw silk 85.02 kg/ha, a renditta of 8.21 and a cocoon yield of 46.79 kg/100 dfl (= disease free layings) employed. During the span of 47 years (1950-51 to 1997-98) there was 17fold increase in mulberry raw silk production (825 to 14,620 MT of raw silk), 3.5 fold increase in mulberry acreage (57000 to 185120 ha) and around five times increase in silk productivity (14.542 to 75.560 kg per ha).

The country earned around Rs. 975 crore worth of foreign exchange by exporting silk goods in 1997-98. The export earnings have presently gone to more than Rs. 2879.56 crore. In anticipation of revival of demand for silk in world market, the Ministry of Textiles has expected that the value of silk export earnings will reach around one billion (= 1000 million) U.S. dollars during the year 2007- 08 which was merely one million US dollars in 1950.

Top Silk Consumers of the World

Japan consumes the highest per capita silk (176grams) followed by Switzerland (126g), Germany (54g), USA (44g), Italy (29g), China (28g), France (20g) and India (13g). The consumption of silk has been increasing in both developed and developing countries. The sand-wash silk boom of 1980 will continue to influence the Western countries. Domestic consumption has increased in the countries like China, Vietnam, Thailand and South Korea in recent years. In India too, it has come upto the extent of 85% of total production. Development of silk denims which are soft, light and comfortable in all seasons, have added a new dimension to the denim and fashion world.

Share of Silk in World Fibre Production

Silk does not enjoy the major share when compared with the other fibres viz. cotton, synthetics and wool produced in the world. Cotton and synthetics account for around 90% followed by wool (3.7%) and silk merely 0.2%

Sericigenous Insect Species and Varieties of Silk

There are nine silk producing (Sericigenous) insect species around the world producing five types of silk viz. (1) mulberry (2) Tropical tasar (3) Temperate/oak tasar (4) Muga and (5) Eri. India is the only country in the world producing all the five types of silk, owing to remarkably diversified agro-ecological conditions. The sericigenous insect species of India are distributed in different parts of the country (Table 1). The salient features are given below.

Mulberry Sericulture

It is produced by the monophagous caterpillars of *Bombyx mori L.* which feeds on the leaves of mulberry, *Morus* spp. The worm is completely domesticated, reared indoors and is found in all voltines. Mulberry sericulture dominates the field of sericulture.

Mulberry is a fast growing deciduous plant occurring in tropical, subtropical and temperate regions. It is reported to grow in many Asian and African countries of the world. It's adaptability under various climatic conditions is a distinct advantage for developing mulberry sericulture in different parts of the country upto 4000 to 5000 ft above mean sea level (AMSL). Mulberry leaves contain an appreciable amount of nutrients viz. crude protein, amino acids (e.g. aspartic acid, methionine, threonine, lysine, arginine, histidine, leucine, proline, tryptophan and isoleucine), carbohydrates, fat and fatty acids, minerals, vitamins (e.g. Vit. C) and sterols, which are required for better growth of worms.

Mulberry silk is chiefly produced in five states Karnataka, Andhra Pradesh, Tamil Nadu, West Bengal and Jammu & Kashmir, contributing about 99% to the total National mulberry silk production. Interestingly Andhra Pradesh and Tamil Nadu which had almost no silk production until 1960, now occupy the second (18.3%) and fourth (7.2%) positions, respectively. West Bengal contributes about 8.5% while Karnataka's share is the max. i.e. 64%. In fact, the implementation of National Sericultural Project (1990-96) has spread it to all parts of the country beyond the boundaries of five traditional states. World Bank aided Sericulture project has increased both quality and quantity of silk production in Karnataka. Recently mulberry sericulture has been introduced in non-traditional states viz. Assam, Bihar, Haryana, Punjab, Himachal Pradesh, Uttarakhand, Uttar Pradesh, Madhya Pradesh, Gujarat, Rajasthan, Maharashtra, Kerala and Orissa, where a vast potential exists.

High yielding commercial races of *B. mori*

Multivoltine: Pure Mysore (PM), Tamil Nadu White (TNW), P2D1, MY1, RD1, ND7 Nistari.

Bivoltine: Kalinpong (KA), Nandi (KA **x** NB4D2), C. Nichi.

Multi x Bi:

- P2D1**x**NB18, MY1**x**NB18 (For AP and WB)
- MY1**x**NB18, P2D1**x**NB18, PM**x**NB18 (For Assam, Bihar, Orrisa, M.P.)
- P2D1**x**NB18, RD1**x**NB18 (For U.P.)
- BL23**x**NB4D2 (For rain fed areas)
- BL24**x**NB4D2 (for irrigated areas)

Bi x Bi:

- CSR12**x**CSR6, CSR18**x**CSR19, CSR3**x**CSR6; KS01**x**SP2 (For tropical zone)
- CSR2**x**CSR5 (For sub-tropical/temperate zone)
- CSR2**x**CSR4 (For south India temperate/ subtropical zones)
- YS3**x**SF19, SH6**x**KA, SH6**x**NB4D2, CA2**x**NB4 D2, PAM101**x**NB4D2, CC1**x**NB4D2, PAM111**x**SF19 (For U.P. and J. & K.)
- SKUAST-1**x**SKUAST-6 (For J. & K.)
- SH6**x**KA, CA2**x**NB4D2, NB18**x**P5 (For M.P.,

Assam, Bihar, Orrisa)

- SH6**x**KA, CA2**x**NB4D2 (For A.P. and W.B.)

Mulberry varieties

Local: Mysore Local

Improved cultivars:

- Kanva-2 or M5 (All Indian States)
- MR2 (Mildew Resistant variety-2)

High yielding varieties:

- **S30, S36, S54, viswa (DD), Victory-1 (V1).**

Varieties for rainfed conditions:

- K2, S13 (for red soils)
- S35 (for black cotton soil) ■ RFS135 ■ RFS175

Tropical tasar sericulture

The total tropical tasar forest area available for tasar sericulture is 11.166 million ha. It contains 9.700 million ha of sal forests and 1.400 million ha of asan, arjun and other food plants, out of this a small per cent of sal forest and 0.560 million (=5 lac 60 thousand) ha of asan and arjun forest is put to use for the rearing of tasar silkworm, and a large portion of tasar food plants remain unused.

Tasar is copperish-coloured silk and does not possess the lusture of mulberry silk. In India it is produced in the states viz. Jharkhand, Bihar, Chattisgarh, MP, and Orissa and on a small scale in Maharashtra, AP and WB by the tribal/adivasis inhabiting forest areas. It is practiced as part of rich traditional culture. Unlike mulberry sericulture where 60% of the cost of the cocoon accounts for growing food plants, in tasar culture millions of ha of forest plantation is readily available for silkworm rearing.

Temperate/Oak tasar sericulture

Oak tasar culture employing *A. proylei* J. in India as such, is of recent origin in Uttarakhand particularly it was introduced in 1970. Encouraged with the preliminary results, RSRS, Bhimtal (CSB) was established in 1972. Unfortunately, it did not gain up momentum until 1995 and remained confined in certain pockets of Garhwal and Kumaon hills. An NGO, Appropriate Technology, India (ATI, Ookhimath) took it up in 1996 with the know-how developed by CSB, and has opened new avenues of employment for the unemployed youths.The states producing temperate tasar have 22.545 million ha of forests. Of this 1.841 million (= 18 lac 41 thousand) hectares are under food plants for oak tasar silkworm. The utilization percentage of oak tasar flora is very little owing to thin population and absence of traditional rearers in the oak tasar belt.

Considering the climatic conditions prevalent in sub-Himalayan belt, oak tasar has high potential for its eco-friendly use. The oak tasar belt stretches from J & K in the North-West, Kumaon and Garhwal hills, Himachal Pradesh in Central Zone, to Manipur, Nagaland, Assam and Arunachal Pradesh in the North-East at altitudes ranging between 3000-9000 ft AMSL. UP, UK, HP and JK comprise more than 80% oak tasar flora of the country. HP, UP and UK alone constitute oak forest belt to the tune of 6.80 lac ha. HP situated in the heart of Himalayas has about 1.40 lac ha of oak plantation constituting about 6% of the total state's forest wealth. The three species of *Quercus* viz. *Q. incana*, *Q. semicarpifolia* and *Q. himalayana* form 99% of the oak flora of HP. *Q. leucotricophora, Q. floribunda* and *Q. semicarpifolia* are the main food plants in North-West, taking only one established crop during spring. In UK, commercial production is restricted mainly to high altitudes (5000-9000 ft AMSL) using *Q. semicarpifolia* supported by *Q. floribunda*.

Muga sericulture

Muga silk is obtained from muga silk worm, *A. assama* which is quite similar to *A. mylitta* and *A. proylei*. It is multivoltive producing 5-6 broods per year. This semidomesticated species is cultured almost exclusively in Assam, recently it has spread to the other North-eastern states too. The cocoons are fawn coloured and hence the colour of the reeled silk is golden yellow particularly those produced on the food plants viz. Som, Soalu and digloti; on mejankori, creamy white silk is produced. The host plants are widely distributed in the valley of the river Brahmputra.

Food plants of muga silkworm exist largely in Assam and little in Meghalaya, the total forest area being 1,41,469 ha. Som is prevalent in lower Himalayan region extending from Almora (UA) to Nepal, Burma, Malaysia and Indonesia. In India this plant is prevalent throughout North-east upto an altitude of 1500 ftAMSL. Soalu is found in the foothills of Himalayas ascending to 3000 ft AMSL eastwards to North-eastern India and southwards to Satpura range which includes prevalence throughout Assam, Meghalaya, Mizoram, Nagaland, Manipur, North Bengal and Arunachal Pradesh. In North-western sector also the food plants are available in plenty esp. in UK and HP. In UK the food plants are distributed over two major hills i.e. Garhwal and Kumaon.Presently a total of 2500 ha of land is under muga food plantation, developed under Muga Sericulture Development Project (MSDP). Thus a total of 13.148 million (more accurately 1,31,48,469) ha of forest food plants are available for muga sericulture.

Vanya Silk and National Forest Policy 1998

The tropical, temperate (oak) tasar and muga silk constitutes vanya silk. Rearing of these silkworm species is done in forest areas by tribal/adivasis. The present emphasis on 'vanya silk' is to utilize the forest flora in silk production i.e. FOREX earning and to improve the livelihood of people associated with it. National Forest policy 1998 envisaged and stressed the need for Joint Forest Management wherein government agencies and people share the burden (excluding financial) and bounty together and work for growth and long stay of forests. It is often said that “Forests precede civilization and deserts follow it”. Therefore protection of the forest and conservation of the civilization is the joint responsibility.

Eri silk - A silk for the new millennium

It is produced by eri silkworm, *Philosamia ricini* (food plant: Castor) and its culture is called ericulture. It's production ranks first amongst non-mulberry silks. Many communities in Assam, especially the Bodos consider eri silk a part of their age old culture and civilization. The use of eri silk over centuries has been confined to only a few pockets in India-Tibet, Bhutan and Myanmar. For years it has remained a locally available substitute for wool in North-East India for making winter clothing. Primitive techniques of spinning, crude ways of processing and production of fabric on very basic handlooms, all ensured that eri became almost a synonym of *chaddar*. The Brahmaputra valley of Assam and its adjoining foothills is believed to be the home of eri silkworm. It is also practiced in a few districts of the neighbouring states namely Meghalaya, Nagaland, Manipur and Arunachal Pradesh. A small quantity of eri cocoons is also produced in WB, Bihar, Orissa and Andhra Pradesh.

Contribution of ericulture in rural upliftment

Eri sericulture was introduced in Andhra Pradesh in 1958 to improve the economic status of castor growers. During 2002-03, about 3.5 lac ha of land was under castor plantation grown by over 2.5 lac farmers, 85% of this exists in Mahbubanagar and Nalgonda districts. The average yield of castor per ha is 356 kg (Rainfed) which fetches Rs. 4,900/- only unlike in Gujarat where it is cultivated under irrigated conditions and the annual avg. yield/ha is 1780 kg fetching Rs. 25,000/- five times more than the income earned by their counterparts in A.P.

About 140 kg of pupae are generated from 400 dfls reared per ha which could fetch Rs. 2800/- @ Rs. 20/kg. In addition to the annual income of Rs. 4900/ ha from castor Rs. 6400/- per ha could be generated through eri culture.

By-Products of Sericulture and Industrial Utilization

Eri silk industry estimated at Rs.12 crores, stands the largest and most; important of the three; types of silk produced; in the North-east. In 1985 the global production of lipids (fats and oils) of vegetable and animal origin was 44.6 and 19.2 MT, respectively. About 80% of this was used as human food and 6% as animal food to produce yet more human food. The remainder 14% served as source material for oleochemical industries, about 90% of this was used in the production of soap and other surface active compounds and the balance was used for other industrial purposes. The demand for lipid is increasing every year.

The lipids extracted from silkworm pupae are of animal origin. Oils extracted from mulberry and muga waste silkworm pupae have potentiality for their use in different industrial areas. The tribal communities rear eri for two purposes viz. to obtain silk for clothing and to consume pupae as a delicious food item. Eri pupa is therefore not a waste product while mulberry, tasar and muga pupae are obtained as waste after processing and reeling the cocoon. Eri pupa can be taken out of the cocoon in live condition without affecting the quality of silk (as it is open mouthed) and consumed by tribals as live and fresh pupae.

The main constituents of pupae are 62% crude protein, 5-8% free amino acids, 25% total lipid and 5.2% ash content, on dry wt basis. The lipid is extractable in petroleum ether and n-hexane. Pupae oil contains a higher amount of long-chain unsaturated fatty acids than the common animal lipids. It has great utility in food industry (Fishery, Piggery and Poultry) as well as oleochemical industries e.g. soap manufacturing.

Eripupae - A Popular Cuisine

In the silk producing countries of Asia, the eri silkworm, in the form of dried larvae and pupae, is exploited as a food source. In Africa, the mature larvae of saturniids are collected and sold live in the markets for human consumption. They are eaten raw, dried or powdered or used as a garnish in stew. In the Western US, the aboriginals of California and Oregon consume pupa and pre-pupa. The dried product is called “peaggie”. The dried larvae are frequently used in stews, sometimes pupae too are roasted and consumed. In North-East India, the eri silkworm is a novelty for diners and a dietary culinary for many tribals, besides warm clothings that it offers. Nevertheless, people describe the consumption eri silkworm as “filthy practice”.

Non-textile diversified uses of Silkworms and Silk bave

Silk bave (thread) is composed of mainly two proteins- the outer water- soluble sericin and the inner hard core of water- insoluble protein fibroin. Uses of silkworms and silk are listed below:

1. Silk has been used as medical suture for centuries. Sericin causes biocompatibility problems but fibroin exhibits a good biocompatibility *in vitro* and *in vivo* comparable to other used biomaterials.
2. Fibroin is used as a matrix for cell growth and tissue engineering, when seeded with osteoblasts, fibroin films induced bone tissue growth *in vitro*. It is promising in skin wound healing, vascularization of implants, bone and ligament regeneration.
3. Silk is a long term absorbable material *in vivo*. Silk fibroin loses its tensile strength within one year. This biopolymer is very promising to develop innovative biomaterial for clinical high tech application.
4. Traditional medicines in various countries use silkworm moths or pupae in different forms for several diseases e.g. 'moth wine' prepared at Shaansi Sericultural Technology Station in China is used to treat some ailments.
5. The antibacterial peptides present in mulberry silkworm are reported by the Chinese scientists to work against diseases in human beings e.g. a Chinese medicine 'guanxuebao' developed from silkworm excreta has an efficiency for cancer treatment.
6. Japanese Scientists from Iwate University have prepared antifungal fraction from haemolymph of silkworm. It has inhibitory effect on the mycelial growth of *Pyricularia oryzae, Fusarium oxysporum, Glomerella cingulata* and *Alternaria porri.*
7. Large quantities of lecithins have been detected in silkworm pupae waste. Lecithins are traditionally extracted from egg yolk, soybean, mustard seeds, pulses and mustard cakes on commercial scale. Lecithins are used as an antioxidant for vegetable oil, fish liver oil and in various food and pharmaceutical products.
8. Silkworms are used as bioreactor to produce proteins of interest using a recombinant baculovirus. Using this technique several proteins of medical interest have been produced in the silkworm larvae: human alpha-interferon, feline-interferon, human growth hormone etc.
9. Sericin is considered as an undesirable component of silk. It is used in cosmetic industry, as a hygroscopic coating material on polyester fabrics, nutrient, coagulant, antioxidant etc.
10. Indian production of 16,000 tons of silk can be a source of 250 to 300 tons of sericin (on world basis 50,000 tons of sericin from 400,000 tons of dry cocoon generated) per year would be of significant economic and social benefit.
11. Pentafarma of Switzerland has developed SETAKOL, a hair care product, containing 6-8% hydrolyzed sericin. It is said to aid hair growth.
12. Milbon Co. Ltd. Japan has developed hair-

conditioning composition containing silk hydrolyzates and sericin.

13. Sericin has been used in the preparation of Moisturizing mask, cosmetic and sleepwear.

Non commercial sericigenous insect species : *Anapha sp*. (Anaphe silk, south and central Africa); Giant silk moth, *Attacus atlas* (Fagara silk, China, Sudan); *Pachypasaotus sp.* (Coan silk, Mediterranean region, Crimson dyed apparel worn by the dignitaries of Rome).

Non insect sericigenous species : *Pinna squamosa* (Fishwool/Mussel silk), *Miranda aurentia* and *Nephilia madagascarensis* (Spider silk, not exploited in textile industry, used in optics).

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Food Security of Fishermen Community: An Impact of Change in Biodiversity of River Ganga System

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Social requirement or economic need of human being is the agenda item of top priority for the policy makers but in doing so we conflict with nature. Alarming poverty and malnutrition is one of the biggest challenges before the human society all over the world. In order to promote the welfare of the mankind and eliminate the misery of the larger section of the society the development in sustainable manner is the need of the hour. Here it should be impliedly understood that the development of human society means to take the social welfare of the society a step forward at least if not at most. The history of the development around the world has given a bitter lesson- a conflict between nature and economic development. The question arises how to ensure the sustainable development with least cost. In an ideal society, we assume that the development of humanity and economic welfare is possible without any conflict with the nature through such policies so well designed and suited to model of social change.

The Ganga is the country's most respected and holy river housing more than 37% of the country's population in its fertile basin. It drains into 8 states, watering 47% of the total irrigated area and has been geographically, historically, and culturally significant for centuries now. Ganga River basin, which was comparatively free from anthropocentric activities until the 1940s, became a disposal site for agricultural, industrial and sewerage wastes after independence of India in 1947. Discharge of wastes generated due to developmental activities including irrigation projects, river course modifications and demographic explosion in the basin, have ecologically impaired the river system, so that water quality is degraded, and fish yield as well as biodiversity has decreased. Amongst these, irrigation projects and flood control measures have almost destroyed flood plains, sloughs, inundation zones and oxbow lakes, all of which are the

breeding and nursing grounds of the prized Indian major carp. This led to decline of the major carp population, while less economic fishes (minor carps and small catfishes) are increasing in relative abundance. The hydraulic structures have destroyed the anadromous fisheries (Tenualosa ilisha, Pangasius pangasius) of the riverine stretch of the Ganga. The Ganga ecosystem has suffered severe ecological imbalances with pollutants far exceeding its self-purification capacity. There has been periodic 'fish-die' (large scale death of fish due to low oxygen level and toxic substances in water), heavy metal residues have been found in cow/buffalo milk, (as they drink the polluted Ganga water) vegetables (grown downstream and supplied to most of Kanpur) and ground water (as untreated chemical wastes are dumped into landfills. The present paper discusses the impact of environmental aberrations on the fishermen community of the Ganga River.

A case study of the impact of interventions into river Ganga on welfare of fishermen community was undertaken. The Ganges originates in the Himalayas after the confluence of six rivers Alaknanda meets Dhauliganga at Vishnuprayag, Mandakini at Nandprayag, Pindar at Karnaprayag, Mandakini at Rudraprayag and finally Bhagirathi at

Devaprayag(from here onwards, it is known as Ganga) in the Indian state of Uttarakhand. Out of the five, the Bhagirathi is held to be the source stream originating at the Gangotri Glacier at an elevation of 7,756 m (25,446 ft). The streams are fed by melting snow and ice from glaciers including glaciers from peaks such as Nanda Devi and Kamet.

Based on morphological and socio-economic characteristics the study was taken dividing the stretch of river Ganga into five parts:

- Devprag to Haridwar
- Haridwar to Sukurtal
- Sukurtal to Patna
- Patna to Farakha
- Farakha to Gangasagar (Bay of Bengal)

The pressure from growing impoverished human populations, increasingly concentrated in cities, has forced governments to focus on economic development (industrialization) rather than environmental protection and conservation. Construction of Dams and barrages for electricity generation, domestic sewage from townships, and establishment of industries out flowing their chemical effluents into river Ganga. There are some 30 cities, 70 towns, and thousands of villages along the banks of the Ganga. Nearly all of the sewage from these population centers over 1.3 billion litres per day passes directly into the river, along with thousands of animal carcasses, mainly cattle. Another 260 million liters of industrial wastewater, also largely untreated, are discharged by hundreds of factories, while other major pollution inputs include runoff from the more than 6 million tones of chemical fertilizers and 9,000 tones of pesticides applied annually within the basin.

Fisheries along the river are of considerable economic value and their output makes a major contribution to regional nutritional needs. This industrialization has wider implications on habitat degradation of the river ganga in context of fishery ecology and biodiversity having a direct effect on their breeding environment and their by effecting the conservation of fisheries. These implications can be visualizes as follows:

- Slow pace of formation of glaciers
- High pace of melting of glaciers because of global warming
- Inflow of domestic sewage and toxic industrial effluents
- Construction of dams and barrages (like farraka, tehri and rishikesh)
- Mining of stones and reshaping the flow of rivers at various stretches adversely affecting the Habitat for breeding of fishes
- Taking out canals for irrigation and ports
- Power generation for industry and domestic use
- Low water velocity and high silting
- Contract of river to influential non fishing community
- No movement of brooder fishes from ocean to river and from Devprayag to down
- Changing proportion of fish species is self defeating loss of biodiversity
- Endanger of dolphin and crocodile
- High siltation and decreased flow in tributaries

of Ganga

- Low availability of fishes in river Ganga and high tech fishing by Entrepreneurs
- Over exploitation of fishes because of high dependence and use of sophisticated net technology for fish catch.
- Habitat degradation
- Harvesting of brooder stock and juveniles
- Conservation of aquatic living organisms / fish (crocodiles, dolphins ....)
- Presence of exotic fish species like thai mangur, common carp ..... into the river system

The final and ultimate effect of modification in river Ganga is that more than the 90% of the fishermen community has been taken out of employment and were compelled to leave their livelihood because as they were totally depending on fisheries of Ganga. It has also been noted that more than ten species like Hillsa, Mahasheer and Tiger Prawn has been disappeared because of construction of Farrakka barrage. Other almost all the species of the river eco-systems are endangered and declining to the extent of 90 percent or even more. Tables for the different stretches studied are as follows:

Table 1: BIODIVERSITY OF FISH IN STRETCH-I

Name of Fish	Weight (Kg)	% Change
Ausla	100-200	NC
Kalthia	100-200	NC
Bam	5-10	NC
Mahasir	5-30	NC
Dungra	3-5	NC
Moili	1-2	NC
Sur	15-20	NC
Goonch	50-100	NC

Table 2: BIODIVERSITY OF FISH IN STRETCH-II

Name of Fish	Weight (Kg)	% Change
Mahaser	5-30	30 (D)
Dungra	3-5	40 (D)
Moili	1-2	30 (I)
Rohu	15	NC
China Rohu	12	5 (I)
Sur	15-20	NA
Selha	5-10	NC
Potu	0.300	NC
Patharchata	0.300	90 (D)
Kater	0.500	90 (D)
Prawn	0.020	20 (I)
Kekra	0.300	NC
Tegra	1	NA
Gooch	100	NA
Lanchi	10	NA
Galar	1	NA
Magur	1	NA
Singhi	0.200	NA

Table 3: BIODIVERSITY OF FISH IN STRETCH-III

Name of Fish	Weight (Kg)	% Change
Siland	5-25	NA
Magur	0.800	NA
Sakchi	0.500	NA
Papta	0.200	NA

Gurda	0.100	NA
Hilsa	2.5	NA
Sur	1-25	NA
Buari	1.5	NA
Prawn	0.250	NA
Kukra	0.100	NA
Rohu	1-30	75 (D)
Nain	0.5-20	70 (D)
Catla	0.5-70	50(D)
Baghar	50	50 (D)
Chetal	1.5-10	25 (D)
Tegra	2-12	75 (D)
Chelwa	0.200	50 (D)
Baspatta	0.300	50 (D)
Palwa	0.150	60 (D)
Bami	0.250-6	70 (D)
Bachwa	0.500	70 (D)
Sugwa	0.250	50 (D)
Arwari	0.250	50 (D)
Chipoi	0.050	80(D)
Baghwa	0.100	60 (D)
Prawn-S	0.01-0.02	40 (D)
Bata	0.200	80 (D)
Ritha	0.100-1	80 (D)
Chepua	0.020	25 (D)
Fasla	0.250	60 (D)

Table 4: BIODIVERSITY OF FISH IN STRETCH-IV

Name of Fish	Weight (Kg)	% Change
G-Prawn	0.250	NA
Hilsa	2.5	NA
Bulla	1	NA
Maya	0.05	NA
Sanpotha	1	NA
Bachwa	0.250	NA
Siland	40-50	NA
Karti	0.050	NA
Telgagra	0.500	NA
Pagas	12	NA
Cheetal	10-50	90 (D)
Rekhar	0.400	50 (D)
Tegra	20-40	60 (D)
Rohu	4-20	75 (D)
Mrigal	4-15	75 (D)
Catla	50	75 (D)
Calbasu	10	60 (D)
Buali	100	50 (D)
Baghar	100	80 (D)
Bam	1	50 (D)
Sur	2-5	60 (D)
Gajal	10	60 (D)
Reetha	5	50 (D)
Urela	0.400	90 (D)
Palwa	0.100	60 (D)
Fulli	20	80 (D)
Piyali	0.010	40 (D)
Rohu-C	3	10 (I)
Grass-C	5	10(I)
Thai-M	5	2 (I)

Here, NC stands for no change, D stands for decline and I stand for increase.

Table 5: ECONOMICS OF FISHING IN RIVER GANGA (Year Wise Net Income)

Stretches	Mean (RS)	Min. (RS)	Max. (RS)
ST-I	110250	57000	1,23,750
ST-II	82250	41250	95,000
ST-III	89000	32250	1,06,500
ST-IV	84500	36050	90,000

Livelihood of Fishing Community is Under Question (?):

Return from the Development Cost (Damages from the Development) =?

It is the question before the policy maker and development agencies to look whether the returns gained out of industrlization and development is accordance with the loss of livelihood of fishermen community under question.

An Overview of Agricultural Biodiversity

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Our country sustained itself during long droughts in the past as the villagers had large stocks of food grains and hay for their livestock. But in these times they can not survive even during one monsoon failure. This is mainly due the fact that they are producing commodities for fat off cities and export markets which has narrowed the agricultural biodiversity.

Basically, agriculture is to meet the needs of local community and its livestock. But unfortunately preference is being given to crops for export market, which ultimately encourage mono-cropping, which has exploited the soil continuously. Thereby the farmer has to invest more and more on his cultivation to keep up the yield level. Then, coming to the point of sustainability, due to lack of one's own resources like fodder, manure, seeds, and the lack of knowledge about biological pest management practices, many farming families are not able to meet the cost of cultivation or take high risk. They have sold away their small holdings and migrated to big cities in search of additional jobs to earn their livelihood, encouraging the growth of slums and other social problems. Agriculture is not just growing crops, but it is a co-existence of soil, vegetation, livestock, human and crop production, with mutual dependence on one another, recycling all the natural resources efficiently, enriching the soil health and preserving the ecological balance for the benefit of out future generations. There is general feeling that we have to use chemical fertilizers, pesticides and hybrid seeds to meet the need of food grains for the huge population of our country. In my opinion if we can cut down the grains even to 50% which are being used in the manufacture of animal feeds, there should not be any shortage of food grains. It can not be justified that grains like maize should be used in the manufacture of feeds for animals, which are supposed to be brought up on vegetation.

Ensuring a steady supply of food for the growing population has long remained the singular focus of agriculture. But while the demand for food and other farm products increases, the quality of the basis agricultural resources is deteriorating inexorably. Soil erosion, land degradation, shrinkage of water resourced, pollution and toxicity are a few of our ever-expanding perils. This not only jeopardizes the livelihood security of the rural poor but also future of our jeopardizes the livelihood security of the rural poor but also future of our agriculture. Even when there is enough food grains reserve in the country, a large chunk of the people remains undernourished. Food is available but there is famine of employment. Need arises of a new farming approach that provides food and livelihood security to the current and future generations without degrading the production base. With changes in the trade regime under globalization efforts, the farm sector needs to display greater efficiency in input use to remain competitive. Creation of more chemical free organic zones like Sikkim and Uttaranchal may help capture the emerging market for organic foods. Conservation orientation, use of various biological inputs, product diversification and participatory processes will be the keywords for agricultural sustainability in the future. This calls for a transition to eco-friendly agriculture and bio-resource-based micro-enterprises as a means for poverty alleviation and rural progress. We explore here ideas for achieving these goals while designing pro-poor agricultural interventions.

We begin with laying a conceptual foundation on sustainable land use, while providing technological as well as participatory tools for rebuilding and enriching grasping the concept of sustainable agriculture in environmental and economic terms as well as in terms of livelihood security for the rural poor, locating systems, and exploring participatory methods for evolving location-specific solutions to the problems of resource-poor farmers. First, we shall take a look at our basic agricultural resources.

INDIA : AGRICULTURAL RESOURCES

Land is a vital natural resource. It is the basic substrate that provides food, fibre, fodder and fuel for meeting basic human and animal needs. However, its own capacity to produce is limited, and the limits are set by its intrinsic characteristic, agro-ecological settings, type of use and management. Thus, its proper use determines the capability of life-supporting systems and the socioeconomic development of the people.

Land Resources

- India has 2.4 percent of world's land, 4 percent of its fresh water resources but carries 16 percent of world's population and 10 percent of its cattle.
- India has 329 million ha geographical area of which 47 percent is cultivated, 23 percent under forests, 7 percent under non-agricultural uses and the remaining 23 percent falls under categories of barren and uncultivable land, cultivable wasteland, permanent pastures and fallow lands.
- Per capita availability of land declined from 0.89 ha in early 1950s to 0.37 ha in mid-1990s and will reduce to 0.19 ha in 2020.
- India's 142 million ha of cropland produces over 200 million tons of foodgrain, of which 55 percent production is contributed by irrigated areas (accounting for 37 percent of cropland) and 45 percent foodgrain contributed by rainfed areas (i.e., 63 percent of cultivated land).

Rainwater Resources

- India receives 400 Mha m of rainwater annually, of which nearly 160 M ha m falls on agricultural land.
- Around 24 M ha m equivalent of rainwater is available for harvesting in small-scale water harvesting structures.
- Regions with up to 1000 mm rainfall potentially produce 6.32 M ha m harvestable runoff.
- Nearly one-fourth of the total annual rainfall is received during the pre-or post-monsoon seasons.

AREA OF CONCERN

The health of the land along with its natural endowments and the quality of life of the community depending on it are intrinsically related. Adverse changes in the natural resource regime directly affect the lives of the people. A degraded land and ecosystem spells only poverty and misery for the local community. Yet, vast stretches of our land are becoming wastelands or 'wasted lands' day by day.

- Of the total geographical area of 329 M ha, about 175 M ha are under various stages of degradation.
- About 60% of cultivated land suffers from soil erosion, water logging and salinity problems.
- About 30 M ha of fragile land now under cultivation are progressively degrading.
- Over 5.3 billion tonnes of topsoil is lost every year due to soil erosion. The average soil loss is over 16 tonnes/ha/year or about 1 mm each year.

Globally, soil fertility declined about 13 percent during 1945 and 1990, which is a global average disguising far worse figures for Central America (37 percent) and Africa (25 percent). Although the global food supply is not threatened in the short-run, trends in Africa are of great concern (World Bank 2002). The productivity of some lands has declined by 50 percent due to soil erosion and desertification. Yield reduction in Africa due to past soil erosion may range from 2 to 40 percent, with a mean loss of 8.2 percent for the continent (Eswaran et al. 2004). In South Asia, annual loss in productivity is estimated at 36 million tons of cereal equivalent valued at US$ 5,400 million by water erosion, and US$ 1,800 million due to wind erosion. It is estimated that the total annual cost of erosion from agriculture in the USA is about US$ 44 billion per year, i.e. about US$ 247 per ha of cropland and pasture. On a global scale the annual loss of 75 billion tonnes of soil costs the world about US$ 400 billion per year, or approximately US$ 70 per person per year (Eswaran et al. 2004)

EXTENSION IMPLICATIONS

The Importance of land degradation and water sources depletion among global issues is enhanced because of their impact on world food security. Land degradation reduces agricultural productivity and thus affects food security. Land degradation reduces agricultural productivity and thus affects food security and poverty reduction in rural areas. Land degradation is as much a socio-economic problem as it is a biophysical problem. Economic growth or lack of it (poverty) is intractably linked to land degradation. Similarly, attempts at increasing food production through conventional approaches will create more pressure, with heavy environmental costs : pesticide pollution, water table depletion, biodiversity loss, and soil degradation, all the result of inappropriate land-use systems. High population density is not necessarily related to land degradation, it is what a population does to the land that determines the extent of degradation. People can be a major asset in reversing a trend towards degradation, However, they need to be empowered politically and economically and motivated to care for the land, as faulty agriculture, poverty, and illiteracy can be important causes of land and environmental degradation. People living in the lower part of the poverty spiral are in a weak position to provide the stewardship necessary to sustain the natural resource base. As a consequence, they move further down the poverty spiral, setting in motion a vicious cycle.

To avert the catastrophe resulting from an interlinked complex of unsustainable land use, resource degradation and poverty, which threaten many parts of the world, the responses must absorb new concepts. The current efforts as wasteland development and watershed management indicate a movement towards halting and indeed, reversing the degeneration process. The aim is to put in motion a community-centred management system that strikes a balance between environmental concerns and developmental aspirations. This can best be achieved through inspired grassroots initiatives of primary stakeholders and their involvement in every stage of the project cycle.

Table 1 India: Resources in global terms

Parameters	**India's share in the world total (%)**
Human population	16.0
Farm animal population	15.0
Cattle population	10.0
Geographical area	2.4
Fresh water	4.0
Rainfall	1.0
Forests	0.5
Grazing land	0.5
Floral biodiversity	10.78
Faunal biodiversity	7.3

Source: Developed from Swaminathan (1999), GOI (2001) and other sources

Table 2: Rainwater availability in India

Monsoon activity	**Precipitation (Million ha m)**	**Percentage share**
South-west	296	74
North-east	12	3
Pre-monsoo	52	13
Post-monsoom	40	10
Total	400	100

Source : Fertilizer Statistics, FAI (1994).

Note: 400 Mha m=4000 billion cubic metres. One hectare-metre of water weighs approximately 100 tonnes.

Table 3: Inland & marine capture fishery resources in India

Resources	**Extent of potential**
Inland Resources	
Rivers	45,000 km
Canals	1,26,334 km
Estuaries	2.70 million ha
Reservoirs	2.05 million ha
Marine Resources	
Indian Marine EEZ	2.02 million square kilometers

Indicators of resource degradation:

1. Deterioration of soil nutrients

- Disappearance of vegetative ground cover
- Degree of bare ground
- Different forms of erosion
- Scaling/crusts on soils
- Appearance of sand dunes

- Reduced fallow period
- Abundance of specific vegetative species/ weeds
- Increased use of chemical fertilizers

Water logging and salinity (white spot) and acidity (cat-clay)

2. Degradation of vegetative cover

- Disappearance of vegetative ground cover
- Use of agricultural residues and cattle dung asdomestic fuel
- Increased lopping of certain vegetative species
- Reduced diversity of forest products
- Reduced diversity and number of wildlife

3. Decreasing biodiversity

- Disappearance of traditional crop species and varieties
- Increased use of pesticides
- Disappearance of bio-control fauna and soil biota
- Increased recurrence of pests and diseases
- Decreased diversity in forest/farm products
- Reduced wildlife

4. Hydrological deterioration

- Lowering of groundwater
- Drying up water streams/ponds
- Irregular river flow
- Increased sedimentation of lakes/water channels
- Reduced freshwater fish, lowering of quality and increased market price

5. Socio-economic deterioration

- Lowering of crop yield
- Reduced meals per day
- Poor conditions of thatched roofs
- Increased migration
- Increased women's time for fetching water and fuelwood
- Lowering of health of people and animals
- Reduced nutritional standards

Biodiversity in small millets and its nutraceuticals

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The term "millet" is used loosely to refer to several types of small seeded annual grasses belonging to species under five genera in the tribe *Paniceae*, namely *Panicum, Setaria, Echinochloa, Pennisetum* and *Paspalum,* and one genus, *Eleusine,* in the tribe Chlorideae. Millets are used for food, feed and forage all over the world particularly in tropical and certain parts of the warm temperate region of the world. India is considered as hub for these minor crops, as large numbers of millets are grown in different parts of the country, starting from sea level in south up to 8000 ft altitude in north particularly in Himalayas and north eastern hills. Some species are domesticated and some are growing in wilderness. However, six small millets viz; finger millet(*Eleusine coracan Gartn.*) barnyard millet (*Echinochloa frumentacea (Roxb.*) Link.), foxtail millet (*Setaria italica Beauv.*), proso millet (*Panicum miliaceum Linn,*) and kodo millet (*Paspalum scrobiculatum Linn.*), little millet (*Panicum miliare Larn.*) are the most important small millet crops, in view of their area and production in different parts of the country. Among small millets, finger millet accounts for 8 per cent of the area and 11 per cent production of all the millet cultivation in the world. In India finger millet accounts for 60 per cent area and ¾ of total small millets production.

Small millets are hardy crops and withstand weather vagaries. History tells that these crops have saved many lives of people under famine or starvation in ancient times in many countries including India, Japan. In India and other countries production and consumption of small millets has decreased during last several decades. The millets have been wiped off from the field, kitchen and our mind. Millet marketing channel in India is not developed due to scattered and irregular supplies, large distances between producing areas and the main urban centres and limited demand in urban areas.

Small millets are potential sources of nutraceuticals. These are highly nutritious and even superior to rice and wheat in certain constituents. Finger millet is the richest source of calcium (344 mg/100g) and other small millets are good source of phosphorus and iron too. The millet protein has balanced amino acid profile and good source of methionine, cystine and lysine. Small millets could, therefore, have very high potential for those suffering from lactase deficiency as well as Vegetarians who avoid all animal produce in their diet and often develop calcium and protein deficiency. More calcium, high soluble fiber, low fat content and high digestibility power of malted grains, give small millets a unique status among food grains for producing a variety of nutritionally designed food products. The millet grains and their flour contain a high proportion of non starchy polysaccharides and dietary fiber, which help in prevention of constipation, lowering of blood cholesterol and slow release of glucose to the blood stream during digestion. It is of interest to note that lower incidence of cardiovascular diseases, duodenal ulcer and hyperglycemia (diabetes) are reported among millet consumers.

Reintroducing millets is to trace back the history and to bring back life and environment rich in diversity. Biodiversity conservation can be achieved by growing of millets which in turn will lead to more ecological farming and better land use. Revival of millets means a diversity of staple food in the kitchen. The diversified uses of millets in the form of delicious dishes will encourage farmers to grow more millets and entrepreneurs to commercialize the millets food products.

Conservation of Biodiversity with the Aid of Bioinformatics

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Biodiversity is the variety and differences among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are a part. This includes genetic diversity within and between species and of ecosystems. Thus, in essence, biodiversity represents all life. India is one of the mega biodiversity centers in the world and has two of the world's 18 'biodiversity hotspots' located in the Western Ghats and in the Eastern Himalayas .The forest cover in these areas is very dense and diverse and of pristine beauty, and incredible biodiversity. The country is estimated to have over 45,000 plant species and 81,000 animal species representing 7% of the world's flora and 6.5% of its fauna. The 1999 figures are 49,219 plant species representing 12.5% and 81,251 animal species representing 6.6%. Biodiversity refers to a vast array of life forms that make up ecological communities from the minutest bacteria to a vast tree. It encompasses all life forms which involves microorganisms, plants and animals all over the world.

In these days of rapid increasing of human population and concomitant habitat destruction, knowledge of centers of high biodiversity is critical if rational conservation decisions are to be made. The problem is that this information is largely unavailable to the decision makers. The reason for this is two - fold. There are two areas in biology where enormous amounts of information are generated. One is in molecular biology which deals with base sequences in DNA and amino acid sequences in proteins, and the other is the biodiversity information crisis. Mathematics and computers are being used to tackle these problems with procedures which come under the label of Bioinformatics. This is an enormous and complex task, but this is only part of it. To make the data efficiently available world-wide it has to be accessible via the internet.

Global environmental change affects the sustained provision of a wide set of ecosystem services. Although the delivery of ecosystem services is strongly affected by abiotic drivers and direct land use effects, it is also modulated by the functional diversity of biological communities. A systematic way for progressing in understanding how lands cover change affects these ecosystem properties through functional diversity modifications. Genomic discovery in forest trees follows paradigms from both agricultural crop and livestock improvement and human medicine. Forest trees in a domesticated state can be improved using genomic-based breeding technologies, whereas the health of trees in a natural and undomesticated state might be managed using those same technologies. These applications begin by first dissecting complex traits in trees to their individual gene components and for that the association genetics approach is quite powerful in trees. Genomic discovery in forest trees follows paradigms from both agricultural crop and livestock improvement and human medicine. These applications begin by first dissecting complex traits in trees to their individual gene components and for that the association genetics approach is quite powerful in trees. This is true for several reasons including large, random mating, and unstructured populations and the rapid decay of linkage disequilibrium in many tree species. Once marker by trait associations is discovered, they can be used in genomic-based breeding and forest health diagnostics. Initial studies in trees have found ample nucleotide diversity in candidate genes to perform association studies and single nucleotide polymorphisms have been associated with economic and adaptive traits. Population genetic neutrality tests have been applied to identify genes probably under natural selection and thus make good candidates for developing forest health diagnostic tools.

Phylogenetic analysis will be done with the assistance of using the 18S, ITS, 28S, 5S sequencing and cladogram. 16S Mitochondrial and chloroplast DNA might be useful for the diversity study. Several biomarkers have been available for the diversity study of plants like RAPD, RFLP, Microsatellite, Mitochndrial DNA, ITS, chloroplast DNA analysis, cytochromes etc. All these techniques are useful in the biodiversity analysis. Ex-situ, in situ conservation will be used to preserve the plants resources in the longer times. Plants explants may be used to propagate the plants through the tissue culture. Storage of live gene bank can be made for future use in the liquid nitrogen. The important gene construct (strong promoter, disease resistance, cold resistance etc) may be store for longer time and introduced into the plant through various biotic and abiotic gene transfer techniques. Prediction of RNA secondary structure and their free energy are also giving the clue the endangered and normal plants. Endangered plants may be conserved.

Certain primary and secondary metabolic pathways which are common in all sort of biodiversity between lower (fungi, bacteria, algae) and higher plants (monocots, dicots etc.) and animals have conserved domains in their genome. With the help of bioinformatics study we analyze common phylogeny between the two most diversified organisms. Till now, *Arabidopsis thaliana* is the only plant species in which the whole genome has been identified. Various genes, their transcription factors and their binding sites have been recognized. This plant is now being used as a model plant system for various bioinformatics studies in different related/unrelated lower and higher plants.

Signal transduction phenomenon in plants and animals has some common factors and directly (through influencing different pathways) or indirectly (via influencing transcription factors) influence gene expression to its ambience. This kind of study can be done with the help of *insilico* techniques and can be further validated with the help of wet lab practices.

Although a few groups of organisms such as birds and mammals and a few geographic areas, such as Western Europe, are well studied and well characterized most groups of organisms are only partly known and the tropical parts of the world and the deep ocean have only just begun to be studied in detail. These problems are compounded by the fact that there is little incentive for biologists these days to go into the classical fields of taxonomy and systematics. The glamour (and money) is in molecular and cell biology. Secondly, although there is an enormous amount of biodiversity information in the world museums and universities it is not readily accessible.

It is ironic that most of these data are in the great museums which are located in the cool temperate parts of the world where as, most of the organisms are in the warm humid parts of the world. The data that exist are paper based. Descriptions by collectors and curators, herbarium sheets, diagrams and photographs, and of course, pickled and preserved specimens with their labels. If a researcher wishes to consult these data he/she has to travel to the museum in question and do the work there. When, we reach a point where most of the information has been accumulated and furthermore, is readily accessible, it will be much easier for concerned individuals and groups to make the case for the preservation of areas that are particularly rich in diversity.

The data generated through various research will led to the development of a wide range of information in the forms of molecular biology databases, non-bibliographic databases of information such as DNA sequences , protein sequences , and genomic mapping information . The development, management and use of these databases is one of the component in field of bioinformatics, "the computer-assisted data management discipline that helps us gather, analyze and represent this information" for the better future use.

Biodiversity : A Key to Resilience

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Biodiversity is the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems.

Mankind has drawn on biodiversity throughout history, for basic needs such as food and shelter, but also in much deeper cultural and spiritual ways. People are drawn to the beauty of nature for recreation, relaxation and inspiration. In recent years, we are seeing biodiversity in increasing practical terms as a source of cures to diseases and helping us to adapt to changing conditions such as global warming. In the last couple of decades biodiversity has been recognized as lifeblood of sustainable development and human welfare. An ecosystem service is a service people obtain from the environment. Ecosystem services are the transformation of natural assets (soil, plants, and animals, air and water) into things that we value. They can be viewed as (a) Provisioning such as food and water; (b) Regulating for example flood and disease control; (c) Cultural such as spiritual, recreational and cultural benefits; (d) supporting like nutrient cycling that maintain the conditions for life on Earth. Ecosystem goods include food, medicinal plants, construction materials, tourism and recreation, and wild genes for domestic plants and animals. Resilience is the ability of natural and social systems to adapt to change and biodiversity is a key of it.

Loss of biodiversity, deforestation, climatic fluctuations and rapid population growth are examples of the serious environmental problems that are becoming more complex each year. The critical nature of these issues will bear a heavy burden on the geopolitical, economic, and social agendas of the world during this century. Their importance was emphasized by the United Nations Conference on Environment and Development held in June 1992 at Rio de Janeiro, the largest meeting of heads of state in history.

Science and technological knowledge will play heroic role in confronting the issues of environmental salvation. But our nation's decision makers often lack the scientific information they need to find long-term, cost effective solutions. But we are rapidly loosing biodiversity, despite all the warnings. We know that ancient civilizations collapsed because of environmental damage. We understand how monocultures contributed to agricultural disasters like the Irish Potato Famine. Excessive development and consumerism are destroying our natural systems, standardizing landscapes and eroding cultures. We know current growth rates are not sustainable and are not leading to the life we want.

When we cut a mature tree to make furnitures, we lose a host of lichens and invertebrates; part of an entire web of life is lost. People in the developing world know exactly what's at stake as they set out each morning to collect fuel wood from a dwindling forest, travel ever further to hunt animals for food and collect medicinal plants to treat their sick children.

How can we expect to tackle poverty and climate change if we don't look after the natural wealth of animals, plants, micro-organisms and ecosystems that make our planet inhabitable. By making the scientific, social, economic and cultural case for keeping biodiversity we must highlight how much it supports nearly every aspect of human life. But the arguments for biological and cultural diversity should not be all utilitarian.

If we don't hurry up and convince governments, politicians, business leaders and the public why we need biodiversity and how urgent it is that they mobilize to save it, the world will move on and our fate will be sealed. We need to do better at showing how much progress has been made and how more can be done.

Biodiversity hotspots for conservation priorities

It is known that the number of species

threatened with extinction far outstrips available conservation resources and the situation looks set to become rapidly worse. Therefore it is important to identify priorities. How can we protect the most species per rupee invested? This key question is at forefront of conservation planning. By concentrating on areas where there is greatest need and where the payoff from safeguard measures would also be greatest, conservationists can engage in a systematic response to the challenge of large-scale extinctions ahead.

A promising approach is to identify 'hotspots', or areas featuring exceptional concentrations of endemic species and experiencing exceptional loss of habitat. There are other types of hotspot featuring richness of, for example, rare or taxonomically unusual species. The hotspots' boundaries have been determined by 'biological commonalities'. Each of the areas features a separate biota or community of species that fits together as a biogeographic unit. This is apparent in the case of islands or island groups and 'ecological islands'. To qualify as a hotspot, an area must contain at least 0.5% or 1,500 of the world's 300,000 plant species as endemics (Myers et al 2000). The four vertebrate groups, mammals, birds, reptiles and amphibians, comprise 27,298 species, consisting of 4,809 mammals (Nowak, 1999), 9,881 birds (Sibley and Monroe, 1990), 7,828 reptiles (Uetz and Etzold, 1996) and 4,780 amphibians (Glaw and Kohler, 1998). The data on fishes are generally poor and it expected that at least 5,000 species are waiting to be discovered (Eschmeyer, 1998). Vertebrates do not serve as an alternative determinant of hotspot status, nor do their endemics have to comprise 0.5% of global totals (Myers et al 2000). Vertebrates serve as back-up support, and also to determine congruence and to facilitate other comparisons among the hotspots. The invertebrates are largely undocumented but probably make up at least 95% of all species, the bulk of them insects. If we lose half of endemic plant species we will lose a large and perhaps similar proportion of insect species. For example, the fig genus being the most widespread of plant genera in the tropics, comprises more than 900 species, each of which is pollinated by a single wasp species; conversely, the wasps depend on the figs' ovaries as sites for their larvae to develop (Janzen, 1979). So far the endemism is concerned, there is lack of recent documentation in the form of modern floras, secondly and more importantly, endemism data almost always relate only to individual countries or parts of countries, whereas 12 of the 25 hotspots extend across two or more countries and six across four or more countries. In these cases, it has been difficult to compute regional totals for hotspot-wide endemics and many of the endemism estimates are distinctly conservative.

A second determinant of hotspot status, applied only after an area has met 'plants' criterion, is the degree of threat through habitat loss. To qualify, a hotspot should have lost 75% or more of its primary vegetation, this being the form of habitat that usually contains the most species, especially endemics. Eleven hotspots have already lost at least 90% and three have lost 95%. The 70% cutoff is justified on the grounds that most large-scale concentrations of endemic plant species occur within the 25 hotspots as delineated.

The 25 hotspots contain the remaining habitats of 133,149 plant species (44% of all plant species worldwide) and 9,645 vertebrate (except fish) species (35% of all vertebrate species worldwide). These endemics are confined to an aggregate expanse of 2.1 million km^2, or 1.4% of the Earth's land surface. They formerly occupied 17.4 million km^2 or 11.8% of the Earth's land surface. They are so threatened that, having already lost an aggregate of 88% of their primary vegetation, they all seem likely, in the absence of greatly increased conservation efforts, to lose much if not most of their remaining primary vegetation within the foreseeable future. The 25 hotspots feature several habitat types at global scale. Predominant are tropical forests, appearing in 15 hotspots, and Mediterranean-type zones, in five. Nine are mainly or completely made up of islands; almost all tropical islands fall into one or another hotspot. Sixteen hotspots are in tropics, which largely means developing countries where threats are greatest and conservation resources are scarcest.

The hotspot analysis indicates that much of the problem of extinction of species could be countered through protection of the 25 hotspots. An aggregate expanse of 800,767 km^2, 38% of the hotspots total, is already protected in parks and reserves. All are in urgent need of stronger safeguards. The areas without any protection at all amount to 1.3 million km^2 or 62% of the total area of the hotspots. This expanse surely represents the greatest biodiversity challenge of the foreseeable future, and should be safeguarded. In some areas, outright protection is still the best option. In other areas, this is not feasible because of human settlements and other activities long in place. These areas could receive a measure of protection as 'conservation units' that allow some degree of multiple use provided that species safeguards are always paramount. This is not to say that protection of the hotspots would safeguard all their species indefinitely, but the hotspot strategy with its tight targeting of conservation efforts, will make the prospect of a mass extinction far less daunting and much more manageable.

Mass extinction of species, if allowed to persist, would constitute a problem with far more enduring impact than any other environmental problem. According to evidence from mass extinctions in the prehistoric past, evolutionary processes would not generate a replacement stock of species within less than several million years. What we do (or do not do) within the next few decades will determine the long-term future of a vital feature of the biosphere, its abundance and diversity of species. This expanded hotspots strategy offers a large step toward avoiding an impoverishment of the Earth lasting many times longer than *Homo sapiens* has been a species (Myers et al 2000).

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International Day for Biological Diversity - 22 May

The United Nations proclaimed May 22 The International Day for Biological Diversity (IBD) to increase understanding and awareness of biodiversity issues. When first created by the Second Committee of the UN General Assembly in late 1993, 29 December (the date of entry into force of the Convention of Biological Diversity), was designated The International Day for Biological Diversity. In December 2000, the UN General Assembly adopted 22 May as IBD, to commemorate the adoption of the text of the Convention on 22 May 1992 by the Nairobi Final Act of the Conference for the Adoption of the Agreed Text of the Convention on Biological Diversity. This was partly done because it was difficult for many countries to plan and carry out suitable celebrations for the date of 29 December, given the number of holidays that coincide around that time of year.

Themes

2008 - Biodiversity and Agriculture

2007 - Biodiversity and Climate Change

2006 - Protect Biodiversity in Drylands

2005 - Biodiversity: Life Insurance for our Changing World

2004 - Biodiversity: Food, Water and Health for All

2003 - Biodiversity and poverty alleviation - challenges for sustainable development

2002 - Dedicated to forest biodiversity

Source : CBD, 2008

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(Flacourtia jangomas)

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Let us save our legacy for future : Only few hundred trees of Puneala plum are there in Gorakhpur

Photo courtesy : Shri B.N. Yadav, Lecturer (Biology), M.P. Inter College, Gorakhpur

Biodiversity Profile of India

(Source: Internet)

India is the seventh largest country in the world and Asia's second largest nation with an area of 3,287,263 square km. The Indian mainland stretches from 8 4' to 37 6' N latitude and from 68 7' to 97 25' E longitude. It has a land frontier of some 15,200 kms and a coastline of 7,516 km (Government of India, 1985). India's northern frontiers are with Xizang (Tibet) in the Peoples Republic of China, Nepal and Bhutan. In the north-west, India borders on Pakistan; in the north-east, China and Burma; and in the east, Burma. The southern peninsula extends into the tropical waters of the Indian Ocean with the Bay of Bengal lying to the south-east and the Arabian Sea to the south-west. For administrative purposes India is divided into 24 states and 7 union territories. The country is home to around 846 million people, about 16% of the World's population (1990 figures).

Physically the massive country is divided into four relatively well defined regions - the Himalayan Mountains, the Gangetic river plains, the southern (Deccan) plateau, and the islands of Lakshadweep, Andaman and Nicobar. The Himalayas in the far north include some of the highest peaks in the world. The highest mountain in the Indian Himalayas is Khangchenjunga (8586 m) which is located in Sikkim on the border with Nepal. To the south of the main Himalayan massif lie the Lesser Himalaya, rising to 3,600- 4,600 m, and represented by the Pir Panjal in Kashmir and Dhaula dhar in Himachal Pradesh. Further south, flanking the Indo-Gangetic Plain, are the Siwaliks which rise to 900-1,500 m.

The northern plains of India stretch from Assam in the east to the Punjab in the west (a distance of 2,400 km), extending south to terminate in the saline swamplands of the Rann of Kachchh (Kutch), in the state of Gujarat. Some of the largest rivers in India including the Ganga (Ganges), Ghaghara, Brahmaputra, and the Yamuna flow across this region. The delta area of these rivers is located at the head of the Bay of Bengal, partly in the Indian state of west Bengal but mostly in Bangladesh. The plains are remarkably homogenous topographically: for hundreds of kilometres the only perceptible relief is formed by floodplain bluffs, minor natural levees and hollows known as 'spill patterns', and the belts of ravines formed by gully erosion along some of the larger rivers. In this zone, variation in relief does not exceed 300 m (FAO/UNEP, 1981) but the uniform flatness conceals a great deal of pedological variety. The agriculturally productive alluvial silts and clays of the Ganga-Brahmaputra delta in north-eastern India, for example, contrast strongly with the comparatively sterile sands of the Thar Desert which is located at the western extremity of the Indian part of the plains in the state of Rajasthan.

The climate of India is dominated by the Asiatic monsoon, most importantly by rains from the south-west between June and October, and drier winds from the north between December and February. From March to May the climate is dry and hot.

Wetlands

India has a rich variety of wetland habitats. The total area of wetlands (excluding rivers) in India is 58,286,000ha, or 18.4% of the country, 70% of which comprises areas under paddy cultivation. A total of 1,193 wetlands, covering an area of about 3,904,543 ha, were recorded in a preliminary inventory coordinated by the Department of Science and Technology, of which 572 were natural (Scott, 1989). Two sites - Chilka Lake (Orissa) and Keoladeo National Park (Bharatpur) - have been designated under the Convention of Wetlands of International Importance (Ramsar Convention) as being especially significant waterfowl habitats. The country's wetlands are generally differentiated by region into eight categories (Scott, 1989): the reservoirs of the Deccan Plateau in the south, together with the lagoons and the other wetlands of the southern west coast; the vast saline expanses of Rajasthan, Gujarat and the gulf of Kachchh;

freshwater lakes and reservoirs from Gujarat eastwards through Rajasthan (Kaeoladeo Ghana National park) and Madhya Pradesh; the delta wetlands and lagoons of India's east coast (Chilka Lake); the freshwater marshes of the Gangetic Plain; the floodplain of the Brahmaputra; the marshes and swamps in the hills of north-east India and the Himalayan foothills; the lakes and rivers of the mountain region of Kashmir and Ladakh; and the mangroves and other wetlands of the island arcs of the Andamans and Nicobars.

Forests

India possesses a distinct identity, not only because of its geography, history and culture but also because of the great diversity of its natural ecosystems.The panorama of Indian forests ranges from evergreen tropical rain forests in the Andaman and Nicobar Islands, the Western Ghats, and the north-eastern states, to dry alpine scrub high in the Himalaya to the north. Between the two extremes, the country has semi-evergreen rain forests, deciduous monsoon forests, thorn forests, subtropical pine forests in the lower montane zone and temperate montane forests (Lal, 1989).

One of the most important tropical forests classifications was developed for Greater India (Champion, 1936) and later republished for present-day India (Champion and Seth, 1968). This approach has proved to have wide application outside India. In it 16 major forests types are recognised, subdivided into 221 minor types. Structure, physiognomy and floristics are all used as characters to define the types.

The main areas of tropical forest are found in the Andaman and Nicobar Islands; the Western Ghats, which fringe the Arabian Sea coastline of peninsular India; and the greater Assam region in the north-east. Small remnants of rain forest are found in Orissa state. Semi-evergreen rain forest is more extensive than the evergreen formation partly because evergreen forests tend to degrade to semi-evergreen with human interference. There are substantial differences in both the flora and fauna between the three major rain forest regions (IUCN, 1986; Rodges and Panwar, 1988).

The Western Ghats Monsoon forests occur both on the western (coastal) margins of the ghats and on the eastern side where there is less rainfall. These forests contain several tree species of great commercial significance (e.g. Indian rosewood *Dalbergia latifolia*, Malabar Kino *Pterocarpus marsupium*, teak and *Terminalia crenulata*), but they have now been cleared from many areas. In the rain forests there is an enormous number of tree species. At least 60 percent of the trees of the upper canopy are of species which individually contribute not more than one percent of the total number. Clumps of bamboo occur along streams or in poorly drained hollows throughout the evergreen and semi-evergreen forests of south-west India, probably in areas once cleared for shifting agriculture.

The tropical vegetation of north-east India (which includes the states of Assam, Nagaland, Manipur, Mizoram, Tripura and Meghalaya as well as the plain regions of Arunachal Pradesh) typically occurs at elevations up to 900 m. It embraces evergreen and semi-evergreen rain forests, moist deciduous monsoon forests, riparian forests, swamps and grasslands. Evergreen rain forests are found in the Assam Valley, the foothills of the eastern Himalayas and the lower parts of the Naga Hills, Meghalaya, Mizoram, and Manipur where the rain fall exceeds 2300 mm per annum. In the Assam Valley the giant *Dipterocarpus macrocarpus* and *Shorea assamica* occur singly, occasionally attaining a girth of up to 7 m and a height of up to 50 m. The monsoon forests are mainly moist sal *Shorea robusta* forests, which occur widely in this region (IUCN, 1991).

The Andamans and Nicobar islands have tropical evergreen rain forests and tropical semi-evergreen rainforests as well as tropical monsoon moist monsoon forests (IUCN, 1986).The tropical evergreen rain forest is only slightly less grand in stature and rich in species than on the mainland. The dominant species is *Dipterocarpus grandiflorus* in hilly areas, while *Dipterocarpus kerrii* is dominant on some islands in the southern parts of the archipelago. The monsoon forests of the Andamans are dominated by *Pterocarpus dalbergioides* and *Terminalia* spp.

Marine Environment

The nearshore coastal waters of India are extremely rich fishing grounds. The total commercial marine catch for India has stabilised over the last ten years at between 1.4 and 1.6 million tonnes, with fishes from the clupeoid group (e.g. sardines *Sardinella* sp., Indian shad *Hilsa* sp. and whitebait *Stolephorus* sp.) accounting for approximately 30% of all landings. In 1981 it was estimated that there were approximately 180,000 non-mechanised boats (about 90% of India's fishing fleet) carrying out small-scale, subsistence fishing activities in these waters. At the same time there were about 20,000 mechanised boats and 75 deep-sea fishing vessels operating mainly out of ports in the states of Maharashtra, Kerala, Gujarat, Tamil Nadu and Karnataka.

Coral reefs occur along only a few sections of the mainland, principally the Gulf of Kutch, off the southern mainland coast, and around a number of islands opposite Sri Lanka. This general absence is due largely to the presence of major river systems and the sedimentary regime on the continental shelf. Elsewhere, corals are also found in Andaman, Nicobar and Lakshadweep Island groups although their diversity is reported to be lower than in south-east India (UNEP/IUCN, 1988).

Indian coral reefs have a wide range of resources which are of commercial value. Exploitation of corals, coral debris and coral sands is widespread on the Gulf of Mannar and Gulf of Kutch reefs, while ornamental shells, chanks and pearl oysters are the basis of an important reef industry in the south of India. Sea fans and seaweeds are exported for decorative purposes, and there is a spiny lobster fishing industry along the south-east coast, notably at Tuticorin, Madras and Mandapam Commercial exploitation of aquarium fishes from Indian coral reefs has gained importance only recently and as yet no organised effort has been made to exploit these resources. Reef fisheries are generally at the subsistence level and yields are unrecorded.

Other notable marine areas are seagrass beds, which although not directly exploited are valuable as habitats for commercially harvested species, particularly prawns, and mangrove stands. In the Gulf of Mannar the green tiger prawn *Penaeus semisulcatus* is extensively harvested for the export market. Seagrass beds are also important feeding areas for the dugong *Dugong dugon*, plus several species of marine turtle.

Five species of marine turtle occur in Indian waters: Green turtle *Chelonia mydas*, Loggerhead *Caretta caretta*, Olive Ridley *Lepidochelys olivacea*, Hawksbill *Eretmochelys imbricata* and Leatherback *Dermochelys coriacea*. Most of the marine turtle populations found in the Indian region are in decline. The principal reason for the decrease in numbers is deliberate human predation. Turtles are netted and speared along the entire Indian coast. In south-east India the annual catch is estimated at 4,000-5,000 animals, with *C. mydas* accounting for about 70% of the harvest. *C. caretta* and *L. olivacea* are the most widely consumed species (Salm, 1981). *E. imbricata* is occasionally eaten but it has caused deaths and so is usually caught for its shell alone. *D. coriacea* is boiled for its oil which is used for caulking boats and as protection from marine borers. Incidental netting is widespread. In the Gulf of Mannar turtles are still reasonably common near seagrass beds where shrimp trawlers operate, but off the coast of Bengal the growing number of mechanized fishing boats has had the effect of increasing incidental catch rates (Kar and Bhaskar, 1981).

Biodiversity

Species Diversity

India contains a great wealth of biological diversity in its forests, its wetlands and in its marine areas. This richness is shown in absolute numbers of species and the proportion they represent of the world total (see Table 1).

Table 1: Comparison between the Number of Species in India and the World

Group	Number of species	Number of species	SI/SW

	in India (SI)	in the world (SW)	(%)
Mammals	350(1)	4,629(7)	7.6
Birds	1224(2)	9,702(8)	12.6
Reptiles	408(3)	6,550(9)	6.2
Amphibians	197(4)	4,522(10)	4.4
Fishes	2546(5)	21,730(11)	11.7
Flowering Plants	15,000(6)	250,000(12)	6.0

India has a great many scientific institutes and university departments interested in various aspects of biodiversity. A large number of scientists and technicians have been engaged in inventory, research, and monitoring. The general state of knowledge about the distribution and richness of the country's biological resources is therefore fairly good.

Inventories of birds, mammals, trees, fish and reptiles are moderately complete. Knowledge of special interest groups such as primates, pheasants, bovid, endemic birds, orchids, and so on, is steadily improving through collaboration of domestic scientists with those from overseas. The importance of these biological resources cannot be overestimated for the continued welfare of India's population.

Endemic Species

India has many endemic plant and vertebrate species. Among plants, species endemism is estimated at 33% with c. 140 endemic genera but no endemic families (Botanical Survey of India, 1983). Areas rich in endemism are north-east India, the Western Ghats and the north-western and eastern Himalayas. A small pocket of local endemism also occurs in the Eastern Ghats (MacKinnon & MacKinnon, 1986). The Gangetic plains are generally poor in endemics, while the Andaman and Nicobar Islands contribute at least 220 species to the endemic flora of India (Botanical Survey of India, 1983).

WCMC's Threatened Plants Unit (TPU) is in the preliminary stages of cataloguing the world's centres of plant diversity; approximately 150 botanical sites worldwide are so far recognised as important for conservation action, but others are constantly being identified (IUCN, 1987). Five locations have so far been issued for India: the Agastyamalai Hills, Silent Valley and New Amarambalam Reserve and Periyar National Park (all in the Western Ghats), and the Eastern and Western Himalaya.

There are 396 known endemic higher vertebrate species identified by WCMC. Endemism among mammals and birds is relatively low. Only 44 species of Indian mammal have a range that is confined entirely to within Indian territorial limits. Four endemic species of conservation significance occur in the Western Ghats. They are the Lion-tailed macaque *Macaca silenus*, Nilgiri leaf monkey *Trachypithecus johni* (locally better known as Nilgiri langur *Presbytis johnii*), Brown palm civet *Paradoxurus jerdoni* and Nilgiri tahr *Hemitragus hylocrius*.

Only 55 bird species are endemic to India, with distributions concentrated in areas of high rainfall. They are located mainly in eastern India along the mountain chains where the monsoon shadow occurs, south-west India (the Western Ghats), and the Nicobar and Andaman Islands (ICBP, 1992).

In contrast, endemism in the Indian reptilian and amphibian fauna is high. There are around 187 endemic reptiles, and 110 endemic amphibian species. Eight amphibian genera are not found outside India. They include, among the caecilians, *Indotyphlus*, *Gegeneophis* and *Uraeotyphlus*; and among the anurans, the toad *Bufoides*, the microhylid *Melanobatrachus*, and the frogs *Ranixalus*, *Nannobatrachus* and *Nyctibatrachus*. Perhaps most notable among the endemic amphibian genera is the monotypic *Melanobatrachus* which has a single species known only from a few specimens collected in the Anaimalai Hills in the 1870s (Groombridge, 1983). It is possibly most closely related to two relict genera found in the mountains of eastern Tanzania.

Threatened Species

India contains 172 species of animal considered globally threatened by IUCN, or 2.9% of the world's total number of threatened species (Groombridge, 1993). These include 53 species of mammal, 69 birds, 23 reptiles and 3 amphibians. India contains globally important populations of some of Asia's rarest animals, such as the Bengal Fox, Asiatic Cheetah, Marbled Cat, Asiatic Lion, Indian

Elephant, Asiatic Wild Ass, Indian Rhinoceros, Markhor, Gaur, Wild Asiatic Water Buffalo etc.

A workshop held in 1982 indicated that as many as 3,000-4,000 higher plants may be under a degree of threat in India. Since then, the Project on Study, Survey and Conservation of Endangered species of Flora (POSSCEP) has partially documented these plants, and published its findings in Red Data Books (Nayar and Sastry, 1987).

Protected Areas Network

Development and History

The protection of wildlife has a long tradition in Indian history. Wise use of natural resources was a prerequisite for many hunter-gatherer societies which date back to at least 6000 BC. Extensive clearance of forests accompanied the advance of agricultural and pastoral societies in subsequent millennia, but an awareness of the need for ecological prudence emerged and many so-called pagan nature conservation practices were retained. As more and more land became settled or cultivated, so these hunting reserves increasingly became refuges for wildlife. Many of these reserves were subsequently declared as national parks or sanctuaries, mostly after Independence in 1947. Examples include Gir in Gujarat, Dachigam in Jammu & Kashmir, Bandipur in Karnataka, Eravikulum in Kerala, Madhav (now Shivpuri) in Madhya Pradesh, Simlipal in Orissa, and Keoladeo, Ranthambore and Sariska in Rajasthan.

Wildlife, together with forestry, has traditionally been managed under a single administrative organisation within the forest departments of each state or union territory, with the role of central government being mainly advisory. There have been two recent developments. First, the Wildlife (Protection) Act has provided for the creation of posts of chief wildlife wardens and wildlife wardens in the states to exercise statutory powers under the Act. Under this Act, it is also mandatory for the states to set up state wildlife advisory boards. Secondly the inclusion of protection of wild animals and birds in the concurrent list of the constitution, has proved the union with some legislative control over the states in the conservation of wildlife (Pillai, 1982). The situation has since improved, all states and union territories with national parks or sanctuaries having set up wildlife wings.

The adoption of a National Policy for Wildlife Conservation in 1970 and the enactment of the Wildlife (Protection) Act in 1972 lead to a significant growth in the protected areas network, from 5 national parks and 60 sanctuaries to 69 and 410 respectively, in 1990 (Panwar, 1990). These protected areas are distributed throughout mainland India and its islands.

The network was further strengthened by a number of national conservation projects, notably Project Tiger, initiated in April 1973 by the Government of India with support from WWF (IBWL, 1972; Panwar, 1982), and the crocodile Breeding and Management Project, launched on 1 April, 1975 with technical assistance from UNDP/FAO (Bustard, 1982).

Protected Areas of the Western Ghats

The Western Ghats are a chain of highlands running along the western edge of the Indian subcontinent, from Bombay south to the southern tip of the peninsula, through the states of Maharashtra, Karnataka, Kerala and Tamil Nadu. Covering an estimated area of 159,000 sq. km, the Western Ghats are an area of exceptional biological diversity and conservation interest, and are "one of the major Tropical Evergreen Forest regions in India" (Rodgers and Panwar, 1988). As the zone has already lost a large part of its original forest cover (although timber extraction from the evergreen reserve forests in Kerala and Karnataka has now been halted) it must rank as a region of great conservation concern. The small remaining extent of natural forest, coupled with exceptional biological richness and ever increasing levels of threat (agriculture, reservoir flooding plantations, logging and over exploitation), are factors which necessitate major conservation inputs."

There are currently seven national parks in the Western Ghats with a total area of 2,073 sq. km (equivalent to 1.3% of the region) and 39 wildlife sanctuaries covering an area of about 13,862 sq. km (8.1%).

The management status of the wildlife sanctuaries in this part of India varies enormously. Tamil Nadu's Nilgiri wildlife sanctuary, for example, has no human inhabitants, small abandoned plantation areas and no produce exploitation, while the Parambikulam wildlife sanctuary in Kerala includes considerable areas of commercial plantations and privately owned estates with heavy resource exploitation.

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Biodiversity : Flagging the Issue

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The global biodiversity wealth is vast and only a small fraction is known as yet. Indian bio-resources are considerably rich; some even endemic. In general, the Indian subcontinent is richer floristically than in its fauna. Within the subcontinent Eastern and North-eastern Himalayas and Western Ghats are rich in floristic diversity.

Biodiversity is a neologism and portmanteau word, from biology and diversity.The term *Biodiversity* was coined by W.G. Rosen in 1985 while planning the *National Forum on Biological Diversity* organized by the National Research Council (NRC), and first appeared in a publication in 1988 when entomologist E.O. Wilson used it as the title of the proceedings of that forum. The term *biodiversity* appear more effective in terms of communication than *biological diversity.*

Since 1986, the terms and the concept are widely used by biologists, environmentalists, political leaders and concerned citizens worldwide. It further emphasizes the concern for the natural environment and natural conservation and become more revelant with the expansion of concern over extinction of species in last few decades.

Biodiversity is defined as 'variation of life at all levels of biological organization' or Biodiversity is a measure of the relative diversity among organisms present in different ecosystems. 'Diversity' in this definition includes diversity within a species and among species, and comparative diversity among ecosystems.

A third definition that is often used by ecologists is the "totality of genes, species, and ecosystems of a region". This definition describes most circumstances and present a unified view of the traditional three levels at which biodiversity has been identified:

Genetic diversity: Diversity of genes within a species. There is a genetic variability among the populations and the individuals of the same species. If the gene is the fundamental unit of natural selection, according to E. O. Wilson, the real biodiversity is genetic diversity. For geneticists, *biodiversity* is the diversity of genes and organisms. They study processes such as mutations, gene exchanges, and genome dynamics that occur at the DNA level and generate evolution.

Species diversity: Diversity among species in an ecosystem. "Biodiversity hotspots" are excellent examples of species diversity.

Ecosystem diversity: Diversity at a higher level of organization, the ecosystem. Diversity of habitat in a given unit area. To do with the variety of ecosystems on Earth. For ecologists, biodiversity is also the diversity of durable interactions among species. It not only applies to species, but also to their immediate environment (biotope) and their larger ecoregion. In each ecosystem, living organisms are part of a whole, interacting with not only other organisms, but also with the air, water, and soil that surround them.

Table 1: Composition and Level of Biodiversity

DIVERSITY

ECOLOGICAL GENETICS ORGANISATIONAL

Biomes	Populations	Kingdoms
Bioregions	Individuals	Phyla
Landscapes	Chromosomes	Families
Ecosystem	Genes	Genera
Habitats	Nucleotides	Species
Niche		Sub-species
Populations		Populations
		Individuals

Biodiversity is a broad concept, so a variety of objective measures have been created in order to empirically measure biodiversity. Each measure of biodiversity relates to a particular use of the data.

For practical conservationists, this measure should quantify a value that is broadly shared among locally affected people. For others, a more economically defensible definition should allow the ensuring of continued possibilities for both adaptation and future use by people, assuring environmental sustainability.

As a consequence, biologists argue that this measure is likely to be associated with the variety of genes. Since it cannot always be said which genes are more likely to prove beneficial, the best choice for conservation is to assure the persistence of as many genes as possible. For ecologists, this latter approach is sometimes considered too restrictive, as it prohibits ecological succession.

Biodiversity is usually plotted as taxonomic richness of a geographic area, with some reference to a temporal scale (Shanon Index).

There are three other indices which are used by ecologists:

Alpha diversity: refers to diversity within a particular area, community or ecosystem, and is measured by counting the number of taxa within the ecosystem (usually species)

Beta diversity: is species diversity between ecosystems; this involves comparing the number of taxa that are unique to each of the ecosystems.

Gamma diversity: is a measure of the overall diversity for different ecosystems within a region.

Benefits of Biodiversity:

There are a multitude of benefits of biodiversity in the sense of one diverse group aiding another such as resistance to catastrophe, food and drink, medicines, industrial materials, intellectual value, better crop-varieties, other ecological services, leisure, cultural and aesthetic value.

Biodiversity as an area of state intervention may be restricted initially to sensitized people with an aim of preserving the existing possible areas with biodiversity rich flora and fauna, but, this issue has to run deeper and whole lot of scientists, crop promoters and other stakeholders will have to join hands in pushing this concept in possibly all areas of operations. This paper is an effort to track down couple of issues concerned with biodiversity and flag them for discussions:

Agriculture: Out of vast majority of vascular plants only a few species were domesticated and cultivated for human consumption. These are cultivated on large areas through modern agricultural techniques for higher yield and production over the years leading to a sort of monoculture of these species leading to shrinking of other species of the existing flora and fauna.

Horticulture: Modern techniques of horticultural practices lead to further decline in biodiversity. For example the practice of pruning of trees can disturb the flora growing underneath and fauna on the trees.

Food Security: About 25% of the world plant species might be lost by the year 2025 A.D., due to continued genetic erosion. If this problem of plant genetic erosion continues, there will be a loss of source of resistance to pests, diseases and climatic stresses finally leading to crop failure in future. This is true for 20,000 edible species, 50,000 forest trees and a large number of mammals (~3500 species) and insects (9000 species). In coming decades, better yield of agriculture products is essential to feed the teeming million, but preserving biodiversity is a must.

Medicine: World over, there is a long tradition of use and trade of medicinal plants especially in Western Himalayas in India. But commercial extraction led to adversely affect the distribution and abundance of various medicinal plants. Some unregulated targets are *Taxus baccata* in Kulu Valley, Barberis from Mandi district, *Dioscorea deltoidea,* and so on.

Use of Chemicals: When as an enthusiastic agriculturist and crop developer we use chemicals i.e. pesticides, insecticides or even biocides and fertilizers as inorganic or organic, we threaten the ecosystems of that area including soil micro flora in one or the other way. With the introduction of new species to the environment there is a change in the ecosystem and some of the existing biodiversity is lost.

Bio-prospecting: Commercial venture for utilizing plants and plant product in large scale by the community for drugs, crop protection, novel chemical compounds or for discovering new drugs for diseases like AIDS or cancer, ultimately effects the biodiversity. Other cultural practices like Pisciculture, Silviculture etc also affect the marine, fresh water and forest ecosystem.

Biotechnology: Biotechnology has come up as a new field in science and uses latest techniques in the field of biological sciences. The profit margins involved in the biotech products, have resulted in huge investments in the development of new products, which may ultimately adversely affect the biodiversity.

Urbanization: Unplanned plantations and felling of trees in urban areas and constant burning of leaves, dumping of garbage, plastic materials etc along the plantations adversely affect biodiversity, instead it effects the flora and micro fauna and soil micro flora of the area.

Awareness: Environmental awareness programs that are taken up frequently by different organizations do not inculcate a feeling of belongingness among the people with biodiversity. Therefore, effort should be made to encourage biodiversity protection through basic education, creating the sense of belongingness and so on. In the light of this the sporadic incidences like commitment of Bishnois' in protecting biodiversity should be promptly promoted.

In the end, it will not be unfair to say that whether it is a question of use of fertilizer, exotic varieties of seeds or other scientific practices, every thing tend to maximize the crop production at the cost of exploitation of biodiversity. This attitude of exploitation has to be fought at multiple level and comaraderie need to be built among scientists, farmers and other stakeholders for promoting biodiversity conservation.

Best Quality

Bamboo Tissue Culture Plants

D. hamiltonii
D. strictus

D. asper
Bambusa nutans

Bambusa bambos
Bambusa balcoa

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