Reflections on Science Nature, and the Future

Selected works of

Triloki Nath Khoshoo

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Edited by : Prasanna N. S.

ASHOKA TRUST FOR RESEARCH IN
ECOLOGY & THE ENVIRONMENT

"Dr. TN Khoshoo's work both in high office and outside relating to management of resources, the utilization of biodiversity and the need to develop forests for long range ecological security, are pathbreaking. The content and width of Dr. Khoshoo's understanding of issues focussing on sustainable development in the Indian context, on the ethical aspects of resource consumption, on environment friendly technology and the bio-industrial development of rural India and developing countries have contributed greatly to the integration of environmental considerations into our developmental imperatives."

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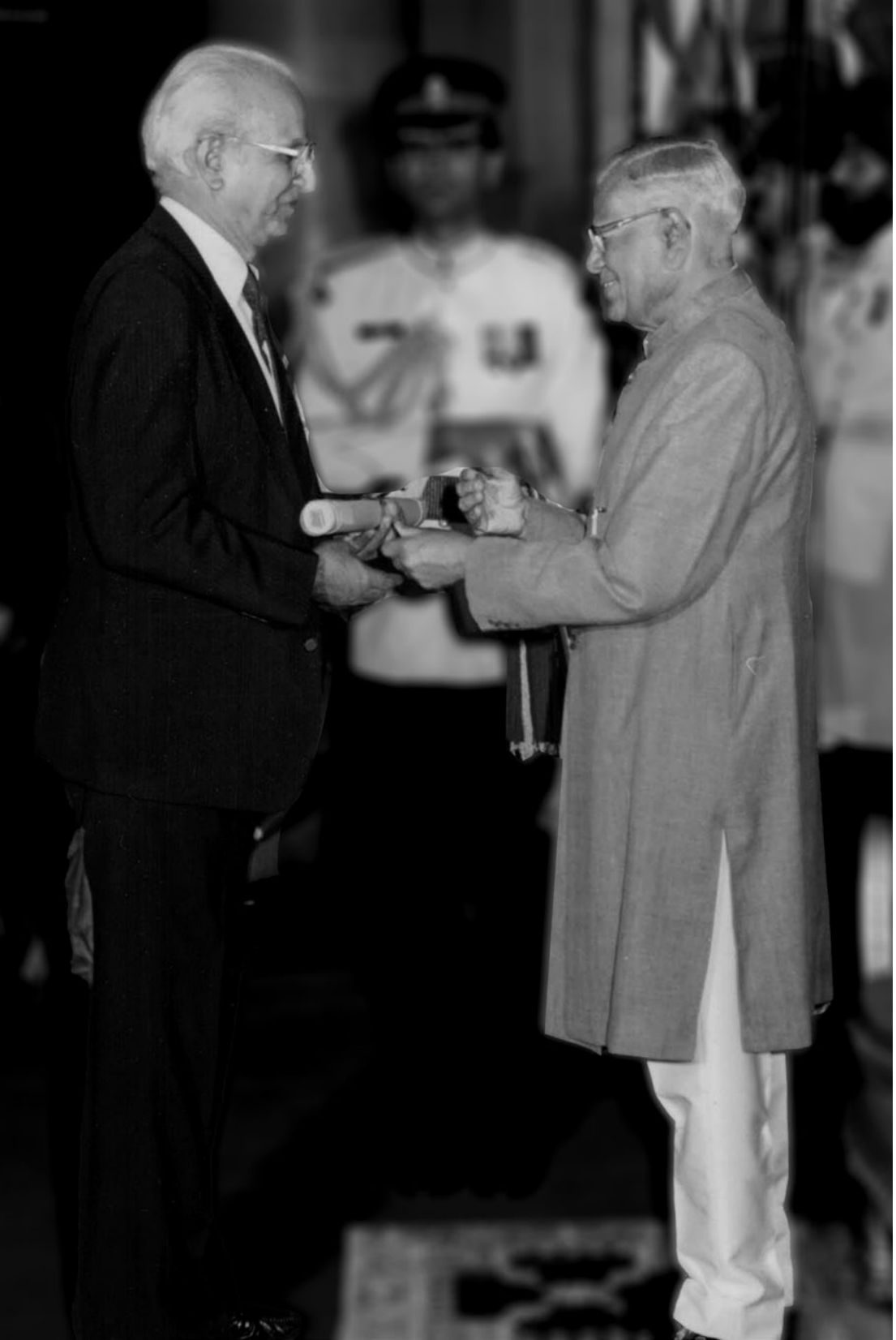

FOREWORD

I am pleased and honored to write the Foreword for this collection of papers written by Professor T. N. Khoshoo from 1987 to 2002. Professor Khoshoo was my teacher, mentor, and friend. He encouraged and inspired Professors R. Uma Shaanker, K. N. Ganeshaiah, and me to establish ATREE in 1996. Subsequently, he also became a trustee of ATREE, helping shape its vision and mission.

Professor Khoshoo was trained as an evolutionary botanist. Later in his career, as the Director of the National Botanical Research Institute in Lucknow and Secretary to the Government of India for Forests and the Environment, he became a leading spokesman for nature and sustainable development in India. This remarkable collection of papers showcases the breadth of his knowledge and understanding of the human predicament.

The papers are divided into three sections: The Science of Restoration, Nature Conservation & Sustainable Development, and Ecosophy for a Sustainable Future. The first two sections outline our major environmental challenges, while the third suggests ways humanity may sustain itself. These writings demonstrate the depth of Professor Khoshoo's thinking and perspective. In the decades since he wrote these papers, the state of our planet has continued to decline, exposing society-especially its most vulnerable sections-to grave socio-economic and health risks.

Thus, his reflections on our moral duty and the Gandhian way are even more relevant today than when he first articulated them. Clearly, he was ahead of his time in addressing the problems we face now.

Professor Khoshoo would have been pleased to see that ATREE continues to translate his thoughts into action. ATREE has vibrant programs in restoration and conservation. My colleagues at ATREE consistently reflect on our *dharma* and our dedication to ATREE's vision of a society living in harmony with nature.

Finally, for doctoral students, whose success we will celebrate alongside the release of this collection of papers, and for other young leaders, let me emphasize the importance of role models such as Professor Khoshoo. I was thrilled when I first enrolled in a class taught by him. I was deeply honored when, as a graduate student, he would speak to me as an equal. Even after I became well-established in my field, I would feel excitement and joyful anticipation whenever I had the opportunity to meet him, knowing I would learn something new.

By emulating the wisdom and vision of mentors like Professor Khoshoo, we not only honor their legacy but also equip ourselves to tackle the pressing challenges of our time. Let his writings and philosophy continue to inspire us to build a better, more sustainable, and just world.

Kamal Bawa
Distinguished Professor Emeritus
University of Massachusetts, Boston and
President Emeritus, ATREE, Bangalore

PREFACE

Professor Triloki Nath Khoshoo was not only a visionary scientist but a deeply compassionate individual whose work continues to shape environmental and ecological thought in India and beyond. His life is one of intellectual rigor, personal conviction, and a commitment to a world where science serves humanity and biodiversity in equal measure.

Born in the beautiful Kashmir Valley in 1927, T. N. Khoshoo's surroundings imbued in him a profound appreciation for nature. Growing up in Srinagar, he was surrounded by landscapes rich in biodiversity, sparking his early interest in plants and ecology. His education marked the beginning of a remarkable academic career. After excelling in school, he attended Punjab University in Lahore, earning his B.Sc. and M.Sc. in Botany before returning

to India post-Partition. His initial research interests focused on plant cytogenetics, especially the genetic systems of trees and ornamental plants, subjects that would eventually grant him national and international acclaim.

Professor Khoshoo joined the Panjab University in India as a lecturer, where he soon became known as a talented teacher and an inspiring mentor. Colleagues and students alike recognized him for his humility, approachability, and sharp intellect. After completing his Ph.D. under the mentorship of Professor P.N. Mehra, he ventured into plant cytogenetics, making pioneering contributions in genetic studies on conifers, ornamentals, and other non-agricultural plants. Professor Khoshoo's early research elucidated evolutionary relationships and genetic systems that were previously unknown, leading to practical applications in forestry and plant breeding. His work on the evolutionary genetics of ornamental plants, such as *Canna, Bougainvillea* and *Chrysanthemums*, introduced important concepts that continue to shape horticultural studies today.

In 1964, Professor Khoshoo joined the National Botanic Gardens (later renamed as the National Botanical Research Institute, NBRI) in Lucknow as Assistant Director, eventually rising to become the Director. His leadership transformed NBRI into a hub of interdisciplinary research, blending plant genetics with environmental conservation and rural development. Unlike many scientists who stay within purely theoretical domains, Professor Khoshoo directed his research toward solving practical challenges. He viewed NBRI as an institution not only for academic research but for social change, aiming to make science a means to uplift rural communities and improve lives. By the 1970s, his leadership had positioned NBRI as a beacon of applied environmental science, recognized internationally. Under his guidance, NBRI's research expanded into biomass energy, forestry, and reforestation—fields that were cutting-edge at the time and have grown even more critical in today's context of climate change.

Professor Khoshoo's expertise and commitment to sustainability led to his appointment in 1982 as the first Secretary of the Department of Environment (now the Ministry of Environment, Forests, and Climate Change). This was a period of substantial environmental awakening in India, as rapid industrialization began to take its toll on the country's forests, water resources, and biodiversity. Professor Khoshoo became the driving force behind the creation of some of India's most critical environmental policies and programs.

Professor Khoshoo's approach was unique for its time because it incorporated Gandhian principles of sustainability and ethics with scientific rigor. In his later years, he would delve deeply into Mahatma Gandhi's views on nature, ultimately publishing influential works that linked Gandhian values with modern ecological thought. He argued that Gandhi's ideals of simplicity, self-reliance, and local resilience were essential components of sustainable development, especially for developing countries like India.

His tenure in government service also marked the inception of India's biosphere reserves, policies on biodiversity conservation, and frameworks for pollution control. Professor Khoshoo was instrumental in laying the groundwork for environmental impact assessments, promoting the idea that sustainable development had to be central to India's growth. This was the period when he brought forward the concept of "ecodevelopment," a community-led approach to sustainable land use that harmonized local livelihoods with conservation. His policy work championed ecological balance not only as a scientific goal but as a moral imperative for India and the developing world.

Even after retiring from formal positions, Professor Khoshoo continued to influence environmental policy and discourse as a consultant and Senior Fellow at the Tata Energy Research Institute (TERI) in New Delhi. His extensive body of work—comprising research papers, books, and countless public talks—reflects his unwavering commitment to environmental sustainability.

He published widely on topics ranging from biomass energy and biodiversity to the ethical dimensions of resource use, emphasizing that true progress required harmony between people and nature. His writings inspired a generation of young scientists, policymakers, and activists to look at the environment not just as a scientific domain but as a space for ethical and community-centered action.

In one of his most celebrated books, *Mahatma Gandhi: An Apostle of Applied Human Ecology*, Professor Khoshoo explored Gandhi's environmental philosophy, advocating for "bottom-up" approaches to development that begin at the grassroots level. He believed that such an approach was vital for countries like India, where the majority of people depended directly on natural resources for their livelihoods. His writing on Gandhi provided not only a fresh perspective but also a powerful call to action for sustainable, community-driven development.

Professor T. N. Khoshoo passed away in 2002, leaving behind a legacy that continues to resonate in the fields of environmental science, policy, and education. His life and work serve as a reminder of the transformative power of compassion in science and the importance of integrating ethics into our relationship with the natural world. In today's global environmental challenges, his approach to community-centered conservation, sustainable policy, and ethical environmentalism offers a blueprint for a more balanced and sustainable future.

His legacy lives on not only through the institutions he built and the policies he influenced but in the landscapes he helped heal and in the lives he touched. Professor Khoshoo's work stands as a testament to his vision of a world where science and compassion work hand in hand to create a sustainable, equitable, and harmonious relationship between humanity and nature.

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I first came across Professor Khoshoo's work as a graduate student of Botany. At the time, I was studying a succulent plant from the Himalayas, which proved challenging to cultivate in the lowlands near our laboratory in central India. Given the taxonomic complexities of the group, I wondered if cytological studies could shed any light. However, my efforts to grow these plants in the central Indian landscape had failed, and most standard protocols required fresh tissues for cytological studies, such as the aceto-carmine squash method. This led me to question whether it might be possible to obtain chromosome counts from dried herbarium specimens. A quick search brought me to a 1956 paper titled *Chromosomes from Herbarium Sheets of Impatiens* by T. N. Khoshoo, published as part of his Ph.D. thesis. In this study, he demonstrated that chromosome counts could reliably be determined from pollen present in herbarium specimens. Adapting his method provided immense relief, enabling me to successfully replicate and study the chromosome counts of the species I was working on using dried herbarium collections.

After completing my Ph.D., I was honored to accept a postdoctoral fellowship named after Professor Khoshoo at ATREE, Bangalore. This role allowed me to align my botanical studies with his remarkable body of work and gain insight into his multifaceted persona—not only as an exceptional botanist and scientist but also as an administrator and eco-philosopher. My interest in sustainable farming and Gandhian philosophy deepened my appreciation for Professor Khoshoo's contributions. Last year, his family generously donated his extensive collection of books, notes, photographs, and other archival materials to ATREE. These archives, including his post-publication notes, provided invaluable insights and additional context, enabling me to better understand his legacy.

Professor Khoshoo authored over 250 academic papers and numerous articles for wider audiences, showcasing his ability to communicate effectively with academic peers, policymakers, and the public. He was also an eloquent orator, adept at clearly articulating his ideas. In the later years of his life, his writings

focused on sustainable development, Gandhian principles, and the philosophy of Sarvodaya. He advocated for a bottom-up approach to development, for the upliftment of marginalized communities alongside nature conservation and sustainability. As M. S. Swaminathan aptly described, Professor Khoshoo was indeed "a dedicated strategist for human survival."

Compiling a selection of articles from Professor Khoshoo's extensive writings—spanning over five decades of scientific research and public discourse—was no small task. Fortunately, the CSIR had previously published a volume of his works on cytology and evolutionary genetics, and some of his talks had been compiled into a book. However, his timeless articles on sustainable development and deep ecology, written during the late 1980s and 1990s, were scattered across various journals. We decided to consolidate some of these writings into thematic volumes.

As this volume is being released during the 21st T. N. Khoshoo Memorial Award and Lecture, focusing on the theme of "Reviving India's Ecosystems," we have included a chapter on the restoration of Banthra, a pioneering project led by Professor Khoshoo. Chapter 1 of this book documents the efforts and impacts of this remarkable restoration initiative, offering valuable insights and a model for similar projects in the future.

I extend my heartfelt thanks to Raj Khoshoo and his family for their unwavering support to ATREE in preserving Professor Khoshoo's work and wisdom through the T. N. Khoshoo Memorial Award and Lectures over the past two decades. Their recent generous donation of archival materials to ATREE has been instrumental in enhancing and compiling this volume. I am also grateful to the Current Science Association for granting permission to reproduce several articles from the journal in this volume.

Finally, I sincerely thank Anita Arjundas, ATREE's Executive Director and Ravikanth G., my postdoctoral advisor for their encouragement and for allowing me to digress from my academic research to work on this book as part of the T N Khoshoo Postdoctoral Fellowship.

These writings not only offer a glimpse into the thought processes behind India's environmental policies but also serve as a valuable historical resource. While many of the goals that Professor Khoshoo advocated for have been achieved, much remains to be done. Most of these writings were composed during a critical period when India's economy was opening up to the world post-liberalization, and the impacts of environmental degradation were becoming increasingly evident. I hope readers will keep this context in mind while exploring the volume.

These writings not only offer a glimpse into the thought processes behind India's environmental policies but also serve as a historical resource. I sincerely believe that this book will serve as a source of inspiration for future generations of biologists, policymakers, and the public.

Prasanna N. S.
T. N. Khoshoo Postdoctoral Fellow
Ashoka Trust for Research in Ecology and the Environment

THE SCIENCE OF RESTORATION

While at NBRI, Lucknow, one of T. N. Khoshoo's major initiatives was the eco-restoration of degraded lands in Banthra, Uttar Pradesh. Once an alkaline, barren expanse unsuitable for cultivation, Banthra was transformed through his visionary leadership. Professor Khoshoo assembled a multidisciplinary team of experts, including botanists, agricultural scientists, and soil specialists, to develop and implement a scientific restoration plan. Today, Banthra stands as a living testament to his efforts. His approach was simple yet revolutionary: transform wastelands into productive ecosystems by actively involving local communities. Over two decades, he spearheaded a project that trained rural communities to grow medicinal plants, cultivate biomass for energy, and use native flora to regenerate barren lands. The following chapter documents the efforts and impacts of this restoration project, offering valuable insights and a replicable model for similar restoration initiatives across the country.

1
ECODEVELOPMENT OF '*USAR*' LAND AT BANTHRA

Land is a finite resource, and due to increasing population and escalating demands associated with accelerated developmental needs, there is a considerable pressure on land on account of the competing land uses (Khoshoo, 1986). It is therefore, natural as well as necessary that our country with a very high man-to-land and animal-to-land ratios should turn its attention to the less fertile and problematic soils which are at present lying fallow. Of the 158 million hectares of such land in the country, nearly 7 million hectares are saline and alkaline (*usar*) and have been regarded as unfit for agriculture on account of high concentration of soluble salts and exchangeable sodium. The pH goes upto about 11. A layer of kankar (calcium carbonate concretion) is present at a depth of about a metre below the surface. The soil suffers from water logging as it is impermeable. Every year the country is adding substantial acreage to such derelict land on account of salinization due to irrigation and a host of developmental activities including mining. Development of all such land is urgently called for to relieve pressure on the arable land.

In fact, development of salt-affected land is a global problem, even when the world as a whole has enough good land to meet the needs of the projected population growth. Many countries do not have enough arable land resources to be self-sufficient at least in food and fuel. There is, therefore, a need to take steps to enhance yield, intensify production and develop potentially productive wasteland. Nearly 7% of land at the global level is salt-affected (Dudal and Purnell, 1986). In order to achieve full potential from such lands, studies on their distribution, classification and productive potential need to be undertaken in conjunction with the prevailing social and economic conditions in the area.

So far these lands have not been put to any productive use because of the severe soil and climatic constraints. However, such lands offer a major R & D challenge and merit increased attention.

In 1956, the late Professor K.N. Kaul, the Founder-Director (1953-65) of the then National Botanic Gardens (later renamed in 1978 as National Botanical Research Institute) had started a project on the reclamation of *usar* soil at Banthra (on Lucknow-Kanpur Road) involving organic amendments and biological methods and growing alkali-tolerant herbaceous, shrubby and tree species, both domesticated and undomesticated. This work benefited the small farmers through intensification and diversification of biomass production for food, fuel, fodder, fertilizer, medicare, small timber, animal husbandry, aquaculture, bioaesthetics, soil amelioration, small vocations for villagers, better micro-meteorology, etc. The guiding principle of the work was to involve people so as to promote decentralized small-scale community-based development. There are reasons to believe that in the historical past the condition of the land at Banthra had been quite different. The area was known then as 'Vani Banthra' indicating that it had a thick blanket of forest trees. Sen Gupta (1986) collected stone implements, pieces of pottery. earthen toys, sand stones, matkas, grey pottery, bricks, etc., from the mounds lying in villages of Aurawan, Pipersand and Hamirpur-Banthra. Even now, these objects are strewn all around

the mounds. He feels that these relics may be older than the Aryans. Obviously, settlements existed during 5000 BC to 600 AD. Perhaps, following the loss of vegetal cover, the ravages of increased salinity and alkalinity might have ultimately resulted in vanishing of these settlements.

Socio-Economic Scenario

The common resources afford benefits by way of physical products (food, fodder, fuel, timber, water, manure, silt), income generation (additional income through crops, cattle, petty trading, handicrafts, etc.) and social gains (conservation of resources, drainage, recharge of ground water. renewable resource supply, better micro-climate and environment, etc.). Furthermore, the common resources help in traditional farming systems which become stable due to integration of crops, livestock and fuelwood.

Normally, villagers get unaccounted benefits from common resources of a village. The common resources are accessible to the whole community and no single individual has exclusive rights on them (Jodha, 1986). The dependence of rural poor on these is 84 to 100%. Among other things, the common village benefits are:

- Silt from river and tank beds for enriching land;
- Free firewood from community woodlands;
- Free fodder and grazing space for maintaining livestock and draft animals;
- Private cropland available for grazing after harvesting crops;
- Community ponds, wells and tanks, rivers, rivulets, etc., for water and free irrigation and off-season crops;
- Watershed drainage;
- Animal watering points:
- Common rubbish heaps/waste dumps for feeding pigs and chicken;
- Fish from rivers/ponds;
- Thatching materials collected from forests;
- Grass collected from wild species for ropes and baskets,
- Construction and fencing materials (mud, thatch and poles);

- Seeds, fruits (jujube, etc.); flowers (mahua), leaves (bidi, pattal); toddy, tooth sticks, honey, etc, from wild species.

In the historical past, about 80% of the natural resources were common property and provided a resource base for non-cash and non-market economy and a whole range of basic necessities of life. These were freely available. Life was simple. However, the system worked well as long as people were few, resources were in plenty, and regenerative capacity of an ecosystem was greater than the degradative process.

Today this is no longer the case because of the continued dependence of villagers on common resources of the village, which shrink and result in degradation of the resource base and serious loss in their productivity. However, on account of the escalating demand and chronic shortage, the villagers often spend an increased amount of time in gathering resources from farther and farther places. In time to come, it affects the very biomass base on which the poor depend. In turn, the poor villagers are unable to sustain themselves and they often mortgage and even sell their land and soon they are deep in debt, losing their assets like land and livestock, which end up in the hands of the "*non-poor*". Such are the socio-economic conditions under which a majority of the Indian villagers in eastern Uttar Pradesh, Bihar, Orissa, Rajasthan and even Madhya Pradesh eke out their living. It is, therefore, not surprising that poor villagers from eastern UP and Bihar now go in large numbers to Punjab in search of livelihood as seasonal agricultural labour.

To bring a villager out of such a state of penury is not easy and the only way to do so is through cooperative action, and food-for-work programmes. The food-stocks can be utilised to employ idle village labour not for building kuchha roads (as is the common practice), which vanish after the very first monsoon, but to harvest rainwater in ponds and tanks, dig village wells, raise firewood and fodder, take to contour bunding and terracing, make percolation channels,

control water logging, etc. Such schemes would go a long way to mitigate the poverty of the villagers.

Due to very low productivity of *usar* land, the people had been living in dilapidated conditions at Banthra. Agriculture was dependent only on rain and farmers could hardly harvest one crop per year from their fields. On account of poor fertility status of land, underdeveloped infra-structure and no other source of income, the people continued to be poor and often resorted to crime.

Starting ecodevelopmental work under such conditions required conviction on the part of those who were to run the project. Further, under such conditions of penury, the will, self-confidence and initiative of the villagers were gone and no villager in such a grim situation would believe that anything was possible to relieve his poverty. The only way was to demonstrate that it was possible to retrieve the situation, because seeing is actually believing. This meant great dedication on the part of those who were to carry out the project.

Land and Water

The revenue records indicated the land to be barren, and except for very sparse growth of grasses and isolated plants of Calotropis procera, the land did not support any worthwhile vegetation. High sodium content deflocculates the soil and makes it amenable to the vagaries of nature, landing to soil loss due to erosion through wind and rain. Furthermore iron nodules were found in the soil profile, drainage was poor, alkalisation was severe, water table was at 4-5 m, pH was 8.5-11, electric conductivity at 15 cm depth was 0.7 m mhos/cm and exchangeable sodium percentage ranged between 40 and 73%. Average organic carbon was 0.2%, available phosphorus 7.9 kg/ha and potassium 300 kg/ha. The general feeling was that working with such land held bleak prospects.

A very small group of enthusiastic and dedicated workers led by Mr. Virendra Chandra was picked up. Soon after his arrival at Banthra, Mr.

Chandra set up an operational centre in a thatched hut in the midst of barrenness. The group prepared contour maps, constructed embankments across the gradient and dug trenches all over which served both, as water reservoirs and drainage channels. The first task however, was to ensure water. The rainwater was stored in a pond and excess was let off in Nagwa Nala. The land was levelled and 0.5 to 2 ha large plots made to allow uniform spread of water during irrigation. Side by side, 14 cavity tube-wells were sunk (20-25 m deep) which gave a discharge of about 13,000 g/hour. A cavity tubewell, complete in all respects, costed Rs. 3,700 in 1956-58.

Administrators, visiting the area in 1956 prior to the start of the work, had felt that the experiment was bound to fail like the previous ones. The local people believed that cultivation on such hard barren black alkali land meant high-cost inputs with no returns. Before the work was to start, the local people expected that big machinery like tractors, bulldozers, subsoilers, rollers, etc., will be used. However, soon they found things were different.

Since the very inception of the project, the leaders of panchayats (village councils at the grass root level) were associated with the work. They saw that the senior scientists, who were responsible for the project, started working by living in thatched huts in the barrenness. This created both interest in and respect for those who were involved in the project. The local people were fully involved and even the daily wage labour was selected in consultation with the representatives of the panchayats. This helped the institute in gaining the confidence of the local people.
Analysis of irrigation water has shown that it is free from sodium hazard and is of good quality. The slightly higher than the prescribed limit of bicarbonates can be countered by addition of gypsum which can reduce the harmful effect of the residual sodium carbonate.

The Approach
A distinctive feature of the work was the use of any easily available organic matter for improving the soil. The organic matter principally

included green manures like dhaincha (Sesbania bispinosa), dung and weeds like Argemone mexicana. Addition of the Argemone powder before planting paddy brought down the pH of the soil. This helped in the establishment of paddy seedlings. Between 1956 and 1973, the land was transformed, and is today supporting a woodland, grassland and a cropland. In general, it may be said that once a tolerant species got established, it encouraged growth of relatively less tolerant ones. In this process, there was an overall improvement of soil.

The algae, fungi and the weeds growing on the *usar* soil of Banthra were recorded. Out of the 43 species, the most common species of weeds in 1956 were grasses (17 species), followed by members of Compositae (6 species), Leguminosac (4 species) and others.

However, in 1974, the same spot had 68 species (1.5 times increase) and the profile had also changed. While the number of grass species decreased by about 50%, those of Compositae and, in particular, Leguminosae increased by 150 and 300% respectively. Furthermore, 18 species belonging to 15 families, not encountered earlier, were found to be quite common. The increase was not only in the number of species but also in their density. Initially, weeds were mostly found during and after the rainy season but in 1974 these were seen to grow profusely all the year round. In fact, in 1974, some of the crops (like Mentha arvensis) could not grow well because of excessive weeds. Today some weeds have also become noxious. Prolificity of weeds may also be a sign of soil fertility.

Cropland
Regarding use of *usar* as cropland, the major problem is the inhospitability of the habitat for the conventional crop varieties which have been bred in good habitats. There are, therefore, hardly few cultivars as such suited to *usar* land, in fact not much attention has been paid so far to this aspect. Furthermore, while there are studies on the physiological and ecological aspects of the adaptation of plants, the genetic basis of tolerance or resistance to the harsh

conditions has never been worked out. Time has come when our breeding strategy has to change from the one where habitat/land is tailored to suit the requirements of a high-yielding cultivar, to where we tailor the cultivars to suit the harsh and ordinarily inhospitable habitats. As long as this does not happen, existing varieties of crop plants have to be evaluated for their response to *usar* land.

The general first-aid step recommended for the amelioration of alkaline land is to grow dhaincha (green manure), followed by paddy for a few years. The reasons are obvious. However, in the present case organic amendments like Argemone powder, dhaincha, dry leaves, paddy husk and straw and farmyard manure were also used. Argemone powder helped to reduce the pH and increase the establishment of paddy seedlings with reduced mortality and enhanced yield. There was also noted a residual effect of the application of Argemone powder as evidenced by increased yield of onion crop grown on the treated plots (Chandra and Misra, 1987).

The evaluation of sunflower trials has shown that the crop can be grown on soils with moderate levels of alkalinity but oil production is significantly low. However, *usar*-tolerant/resistant varieties will need to be specially bred. Among other oil crops safflower, linseed, mustard and niger were tried (Chandra, 1987; Misra, 1987; Khanna, 1987). Although their performance was not the same as on good soil, safflower and niger did perform relatively well. The former is cost-effective.

One variety of cotton (Pramukh) performed reasonably well and it can be used for near-economic cultivation on alkali soils. Increase in the yield can be obtained with the application of nitrogen, supplemented with phosphate.

Triticale did not fare well. Although due to its preferential accumulation, sugarbeet is regarded as a scavenger of sodium, it has not performed well both regarding the yield of root biomass and sucrose/ha. Sugarcane is regarded as a salt-tolerant crop,

but only one variety (CO 951) performed reasonably well as far as yield of biomass, sucrose percentage and purity were concerned. Both sugarbeet and sugarcane may hold promise, after more work, as possible energy crops on *usar* land. This is particularly true of sugarcane because it gives higher alcohol yield/ha.

Vegetables and fruits have not received the attention they deserve. This is particularly true under the village setting where people are in need of improvement in the quality of their diet as vegetables provide essential nutrients, including minerals and vitamins. In a village setting, these have to be produced in a decentralised fashion because they are both seasonal and perishable and there are no marketing facilities. Towards this end, ICAR planned Nutritional Gardens in which a total package was worked out to grow vegetables and fruits round the year for a 5-7 member family on a small plot of land. The size of the plot is well within the physical capacity and other facilities of an average peasant family. At Banthra it has been possible to grow 40 different kinds of vegetables. In addition, 17 different fruit trees can also be accommodated in an overall area of 33.5 x 20 m (670 sqm) inclusive of the vegetable garden (13 x 30 m or 390 sq m) (Misra, 1987).

The data on the trials of grapes on *usar* land show that Beauty Seedless and Gulabi are both amenable to head system of training and can be conveniently grown for domestic consumption. In fact, both these cultivars are promising candidates for commercial plantings on moderate sodic soils.

Commodity and industrial plants: A number of aromatic plants were tried on *usar* soil and some of these performed reasonably well, both in terms of biomass production and quantity and quality of oil. Special mention may be made of vetiver which has the exceptional ability to withstand high pH as also waterlogging and is one of the very suitable candidate species. Growing this species is least expensive as no amendments or fertilizers are needed for its establishment. The crop matures in 15-18 months. In fact, this was

one of the preferred species as a first aid to reclaim the soil. The species is valued for its aromatic roots (khus) and its essential oil is in demand in cosmetic and perfumery industries (Sharma et al., 1987).

Closely following is German Chamomile which has performed exceedingly well and is another important species whose techno-economics has been established. It is a winter crop grown in rotation with paddy. Its high salt uptake helps to decrease salt concentration from the top soil in *usar* land, thus making it exceptionally suitable for cultivation on sodium-saturated soil (Misra, 1987).

Henna, cymbopogons and umbellifers (celery, fennel, coriander, dill, trachyspermum) are also very promising species for cultivation of *usar* land. Same is true of tuberose which also has ability to remove sodium from the soil and its cultivation is techno-economically feasible. Closely following is damask rose, yielding rose oil (itar), rose water, gulkand, etc. All these items are in demand in indigenous aromatic industry.

In the next category are cymbopogons, ocimums and mints, followed by jasmine, eucalyptus and tagetes, which can be grown on alkaline land reasonably well.

From the foregoing account, it is clear that the cultivation of vetiver, German Chamomile, henna, umbellifers, cymbopogons, tuberose and damask rose is techno-economically feasible as a cottage scale industry.

Betelvine is both successful and remunerative provided diseases are controlled effectively. A complete technology for the same has been developed. In fact, this crop requires intensive cultivation and is then economically viable (Balasubrahmanyam, 1987).

Seed gum yielding legumes, such as guar and dhaincha in particular, and species of Cassia and tamarind in general, can be grown

successfully and the benefits are both direct (economic) and indirect (soil amelioration). Gum exudates from species of Acacia, Prosopis and other legumes offer another important economic possibility (Farooqi, 1987).

Winged bean has performed very well on *usar* soil. Apart from its tender green pods used as vegetables, the seed can be used as pulse, and as a source of carbohydrate (22-35%), protein (31-39%) and oil (14-17%). The plants also yield thick fleshy roots with good quality starch (25%) (Misra, 1987). This species is a new introduction to North India, particularly, to the *usar* belt. While it has yet to become a commercial crop, the villagers are now growing a few plants in their backyards for its tender pods.

The people in the *usar* belt are predominantly vegetarian. Apart from pulses, another way the protein deficiency can be supplemented is by growing mushrooms on crop-waste like paddy and wheat straw. It has been possible to raise crops of mushrooms in cool places in a mud house, throughout the year by growing various species at different times of the year. Agaricus bisporus (September 15 February 15), Pleurotus flabellatus (February 15-May 31.), Volvariella volvacea (March 25-July 15), Pleurotus cystidiosus (June 15-October 15), P. sajor-caju (October 15-February 15), and P. eous(October 1-March 15) (Pathak and Goyal, 1987).

The technology is simple and can be followed by a villager. The spawn, however, was supplied by the Mycology Division of the NBRI. In villages, there are taboos associated with mushrooms. Initially, there was considerable reluctance on the part of villagers to grow and, particularly, to eat mushrooms, However, with better awareness, it was possible to bring them round and convince them that mushrooms are an article of diet and have considerable economic potential once supplies are made to urban areas on a sustained basis.

Traditional medicare: The allopathic system of medicine is available only to about 20-25% of Indians and that too in the cities and towns; for the remaining 80% living in the rural areas, it is the traditional system which is relevant. The "Grand-Mother Remedies" are still in vogue in villages of India and of late, there has been a tremendous resurgence of interest in the western countries in the traditional systems of medicare. Of the 113 species of herbal drugs from Ayurvedic and Unani systems relevant to our conditions, nearly 93 are being grown on *usar* land at Banthra. These are essentially used to cure routine ailments (Sharma., 1987).

Grassland

Fodder is an important element in socio-economic life of the rural people because most farmers/villagers maintain some livestock. Generally, fodder is not grown and cattle are let loose to graze on the naturally growing grasses, such as, species of Sporobolus and other genera (Chandra, 1987). However, uncontrolled and excessive grazing ultimately results in ecodegradation. A number of forage crops, particularly berseem (Trifolium alexandrinum), can be grown in the very first instance which by itself results in soil amelioration followed by higher paddy yields. Some varieties of Pennisetum pedicellatum (Dinanath or Dinabandhu grass) give fairly good yields as do some of the fodder legumes like berseem.

Abrol (1986) has reported that Diplachne fusca, Brachiaria mutica and Chloris gayana are promising grasses on *usar*. Under irrigated conditions a dry matter yield of 20-25 tonnes per hectare per year can be obtained with some of these species. With the growth of grasses there is a reduction in soil sodicity and an improvement in infiltration and better recharge of good quality rainwater.

Woodland

A high percentage of fine particles in *usar* soil increase the problem of poor aeration and poor water transmission. These together with the presence of kankar pan give a short life span to the trees on *usar* land. The best method to plant trees is in pits (2m X 2m) that

are in deep where kankar layer is broken if it is not at a greater depth (Chaturvedi, 1987). The same results have been obtained by the Central Soil Salinity Research Institute, Karnal, by piercing 15 cm wide holes in the calcareous pan by use of auger (Abrol, 1986), otherwise the cost of breaking kankar itself will become prohibitive. The excavated earth needs to be exposed to sun for weathering for at least a month. Amendments to the soil can be added after proper soil analysis.

These can be in the form of green manure, or addition of organic matter such as leaves, husk, farmyard manure or chemical amendments like pyrites and gypsum. At Karnal, the auger hole is refilled with a mixture of the original soil, gypsum and farmyard manure (25:1:4) (Abrol, 1986). Availability of sweet water has also to be ensured.

The best time of planting trees is soon after rainy season (i.e. September-October) when soil pH is low. Immediately thereafter, there is a relatively dry season and sometimes later, even frost. For the success of plantations, irrigation is essential but it has to be light and frequent. Mulch, wherever possible, may be provided. In this manner by the time the next monsoon sets in, the trees are reasonably well established and can stand waterlogging.

Planting on mounds, though often practised during rainy season, does not succeed. Such plants not only die during drier periods but also get uprooted easily by storms. The area needs to be fenced either with barbed wire, or with a trench and a ridge or even live fence of suitable shrubs, preferably possessing thorns which can prick the bellies of the grazing animals.

The selection of species is site specific. Major considerations are: capacity to recycle nutrients at a faster rate. N_2-fixing ability, large leaf litter, shading of the ground, ability to absorb larger quantities of salt, surface root system, high regenerative and coppicing ability, etc. Experience has shown that nearly 22 tree species and 3 shrub

species as also bamboos can be planted. Foliar spray of 1% zinc plus iron and 1% urea at the time of new growth in April or September helps considerably.

A statistically designed experiment, to assess the biomass production of 12 species, has been laid out, in collaboration with UP State Forestry Department. In each species, replicated 3 times in a randomized block, 1875 saplings, spaced 1.5 m x 1.5m, have been planted in 36 plots measuring 41 m x 41 m each. The seedlings were raised in February 1981 in polythene bags and transplanted in the experimental site in October 1981. Prior to planting, each plot was irrigated to field capacity. In all 22,500 saplings have been transplanted covering an area of 10 hectares. The species included in the study are: *Acacia nilotica, A. auriculiformis, Albizia lebbeck, A. procera, Azadirachta indica, Dalbergia sissoo, Eucalyptus hybrid, Leucaena leucocephala, Pithecellobium dulce, Pongamia pinnata, Prosopis juliflora and Terminalia arjuna.*

In another experiment, five fast-growing firewood shrubs, viz. *Vitex negundo, Hibiscus tiliaceus, Sesbania sesban, S. grandiflora and Leucaena leucocephala,* were evaluated for their biomass yield and suitability for combustion.

The concept of short-rotation forestry (SRF), as applied to firewood crops, is relatively new, and information on plant spacing response to fertilization and coppicing disease and pest resistance, etc., is not available for the species under study. Therefore, a series of silvicultural trials have been laid out to collect data on these aspects. High density plantings of *Terminalia arjuna and Leucaena leucocephala* have also been established by planting 10,000, 20,000 and 30,000 plants in 55 m^2 plots, with each have also replicated 6 times in a Randomized Block. A coppicing trial with *Leucaena leucocephala* to be harvested at yearly intervals, has also been laid out. These trials would yield useful basic data for evaluating the economic feasibility of short rotation forestry of firewood crops on marginal soils (Misra, 1987).

Realizing the need for a low technology solution to the use of fertilizers, which militates against the basic philosophy of minimizing energy inputs in managing firewood plantations, fast-growing leguminous species, indigenous as also exotic, have been included in the study to assess their nitrogen fixing capacity.

Productivity of biomass (wet and oven dry) as estimated after 3 years from destruct sampling shows that the best species is *Prosopis juliflora followed by Acacia nilotica and Eucalyptus hybrid, Terminal arjuna. Auriculiformis, Alibizia spp, Pongamia pinnata,* and Dalbergia sissoo. Other species stagnate, indicating their unsuitability.

The rotation should not be less than 6 years and may go up to 10 years in the case of some species.

Based on the studies at Banthra, the cost of afforestation/ha at 1984 level would be Rs. 10,000 and a return of 4 oven-dry tonnes (ODT) of firewood per year per hectare is reasonable. If the harvesting age is 8 years, the 32 ODT of firewood would give Rs. 16,000 at Rs. 500 per tonne. This would give Return/Investment ratio of 1.6 in 8 years and a compound interest rate of 6%. Added to this are factors like appreciation of soil value, as also land value. A second crop would be far more remunerative (Chaturvedi, 1987). When one considers the fact that this land produces nothing at present, the modest return of even 6% is not small. To this can be added social and environmental benefits as also economic ones by way of generation of rural employment.

A number of species of acacias and eucalyptus received special attention. These species are indeed multipurpose, ranging from protective hedges to plantations for tannins, gum, fodder, timber, pulp, fuel, etc., depending on the individual species (Srivastava and Srivastava, 1987).

The firewood crisis is very acute and if we start planting trees today for firewood, it will not be before 6 years that the first signs of firewood production would be visible. During the interim years, the shortage would aggravate further unless we go in for such species that can meet most immediate village needs. The logical choice is firewood shrubs planted as high-density and short-rotation biomass. Obviously, such biomass would be in the form of sticks which is what an average farmer uses all the time namely stems of *arhar (Cajanus cajan)*, cotton, jute, sun-hemp, *dhaincha* and even wild growth. Such fuel provides for subsistance fuel needs. Out of the 5 shrub species, the results so far have shown that *Sesbania sesban* (*aegyptiaca*) has out yielded, particularly, at higher densities (25,000 and above per ha), the others species. Maintenance of higher population per ha has been found conducive to the increased biomass production. A yield of 2.0 to 4.8 t/ha of air dried fuel per annum has been obtained from the shrubs cultivated on *usar* land. The species recommended are: *Hibiscus tiliaceus, Vitex negundo, Sesbania grandiflora and S. sesban* (Misra, 1987).

Marked changes in soil composition in respect of its pH, EC and organic carbon were registered and these brought about definite improvement in soil conditions as indicated by increased Ca/Na ratio.

Abrol (1986) has observed that at Karnal the most promising species for alkaline soils appear to be *Acacia nilotica, Casuarina equisetifolia* and *Prosopis juliflora.* A fuelwood yield of 2-3 t/ha/year was obtained by him from plantations of *A. nilotica* over the four years from prunings of horizontal growth.

Aquatic Biomass

The artificial water bodies (ponds, channels, etc), constructed to drain water in order to prevent water logging, were planted with water plants, both wild and economic (Chandra, 1981). Among the latter were salix, trapa, scirpus, typha and nelumbo. While no estimate of aquatic biomass production was made, the species appeared to

thrive very well. There was also noted ameliorative effect on soil as well. Fish and geese also did well in man-made water bodies.

***USAR* tolerant species and soil amelioration**

Knowledge about mineral composition of plant parts of the woody perennials grown on *usar* land gives an idea about the sodic tolerance of plants. Species that accumulate maximum amount of sodium and absorb nutritionally adequate levels of calcium and magnesium from low concentrations in soil solution are the ones that are more tolerant to such conditions. Based on this approach, fruit trees like jujube, followed by *aonla (Emblica officinalis)* and guava, are tolerant to soil sodicity. Among the firewood species, *Prosopis juliflora*, followed by *Acacia nilotica* and *Terminalia arjuna*, are also tolerant to soil sodicity (Kanduja et al., 1987).

These observations on firewood species tally with their biomass production. The same is true of a number of ornamental shrubs which show fairly high tolerance and adaptability to alkali soils. Thus there are a number of tree and shrub species available which can tolerate rather inhospitable conditions of alkali soils and can be used for food, fuel and for purposes of landscaping.

Connected to the tolerance studies are the studies on ameliorative effect on the soil after trees and shrubs get established (Verma et al., 1987). This was done by comparing data on soil at the start, and as prevailing now. There is definite amelioration of soil under jujube, followed by other fruit trees like guava, aonla and mango as is clear from the overall reduction in soil pH, electrical conductivity and exchangeable sodium and increase in potassium and organic carbon due to decomposition and mineralisation of litter beneath the canopy.

The other tree species, which are a part of the man made forest, began as plantations over 25 years ago. Here the litter deposition over the years has changed soil texture with the result that annuals form a good ground cover. It is obvious that afforestation with any

tolerant tree species helps in improving the soil by reducing its pH and increasing its organic carbon content. This is found in the top 30 cm layer of the soil. The mixed canopy of *Acacia nilotica, Syzygium cumini, Ficus bengalensis, Emblica officinalis* and *Dalbergia sissoo* was very effective in reducing pH (Verma et al., 1987). Data show that different tree canopies have greatly improved soil composition due to humus deposition. However, heterogeneity in the chemical composition of forest soil can be related to the litter types.

Ecodevelopment

The *usar* with its high pH, poor permeability and presence of impervious hard pan at 1 m depth supports very sparse vegetation. In fact one finds the micro-relief of the *usar* land rather heterogeneous. Even a moderate rainfall or light irrigation creates a situation with micro-runoff and micro-erosion from higher to lower spots. This makes the whole area ecologically intolerable to most plants. Such a saline-alkaline barren land has been called halosere.

Essentially there are two approaches to the ecodevelopment of *usar* land; either by improving land and planting high-yielding crop species, or by screening and identifying from amongst the existing species or even by designing new ones that can tolerate sodicity. The latter alternative is relatively far less costly and, in course of time, due to litter fall and its consequent decomposition and mineralisation, even improves the soil.

At the outset, it became apparent that it was indeed not practicable to grow anything worthwhile in the absence of suitable shelter belts to reduce the velocity of wind and check wind erosion and conserve soil moisture. Recourse was, therefore taken to contour bunding, digging pits, breaking hard pan and filling the pits, and planting tolerant species together with the connected operations like irrigation, etc. In fact, providing ground cover of hardy creepers and/or salt-tolerant shrubs greatly improved the land and helped the tolerant tree species to establish. The utilisation of halosere was possible through a series of well-conceived, essentially low-

cost successional stages and utilisation of biomass amendments, followed by cultivation of carefully selected tolerant species. As soon as the plants were established, they, in turn, contributed to the physical, chemical and biological changes in the rhizosphere.

During the period 1956-83, there developed a man-made forest leading to a climax terrestrial mini- ecosystem which is inhabited by wild-life of a number of small mammals, reptiles, birds (including peacocks) and insects. The tolerant trees and shrubs improved the soil and made it hospitable for less tolerant species. Thus a piece of land that was totally barren and desolate is today a self-sustaining green patch with a top storey of trees, middle storey of shrubs and a ground cover of herbs.

It was also observed that algae inhabiting the halosere were able to make the land hospitable for grasses and weeds, resulting in a grassland ecosystem dominated by some grasses. The grassland, over a period of time, can get converted, in a natural succession, into a shrub community and then lead to a climax forest. However, the same can be achieved by biotic influence and successional changes induced by alkali-tolerant tree and shrub species.

With the accumulation of litter and organic matter, there follows a decomposer succession leading to soil amelioration. This makes it possible for new plant communities to invade. Thus, the forest ecosystem, which was dominated by trees forming the top storey, was followed by a middle storey of shrubs and then a ground storey of grasses and herbs. Apart from the plant communities, there are decomposers like bacteria, fungi and earthworms and the wild life. These aspects have not been studied.

The cropland ecosystem has also been developed, utilising a mixture of food, oil and aromatic plants that are tolerant to sodicity. Unlike forest ecosystem, where community respiration may balance community production, in the cropland, the production is greater

than respiration, with the result, that the harvest is the removable product of the ecosystem.

Thus halosere has given rise to cropland, grassland and woodland and wilderness areas. The rainwater when impounded in artificial water bodies and planted to salix, typha, trapa, nelumbo, scirpus and nymphaea, associated with fish and geese led to aquaculture development. All these systems, if managed on ecological principles, can be utilised for both tangible and intangible benefits to the human being.

Bio-aesthetics: A number of trees of ornamental value have done well and can be used for beautifying the *usar* land. In fact, a very nice park with a 2 acre lawn, all round, bordered with ornamental trees, has been laid at Banthra (Bhutani, 1987). The ornamental tree species that have proved exceptionally hardly belong to the *genera Acacia, Albizia, Azadirachta, Bauhinia, Butea, Callis-temon, Cassia, Cordina, Delonix, Erythrina, Ficus, Lagerstroemia, Millettia and Thespesia.*

Besides, there are a host of ornamental shrubs that have been grown for beautification purposes, particularly, belonging to Acanthaceae, Apocynaceae, Malvaceae, Oleaceae (*Jasminum, Nyctanthes*). Rutaceae and Verbenaceae. Other successful shrubs are bougainvilleas, ixora, hibiscus and roses. Besides, a number of summer and winter annuals have also been grown as annual borders. In the conservatories, a number of foliage plants, palms and ferns have also been grown. In water bodies, as indicated above, a host of aquatic plants, including nympheas, have been grown. In short, the drab and dusty landscape has been made very aesthetic and pleasing.

Strategy

The *usar* land lying barren at present is either in the possession of Gram Samaj (Village Council) or individuals. The former is in relatively large blocks, while the latter is in the form of small holdings of 0.5

to 2 ha. The present study has shown that such a land can be put to use. However, these lands have heterogenous micro-relief and it is not possible to have one strategy for all alkaline lands. What is being advocated here is a general strategy for such lands in Uttar Pradesh (Chandra and Khanduja, 1987). The following are the important steps involved:

- Soil survey and testing -This involves demarcating the land into different categories for its suitability for use according to its capability and fertility status, followed by enclosure of the area to check free access of humankind and grazing animals.
- Field layout-Proper layout is necessary. This should involve digging of trenches around the field to ensure proper drainage and to prevent soil erosion, laying of plots of suitable size and levelling of land. Planting of proper shelter belts helps to reduce top soil loss.
- Irrigation- This needs to be ensured by sinking cavity tube-wells both for irrigation and for serving as vertical drainage for high ground water table. Testing of water is important. Storage of excess rainwater should be ensured for recycling for irrigation purposes.
- Fertilization- Collection of all unwanted vegetation and leaving it to rot in the pits and adding such organic matter as crop residues, green manure, dung etc. to the soil to improve its fertility. Green manuring and blue green algae hasten reclamation process.
- Selection of proper crop species and rotations- This has to be done keeping in view the end use, like food, fuel, fodder, fertiliser, fibre, medicare and small agro-based vocations for the local people (Khoshoo 1987). For getting the best out of this land, the farmer will need to diversify to suit his particular agri-silvi-horti-pastoral requirements. Suitable mix of annual and perennial species will have to be used. Work can start with paddy, berseem, vetiver, dhaincha, Prosopis juliflora, etc. to be followed by less tolerant species. The most important point is to keep the land under appropriate cropping pattern continuously so as to derive full benefit of reclamation process.

Socio-economic change

Voluntary bodies: Before the start of the project, the idea of utilization of alkaline soils to the people of the area, was nothing but an unremunerative exercise. However, once the villagers saw things for themselves, they began to change their opinion. The time was ripe to organise voluntary bodies like the *Krishi Parishad, Vigyan Mandir and Krishi Pathshala. The Vigyan Mandir* (School of Science) was started where workers and villagers were persuaded to acquire practical knowledge on *usar* land management. They were taught by specialists both within and outside the Institute and were encouraged to ask questions and offer suggestions. There used to be free and frank discussions. This gave them a feeling of being an integral part of the cooperative effort in harnessing *usar* land. During these meetings, plans for development of resources, energy, environment, health, housing, etc. were also discussed. In the village Aurawan, a school for primary education and agricultural training for village boys and girls was also established.

Today, most of these villagers have reclaimed their own *usar* land and are cultivating land profitably with several types of biomass with reasonably good yields. The crime rate has also declined substantially.

Cost Benefit: Most farmers in the area wanted to spend the least and have quick returns. According to V. Chandra (personal communication), the initial cost in alkali soil utilization is on bunding, drainage, ploughing, levelling, etc. This came to Rs. 144 per hectare in 1956. Simultaneously, water and irrigation problems were solved by boring cavity tubewells with the help of local daily paid workers. The total cost, including the cost of engine pumps, etc. was Rs. 3,700 in 1956 (NBG, 1961). The tubewell gave a discharge of 13,000 gallons of water per hour, which was sufficient for a command area of 15-20 acres of land. The cost of running the tubewell for about 6 to 8 hours with diesel oil was about Rs. 5.24 in 1956, The tubewells have stood the test of time and have been working satisfactorily for over 30 years. The land survey cost was approximately Rs. 3 per

acre in 1956. The fields were ploughed in June and July and utilising rainwater, paddy T-100 was grown. In the very first year, there was a net income of Rs. 93 per acre in 1956. Soil amelioration was the intangible benefit. During summer, irrigation water was supplied to farmers from the tubewells of the station itself.

Similarly crops like safflower, German Chamomile, betelvine, tuberose, damask rose umbellifers, aromatic grasses, dhaincha gum, some firewood trees and shrubs, etc. also have favourable benefit- cost ratio which ranged between 1.0. to 1.7.

The data on reclamation of *usar* land from the Daleep Nagar Farm of the Chandra Shekhar Azad Agricultural University, Kanpur (1968-70), indicate that the crops grown by them were dhaincha (green manure), paddy, wheat, barley, berseem, oats, safflower, mustard, potato, vegetables and fruit trees, together with fish culture. The capital cost came to Rs. 4998.10 per hectare. The total input cost of cultivation of paddy per hectare was Rs. 2203.31 which included overhead costs (depreciation, interest on and repairs of fixed capital, and interest on working capital. These costs were charged cropwise, depending on the duration of the crop). The value of the total output from paddy was Rs. 3844.00 per hectare, being the value of 4 tonnes of grain @ Rs. 76 per tonne and 8 tonnes of straw @ Rs.10 per tonne. The net income during 1968-70 from paddy/ hectare was Rs.1636.69, giving a benefit:cost ratio of 1.7.

Jain et al. (1985) tried a number of species, but rice-wheat followed by *dhaincha* as green manure is one of the best agricultural sequences on *usar* land. In fact, in Madhya Pradesh, these authors calculated a benefit-cost ratio of 1.0 to 1.7, involving rice-berseem, rice-barley, rice-wheat and rice wheat-berseem rotations.

Training in *Usar* utilization: A large number of villagers have their own ***usar*** lands in villages. The data on land utilization in 1956 and 1979 show an overall decrease in area of *usar* in the villages.

What has been described for the two villages, is also applicable to the neighbouring villages where the area under cultivation has also increased by the adoption of methods developed by the National Botanical Research Institute, Lucknow.

Biomass-based vocations: Apparently, betelvine cultivation does not appear to be an industry of much economic significance. However, a survey conducted by NBRI in 1980 showed that nearly 30,000 ha are under betel vine cultivation in India and the annual turnover of its trade exceeds Rs. 700 crores. This industry has been languishing for S & T inputs. Due to diseases, improper use of manure and poor storage facilities, there has been considerable decline with uneconomic returns to the growers (Balasubrahmanyam, 1987). As a first step, the institute built up a country-wide collection of 85 cultivars which was studied morphologically, anatomically and chemically. It emerged that the entire collection could be resolved in 6 discrete cultivars. The differences in the 6 cultivar groups could also be related to their different chemical compositions. Based on critical scientific studies, it was found that a plant density of 1,11,100 vines/ha is commercially advantageous. Similarly, nutrient elements and fertiliser needs were determined to enhance the productivity. The shelf-life could be increased from the normal 7-15 days to 50 days after depetioling, demidribing and treatment with benzyl adenine (BA) at 25 ppm and kinetin at 50 ppm. Thereafter, senescence starts. Diseases of the vines could be controlled by pretreating planting sets with 500 ppm streptocycline and 0.5% Bordeaux mixture for 20-30 minutes before planting.

Upto 1956, sugarcane was never cultivated in Banthra area. Seeing the success at Banthra Research station, the villagers took to its cultivation and there followed the Gur industry by processing sugarcane juice. Mango orchards have also come up on the *usar* land.

Farmers have taken to growing ornamentals around their homes. In

the village Gauri, a nursery of ornamental plants has sprung up and others are coming up.

The life in the villages in the neighbourhood of Banthra has been transformed. Cultivators have now started raising even three crops a year on their fields. They have constructed inexpensive tubewells and bought tractors which has led to prosperity and employment generation. The same can be judged from the fact that commercial banks have opened their branches in the village Banthra. Use of television, telephones and electricity in the area by the villagers is another indication of prosperity of this area.

The Indian Council of Agricultural Research, taking into account the enormity of the problem of alkaline soils in India, also started Central Soil Salinity Research Institute, Karnal in 1972. Yadav (1975), the then Director of this Institute, has, in his paper, on improvement of saline alkaline soils through biological method, supported the concept. He has indicated that the performance of various forest trees, grasses, ornamentals and agricultural crops has been good. He has also pointed out that the improvement brought about by biological methods is lasting, economical and within the available means of an individual cultivator.

In the field of aromatic plants, the investigations on cultivation and processing of scented flowers have led people to utilize the technology developed by NBRI. They also took to planting of tuberose, Damask Rose, German Chamomile, jasmine, Cymbopogon spp., etc.

Various perfumers have taken advantage of experimental crops raised by NBRI. Among them are: Messrs Ram Narain Pratap Narain, Kannauj; Perfumers India Ltd., Lucknow; Agro-Industrial Corporation, UP, German Remedies, Bombay; and others. Some of them even distilled the materials on site. For the last several years, rose water is being distilled at the station and supplied to consumers. Honey is yet another byproduct of ecodevelopment.

Thus, among the vocations were production of food (cereals, vegetables, edible oil crops, sugar crops, fruits, mushrooms), fodder, fuelwood, ornamentals, betelvine, aromatic and spice plants, herbal drugs, seed gums, honey, economic water plants, fish, geese, eggs, etc.

Impact on the local market and production: The foregoing developments have resulted in overall development of the area as can be judged from the fact that in 1956 there were no shops of hardware, merchandise, fertilizers, diesel, etc. at Banthra, but today there are shops where boring pipes and other machinery along with other merchandise can be purchased. Besides this, village market has improved much and is now organised three days a week. The State Government is now proposing to establish a Mandi (Market) Organization. In this market, the supply of cereals, pulses, oil crops, vegetables and fruits, has increased. Similarly, there is a change in the employment pattern in these villages. The number of unemployed persons has decreased. The villagers are taking at least two crops a year from the same field where nothing grew in the past. The farmers are taking on lease more of such lands from the Panchayat (Village Council) for cultivation. A self-sustainable area has been generated.

Conclusions

The on-going soil destruction process due to salinisation and after-effects of developmental projects make it obligatory to turn our attention to the use for productive purposes of alkaline and other substandard lands, at present lying fallow. The work done at Banthra (1956-84) has been summarized (Khoshoo 1987). A perusal of the papers also indicates the weaknesses of the project. The objective of the work in 1956 was to put *usar* land to some productive use. Initially, too much reliance was put on Argemone amendment. However, from 1973 onwards, more scientific and technological inputs, particularly to meet rural energy crisis, were made available, thanks to the Department of Science and Technology, Government of India which declared it as a Biomass Research Centre.

This was indeed a major step and, for the first time, a tacit recognition of the good work done at the Station. The prevailing socio-economic conditions demand that we go in for low input polycultural (simultaneous or sequential), rather than high input monocultural, commercial agriculture. This alone would bring the villagers out of their present subsistence conditions, as also help them earn small surplus money through some biomass-based vocations. It was soon realised that there is a nexus between food, fuel, and fodder needs of the rural folk. With this, developed a holistic strategy to cover various faces of the programme in an integrated manner. Water availability and protection from grazing were among the first important steps to be taken. The strategy involved ecologically clean, low energy as also low engineering inputs, coupled with utilisation of human power on a willing basis and in full measure. Many things were accomplished by Shram Dan (voluntary and willing labour utilised for a cause). This had a multiplier effect and people of the area developed a stake, they became a social fence and protected the Station willingly against intruders, both human and livestock. The underlying principle was to "learn and earn by doing" Banthra became a training ground, as there were very few permanent employees.

The work done in the first phase ended in the development of a micro-ecosystem which affected the micro-meteorology. From 1973 onwards, the objective was to combine production and conservation (of soil, water, energy, biomass materials, labour, etc.). The basic idea was to produce goods and services from this land for the rural people. Among the goods produced were food, fodder, fuel, timber, medicine and other cognate small economic products and ventures. The services included soil and water conservation, shade, change in micro-meteorology, recreation etc. Ameliorative effect of tree canopy was indeed remarkable on soil which originally was almost totally inhospitable. Tolerant species/varieties were succeeded by less tolerant ones. Thus cultivation of food, fodder and fuel species offer an excellent land use for these deteriorated soils. With this started the whole series of successional changes.

Such a micro-level success has changed the socio-economics of the whole area. However, *the challenge now lies to turn it into a macro-level success by motivating and mobilising rural communities in the entire usar belt*.

It must be admitted that we still do not have answers to all the questions regarding eco- development of *usar* land. Many important ones await solution; some of these are:

- Understand precisely the physical, physiological and genetic architecture of the species that is conductive to their adaptation in this inhospitable habitat. In other words, why and how a species succeeds;
- Evolve more location-specific crop rotations which involve low input polyculture rather than high input commercial monoculture;
- Breed for stress resistance (high sodicity, aridity in dry seasons, water logging in wet season). This would involve work in the areas of plant physiology bio-technology and genetics:
- Detailed biochemical account of the soil amelioration (including soil-root interaction and decomposer chain). This would involve work on soil microbiology, tree rhizobia, mycorrhiza, etc;
- Precise cost-benefit analyses of different crops and cropping systems (agri-silvi-horti-pastoral);
- Application of ecological principles to make *usar* land agriculture sustainable.

In retrospect, one can say that the fiscal costs (at present about Rs. 10,000/ha only in the first year) on a project like this are far less than the social, economic and environmental costs of in action. The important lesson we draw from the Banthra Experiment is, as some one has said, "Start where you are, with what you have. Make something of it and never be satisfied".

Banthra in 1956 was a barren and desolate landscape, but today the whole area has changed for the better, both environmentally and socio-economically. However, the goal has to be to develop *usar* land agriculture that is ecologically, socially and economically sustainable.

Let me end with what Sir Charles Pereira (1987) wrote to me. "I am rather astonished by the good quality ground water which lay within hand-pump levels below the crusted alkaline desert." Why then does the Gangetic Plain present a "bleak and a barren landscape?" Why has not a micro-level success (like Banthra) been converted into a macro-level to benefit thousands of small farmers?" The answer is apathy, but how long will apathy continue to dog us?

Ecodevelopment of alkaline land: Banthra-A case study, 1987, National Botanical Research Institue, Lucknow

NATURE CONSERVATION & SUSTAINABLE DEVELOPMENT

After serving as Secretary to the Government of India for Forests and the Environment, Professor Khoshoo emerged as a leading advocate for nature and sustainable development in India. The following chapters emphasize the complexity of integrating conservation and development, particularly in rapidly developing nations. He not only provides a roadmap for sustainable development and nature conservation in India but also reflects on the interplay between science, politics, and community dynamics, highlighting the challenges of addressing immediate human needs while preserving ecological balance.

1
INDIA'S BIODIVERSITY: TASKS AHEAD

Biodiversity can be defined as species richness (plants, animals and microorganisms) occurring as an interacting system in a given habitat. The problem of biodiversity is essentially one of conflict resolution between the human kind on the one side, and living organisms occurring on land, in freshwater bodies and marine environment on the other. The UNCED (United Nations Conference on Environment and Development 1992) process helped to place the loss of biodiversity and its conservation on the global agenda, resulting in biodiversity becoming a household word.

There are two main functions of biodiversity. Firstly, it depends on the stability of the biosphere, which in turn leads to stability in climate, water, soil, chemistry of air, and overall health of the biosphere. Secondly, biodiversity is the source of species on which

human race depends for food, fodder, fuel, fibre, shelter, medicine, etc. These, by and large, exist in the 12 Vavilovian Centres of Diversity (Khoshoo, 1990). Biodiversity is not only an important resource but also a strength of developing countries.

Biodiversity exists on earth in eight broad realms with 193 biogeographical provinces. Each biogeographical province is composed of ecosystems, which are constituted by communities of living species existing in an ecological region (Udvardy, 1975).

The developing countries, located in subtropical/tropical belt, are far richer in biodiversity than the industrial countries in the temperate region. The Vavilovian Centres of Diversity of crops and domesticated animals are also located in the developing countries.

Biodiversity is an irreplaceable resource: its extinction is forever. At present there is no way to recreate extinct plants and animals, notwithstanding what is presented in the breathtaking Spielbergian spectacle 'Jurassic Park'. Having become a buzzword, there is considerable myth and illiteracy associated with biodiversity. There is not only a need to formulate meaningful programmes for its conservation and sustainable utilization, but also to demystify this subject and make people knowledgeable about its tremendous implication for human survival. The conservation and sustainable utilization of this resource has to be central to all developmental planning in most developing countries, because economy in most of these countries is dependent on agriculture, horticulture, animal husbandry, fisheries, forestry, medicinals and the likes of these. The genes from wild ancestors of crops endemic to developing countries have made distinctive contribution in crop improvement, with considerable gain to the growers. Such examples have been listed by Witt (1982), Khoshoo (1988) and FAO (1993). The contribution of such genes has been considerable, which has made a difference, for the better, both in social and economic terms.

Biowealth: India's strength

India has a position in between developing and industrial countries: it is developed among the former, but developing among the latter. It is rich in biodiversity as relevant both to the health of biosphere in general and to agriculture, animal husbandry, fisheries, forestry and pharmaceutical industry in particular. It is backed by equally rich cultural diversity and indigenous systems of medicine, and knowledge and wisdom of the indigenous people, and is supported by a reasonably strong scientific and technological base. Biodiversity is indeed one of India's important strengths and is the bedrock of all bioindustrial development in the unusually large rural sector (5,76,000 villages with 76% of the country's population) of the country. However, the real value of biodiversity lies in the information that is encoded in the genes and molecules.

India has over 1,08,276 species of bacteria, fungi, plants and animals already identified and described. Out of these, over 84% species constitute fungi (21.2%), flowering plants (13.9%) and insects (49.3%). In terms of the number of species, the insects alone constitute nearly half of the biodiversity in India.

These species occur on land and in fresh water and marine habitats, or occur as symbionts in mutualistic or parasitic state with other organisms. In the world as a whole, 16,04,000 species of Monera, Protista, Fungi, Plantae and Animalia have been described so far. However, it is estimated that at least 1,79,80,000 species exist in the world, but, as a working figure, 1,22,50,000 species are considered to be a near reality (WCMC, 1992).

Based on the data on the already described species, India is tenth among the plant-rich countries of the world, fourth among the Asian countries (old USSR included), eleventh as far as number of endemic species of higher vertebrates (amphibia, birds and mammals), and tenth in the world as far as richness in mammals is concerned. Out of the 18 'hotspots' identified in the world, India has two: these are Eastern Himalaya and Western Ghats. The two areas

contain 5,332 endemic species of higher plants (3,500 plus 1,600 species, respectively), mammals, reptiles, amphibia and butterflies (WCMC, 1992).

In addition, the country is a very important Vavilovian Centre of Diversity and Origin of over 167 important cultivated plant species and some domesticated animals. To name a few, the following crops arose in India and spread throughout the world: rice, sugarcane, Asiatic vignas, jute, mango, citrus, banana, several species of millets, spices, medicinals, aromatics and ornamentals, etc. India ranks sixth among the centres of diversity and origin as far as agri-biodiversity is concerned.

A large number of institutions in India are involved in conservation and utilization of biodiversity. These fall under Ministry of Environment and Forests (Botanical and Zoological Surveys, Wildlife Institute of India, G. B. Pant Institute of Himalayan Environment and Development), Ministry of Agriculture (several institutes under Indian Council of Agricultural Research), and Ministry of Science and Technology (several institutes under Council of Scientific and Industrial Research). Between them, these three ministries are dealing with *in situ* conservation (biosphere reserves, national parks, wildlife sanctuaries), *ex situ* conservation (field gene banks, seed and other banks), and utilization (gene and drug prospecting), respectively. India is indeed uniquely placed as far as its biodiversity is concerned. But the country can no longer continue with tiger-bird-wildlife syndrome. These are important in their own right but are a miniscule part of the large spectrum that is now encompassed under biodiversity.

In most of the developing countries, biodiversity is generally attached as a frill to environment and forestry agencies, which have no experience in product development from biodiversity. Furthermore, developing countries have yet to comprehend the vast social, economic, scientific, technological, ecological and political potential of biodiversity. If this continues, these countries are likely

to be left out in the race to conserve and sustainably utilize their rich biodiversity for the well-being of their people and the world at large. On account of concealed compulsions of the industrial countries, the developing countries may end up in exporting biodiversity as was done in the colonial times. The result would be disastrous.

Often, those responsible for conservation of biodiversity have no idea whatsoever about the work of those who are engaged in utilization, and vice versa. However, policy makers have to realize that conservation and sustainable utilization of biodiversity has to be central to all development planning in most developing countries because most of these countries are predominantly agricultural. There has to be a national commitment on this account. And, therefore, there is also an urgent need for coordination between various ministries, organizations and institutes working on different facets of biodiversity.

The recent agreement between INBio (Institute of Biodiversity in Costa Rica) and Merck (USA) is hailed throughout the industrial world as a landmark event. Under this agreement, extracts from wild plants, insects and microorganisms from Costa Rica are supplied for drug screening programmes to Merck (USA). In return, INBio has received from Merck over 1.35 million US dollars, and expects royalties on the commercial products that may emanate from this work. INBio is to contribute 10% of the budget and 50% of royalty to the Government of Costa Rica for its National Parks Service. Merck has also offered to provide technical assistance and training to help establish a drug research capability in Costa Rica. The Government of Costa Rica has given to INBio non-exclusive rights to bioprospect. In brief, INBio represents an alliance between biologists/biochemists and businessmen (Reid, 1993).

Costa Rica has over 84,500 species of plants and animals in 51,000 square kilometer area. This number is more than what is found in Canada and USA combined (Reid, 1993). It may be emphasized that, unlike India and some other developing countries, Costa Rica

is not a Centre of Diversity and Origin of any cultivated plant or domesticated animal. There are also no indigenous people in Costa Rica, who normally are an important storehouse of knowledge and wisdom on plants and animals.

Pharmaceutical industry in the industrial countries is a very influential industry, and it has gone all out to publicize and, what is important, eulogize in press and over TV and radio the INBio-Merck approach. There is a growing feeling that this industry is attempting to influence public opinion in biodiversity-rich but technology-poor developing countries in the tropics and subtropics of the world. Perhaps, the underlying idea may be to make these countries follow the Costa Rican approach. Some developing countries are already on their way to doing so.

However, a visit to INBio convinces anyone that, in its present form, it is something of a 'clearing house' rather than an R&D institute of any significance. The only programme they have is to inventorize the Costa Rican biodiversity. In the past also such work has been done by American biologists. One only hopes that INBio will grow scientifically and technologically so as to be able to take up such work independently.

Not so strong biotechnology: India's weakness

There are no two opinions about biodiversity being one of the very important assets of the developing countries. In fact, in the 1930s, when the world was largely asleep, N. I. Vavilov of USSR was wide awake. His monumental studies showed that there have been some major centres of diversity and origin of crop plants and domesticated animals. Most of these centres fall in tropical-subtropical-hot temperate belt, where most developing countries are located (Vavilov, 1951). It is indeed ironical that while developing countries have given to the world all agri biodiversity, they themselves have been areas of low productivity and high population density. This belt has also been the traditional 'hunger belt'. The industrial countries, by making use of the science of genetics and breeding, raised the

productivity. A perusal of **Figure 1** shows that low biodiversity and

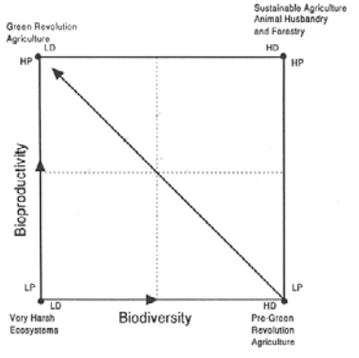


Figure 1: Relationship between biodiversity and bioproductivity

low bioproductivity have been prevalent in harsh ecosystems. Underlying the pre-Green-Revolution agriculture was high diversity and low bioproductivity. The world agriculture then moved to high productivity accompanied by low diversity and the result was Green Revolution. Today, we do realize that Green Revolution has paid its dividends and in many developing countries acute hunger is no longer a reality. However, it has not entirely been ecologically friendly. Green Revolution has also helped the developing countries to feed themselves and not go around with a begging bowl for food. Thus, it has also been a question of balancing immediate economic and social gain and a largely manageable level of environmental degradation and pollution. Among other things, sustainability in agriculture, animal husbandry, fisheries and forestry will depend on the ability to combine high productivity with high diversity. Agriculture all over the world has to move towards such a broad goal. Therefore, what is required is the clarity of vision regarding the relationship between biodiversity, bioproductivity and biotechnology.

Although the 'gene and drug rush' is inevitable, it should not take place in a policy vacuum. The central issue is that formulation of policy in gene-rich/ technology-poor (or deficient) countries is

necessary in order to avoid what could result in 'gene imperialism'. The INBio experience, if implemented without thought and care, could prove to be the thin end of the wedge. Therefore, each country must ensure that such agreements do not hurt conservation, sustainable utilization, development and equity in biodiversity. Biotechnology is inherently knowledge intensive and having good biotech infrastructure would lead to value addition to the products from biodiversity in the general area of agriculture, animal husbandry, fisheries, forestry and medicine.

At the same time, the institutional structure that controls biotechnology should not overshadow those institutions that deal with conservation of biodiversity, and on no account should ignore the rights and privileges of the local communities. While the former involves upstream science and technology, the conservation area is largely languishing even for simple and time-tested scientific and technological inputs.

Technology transfer in biotechnology requires a certain minimum amount of technical and legal capability, which most developing countries lack at present. Therefore, considerable competence and skill are needed in the whole range of subjects starting with taxonomy, genetics, plant breeding, molecular biology, microbiology, biochemistry, fermentation technology, biochemical and process engineering, economics, law and, last but not the least, training of local communities in modern conservation skills is also a must. Furthermore, if the scientific and technological efforts in conservation and sustainable utilization are not properly focused, failure to achieve tangible results is a certainty. For promotion of biodiversity conservation and sustainable utilization, all developing countries must not only take to capacity building · but also work towards innovation, acquisition and adaptation of relevant biotechnologies, legal aspects, trade secrets, intellectual property rights (IPRs), patents, petty patents, and plant breeders' and farmers' rights. This has to be supported by a proper economic and political climate, and proper balancing between those who conserve

and those who use biodiversity. Thus, the right kind of technologies are needed to harvest returns from agriculture and the drug industry. At the same time, there is a need to empower local people to conserve and use biodiversity and participate in management. The whole exercise has to be done objectively and not in an eco-fundamentalist manner.

While a whole range of revised laws on protected areas, wildlife, land use, forestry, water, mining, grazing, etc., promote conservation of biodiversity, they do not promote their sustainable utilization. Thus, there is a need for an all-encompassing law on biodiversity that should take into account its deep interconnection with biotechnology and remove all inadequacies. This would be one tangible step towards sustainable bioprospecting.

The relationship between biodiversity and biotechnology is depicted in Figure 2.

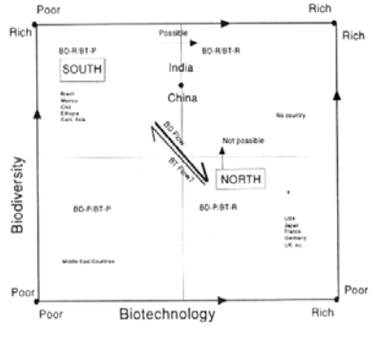


Figure 2: Relationship between biotechnology and bioproductivity

The countries of the world can be divided into four groups: (a) biodiversity-poor and biotechnology poor; (b) biodiversity-poor but biotechnology-rich; (c) biodiversity-rich but biotechnology-poor ; and (d) biodiversity-rich and biotechnology rich. To the first group belong countries in the Middle East (e.g. Saudi Arabia), to the second group belong USA, Japan, Germany, France, Sweden and

UK; the third group comprises southern countries like Indonesia, India, China, Malaysia, Brazil, Mexico and others in the tropical/ subtropical belt, and there is no country which falls in the fourth group. At present there is a flow of biodiversity from the third group (South) to the second group (North). The extent and nature of flow of biotechnology from North to South is not commensurate with the flow of biodiversity from South to North. This is an unequal exchange and will remain so till such time as countries of the South become self-reliant in biotechnology. An important factor underlying this exchange is that while some countries (like India and China) do have the capability to enter the fourth group (rich both in biodiversity and biotechnology), the countries of North can never make it to the fourth group in the real sense of the word. The reason is that they do not have any worthwhile agri-biodiversity growing naturally, although they do have excellent *ex situ* facilities in the form of field gene banks, seed and other banks. The latter do not have the advantage of long-range ecological processes and organic evolution that operate under natural conditions and constantly refine and update biodiversity through mutation, recombination and natural selection. These are the three cardinal elements of organic evolution. In essence, biodiversity stored in industrial countries is in the form of '*gene morgues*', because advantages conferred by exposure to the process of natural selection are not available. In contrast to *in situ* conditions, organic evolution is virtually at a standstill or halted under *ex situ* conditions. Therefore, in all biobanks, germplasm is preserved and not conserved in space and time. However, both *in situ* and *ex situ* conservation are necessary to complement and supplement each other.

Gene-rich/technology-poor developing countries must, therefore, come together and reach an understanding regarding the various aspects, including scientific and technological, economic, social, cultural and legal issues, and collection, supply and costing of the raw material of biodiversity. Today the cost of biodiversity is the cost of collection and travel involved. If these countries remain

divided (as they are today) regarding their stand on prospecting for new genes and drugs and IPR, and compete among themselves, even the type of benefits that INBio has been able to get from Merck (USA) will no longer be forthcoming.

It is, therefore, imperative that a multilateral mechanism is created. One step towards this may be the placing of this matter on the Agenda of the G-15 countries, where other gene-rich/ technology-poor developing countries are also invited, or the G-15 is itself appropriately widened to include such countries. The joint group must explore the possibility of working out a multilateral agreement like the OPEC (Organization of Petroleum Exporting Countries). In such a venture, teething troubles are inevitable, particularly because, unlike oil, genes are still to be recognized as strategic materials. Past experience with biologicals like rubber, coffee, cocoa, tea, palm oil and jute is not encouraging. The time for such a multilateral mechanism is most appropriate because of the tremendous global upsurge of interest in natural products and vegetarianism. Industry would be ready to make investments in this area because gene and drug screening technology itself has reached a level of perfection.

The extent and nature of capability in biotechnology will determine the capability of the country to conserve and sustainably utilize biodiversity. Conservation no longer means simply building a fence around an area, but involves a considerable amount of upstream biotechnology. The longer a country takes to make such a transition, the farther the country would be from reaping the harvest from its rich biodiversity.

Intellectual property rights (IPRs)

The threat of 'Star Wars' has receded perhaps for good, thanks to the international developments during the last few years. Open markets have taken over and are filling the void. Today, the threat of 'Seed Wars' is indeed real. A scramble for prospecting for new genes for biotechnology and biomolecules for drug industry has begun. In this process legitimate traditional rights of farmers and indigenous

people could be jeopardized. One only hopes that it does not lead to 'gene/drug imperialism' and end in developing countries exporting biodiversity to industrial countries and in return importing products from them, a situation reminiscent of the colonial times.

Under IPRs, transformed microorganisms, plants and animals can be patented and become exclusive private property. Such organisms are the result of genetic engineering. In this regard the developing countries need a strong infusion of modern biotechnology and considerable capacity building in this area.

The declared objective of the USA is the adoption of a uniform and strong IPR law throughout the world. In the absence of a proper biotech base, a developing country cannot match an industrial country although the former may be far richer in biodiversity. The Convention on Biodiversity has helped to place IPRs on the top of the agenda of policy and decision makers. Furthermore, access to genetic resources and transfer of biotechnology are treated on the same plane. Thus, an element of reciprocity has been introduced. However, it remains to be seen if, in lieu of the transfer of biodiversity from the developing countries, there would be transfer of biotechnology from the industrial countries. The world is moving towards prospecting of biodiversity, and the developing countries have to ensure that there is sustainability in extraction of the same, because loss of biodiversity is forever.

As of today, IPRs and patenting are inequitable. They help the rich and not the poor, the industrial and not the developing countries, and the sophisticated and not those who possess traditional/ indigenous knowledge and wisdom. Such an imbalance has to be corrected so as to make IPRs more equitable and conservation-oriented.

One good thing about IPRs is that it would stimulate R&D and acquisition of biotechnology. A country with a strong biotechnology

capability can be more self-reliant and be in a strong position to bargain and negotiate royalties. The prerequisite for this is an R&D infrastructure of the right kind. Countries such as Japan, Germany, Sweden, France, USA and even UK, with no worthwhile biodiversity, are today dominating the IPRs issue because they already have excellent biotech capability.

There are two categories of materials involved. The first includes all the wild relatives of cultivated plants and domesticated animals, ancestral species, land races and traditional varieties, which, more often, have low productivity but high diversity. These constitute the raw and unimproved genetic pool, which is critical to the future needs and aspirations of the human race. One marvels at the ingenuity and innovativeness of our remote ancestors, who picked up the right kinds of wild grasses and other grains, legumes, tubers, vegetables, fruits, fibres, medicinals, fish, cattle, sheep, goat, horse, donkey, etc., and made productive cultivated plants and domesticated animals out the same. Thereafter, there have been no new additions of crops or domestic animals but there has been considerable improvement in their production and productivity. Similarly, many pharmaceutical plants and products were first discovered by the indigenous people after large-scale trial-and-error experiments and intensive observation. All these are not ordinary intellectual achievements and innovations, but these have never been rewarded or paid for. However, everyone today takes these for granted and wants to grab all such materials together with the local technical knowledge and wisdom built around such a solid foundation. This is done only to reap the benefits for themselves.

The second group of materials is the improved and high-yielding cultivars produced by geneticists and breeders for commercial purposes, and the chemicals isolated, refined, tested and commercialized by pharmaceutical companies. Underlying this is hard sciences of genetics, breeding, pharmaceutics and upstream biotechnology.

The first group is regarded as an ownerless resource and a common heritage of the humankind, and is non patentable, while the second group is patentable, along with plant breeder's rights, trade secrets, IPRs and what not. The first group has been treated as public property and has never been rewarded. The second group is treated as private property and is rewarded and awarded. Is this justifiable?

There is, therefore, an urgent need for a special multidisciplinary institutional mechanism for attending to IPRs more objectively and more aggressively. This has to take cognizance of the prevailing national and international situations and, above all, enlightened self-interest of the country. The country has to be objective and cannot afford to be puritanical about these issues.

Need for a coordinating mechanisms

The age of an ecosystem harbouring biodiversity is at least 100 years plus. Who will provide a long-range unbiased perspective on biodiversity for decision making? It has to be a think-tank of hard-core informed scientists, technologists, economists, legal experts, sociologists and other professionals.

There is a need for a coordinating body which would advise on conservation and sustainable utilization of biodiversity, which at present is the responsibility of different ministries, organizations and institutes. Such a body should also see the entire spectrum of *in situ* and *ex situ* conservation from genes/molecules to ecosystems as a continuum. In other words, such a body must treat the work of botanic gardens/arboreta, zoos/zoological parks, aquaria, herbaria, musea, the whole range of field gene banks and seed and other banks, and protected areas as a single network. Such a grid has to be properly orchestrated for the good of the country. In addition, it should organize research and development, and teaching, training, demonstration and extension programmes on different aspects of biodiversity, including its economic evaluation (Peters et al., 1989; Bawa et al., 1993).

Any plan on management of biodiversity must take into account the whole spectrum of issues ranging from tenurial security of the protected areas network (on land, lake and marine locations), conservation of biota, rights and privileges of the indigenous people (who have the traditional knowledge), biotechnological aspects of IPRs and many other scientific and technological, social and economic, and legal and political aspects. Many of these issues may seem to be having competing interests, and need to be balanced nationally as also internationally to the best long-term interest of the country.

At present the Wildlife Boards in many countries (including India) oversee the conservation of biodiversity. For all practical purposes these boards are defunct and have lost their legitimacy because, in contrast to wildlife, the concept of biodiversity is all-encompassing. There is an urgent need to have some coordinating structure to look into the planning on a holistic basis of scientific, technical, social, economic, legal, political and international dimensions of biodiversity. The present author advocates the constitution of a National Biodiversity Conservation Board in place of Wildlife Board in order to measure up to the modern challenges and responsibilities.

There are some basic questions that need to be answered in-depth, taking into account the contemporary global thinking and developments in the area of biodiversity, together with their relevance to the developing countries so that these are in their best interest. In this connection it may be pointed out that it would be most appropriate if the countries do not take to an eco-fundamentalist approach. Some of the important questions are listed below.

- Who should own the biodiversity of a country?
- Is it a public or a private resource?
- Can one own natural genes and biomolecules and have exclusive rights on these?
- Should bioprospecting for genes and drug molecules and their utilization be a public and/or private industry?

- What should be broadly the contours of the policy on conservation and sustainable utilization of biodiversity?
- How should the stake of local and indigenous people be strengthened in conservation?
- How does the country use biodiversity to take pro-active action to mitigate the adverse effects of the possible global climatic changes?
- How should biodiversity be valued in fiscal terms, and what should be the mechanism for collection and sale (including pricing) of material for scientific research and commercial purposes?
- What should be the stand of the country on IPRs, which in simple terms means private ownership, and can IPRs apply to wild habitats, species and products of nature?
- Should discoveries and innovations in biodiversity be patented?
- Is it possible to promote equity under IPRs between those who possess the long standing indigenous knowledge and those who innovate in the future?
- How should the indigenous knowledge and wisdom be compensated because considerable innovation has gone into it over the years?
- What should be the role of the government in any agreement on biodiversity driven by market forces?
- Should private industry (seed or drug companies) interested in gene and drug prospecting be asked to help in conservation?
- How is a country's technology policy (including biotechnology) conducive to biodiversity conservation and sustainable utilization?

There has to be a debate (not an endless one) on these questions, where enlightened self-interest of the country is placed at the top. Only when the country is clear about the stand it should take on the foregoing questions, comprehensive policy framework, strategy

and a total management plan on biodiversity could be prepared. This should cover the whole spectrum of activities, from collection regimes to the end use, and from basic science and technology to product development.

The final point

The nations of the world are increasingly moving towards a situation where they can bargain. A country like India needs tools and strength to bargain. In the area of biodiversity, the bargaining power is directly proportional to the strength in biotechnology. Imagine a situation if India had not taken up work in space and nuclear sciences and in missile technology! Surely, we would have been tossed from one end to the other. Let this not happen to biotechnology, for this science is critical not only for managing the use of biodiversity and for enhancing bioproductivity but, above all, also for the overall bioindustrial development of unusually large number of villages in our country. The choice is left to us.

Khoshoo, T. N. (1994). India's biodiversity: Tasks ahead. Current Science, 67(8), 577-582.

2
CONSERVATION OF INDIA'S ENDANGERED MEGA ANIMALS: TIGER AND LION

In the first half of the century, lion and in particular tiger have been decimated by the British and the Indian royalty for purposes of sport. At present tiger is being killed on account of the sale of its bones and other parts to meet the unprecedented demand for traditional Chinese medicine. Even so, India has the largest number of tigers in the world. It also harbours the only living population of the Asian lion existing in the world today. Both these charismatic animals are intervowen with India' s history, culture, religion and philosophy and are no doubt endangered but as yet have not entered in an extinction vortex. These animals can be saved provided, however, we adopt a conservation strategy based on genetic-evolutionary principles.

In the wildlife parlance, India is a unique country because it hosts five mega wild animals (lion, tiger, rhinoceros, elephant and leopard). All these are endangered to varying degree on account of habitat loss

due to increasing deforestation, agriculturalization and urbanization, and poaching of these animals for pecuniary interests. This has happened even when compassion for all life is instinctively ingrained in the psyche of the average Indian from her/his childhood. Indian civilization being very old, has indeed a long history of conservation ethic starting from the vedic period. Furthermore, most of the Hindu gods and goddesses are linked with one or the other plant and/or animal. Tiger is the mode of transport of *Shiv Durga,* while lion is that of *Vishnu Durga* (Singh, 1996). Such associations were a subtle, but an effective way, of giving sanctity to at least some of the prominent species of wildlife (plants and animals) and thereby help to conserve the same effortlessly.

The recent analytical study made by Dinerstein et al. (1997) has revealed that the largest number (16) of tiger conservation units with highest (11) and second highest (5) rating is in India. This country not only tops in the number of tiger habitats but also in variability of the habitats ranging from alluvial grasslands and subtropical moist deciduous to subtropical and temperate upland forests, tropical dry forests, tropical moist deciduous forests, tropical moist evergreen forests, and last, but not the least, mangroves. Such variation in tiger habitats exists in no other country. Furthermore, India being a predominantly vegetarian country, medicaments based on tiger bones and parts including soups of tiger genitalia are items that have been unknown in this country. In addition, the laws are sufficiently strict.

Both tiger and lion are high-profile charismatic species which though endangered, are not yet nearing extinction. These can be saved for posterity following a science-based conservation strategy.

Wildlife has remained largely out of the scientific and technological mainstream not only in India but also in many parts of the world. The wildlifers are indeed very dedicated people but rather possessive of their subject. There is a considerable amount of very interesting data available with Zoo Authority of India, Wildlife Wing of the

Ministry of Environment and Forests and the World Wide Fund for Nature-India. Such data are not available ordinarily to scientists and technologists. Conversely, evolutionary implications of the newer approaches to the study of genetic variability have remained largely out of reach of wildlifers. In fact some wildlifers both in India and abroad refuse to recognize the importance of such genetic-evolutionary aspects of conservation.

With this in mind, it was in 1982 that I had, for the first time, invited the late John Barnabas (a biochemist) to take up a study on genetic variability in tiger and lion using isozyme analysis. The idea was to have some estimation about the extent and nature of genetic variability in the populations of these animals and then bring in genetic-evolutionary approaches in the conservation of these species. He could not take up the work even though he was convinced about the utility of such a study. However, in the intervening years in USA, wildlife attracted molecular geneticists and some very interesting work was done beginning with cheetah. An analysis of 55 South African cheetahs from geographically-isolated populations revealed this species to be monomorphic at each of the 47 allozyme loci. This was a significant finding (O'Brien et al., 1983).

The purpose of the present paper is to stress the need to collate traditional conservation knowledge with the genetic-evolutionary approaches so that these charismatic species are saved in time and space. This would be possible only if more and more scientists and technologists work out the extent and nature of genetic variability existing in these animals using newer approaches. It is indeed heartening to note that at the request of the Zoo Authority of India, Lalji Singh (CCMB) has taken the lead.

The tiger crises

In the past, destruction of India's wildlife has not been done by common people but by the royalty (Mughal, British and Indian). Abundant historical records exist which show that a royal or any

aristocratic home in Britain and India, during colonial rule, was incomplete without stuffed felines, large ornamental birds and such other trophies. Indeed these became status symbols. All this happened in the name of 'sport' in the preindependence era (before 1947). Furthermore, a trip to India by any British royal family member and other dignitaries was incomplete without *shikar* of tiger. It is recorded that 39 tigers were shot in 11 days in 1911 when King George the V visited Nepal. Furthermore, the Maharaja of Surguja claimed the record-shoot of only 1150 tigers in his lifetime (Nowell and Jackson, 1996). Actually these killings fed the ego and vanity of the then aristocracy. This also happened in Russia. After the construction of eastern rail road in the late 19th century, the Russians were encouraged to shoot tigers as a part of military training and for boosting morale of soldiers and settlers moving East. Thus in the 1930s, the population of the Siberian tiger was reduced to a mere 30 animals which has now risen to 150-200. In China and Russia, the tiger was regarded as a menace and wanton killings took place (Nowell and Jackson, 1996). Furthermore, official records also indicate that 480 tigers were shot as sport in India during 1966-69 by European and American tourists. It is not unexpected that many more may have been shot and/or poisoned and their skins exported. No doubt there was large scale and wanton shooting of tigers throughout its range.

Along with tigers, countless leopards, bears, rhinoceros, wild boars and crocodiles were also shot during *shikar* during the British Raj. This resulted in a serious demographic decline in the mega wildlife of India. For instance, about 500 years ago, Babur used to go for *shikar* of rhino near Peshawar (now in Pakistan) (Ali, 1983). Then its range was from Western to Eastern India. But today rhino is found only in eastern parts of Nepal and India. The maximum concentration of rhino is in two small localities like Chitwan (Nepal) and Kaziranga (Eastern India). It is only when the population of tigers and other mega wild animals like rhino and lion became subcritical, that the royalty became conservators. But, in the meantime, incalculable damage was done to several species especially cheetah, tiger,

rhinoceros and lion. Such destruction of mega wildlife took place even when destruction of wildlife (be it plant or animal) has not been in the ethos of an average Indian.

Therefore, while the first cycle of decimation of tiger was on account of wanton shooting by the royalty of India, the second cycle of reduction in number of tigers has been on account of the unprecedented demand for tiger parts in China, Korean and Taiwan, and demand for the products from these in Hong Kong, Japan, Singapore and the entire South East Asia, Middle East (particularly Saudi Arabia), Western Europe and USA. The rich Chinese in some of the South-East Asian countries are willing to pay US$ 300 for a soup based on the penis of a tiger. Therefore, as long as such male vanity for so-called aphrodisiacs (based on tiger bones and organs) will continue, the tiger will continue to live in peril. This is particularly true of China where the newfound affluence, particularly in the coastal belt, has led to unprecedented demand and surreptitious trade in tiger bones and organs. If such killings go un-headed, the human population in these countries will consume all the world's mega cats that exist today in the wild. *Therefore, something tangible needs to be done at the international level to curb the unofficial trade in products based on tiger bones and organs for making aphrodisiacs, lotions and potions.* The poor people living in and around tiger reserves in India and Southeast Asia are enticed by agents involved in such illicit trade. On account of this, the situation has become extremely precarious for the tiger, and India cannot be singled out and accused of not discharging its responsibility.

Historically, tiger had a very wide range from Caspian sea in the west to Siberia in the north, to South China in the East, down to Bali (Indonesia) in the South and covered almost whole of the tropical and subtropical India and Indo-China. Obviously, tiger though zoologically one species (*Panthera tigris*), had eight subspecies at the turn of this century (Sankhala, 1978; Dey, 1996). These are: Caspian tiger (*P.t. virgata*), Siberian tiger (*P.t. altaica*), South Chinese tiger (*P.t. amoyensis*), Indo-Chinese tiger (*P.t. corbetti*), Bengal tiger (*P.t.*

tigris), Javan tiger (*P.t. sondaica*), Sumatran tiger (*P.t. sumatrae*) and Bali tiger (*P. t. balica*). This differentiation probably took place after the late Pleistocene glaciation (10,000 years ago), and was inevitably followed by isolation and genetic drift with no possibility of gene exchange between the subspecies (Wentzel et al., 1999).

Three subspecies namely Caspian, Bali and Javan tigers have become extinct in 1970s, 1940s and 1980s respectively (Linden, 1994). Two other subspecies, namely, Siberian (150-200 animals) and South Chinese (30-80 animals) are on their way to becoming extinct, not only on account of drastic reduction in their numbers but also due to a lack of local commitment for their conservation. This is abundantly clear from the horror stories televised about Siberian and Chinese tigers on the Discovery Channel and the *Earth Files* of the BBC and other international agencies. The Sumatran tiger is also not in good shape with a population of only 650 animals. Of the two remaining subspecies, the prospect for Indochinese tiger (1000-1700) is not rosy on account of the tremendous demand for tiger bones and organs in China, Koreas, Taiwan and other countries, together with weak local laws and little commitment to conservation.

The only hope for tiger, as a species (in its own right), is in India where there are still 3,750 tigers. The largest number (912) is in Madhya Pradesh. There is adequate national commitment for saving this animal. The reason is that tiger is interwoven with India's history, culture, religion and philosophy. As pointed out earlier, tiger is the mode of transport (*vahana*) of Goddess Shiv Durga. Equally important is the fact that globally the best scenario is that altogether there are 7,230 tigers and the worst scenario is that of 5180 (WWF, 1996). Of these, India alone accounts for 64 to 65% of tiger population. *Thus the only country which offers the best prospect of saving the tiger for posterity is India and it is not unexpected that this country is, therefore, under international pressure to save this magnificent animal.* This is possible only if there is parallel action taken in the countries listed above were tiger bone-based medicines are

manufactured, exported and used. Equally important is to mount a campaign by IUCN, WWF (International), FAO, UNESCO and UN Security Council and the General Assembly in this regard. India cannot absolve itself from the biological responsibility of saving the tiger. Furthermore, the saving grace is that the prevailing ethic of Indians is one of non-violence and compassion not only for tiger but for all life.

India also has provided to the world a unique albino line in tiger which began with Mohan - a white tiger caught from the wild in Rewa (Sankhala, 1978). This trait is a simple monogenic recessive. The color is off-white, stripes are brown and eyes are icy blue. There are now a large number of white tigers as celebrities in many zoos of the world. Another mutant is the black tiger, again from India. Originally, this is based on an illegally obtained to clear skin in which back and head are deep black in colour which extends down as black stripes. There have been reports about black tigers since March 1889 to the present times (Dey, 1996). However, the genetics of black tigers is yet to be worked out.

Conservation of tiger in India

Conservation of tiger has been going on in India in a subdued manner for sometime, but it got a fillip on account of the Resolution of the Tenth General Assembly of IUCN held in November 1969 in New Delhi. For the first time, it recommended a moratorium on killing of tigers and sale of tiger skins, trophies, etc. At that time tiger bones and organs were not in such great demand. In 1970 India imposed a total ban on tiger shooting followed by adoption of Wildlife (Protection) Act of 1972. Soon after, in 1973 Project Tiger was launched (WWF, 1996).

Given the commitment of the Indian Government at the level of the then Prime Minister (Indira Gandhi), positive results followed soon. A network of tiger reserves which today number 23 and cover an area of 82,615 hectare, accounts for 1079 tigers, i.e. about 29% of the total tiger population. Each tiger reserve has a core area

around which is the buffer zone. More recently, on the occasion of Tenth Anniversary of Project Tiger (1993), there was the adoption of Delhi Declaration regarding tiger by the Government of India, and a *National Tiger Action Plan* (NTAP) was also chalked out at an international symposium held in February, 1994. The NTAP spelt out international and India's intents. The international intent envisaged formation of a *Global Tiger Forum* (1993) with provision for India entering into agreements with the neighbouring countries so as to prevent illegal trade in tiger hides, bones and organs, exchange of information and help one another in capacity building for protection of tiger. It also emphasized evolving NTAP with a network of viable tiger reserves. Together with their management capabilities, research and monitoring and also management of lesser cats and other endangered species in these reserves. The Plan was holistic in character.

In addition, administrative restructuring and collaboration with voluntary agencies was also envisaged. The local agencies were to be involved in a meaningful ecodevelopment programme. However, underlying science and technology of conservation has not been stressed. Furthermore, decisions have not been implemented in their entirety.

The number of Indian tigers (*P. tigris tigris*) at the turn of this century was around 40,000 (Gee, 1964). However, as indicated earlier, by 1972, in the name of sport, the number of tigers came down to mere 1872. *This was the first tiger crisis in this century in India.* Thus in 72 years (1900-1972) at least 38,128 tigers were killed which means about 530 tigers per year, i.e. at least three tigers in every two days were killed for sport (*shikar*) during this period. This was the biggest decimation of tigers done not by common people of India, but by the British and Indian royalty. However, in 1970, thanks to the then Prime Minister, Indira Gandhi, some very definitive actions were taken inasmuch as tiger was declared as India's *National Animal* and Project Tiger was launched in 1973. The Indian Board for Wildlife (IBWL) was also constituted with Karan Singh as its first Chairperson

and followed by Indira Gandhi as the next Chairperson. The objective was that every single animal was to be saved. The result was that by 1989 the number rose from mere 1872 (in 1972) to 4334 (WWF, 1996). The progress was indeed very impressive. To be exact, there was an addition of 2462 tigers in the intervening 17 years.

After Indira Gandhi's assassination in 1984, the number fell to 3750 by 1993 (WWF, 1996). This was the *second tiger crisis*, the country lost at least 584 tigers in four years (1989-1993), i.e. about one tiger was lost every alternate day. No census has been taken after 1993, but the pace of decimation may have increased and not decreased. This being so on account of an unprecedented extraneous demand for tiger bones and organs for Chinese medicine, coupled with a perceptible decline in the level of conservation effort in India after the demise of Indira Gandhi. The loss was dramatic during 1989-93 when India's political commitment regarding conservation in general and tiger in particular was at the lowest ebb.

This led to holding an International Symposium in 1993 which ended in the *Delhi Declaration* on tiger conservation and recommended setting up of a *Global Tiger Forum* and starting a global campaign to save the tiger. Thanks to Kamal Nath (the then Minister of State, Environment and Forests), an *Indo-Chinese Protocol on Tiger Conservation* was also signed between India and China in 1993 (WWF, 1996). With declining political commitment to conservation, all these decisions remained only on paper.

Bones and skins have been regularly smuggled out of India via Nepal and sometimes also via Singapore. The final destination has been China. There are very harrowing accounts published abroad day in and day out about the serious decline in number of tigers in India. Some of these have not been officially accepted, but the heart of the matter is that conservationists and conservation organizations, all over the world, are interested in saving this charismatic species.

Poachers involved in clandestine trade in tiger hides, bones and

organs are posing the biggest threat for this species. These offenders are rarely caught red-handed because the local people do not reveal information to park authorities for fear of reprisal. In addition, the park authorities do not have magisterial powers to book offenders after summary trials. Poaching is done in the peripheral areas. It is basically a hit-and-run operation. In spite of these drawbacks, there have been successes in catching several culprits. Unless a poacher is caught red-handed, most cases of poaching go unreported and unpunished. This is so because people are reluctant to provide timely information. Between 1993 and 1995, 117 to 133 tigers were poached (WWF, 1996).

It has been suggested that there should be anti-poaching Strike Force organized with the help of the local villagers in core areas. Such a force needs to have modern weapons, and such vigilance groups need to be organized from among villagers who should act as informers. Side by side, the service conditions of staff need improvement. Special courts need to be appointed which should dispose of such cases expeditiously. The knowledge base of conservation for postal and custom staff needs to be regularly updated.

Additional reasons for the decline of tiger and wildlife populations are land diversion for human settlements, agriculture, grazing, roads, mining, etc. which have led to habitat loss Khoshoo, 1986; WWF, 1996). There have to be well-organized and well-thought out education programmes for the *ecosystem people* and villagers about the importance of conserving tiger for long-range ecological security.

Today, for different reasons, there is a renewed interest in tiger conservation even at the global level. Tiger is the National Animal of India and during Indira Gandhi's time has been a symbol of successful conservation effort launched in the country. Thereafter, there has been considerable laxity and conservationists have

been impressing successive Governments of India to take up the conservation of tiger very seriously.

Even the Indian Board for Wildlife became totally defunct after the death of Indira Gandhi. The Honourable Supreme Court had to intervene at the behest of WWF India to urge the Government of India to reconstitute this Board, which had met only once after the demise of Indira Gandhi. The Court has also directed that the states should also constitute Wildlife Advisory Boards and appoint Honorary Wildlife Wardens. The Board was reconstituted in 1996 after a lapse of over 8 years and two meetings have been taken, one each in March and July 1997 by the Prime Minister. The general apathy and inaction by the Government has led to a thinking that wildlife is unimportant and the result has been that the wildlife conservation has been totally neglected. To say the least, this is very sad.

Tiger being a charismatic species, has attracted considerable world attention and WWF (International) is reported to have collected large sums of money in the name of Tiger Conservation. The donors are now pressing WWF (International) to prepare and implement a credible plan of action and do some work on the ground. The performance of WWF (International) needs to be closely watched.

As pointed out above, the only hope for tiger conservation on Planet Earth, is in India. This being so on account of the fact that India is the land of Buddha, Mahavira and Gandhi, where people are predominantly vegetarian and believe in non-violence. Being a poor country, the pecuniary interests dominate in some areas and in some very poor strata of Indian society, where actually *it pays to kill a tiger.*

In sum and substance, in India there have been two tiger crises in this century: the first one due to indiscriminate and wanton shooting by royalty, and the second due to unprecedented commercial poaching. The situation has been aggravated by habitat destruction and

fragmentation due to increase in human population and clearance of forests for non-forestry use; and reduction in prey-base leading to reduction in tiger population. This is likely to result in progressive inbreeding. No professional studies are available in this regard. There is need for a minimal area which is critical for the genetically-viable tiger populations because small populations generally lead to loss of genetic variability. All these factors have led to declining of tigers from a large panmictic population to fragmentation of population in 23 tiger reserves with a total of only 1079 tigers 12. Therefore, there is needed a long-term monitoring of tiger habitats. There has to be establishment of new populations and augmentation of old ones for otherwise tiger may enter into an extinction vortex (Primack, 1993). The situation may lead to such a state. This imposes tremendous responsibility on conservation community of India to take proper and expeditious action.

Asian lion

In the historical past, Asian lion ranged from Southern Europe (where it became extinct 2000 years ago), Northern Africa (disappeared some 50 years ago), Persia including South Asia into India up to Bihar where the last lion was killed in 1814. It is also recorded that 50 lions were killed between 1856 and 1858 around Delhi (Nowell and Jackson, 1996). The present situation is that lion has disappeared in Asia except in the Gir Forest in Gujarat (India). Therefore, the Gir lion is the world's only population of Asian lion which is indeed relict in character. African lion (*Panthera lea lea*) is found in sub-Saharan Africa where it is abundant. Its Asian counterpart (*P. lea persica*) in Gir forest has separated from the former about 100,000 years ago and has some genetic differences with African lion (Nowell and Jackson, 1996). These are coupled with some morphological differences in mane and body size. Albinos in lion are reported in African lion in the vicinity of Kruger National Park and Umfolzi Game Reserve in South Africa (Nowell and Jackson, 1996).

Apart from being the mode of transport of *Shiv Durga*, the lion is also linked with Hindu mythology through *Narasimha*, the fourth

incarnation of Lord *Vishnu* (the preserver). Narasimha has upper half as lion and lower half as man. It is an embodiment of valour and strength. Added importance of lion is the Ashoka seal which was adopted by Government of India as the State Emblem after independence in 1947.

According to the report of Forest Department of Gujarat, there were only 20 lions in 1913 in Gir. Thereafter, a complete ban was imposed on shooting of lion by the then Junagadh State of which Gir was a part. But now the population of lions is about 280 animals restricted to the Gir forest dominated by dry teak in the western part, and by Acacia in the eastern.

Rashid and David (1992) feels that the carrying capacity of Gir is between 200 and 250. O'Brien et al. (1987) and Wildt et al. (1987) have found considerable genetic uniformity in the population. This does not augur well for the Gir lion. Lalji Singh and his associates from Centre for Cellular and Molecular Biology (CCMB), Hyderabad are in the process of making detailed analysis of African and Asian lions and their hybrids.

Apart from large number of livestock (14,000) and *ecosystem people* (7500 Maldharis) found within the Gir sanctuary, there are four major temples and the associated roads, and one rail road within the Gir sanctuary. The number of visitors to Gir is around 30,000 per year. All these are a source of major interference to lion because, like humans, animals also love privacy, which is missing in Gir.

The above description indicates that the only population of Asian lion in Gir is indeed in danger and there is a need for an alternate habitat. Based on habitat viability analysis, a prospective site has been identified keeping in view the habitat and availability of the prey base. The new site is Palpur Kuno Wildlife Sanctuary in northern Madhya Pradesh. This is the most promising site but the State Government of Gujarat does not want to lose the distinction of harboring in its state the only population of the Asian lion. Gujarat

also does not want to lose the tourist traffic. It would be indeed incorrect for Gujarat to continue to harbour such a feeling, because lion, like tiger, is a national concern as epitomized by our State Emblem, history, culture and heritage.

Strategies to save tiger and lion

What should be the broad contours of a short and a long term strategies to save the two charismatic species? All the agencies concerned with tiger and lion at the level of Central and State Government must meet and chalk out a strategy which is implementable and result-oriented both in the short and long terms.

Ecosystem approach: Tiger and lion are integral parts of the respective ecosystems. Therefore, an attempt has to be made to strengthen the concerned ecosystems where a natural herbivore prey-base has to be ensured. Ranjit Talwar (WWF, India) has estimated that for its sustenance, one tiger needs 60-65 animals per year. To ensure this, there are needed at least 300 animals (a mixture of chital, sambar or swamp deer and wild boar). Some feel that the number of animals needed is about 500 so as to ensure a comfortable prey-base.

In turn it means ensuring a good tree and ground cover on which the herbivore base can flourish, and finally ensure water availability. There has to be minimal human interference. To achieve this, and, without sounding heartless, there is a need to translocate *ecosystem people* living in the core areas. These people have to be ensured food and fuel and other basic requirements on a sustained basis. They need to grow these in the vicinity of their habitations. In the eyes of ecofundamentalists, it may appear an anti-people act, but it is not so, and has to be accomplished in record time and with success. As long as people live in the core area, the people and the mega-animals will always be in conflict. Furthermore, anti-social elements will continue to entice the innocent *ecosystem people* to kill the animals under the pretext of self-defence. It pays them to kill a tiger. Translocation will also help the concerned *ecosystem people*

to come into the social and economic mainstream of the country including education so that they take to some vocations and also enjoy at least some of the good fruits of modernity.

There is need to make all-out effort to fortify vigilance, providing better weapons and other equipment including better footwear, and proper uniforms. Furthermore, there is needed training of personnel and providing respectable pay scales for the field staff commensurate with importance of the job and the risks involved. These people are at a high risk from commercial poachers. There is a need to educate them about the higher responsibility and ensuring commitment by a system of awards and rewards. It is also very necessary to take the ecosystem and other local people into confidence and elicit their cooperation and encourage them to join as guards and protectors of the tiger and lion reserves. Equally important is to prevent habitat destruction and soil erosion on account of expanding agriculture, industry, tourism and urbanization and avoidable defense needs. It is important to ensure good vegetational cover, at the same time prevent uncontrolled grazing.

It is necessary to conduct periodic census of tigers in priority tiger reserves. Such information is critical for reasons more than one. Equally important is the problem of predation by tiger and lion on livestock belonging to local communities. In this process, tigers also attack humans, thus become man eaters. Once tiger and lion get the taste of livestock and/or human flesh, the result is alienation of the local people.

Tiger reserves and one lion reserve are in reality small islands. There is demographic decline on account of habitat destruction, encroachment and illegal poaching. The basic question is: Are these islands viable from genetic-evolutionary point of view! *There are no critical scientific studies on minimum size of the population, minimum area demand and the size of prey base to sustain a population of a feline.* This information is critical in the case of tiger because corridors connecting adjacent reserves will not be

possible. The population of tigers within a reserve varies from 4 to 128, average being 47. Data on minimum viable population size is something very critical because of the implicit vulnerability of a population that is too small and isolated. Small populations lead to change in gene frequencies and become vulnerable to extinction on account of increasing inbreeding depression. These are not viable either ecologically or evolutionally. Data need to be generated on these aspects including the consequences of possible inbreeding degeneration. Use of molecular methods must become common. Equally important is the extent and nature of prey base.

By and large the fact is that *ecosystem people* living in core and/or buffer zones, has not worked to the advantage of either these people themselves or the felines. On account of their poverty and penury, these people are prone to the temptation of trading tiger hides, bones and organs for money. The demand for these items is not in India but in China.

A very close centre-state relationship is needed for effective conservation because land, forests, water are state subjects. Equally important is sustained political will and commitment regarding conservation. Therefore, concerned political authorities need to be kept informed about the upstream and downstream ill-consequences of not attending to conservation on proper scientific lines. In turn, it also means that there is a need for informed bureaucracy.

Long-term strategy: Not too long ago, tiger has been a symbol of successful conservation effort in India. It became a success story of which the then enlightened politicians, bureaucrats, wildlifers, scientists, technologists and people at large were justly proud. But, this is not the situation today. Our strategy must be to strengthen conservation effort both at macro- and micro-levels. Secondly, there has to be no let-up in conservation effort because otherwise the whole work done so far will fall apart. Therefore, India has to be ever-vigilant. A lot of populism has entered in this otherwise totally

professional area. No consideration has been given to evolutionary biology, genetical aspects, concept of minimum population size, minimum area demand, prey-base, forest cover, water availability, etc. Generally the importance of these aspects is not fully realized. Furthermore, there is a direct confrontation for space between humans on the one side and tiger and lion on the other. All these questions need professional solutions. There is need to do hard and dedicated conservation work so that it becomes useful in time to come.

There has to be an underlying philosophy of ecological management of tiger, based on principles of conservation biology. This approach has to be anticipatory in character. It should be possible to foresee problems before they become crises. Efforts have to be made to activate self-sustaining and regeneration capacity of such natural areas. In simple words, it means understanding ecologically the habitats and biology of tiger and lion on a holistic basis. One cannot concentrate only on increasing one species, but will have to enhance a set of interdependent but interrelated plant and animal species and revitalize and enhance all other connected biological processes. Thus to ensure tiger and lion we need to ensure plenty of herbivorous prey-base and vegetation. This has to be done through credible ecodevelopment programmes so that there is drastic decrease in soil loss and deforestation, and finally there is sustained supply of water. The bottom line is that we need augmentation and maintenance of a whole range of ecological processes before we can ensure conservation of any charismatic species like tiger and lion. In turn, this would ensure minimization of many types of threats so as to maximize outputs. A long-term strategy does not mean merely increasing numbers of tigers and lions, but also ensuring their survival in perpetuity. The latter can be ensured *on the basis of underlying genetic-evolutionary approaches which have not been a part of conservation strategy of mega animals*. There is a general lack of appreciation and understanding on this account and, therefore, is a high priority.

There is need to map tiger populations and also the only population of lion in Gir for genetic variability.

Based on such data, one may think of saving the tiger and the lion in space and time. This will also require setting up of most modern facilities for genetic fingerprinting. Furthermore, it will involve close liaison between evolutionists, geneticists, wildlife experts, tiger and lion lovers and other personnel involved in the field and above all, people at large.

Genetic approaches to conservation: Mapping genetic variability will not require killing these animals but very small amounts of blood, skin or may be only a few hair follicles. It is done all the time in the case of human beings and animals for health reasons, estimation of genetic variability and establishing paternity: because while maternity is a fact, paternity has been only a conjecture so far.

In addition there is also needed an understanding of the dynamics of the concerned ecosystems and the human communities that live in tiger and lion habitats. Such studies would bring out both adverse and beneficial role of the human-animal relationship. *Restricting conservation effort only to 23 tiger reserves has unwittingly led to fragmentation of the habitat of Indian tiger as a whole.* Nearly 70% tigers exist outside these reserves. This means that in time to come, larger panmictic populations would be needed for conservation work. Otherwise these are likely to be progressively converted into pockets of small inbred populations. This may end up in replication of same or similar genotypes and progressively lead to genetic homogeneity within each reserve. In principle such a danger exists. In turn it would increase vulnerability of tiger and lion. Therefore, it is obligatory to have an idea about extent and nature of genetic variation in the important tiger reserves located in different parts of India and in Gir sanctuary in the case of lion. Such an estimate of genetic variability is indeed a prerequisite for drawing a meaningful conservation strategy. This cannot be done following the conventional approach but through a whole range of

DNA fingerprinting techniques available today which are not only quick but also highly reliable.

The general conclusion arrived by Soule (1976) regarding genetic variation and population size in wildlife is that the two are directly related. Furthermore, widespread species have greater genetic variation than those with restricted ranges; genetic variation is negatively correlated with body size in mammals; endangered species have less genetic variation than non-endangered ones; and small population size reduces evolutionary potential of wildlife species. Though these are generally accepted principles, they can by no means be cited as laws. There is, however, not much controversy about small population size reducing the evolutionary potential of the wildlife species (Frankham, 1996). There are in-built lessons for using these principles for captive breeding and subsequent release in nature of a proper 'genetic mix' of the species concerned. Molecular approaches as applied to tiger and lion would help to clear taxonomic uncertainties regarding species, subspecies, hybrids, inbred population in the wild stock. Such studies would be of help in captive breeding of wild populations. Lastly, these approaches will also help in proper management of these animals.

There is a genuine feeling among wildlife experts like Samar Singh that natural hunting skills of captive-bred tigers are not as good as in the naturally-bred tigers. Besides, the capitive-bred tigers lose fear of man. Thus their 'wild' traits are impaired. This has also been the conclusion of Billy Arjun Singh. Therefore, the technique of captive breeding has to be such that 'ferocity' of these animals is not lost. One needs to replicate an identical 'genetic mix' in captive bred populations, which could be released into specific reserves so as to augment natural populations of tiger.

There are two ways of estimating genetic variability. One involves classical breeding approaches, which are not only time-consuming and cumbersome but also manipulation of mega-felines with long

generation is difficult. The other approach is to use molecular approaches so as to estimate *intra-subspecific genetic variability* taking note of the pioneering work done by Stephen J. O'Brien and co-workers which is more at the *gross specific and subspecific levels*. The future work of Lalji Singh's group (Shankaranarayanan et al., 1997) at CCMB would involve very detailed and intensive genetic profiles at the population level throughout its range. To begin with, this can be undertaken only in the habitats of tiger and lion (Gir) selected after careful consideration. If needed, the work could be extended throughout tiger range in India. This technique is highly reliable for estimating the extent and nature of genetic variation using molecular genetic approaches like DNA fingerprinting, RAPD analysis, microsatellite analysis and mitochondrial D-loop sequencing. The second approach would be semen analysis. The Wildlife Wing and the Zoo Authority of India under the Ministry of Environment and Forests have already sponsored such work at CCMB with Lalji Singh 's Group. The results obtained so far are very revealing.

Wentzel et al., (1999) utilizing micro-satellite analysis revealed significant phylogenetic differentiation between the five living subspecies of tiger. These are indeed fragmented and with hardly any gene exchange between them. Thus differentiation began on account of geographical isolation and then led to morphological differentiation.

The second line of action that can emanate from the genetic approach is to organize a *Tiger and Lion Gene Bank*, an idea mooted by Lalji Singh (CCMB). This Bank would store for posterity, sperms, eggs, embryos and tissues of representative populations of tiger and Gir lion. It would be something similar to the repository or bank(s) envisaged under Human Genome. The materials thus collected need to be ultimately stored under PermaFrost conditions at an appropriate place selected in the Central Himalaya. In this way maintenance costs would indeed be low. The materials thus stored may be of use in future. Jurassic Park was only a fictional but an

imaginative episode which may become somewhat of a reality in future: we may be able to raise full organisms in future. In this regard, the recent work on Dolly (lamb) and a pair of monkeys have taken the technique forward more decisively. Imagine the possibility of a dodo being recreated if such like materials were available for this species.

Alternate site for lion: For lions there is need to utilize the alternate site already identified where natural and/or captive bred populations could be released. Otherwise, in case of Asian lion, at present India is *carrying-all-its-eggs-in-one-basket*. There is a feeling in Gujarat that having another sanctuary for Asian lion would reduce the importance of Gujarat. If true, this is very sad for reasons more than one. This only shows how ignorant and narrow minded some of our politicians can be. Alternate site has been already identified in Madhya Pradesh based on a very elaborate professional analysis. This project is being taken up on a priority basis. Palpur Kuno is located in Northern Madhya Pradesh in Vindhyan Hill ranges, and the project for re-introduction of lion is now taking shape. The sanctuary is about 3455 km2 which will be increased to 3700 km2 by 2015.

With the above in mind and as a first step, the *ecosystem people* living in Palpur Kuno are being shifted 25 km away to a new village (Mishra, 1997). The new site was chosen by the people themselves. The package for 5000 families from 19 villages includes 2 ha of ploughable agricultural land given free to each adult together with Rs. 36,000 for construction of a house on the site. The government will construct wells and install hand pumps for each family. A lift irrigation scheme has also been launched on Kunwari River together with primary health centres for people and schools for children. The *ecosystem people* are happy at such a prospect because the new site is far better than the one they are occupying at present. The transfer is expected to be completed by end 1997.

Soon after this phase is completed, work on the enhancement of prey-base will begin. This would involve considerable eco-restoration including release of herbivorous prey species which include spotted

deer, cheetal, chinkara, nilgai and wild boar. These herbivores would be introduced and time given for them to settle and multiply. A pre-release 20 ha centre of prospective prey base has been established so as to ensure prey in sufficient numbers. Thereafter, the Asian lion will be translocated in 2000-2001 after being tranquilized and flown to the new home where they are expected to settle permanently.

This sanctuary is also home to tigers and it is felt that when lions are introduced, the two mega felines will not clash with each other.

The project will cost nearly Rs.64 crores and would be a fitting use of a dacoit-infested area for a lion sanctuary of international importances where human intervention will help to rehabilitate India's most charismatic species.

This is a unique experiment and a group of conservation biologists, wildlifers, social scientists and other professionals should monitor it for the next 50 years and produce periodic reports.

Demand and consumption of tiger parts

There has been a significant increase in the use of tiger parts during the last decade or so. Primarily this demand emanates from China for the Traditional Chinese Medicine (TCM) and secondarily in South-East Asia. Fifteen tiger parts have been identified in TCM by Mills and Jackson (1994). Apart from bones, which are in maximum demand, other parts include hair, whiskers, testis, penis, brain, eyeballs, blood, bile, etc. The demand is not confined to China and South East and South Asia, but all over the world where Chinese are expatriates. Thus TCMs are regularly imported by England and other European countries, North America and Australia and also in Middle East, particularly Saudi Arabia.

In China there are also 116 factories producing medicinal liquor based on tiger organs (Anonymous, 1996/97). Most of the suppliers of tiger parts and processed derivatives are from China, Hongkong,

Indonesia, Singapore and Thailand. However, although India has the largest number of tigers in the world, this country is not a supplier of tiger parts in the formal sense, but there is commercial poaching followed by illicit export primarily via Nepal and some even via Singapore. The major importers of tiger-based medicines are South Korea, Japan, Taiwan, USA and Singapore. According to Mills and Jackson (1994), between 1970 and 1993, these countries imported at least 10,881 kg of tiger bones, 12,139 kg of tiger or bear bones, and 27 million tiger derivatives in 'various units of measure'. These authors have concluded that 'the only certainty is that wild tiger populations cannot sustain even limited commercial trade of their parts. Given fragmented habitats and small isolated populations, many of the remaining wild tiger populations will require rigorous protection and management just to survive the continuing loss of habitat and the deleterious effects of genetic isolation'. These animals cannot survive the pressures of poaching to supply to the international market with tiger bones and their derivatives.

To stop poaching, there are two courses open. One is to curb the production and sale of tiger products internationally. The world community of conservationists has failed to do this for reasons more than one; primarily, because it touches the Chinese sensibility. It is a fit case for discussion in appropriate international fora. These fora may discuss the use of tiger-based medicine and may be recommend banning these at least outside China. India on account of its conservation ethic ingrained in the people at large has been a willing partner in saving tiger and all other biota. The international agencies have to swing into action and impress upon importing and manufacturing countries about stopping the use of such medicines . It is also clear that once tiger is decimated, the next target will be lion, followed by leopard (even bear) and all other felines from Asia and Africa.

Most people have very serious reservations about the world community of conservationists not taking any worthwhile action in this direction. Regrettably they are more interested in pushing India

against the wall and not even requesting Chinese to stop import of tiger parts. Therefore, a practical view of the situation has to be taken. Perhaps conservation organizations need to help China to raise tiger bones and organs locally by establishing Tiger Farms so as to save tigers in South East Asia and India. Chinese Materia Medica is a 'compendium of traditional Chinese medicinal cures, and lists a wide range of curative applications for feline body parts'. Even cat bones and cranium are prescribed (Anonymous, 1996/97). Tiger farms would decrease substantially, if not eliminate altogether, the demand for tiger bones in SE Asia and India. To be realistic it would be asking too much from Chinese to abandon the tiger bone-based medicines, lotions, potions and soups which they have been using from time immemorial. If something tangible is not done, tiger bones will continue to be smuggled across the borders and tigers will continue to be decimated in South East Asia and India because there is a market for these items in China.

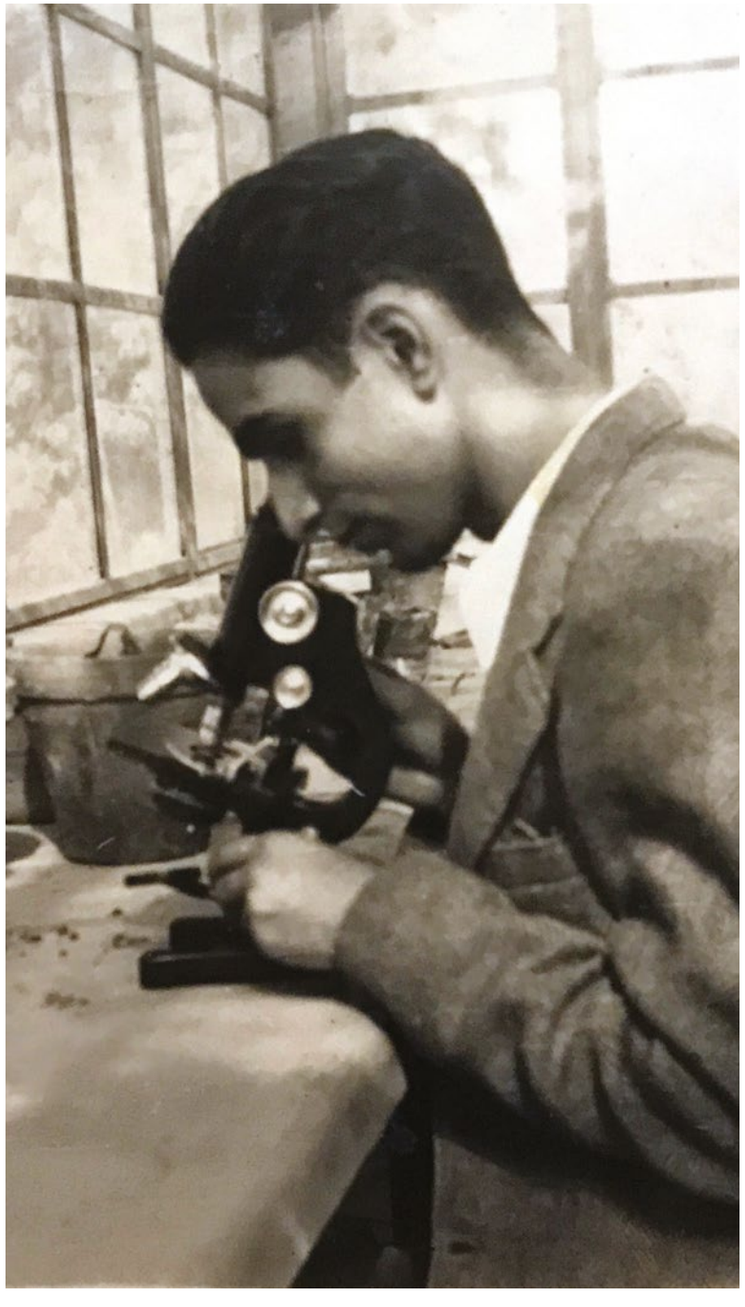
According to Tiger News (Anonymous, 1996/97), the WWF (International) has also been encouraging Chinese traders to introduce substitute bones in place of tiger-bones including those of domestic cats into retail pharmacy outlets. Negotiations with pharmacists and middle men from the main black-market trading areas around Shanghai and Canton, are the latest in a series of WWF (International) moves designed to alleviate pressure on wild tiger populations by persuading consumers to switch from illicit potions containing real tiger-bone to over-the counter remedies containing body parts of both wild and domestic cats.

The suggestion of 'tiger farms' may sound rather bizzare but ethically there is no difference between raising tigers in farms, and raising sheep, cattle, goat, rabbit, poultry, fish, prawns and other domesticated animals, and even raising wild species like kangaroo and ostrich for purposes of meat. The last two have now been added to the Western menu. Tiger bones could as well be added to the list only in the case of China. Tiger farms in China will go a long way to relieve pressure on SE Asian and Indian tigers.

Conclusions

Tiger and Asian lion are making news all over the world. All is not lost; the good news is that both are fast breeders. There is a need to follow a pragmatic genetic evolutionary pathway for their conservation. Otherwise these animals will enter into an extinction vortex. Conservation is no longer merely a game of increase in numbers but of conserving genetic variability after making credible estimation of the same using modern tools. Many wildlife experts are still not ready for such approaches. The heart of the matter is that in general, the smaller a population, the greater is the vulnerability to variation in environment. This will in turn lead to further reduction in population size and drive a particular population into extinction. Genetic problems associated with small populations are well known, and minimum viable population size is a reality. Associated with this are problems due to loss of genetic variability and heterozygosity leading to inbreeding depression and genetic drift. The question arises, what should be the size of a viable tiger or lion population so as to maintain genetic variability in time and space. The answer is that there are no reliable well-researched data on the subject. Therefore, conservation has to be based on science of conservation biology. Alongside there is needed improvement in on-the-ground protection and ensuring abundant and varied prey-base. It may also involve ecorestoration and proper management of *ecosystem people*. Together all these will ensure the future of tiger and lion.

Khoshoo, T. N. (1997). Conservation of India's endangered mega animals: Tiger and lion. Current Science, 73(10), 830-842.



3
MAKING FORESTRY IN INDIA SUSTAINABLE

Being largely dependent on natural forest stands, India's forestry even today is mostly in hunter-gatherer stage. This is going to be increasingly untenable because of the escalating demand for wood and wood products much beyond the mean annual increment of India's natural and man-made forests. Self-sufficiency in forestry is no less important than in food, space science, atomic power, drugs and military hardware. In fact it is equally if not more important because with forestry is tied India's long-range ecological and economic security. To achieve this, leadership in forestry must pass from the present-day so-called self-proclaimed social and management experts, to the professional foresters who are sound in science and technology. Wood imports will become increasingly difficult on environmental considerations, therefore, the country has to swing into action and plan to achieve self-sufficiency in wood in the next 30-50 years. To be sustainable, it would involve

considerable inputs of upstream hardcore S&T, rather than mere social palliatives at present being supported by most international funding agencies.

Escalating wood demand, faulty implementation of the forest policy coupled with undue political and public interference at the local level, and 'caving in' of the Indian Forest Service under populist and political pressure, have, over the years, turned India into a wood-deficit and wood-importing country. This has led to a situation where populism dominates in the area of forestry in place of forest science and technology. Associated with this is the decline in forest cover, accompanied by considerable environmental, social and economic decline. If this decline is not halted, its pace will increase with time. The ultimate result would be that the country may head towards an irreversible desertification on a large scale in the Gangetic Plains which is our bread-basket. In recent years there have appeared a plethora of publications on Indian forestry. The most notable of these is Gadgil and Guha's(1992) treatise written from a historical perspective. Many seminars have been held, and projects sanctioned by international funding agencies to several organizations. A typical example of this is a seminar with 'five-star' lavish hospitality held in India with the support of a foreign agency (Lele et al., 1994), the outcome is a report that is pedestrian in content. The irony is that such five-star seminars in air-conditioned rooms deliberate on India's poor and poverty! The underlying science and technology of forestry has seldom if ever been mentioned even by default. Furthermore, the vacuum in Indian forestry has created many shades of 'foresters'. This is indeed an unfortunate state of affairs. It appears as though forestry in India is being subtly undermined by international organizations and funding agencies.

The basic problem in forestry in India is the widening gap between supply and demand of wood on account of over-population as compounded by low-productivity of the planting stock. The result is that yields are dismally low: the lowest in the world per unit of area and time. This aspect has never been discussed. On the

contrary, the present day forestry crisis has been shown to be a result of wrong management and non-involvement of the people at large. It is claimed that people have all the knowledge to make forestry work. However, no one doubts the importance of the local technical knowledge and wisdom, but there is considerable 'chaff' from which 'grain' has to be separated. This knowledge needs to be systematically unearthed, checked for its veracity and then dovetailed in an overall forest strategy.

The most pressing problem is the enhancement in productivity which can be raised only by application of forest tree genetics and breeding together with some aspects of biotechnology and supported by appropriate silvicultural practices. These aspects have never been discussed. As in agriculture, people's action will follow only when improved and highly productive varieties of forest trees become available. There can be dramatic increase in yield if such cultivars are used in place of plantations raised from seed from the unselected wild stock. Thus for the same effort, money and time, there would result in tremendous gains for the poor. The most pressing need, therefore, is that Indian forestry needs heavy scientific and technical inputs for making it sustainable.

Forestry is today a big business outside India. At the root of such success is the strong input from S&T in forestry coupled with relevant social and economic aspects. The best example of this is Sweden (Hagglund 1991). Unfortunately, funding agencies have seldom supported forest tree genetics and breeding in India. Most agencies have supported the so-called social palliatives. It appears as though vested interests both in India and abroad are undermining India's forestry plans so that this country continues to remain a wood-deficit and wood-importing country. Thus the country will continue to be embroiled in populist issues, and be a perpetual buyer of wood and wood products from abroad. Then wood will become a political weapon to be used against India at an appropriate time. The country was in a similar situation in food some four decades ago. Thanks to a total understanding between the then enlightened

and outstanding political and scientific and technical leadership, India became self-sufficient in food, and today it feeds itself without going round the world with a begging bowl. Associated with this success, there have been some ecological costs. Some environmentalists are concerned about it, but one need not worry on this account, because these costs are entirely manageable. India now needs to ensure high production and productivity in forestry to meet the needs of wood for its increasing population.

There is need to bring about a Forestry Revolution based on lessons from India's Green Revolution. The basic input to Green Revolution was Borlaug's Dwarf Wheats which were specially architectured to give high productivity. These were evolved by the use of genetics and breeding followed by appropriate agronomy, disease and pest control, etc. The leaders of this revolution in India were internationally acknowledged agricultural scientists and technologists. It is time that there is a deep introspection in India about our forestry. Forests in fact guarantee long-range ecologic and economic security, together with soil, water, climate stabilization, biodiversity, etc.

Facts about India's forestry

Unless the Government functionaries, foresters, scientists and technologists and the people of this country recognize the gravity of the situation in forestry, nothing tangible can be achieved in this area.

There are a lot of myths prevailing in forestry, and the facts are rather grim4. Some of these are enumerated below:

- Our close and *effective* forest cover (with a crown density 40% and above) was only 11.73% in 1990-91 (FSI, 1993) which is far below our declared national objective since Nehruvian times, i.e. to have 33% of our country under forest cover. The world average is also 33%. In other words, India is expected to have 110 million ha (total land area of India is 329 million ha) under close forest cover but it has only 38.56 million ha. This means that there is a deficit of about 71 million ha. Furthermore, the average forest cover should be 60% in the hilly regions, which, except in Arunachal Pradesh, is not the case in India.
- Open forests with a crown density less than 40% is 25.08 million ha, which needs conversion into close forest cover.
- India's per capita forest is only 0.1 ha, which is the *lowest* in the world; the world average being 1 ha per capita.
- The annual requirement of firewood, timber and paper and pulp of the country is at least 280 million m^3; but our mean annual increment from the forests is only 52 million m^3 (1.24%). The gap (228 million m^3) between demand and supply is increasingly widening and needs to be closed.
- Our productivity is 0.7 m^3 of wood per ha per year which is also the lowest in the world.
- Crisis in forestry in India is largely a crisis of firewood consumption, because firewood accounts for over 80% of wood use in the country. In addition, there are between 200 and 400 million cattle (more often derelict) which cause fodder crisis and compaction of the forest floor by trampling. This in turn also affects forest cover.

Firewood and grazing crises are very serious. Unfortunately, these facts have been pushed 'under-the-rug' particularly by most non-professional forestry actors. They connect forestry crises only to timber extraction by contractors. An objective analysis shows that forest destruction has been both need and poverty-related, and greed and affluence-related. Except in Jammu and Kashmir where firewood has been a part of forestry plans from the beginning, it is only now that firewood has entered the forestry agenda of other states. Furthermore,

- firewood as a source of energy is going to be relevant for the foreseeable future for a large section of economically poor Indians, and
- at present firewood comes to the megacities from far flung areas. More often it is transported by petrol or diesel-driven trucks and railway wagons. In fact the country may be spending far more energy in hauling firewood than it is recovering out of it.

The conclusion that one can draw from the foregoing facts is that unlike agriculture and animal husbandry (partly so in fisheries), in forestry the country is still in the *hunter-gatherer stage trying to meet the needs of firewood, timber and paper pulp from natural forest stands*. Left to the international funding agencies, the country would remain embroiled in the same state of affairs. There is, therefore, an urgent need for a modern and dynamic outlook in dealing with forestry by taking lessons from a wood-surplus country like Sweden (Hagglund,1991) where forestry is treated as an ideal renewable resource.

It may, however, be pointed out that the forestry crisis is indeed manageable, and can be solved in the next 30-50 years if we start now chalking out a forestry strategy, based on science and technology and keep the good of the people at heart. This will help the country to prevent desertic conditions that have set in the Indo-Gangetic Plains which, according to M. S. Swaminathan, have the potential to be the bread-basket of the world. If unchecked, it will lead to economic decline. Furthermore, we must allow our forests to regenerate, and alongside we must take to forest plantations of elite varieties in a big way for solving our firewood and industrial wood crises. In addition, as indicated above, the biggest lacuna in forestry is the lack of modern scientific and technological expertise, with the result, there is increasing tendency to take to populist approaches. Thus there is need to raise high density and short-rotation plantations of elites of location-specific varieties to meet firewood crisis. Equally important is that simultaneously the animal husbandry agencies need to do something very tangible to meet fodder crisis, and replace the present largely derelict livestock wealth by significantly fewer but improved varieties together with their stall feeding.

Goals of forestry

There is an urgent need for an in depth understanding of forestry problems and then take some short- and long-range practical steps. These would involve some hard non-populist but pro-nature, pro-poor, pro-woman and pro-job-generation decisions. The country has to be clear about the goals of forestry taking into account environmental and economic dimensions. Below are given the important goals in forestry and the type of forestry that emanate from such goals (Figure 3):

- Affording long-range ecological security by having a permanent forest cover for conserving climate, water, soil and biodiversity. This is achievable through *conservation forestry*.
- Meeting the need for goods and services, including firewood, charcoal and fodder of the tribal/rural communities and the urban poor: achievable through different *agroforestry systems*.
- Meeting the wood requirements of the people and industry for timber, pulp, fibre and silvi-chemicals: achievable though *industrial forestry*.
- Ecological amelioration of degraded forest areas and wastelands so as to green and then enhance the productive capacity of such derelict lands and to improve general aesthetics: achievable through *restoration forestry*.

These four types of forestry are not mutually exclusive but mutually highly supportive.

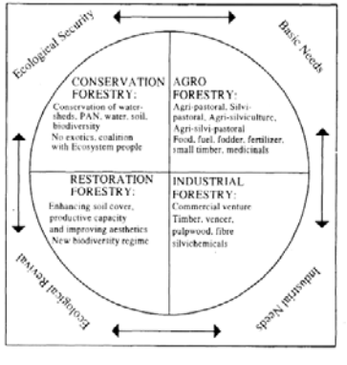


Figure 3: Types of forestry together with their ecological and socioeconomic implications

Conservation forestry

This is most relevant for conserving all water regimes/ watersheds/ catchments; representative ecosystems and biosphere reserves, centres of origin and diversity of crop plants and domestic animals; national parks and sanctuaries and fragile and unique ecosystems, together with conservation of the forest cover that exists in these areas. Among other areas, all mountain systems (entire Himalayan belt, Siwaliks, Aravallis, Vindhyas, Eastern and Western Ghats, etc.) would come under the purview of this category. All these mountains are in fact our water reservoirs and climate-stabilizing areas. In these regions, extraction of wood (not more than the mean annual increment) and non-wood forest resources have to be highly selective and only when warranted on scientific and technical grounds for maintaining the health of the concerned forest or ecosystem. Such extraction has to be done based on well conceived working plans. The restoration and repair of such areas has to be done with local and indigenous species, and *on no account should exotics ever be introduced in the Protected Area Network (PAN).*

Conservation forestry benefits all people both within and outside a country; because it is linked to the stabilization and conservation of climate, soil, water and biodiversity, and is the source of non-wood products including wild economic medicinal, aromatic and other plants and fruits, and other amenities. Conservation areas need to be circumscribed precisely and their tenurial security guaranteed by appropriate stringent legislation. The centre should have the overriding power in this regard.

In these areas there is needed a meaningful coalition between local communities, foresters and the relevant scientists. Such coalition does not mean that these forests need to be handed-over to pastoralists like *bakarwals and gaddhis*, each one of them own cattle wealth worth millions of rupees. Such populist suggestions should be rejected outright. Instead it should help only those who are really poor and needy, i.e. the real *ecosystem people*. Major ethnobiological and developmental programmes need to be mounted to bring the

indigenous people out of the morass of poverty, illiteracy, hunger and want. They also deserve good things of life and on no account should poverty be romanticized as some Indian and foreign NGOs do. Poverty has to be banished, it is a curse.

Agroforestry

Here, the objective is the integration of agriculture, forestry and animal husbandry to meet food, firewood, small timber and fodder needs. Furthermore, villages surrounding a city may also grow firewood for supplying to the adjacent city or cities.

If warranted on the grounds of land-use and end-use to meet the needs, there should be no objection to the use of exotic trees or shrubs in agroforestry systems. After all many of our agriculture crops, including even the holy cow, are naturalized exotics which have undergone artificial selection over the years in this country. Here, the beneficiaries are the rural (even nearby urban poor) people whose needs of firewood and small timber are to be met. Agroforestry would ultimately relieve pressure on natural forests and thereby help in forest conservation. There can be several permutations and combinations under agroforestry.

Industrial forestry

At the outset a distinction must be made between forests and forestry plantations for industry. In essence the latter is *tree-crop farming* (Khoshoo 1987). Here, the objective is to meet the needs of timber, pulpwood, fibre and silvichemicals for industry. *It is exclusively a commercial venture based on wood quality and input-output considerations.* The immediate clients are wood-based industries. Industrial forestry has also to be related to land-use and end-use considerations. Since these are commercial ventures, sustainable production and productivity are the chief objectives, and, if warranted on land-use and end-use criteria, fast-growing exotics are also welcome for this purpose.

India can afford to be oblivious to the needs of industrial forestry only at the cost of its ecological and economic security. Realism demands that there has to be 'a crash programme on industrial forestry in order to save our natural forest wealth; in fact industrial forestry itself would become a forest conservation strategy, because there would be lesser demands on the natural forest stands, which would thus be saved.

According to Central Statistical Organization (CSO, 1995), in 1994 the country imported newsprint and paper board worth about Rs. 706.50 crores and, in addition, wood and pulp worth Rs. 1147.69 crores. Imports worth Rs. 1854 crores ($ 618 million) per year (no doubt a very conservative estimate) is indeed a sizable amount. Thus, if nothing tangible is planned, this amount would increase progressively, and is expected to touch at least Rs. 3000 crores ($ 1000 million) per year by the turn of this century. Import of timber, pulpwood, etc. can help to avert an immediate shortage but, for reasons more than one, it is by no means a permanent solution. Therefore, the best strategy is to give a very high priority to industrial forestry with full back-up support and extend all help by suitable modifications of land laws, etc.

Furthermore, total replacement of wood is not possible. There is increasing realization that use of metals, concrete and plastics as replacements is environmentally stressful and energy-intensive. These create much more environmental damage, which is irreversible and very vicious in character, and above all very costly to depollute. Any damage by silviculturally sound extraction is manageable and cost of ecorestoration is far less than depollution due to manufacture of metals and plastics, and above all plantations grown on sustainable basis are environmentally benign.

Since industrial forestry is a pure commercial venture, high inputs of science and technology would be needed to reduce ecological and economic costs and make it a profitable venture. High-yielding

cultivars of trees have to be selected or bred, and silvicultural practices standardized very precisely. Again, a meaningful coalition between villagers and industry is called for.

Restoration forestry (eco-revival)

Due to paucity of arable land, wastelands have become relevant to meet the escalating demand for diverse land-uses. However, utilization of such lands poses a major R&D challenge. Here the objective is to green derelict and wastelands in order to ameliorate, and finally restore them ecologically. The process can be started by creating natural wilderness areas by using the principles and practices of eco-restoration and plant colonization. Owing to litter fall, a decomposer chain would start, followed by soil amelioration and increased water retention. This would go a long way in improving the quality of these lands. At the same time wood would be produced which could be used for several purposes. Techniques are now available which can make use of ordinary wood (after proper physical and chemical treatments) for a number of sophisticated end-uses. Wood, like leather, being a natural material, has wonderful properties. Wood is there to stay for all times to come. Therefore, wood from wastelands after appropriate treatments can also be used.

About half of India's land is today wasteland (Khoshoo 1992) having been degraded on account of over-harvesting of wood and overgrazing of forest floor which has led to deforestation and land degradation with its attendant social, economic and ecological dimensions. The extent and nature of degradation is related to the nature of the concerned forest or ecosystem. Often some forests are highly fragile or even highly resilient which depends on the particular edaphic factors and the composition of the forest itself.

Figure 4 summarizes in general the major states in forest degradation in response to stress and their tolerance ability (Maini,

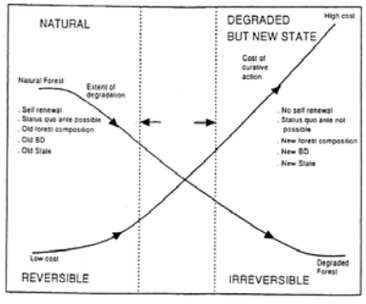


Figure 4: Three states of forest degradation and recovery

1992). Two major trajectories are depicted here, one depicts the extent of forest degradation from natural to degraded condition, and the other depicts the cost of curative action. Three major integrading stages can be recognized.

First stage is reversible on account of self-renewal where *status quo ante* is possible, and composition of forest and its biodiversity can be brought back to old natural state. The central point is that the degradation is light and forest floor has not been destroyed. The resilience of concerned forest ecosystem has not been impaired and can be augmented often simply by closure to grazing and allowing the forest to recuperate. Costs involved are minimal, often negligible in comparison to the gains. There are many examples of this in India, particularly in the Himalaya, where simply by closure to grazing *status quo ante* has been attained within a matter of few years.

The state on the extreme right of Figure 4 represents a situation where forest has been degraded beyond recognition and irreversible changes have taken place on account of loss of soil and soil microflora, biodiversity, water-retaining capacity, etc. No self-renewal or *status quo ante* is possible. Cost of curative action is high and it could lead to new forest composition with new pattern of biodiversity. The change from original composition is irreversible, but a new state of forest is possible. There are instances that the 'new' forest reverts to its original composition with time.

Obviously, costs involved in restoration of such areas are rather high, but should be acceptable because of the permanent greening and halting of erosion that ensues from such an operation. Degradation can take place within a matter of a few years as happened in Uttar Pradesh. Here, with the abolishment of *zamindari* (landlordism) after independence in 1947, the *zamindars* (land lords), out of vengeance, literally clean-shaved the forest on their lands. Thus they made a fast buck and returned the land to the Government. Restoration of such forest will take a long time and curative action would be rather costly. An example of such a rehabilitation process is Banthra. In 20 years, it did lead to the creation of a new man-made forest and new agroecosystem (Khoshoo 1987).

Between the two extremes, is a state, where depending upon the extent and nature of forest degradation and extent of human intervention, the forest could recover to near-original state or to a new state (Figure 4). This intermediate state is indeed labile. The famous case of Sukhomajari (Siwaliks of Haryana near Chandigarh) by R. P. Misra would more or less fall in this category. This may be called as the Indian version of Canadian Model Forests where imperatives of production and consumption were dovetailed on a sustainable basis. This would involve a partnership between Village Council and the people on the one hand, and scientists and technologists, relevant industry, State and Central Government Forest Departments and Wildlife Managers on the other. The idea is socio-economic revitalization of the local communities by improving the health, and productivity of forests and plantations through application of science and technology and participatory resource management.

Some excellent models of development of wastelands are already available in this country. The eco-restoration strategy must involve an intimate study of the ecological aspects and socio-economic costs.

What needs to be done?

A reorganization of forestry is needed in real terms so that the same matches the stupendous tasks awaiting before it. This is only possible if the *leadership in forestry is reverted to technocrats*. In the meantime the following aspects need consideration.

Conservation Forestry needs to be fortified by appropriate laws together with a set of credible and implementable measures to better the lot of indigenous or the *ecosystem people*. Centre must have over-riding powers in this regard.

Agroforestry has to be strengthened by appropriate R&D and location-specific models of agri-silviculture, agri-pastoral, silvi-pastoral, agri-silvi-pastoral so as to increase the production of food, fodder, fuel, fertilizer, medicinals, etc. on a sustainable basis (Figure 3).

Industrial Forestry needs strong inputs of R&D so as to make it a commercial success. Unfortunately, this type of forestry is a *red rag* to ecological fundamentalists. They do recognize the need of wood for timber, paper pulp and fibre, but their populist strategies can never lead to self-sufficiency in wood needs. This type of forestry has to be an industrial venture where genetically superior high-yielding strains have to be used. Obviously it will require back-up support by changing land laws, and inputs of genetics, tree breeding, biotechnology, updated silvicultural practices, use of mycorrhizae, protection from diseases and pests, etc. One of the options is to privatize this venture after plugging the possible 'holes' in the system, where involvement of people (not in populist sense) is ensured. People and industry have to develop an equal stake.

Restoration forestry needs to be taken up with the help of people by warranting and guaranteeing their rights as long as they do not clash with our long-range ecological security. The objective is to green these areas with tree/shrub cover with anything that can grow under these harsh ecological conditions. There are many

instances when after 15-20 years, natural forest composition takes over in such areas. Help of some internationally known Indian and may be even foreign forest ecologists needs to be elicited. Even today the country has some good forest ecology schools with very good traditions. In essence, there is needed a well thought-out programme of enhancement of productivity from the dismally low level of 0.7 m 3/ha year. Productivity enhancement goes well with the concept of forest tree crop farming. It is also in line with the contemporary developments that are taking place in the industrial countries.

Speaking biohistorically, human beings met all their wood needs from natural forests because forests were far in excess of the human numbers and their needs. This stage was akin to the foraging, hunting and gathering food, fuel and fibre needs from the wild, which has been abandoned by human being some 6000-10,000 years ago except by the *ecosystem people* who are very few in number and their wants very limited. The result has been that there are today well-organized agriculture, animal husbandry and fisheries systems. Such a change in forestry in India is long overdue to meet the wood needs through agroforestry and production/industrial forestry. This would help to create alternative resources and employment and thus help in saving the natural forests.

Trees as crops

Another urgent need is to breed special ideotypes for timber and pulpwood, fuelwood and fodder trees. Trees have to be cultivated as crops under agroforestry and industrial forestry. This means that there has to be a period of domestication involving conscious selection of trees for specific end-use, e.g. firewood, fodder, timber, pulp, etc. On account of their high yield, the tree crops would out-do the ancestral species. This change has become necessary. Furthermore, there is a mistaken notion about multipurpose trees. A tree can be multipurpose at the taxonomic level, e.g. different genotypes for fuel and charcoal, timber, pulp, fibre, latex, etc. *One cannot use a tree for all these uses at the same time*. For instance,

if leaves are constantly used as fodder, there would be reduced photosynthesis leading to reduced wood output. This means trees have to be selected and bred for specific uses. Thus the concept of tree-ideotypes must come in. This concept has been followed intuitively by foresters but never by a deliberate design. There is needed a good deal of coordination among tree physiologists, geneticists, breeders and silviculturists to design specific tree ideotypes for timber plantations, fuelwood and as fodder. Again, there would be differences if tree-crops are grown in plantations, or under agro-forestry conditions.

Equally important is to relate yield parameters to morphological, anatomical, physiological, genetical, chemical, canopy architecture and silvicultural requirements. Furthermore, yield parameters have to be related to phenology, photosynthesis, sink dynamics, competition, aging, etc. These characteristics are often strongly correlated. *The objective is to develop tree ideotypes for specific end-uses*.

Eucalyptus provides an interesting case of a total mismatch between end-use and its ideotype. Ideally eucalyptus can be used for pulpwood and/or timber, and not as a firewood crop. The latter is a total waste of the valuable biomass.

Khoshoo (1987) has worked out the idiotypic characteristics of timber, fuelwood and fodder trees. For timber and pulpwood the characteristics are: partitioning of nutrients in favor of wood in the mainstem rather than for branch-wood, bark and even reproductive parts which should be small with few flowers. Other characteristics should be: straight stem, narrow green crown, thin bark, good quality timber, rapid growth, thin branches arising at about 90° to the trunk, more leaf area per unit of branch wood weight, longer lasting foliage, few flowers, tolerant to environmental stress and high survival value under specific agro-ecological conditions. The advantages of such an ideotype are the elimination of expensive thinning operations; and easier pruning. All these characteristics also apply to pulp-wood

species together with appropriate chemical parameters.

Fuel wood ideotypes would be most relevant to the rural subsistence sectors, and for this marginal wastelands with low-nutrient soils would be available for a long time to come. Trees should have rapid growth, wood with medium to high density, high calorific value, straight grain, wood that burns steadily without any toxic smoke and sparks, stem thin and of medium length, thornless, not excessively branched, ability to coppice and pollard, easy vegetative propagation, minimum bark, ability to tolerate competition and amenable to high density/short rotation for high wood biomass production.

Fodder trees with leafy shoots, twigs and fruit were very popular in historical times, but down the ages, attention shifted to fodder grasses and legumes. In the recent times there has been revival of interest as a component of agro-forestry systems, although tree fodder is less nutritious. A desirable ideotype should be a small tree or a shrub, highly branched, possessing the capacity of regrowth after periodic lopping and leaf-stripping without affecting phenology and metabolism, palatability with specific livestock, digestibility and proper chemical characteristics, particularly high protein content.

The foregoing characteristics have to be looked for, while making selections from the natural and man-made variants for a specific end-use, so as to maximize the productivity of the end-product. With time these can be refined. Having identified or bred elites, they would follow a strategy to enhance their productivity further. The following six components are indeed interconnected and can be taken up simultaneously:

- Application of advanced forest tree breeding methodology and selection procedures for evolving superior genetics strains.
- Clonal propagation of elites and planning of a ‘genetic mix’ so as to simulate conditions in nature.
- Judicious use of tissue culture and biotechnology.

- Optimizing silvicultural and nutritional requirements, including use of fertilizer, irrigation and bacterial and mycorrhizal inoculatons.
- Disease and pest control, and
- Weed control.

Forestry, unlike agriculture, has a long gestation period and affects intergenerational equity. Therefore, it is necessary to take a long range view of R&D and policies in forestry. Funding has to be ensured on a long-term basis. This would also help in bridging the gap between the techniques developed in the research establishments and the technologies needed for large-scale application.

The basic rationale of the strategy for forests/plantations of the future is summarized in Figure 5.

Among other things, boosting productivity in forest trees is a function of nature of genetic status and genetic base of the planting stock used, its vulnerability to diseases and pests, its yield and management costs. From this point of view, the present day forestry in India falls in the right hand bottom square where we use unselected seed with wide genetic base, and obtain low yield,

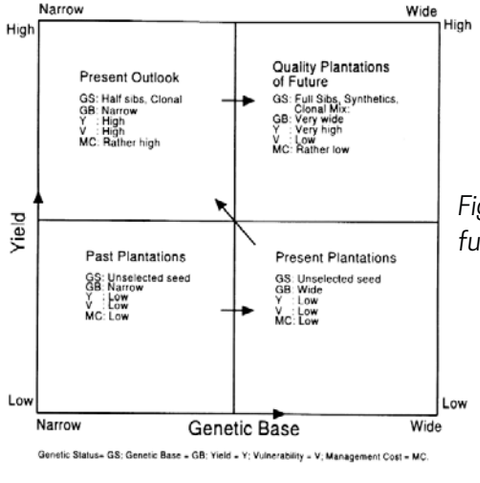


Figure 5: Strategy for future plantations

vulnerability is low and management costs are also low. The present day outlook is to move to left hand top square where it is intended to use selected planting stock (half sibs and clonal material) with rather narrower genetic base, and relatively high yield. Obviously, chances of vulnerability are high and so will be the management costs. However, the future goal (top right hand square) is to go in for full sibs, synthetics and clonal planting stock. This would have wider genetic base and yields would be very high, vulnerability would also be low because the genetic diversity would be wide, and the management costs would also be relatively lower. This would be a step towards future sustainable forestry with higher wood yield at relatively lower maintenance cost.

Summing up

If serious view of the existing crisis situation in forestry is not taken, India will be a perpetually wood-importing country and lose heavily in the long-range on ecological and economic security. Furthermore, the country would also lose the opportunity of being a quality-timber exporting country. Already a small country like Costa Rica is taking steps to raise large-scale scientifically well-managed plantations of teak (an Indian timber tree) as an export earner. Indeed it has been both pleasure and pain for this author to see these well-managed plantations in Costa Rica.

Wood self-sufficiency is possible only when research and development, education and training, and demonstration and extension in forestry are strengthened in real terms. A comprehensive report submitted to the Government of India in 1983 by the then Science Advisory Committee to the Union Cabinet (SACC), presided by M.G. K. Menon made specific recommendations in this regard. The underlying intention was to make Inspector General of Forests (IGF) ex-officio Secretary, so as to revert the leadership to technocrats in charge of the Department of Forestry (DoF). Furthermore, a well known forestry scientist/technologist should take over as the Director General, Indian Council of Forestry Research and Education. If such a person is not available in India,

he/she needs to be hired from abroad. Let us not forget that the first four or five IGFs and Presidents of Forest Research Institutes were Germans and not British, because the latter did not have good expertise in Britain. Secretary DoF should report to the Minister directly as is the case in Department of Scientific and Industrial Research (DSIR) and Department of Agricultural Research and Education (DARE).

Some of these changes need to be undertaken in real terms. These are long overdue and would enable the country to: depend less on present standing forestry stock and plantations of low genetic quality, but more on future quality plantations with high yield where the country needs to depend only on the sustainable allowable cut. This is what Sweden has done. Its export of timber and paper pulp helps that country to buy oil, food, chemicals and clothing.

A quantum jump in wood production through well thought out production strategy would become the best form of conservation of our natural forest wealth. The country should not be averse to the use of exotics as far as production of timber, paper pulp, fibre and firewood are concerned. However, such introductions should not be allowed to enter our natural forests. There is need to evolve a special protocol for forest introductions (Khoshoo, 1996).

India needs a meaningful R&D-based forestry without losing sight of socioeconomic aspects. By planting genetically superior stock in agro-forestry and industrial forestry programmes, there would accrue significantly higher yield with the same effort, money and time. This would change the whole scenario for the better both for the poor and the industry. But where is the expertise to raise such superior stock! It may exist on paper because somebody somewhere

issued a Government Order regarding this. Such expertise has to be built up by a technocrat secretary of the Department of Forests. This would not only help to save our natural forests, but also ensure our long-range ecological security with clean air with its correct chemistry, water, soil and land flora, fauna and microorganisms.

The Indian forestry has to rid itself of populism which is abetted by some international agencies and many of their cohorts floating around in this country. Many symposia and seminars are held not with the idea of helping forestry in India but keeping India in *permanent bondage* to import wood, paper pulp and fibre. They only help to romanticize poverty because such ideas are exotic to westerners. One often wonders if these agencies and their cohorts are India's friends or foes!

Khoshoo, T. N. (1996). Making forestry in India sustainable. Current Science, 70(3), 205-214.

4
INDIA NEEDS A NATIONAL BIODIVERSITY CONSERVATION BOARD

India's stakes in biodiversity are very high not only because it is a country rich in biodiversity but, out of the twelve centres, it is also a very important centre of origin of agri-biodiversity. Furthermore, the country as a whole is predominantly biomass-based with largely bio-industrial pattern of development in an unusually large number of villages, where over 76% of its population lives. The country is also a signatory to the Biodiversity Convention (1992), but such a decision was taken without any serious consultation with the scientific community. This has resulted in India landing itself into a situation where policy on biodiversity has overtaken the underlying science and technology. A major issue is how well scientific and technical knowledge can be harnessed into public policy. This paper summarizes India' s strengths and weaknesses in this area and urges that the Government of India appoint a small scientifically and technically sound National Biodiversity Conservation Board. This

would not only enable to prepare a cadre of conservation biologists, but also help to generate products and give the requisite bargaining power to the country in the international arena during negotiations.In common parlance, biodiversity may be defined as species richness (plants, animals and microorganisms) in a given habitat be it on land, in fresh water or sea, or as parasites or symbionts. Biodiversity is critical to the very health and stability of the biosphere and renewability of biomass, soil, water and air, together with oxygen, carbon, nitrogen and phosphorous cycles. Thus biodiversity renders free recycling and purification services together with natural pest control.

A subset of biodiversity is genetic diversity which occurs in the form of interbreeding populations of a given species. Populations of different plants, animals and microorganisms in a given habitat, existing as an interacting system, are known as *communities*. An aggregate of communities occurring as an interacting system in a given ecological niche makes an *ecosystem*. Different ecosystems in an ecological region occurring as an interacting system constitute a *biogeographical province*. All biogeographical provinces in a major ecological zone constitute a *realm*, and all realms on the surface of the earth together constitute the *biosphere*-the living mantle around the world occurring on land, in fresh water and in sea. Biodiversity is also the source of all living materials used as food, shelter, clothing, biomass energy, medicaments, etc. and host of other raw materials used in bioindustrial development. These along with metallic and non-metallic minerals constitute the basic wealth of any country. Ultimately, economy and ecology of a country depend on the health of these resources.

There is increasing pressure on natural habitats due to growing human population and enhanced pace of socio-economic development. This has led to the degradation of parts of earth's biosphere, and has resulted in loss of biodiversity and agricultural productivity. Such losses of species *are for ever* and affect not only plants, animals and microorganisms in nature together with those

under cultivation/domestication and used in industry, but also those whose value has yet to be ascertained.

The evolutionary history of earth is replete with examples of both extinction of old and origin of new species taking place simultaneously. Infact, geological times have witnessed five major episodes of extinction because of the cataclysmic events, but today's accelerated rate of extinction episodes can be traced only to the influence of human race. Therefore, steps need to be taken to halt such species losses. There is also a need of a well-conceived and dynamic programme of biodiversity estimation, conservation and sustainable utilization.

The overall estimation of the extent of biodiversity in the form of plant cover and forests in different habitats (including deserts, water bodies, coastal areas, etc.) would come under the purview of Department of Space and Forest Survey of India (MoEF), particularly the former because theirs would be a third party evaluation thus more credible. Periodic (say 5-yearly) reports from these bodies are needed to monitor all habitats for the extent of biodiversity. These data would be useful to take up work on ecorestoration of degraded habitats. Such surveys may also help in calculating the overall quantity of biomass, i.e. all living matter plant, animal and microorganism come under its purview.

The entire *in situ* conservation falls within the mandate of the Ministry of Environment and Forests (MoEF) together with some aspects of *ex situ* conservation, like conservation of complete organisms being attempted in field gene banks in botanic gardens, arboreta, zoos, zoological parks and aquaria. However, use of modem technologies in conservation of organism parts, falls primarily under S&T departments like Department of Agricultural Research and Education (DARE), Indian Council of Forestry Research and Education (ICFRE), and secondarily under Department of Biotechnology (DBT), Department of Scientific and Industrial Research (DSIR) and Department of Science and Technology (DST).

These include biological banks for seeds, pollen, sperms, eggs, embryos, tissues, microorganisms and genes (in the form of DNA). A well-managed network of such banks of parts of plants and animals, and microorganisms already exists in the ICAR. This Council has national bureaus on soil and land use, and plant, mammalian, avian, fish and microorganism genetic resources. Some of the bureaus have very large holdings in *ex situ* form. In addition, a large number of collections exist in the Institutes working on crop plants (e.g. wheat, rice, maize, sorghum, potato, tuber crops, sugar cane, cotton, jute, ground nut, gram, soya bean, edible oil crops, pulses, mango, citrus, cashew, banana, grape, tobacco, medicinal and aromatic plants, spices, plantation and horticultural crops, mushrooms, orchids and other flowers, etc.). Among animals large collections exist in the case of cattle, buffalo, pig, sheep, goat, poultry, camel, mithun, yak, fish (freshwater and marine), aquaculture, lac, etc. In these Institutes there is also basic S&T infrastructure and capability, together with long-term funding available for this purpose. Additions/ replenishments have to be made carefully and should also include all the important endangered and rare species; and ancestral and other related species, land races and primitive cultivars of agricultural crops and domesticated animals for purposes of breeding better types. A network of such banks has to be organized to save the relevant materials under threat of endangerment or extinction. This network should act as Native Germplasm Saver Societies of old and discarded varieties.

Biodiversity in India

The Botanical and Zoological Surveys of the country have estimated that as of today India's biodiversity constitutes 1,26,188 species (Khoshoo, 1995). These cover all the five kingdoms, namely Monera, Protista, Fungi, Animalia and Plantae. According to the World Conservation Monitoring Centre (WCMC, 1992), 1,60,4000 species have been described at the global level. Thus India accounts for 8% of the global biodiversity existing in only 2.4% land area of the world.

The country has a coastline of over 7,516 km long, a sizeable

exclusive economic zone (2.15 million km^2) and a large shelf area (0.13 million km^2). EEZ is about two-third of the area of mainland. Marine areas are by and large still to be systematically charted for biodiversity. There is an abundance of seaweeds, crustaceans, molluscs, corals, fish, reptiles and mammals.

Biodiversity exists at three major levels: *genetic diversity, species diversity and ecosystem diversity*. *In situ* conservation at the species and ecosystem levels of diversity fall under the purview of MoEF. The first level (genetic diversity) involves the actual utilization and is the concern of DARE, DBT, ICFRE and to a small extent, of DSIR and DST. Thus from genes to ecosystems, there is indeed a continuum (Solbrig, 1991).

Of late, there has been increasing preference and demand for biodegradable products obtained from different forms of biodiversity. Excessive demand for such products would surely lead to biodepletion of natural biota. There is not only an urgent need for the bioenrichment of the depleted species, but also for evolving strategies that would prevent bio- impoverishment in natural habitats. MoEF is principally responsible for this and has to harness professional expertise across the whole spectrum for this purpose. Unfortunately, this has not happened so far because these are very few science and technology-based ecorestoration programmes.

Biogeographical provinces

Udvardy (1975) recognized eight realms in the biosphere of the earth. These have been discerned based on a holistic approach. Each realm is infact a complex of related Biogeographical Provinces which number 193. India falls in two realms, with a total of 12 Biogeographical Provinces (Khoshoo, 1991), which are listed below:

- Palaearctic realm: Tibetan (Ladakh), Himalayan Highlands.
- Indo-Malayan realm: Malabar Rain Forest, Bengalian Rain Forest, Indus-Ganges Monsoon Forest, Assam-Burman Monsoon Forest, Mahanadian, Coromandel, Deccan Thom Forest, Thar Desert, Laccadive Islands, and Andaman and Nicobar Islands.

The foregoing 12 Biogeographical Provinces have six· broad ecosystem types. These are: Tropical Humid Forest, Tropical Dry or Deciduous Forest (including Monsoon Forest or Woodlands), Warm Deserts and Semi-deserts, Cold Winter (Continental) Deserts, Mixed Mountain and Highland System (with complex zonation) and Mixed Island Systems. This classification does not take into account the marine ecosystems and the interface between land and sea, and freshwater and sea. Such interfaces are also rich in biodiversity.

Rodgers and Panwar (1988) have done a detailed exercise, taking into account all the previous classifications including that of Meher-Homji (1972). According to them, the country can be divided into 10 Biogeographical Zones and 25 Biotic Provinces. These are: Trans-Himalayan (Ladakh); Himalayan (North-West, West, Central and East Himalaya); Desert (Kutch and Thar); Semi-desert (Punjab and Gujarat-Rajwara); Western Ghats (Malabar Coast and Western Ghat Mountain); Deccan Peninsula (Deccan Plateau South, Central, Eastern, Chhota-Nagpur and Central Highlands); Gangetic Plains (Upper Gangetic and Lower Gangetic Plains); North-East India (Brahmaputra valley and Assam hills); Islands (Andaman, Nicobar, Lakshadweep Islands) and Coasts (West Coast and East Coast).

These authors (1988) have taken into account 'land-planning regions of India, largely on geomorphological considerations'. The underlying rationale has been the mega animal part of India's wildlife, rather than the sum total of India's biodiversity. They feel some species are characteristic or indicators of certain habitats (e.g. pheasants in temperate Himalayan communities); other species (such as tiger) are dominant member of communities. Ensuring the long-term survival of such animals means that the communities and habitats are also protected'. However, they feel that, for such purposes, 'in general, animals are used more often than plants, mammals are used more than other animal groups, and larger species are used more than smaller ones'.

The report has also brought out that in 1987, there were 54 national

parks and 372 sanctuaries with a total area of 1,09,652 km^2 or 3.3% of the area of the country. After their review and identification of new sites, they recommended that the country should have 148 national parks and 503 sanctuaries which totals to 1,51,342 km^2 or 4.6% of the country's total area.

The report of Rodgers and Panwar (1988) is indeed an excellent effort but takes a traditional view of wildlife. However, today wildlife is regarded as a part of overall biodiversity so as to make the former more holistic. It must encompass the whole gamut of plants, animals and microorganisms. This change is necessary, because the traditional concept of wildlife is rather restricted in outlook. This laudable report is now a decade old and MoEF has yet to take a decision on the recommendations and publish the report for wider circulation and use.

Hotspots in India

Among the 18 hotspots in the world (Myers, 1988) two are in India. These are two disjunct areas: Eastern Himalaya and Western Ghats. Their floral wealth is particularly rich so is their endemism not only in flowering plants but also in reptiles, amphibians and swallow-tailed butterflies. Western Ghats have endemic mammals as well.

Apart from the two foregoing mega 'hotspots', 26 endemic centres have been identified by Nayar (1989). These are: Karakoram and Ladakh of Kashmir Himalaya; Kumaon-Garhwal Himalaya; Siwaliks; Terai; Sikkim Himalaya; Arunachal Pradesh; Lushai Hills; Tura-Khasi Hills; Aravallis; Chhota-Nagpur Plateau; Panchmarhi-Satpura Range; Simplipal and Jeypore Hills of Orissa; Bastar and Koraput Hills; Vizagpatnam Hills and Araku Valley; Tirupati-Cuddappa Hills; Marathwada Hills; Saurashtra Kutch; Mahabaleshwar-Khandala Ranges of W. Ghats; Agumbe-Phonda Ranges of W. Ghats; Ratnagiri and Kolaba Ranges; Nilgiris, Silent Valley and Wynad; Anamalais of W. Ghats; Palni-Yercaud; Kalakad and Agastyamalai Hills of W. Ghats; Andaman Island; and Great Nicobar Island.

The northeastern region is the home of some botanical rarities. One of these is *Sapria himalayana* which is a parasitic angiosperm and has been sighted only twice since 1836. The flowers are about 35 cm across and buds are about the size of a grape fruit. Besides this, Sahni (1982) has enumerated several such vanishing taxa. The region is meeting ground of IndoMalayan and Indo-Chinese biogeographical realms as well as Himalayan and Peninsular Indian elements. It may be recalled that it was here that the Peninsular plate struck against Asian landmass, after it broke off from Gondwanaland. It is, therefore, not surprising that the northeastern India is the region where a large number of primitive angiosperm families are also found. These are: Magnoliaceae, Degeneriaceae, Himantandraceae, Eupomatiaceae, Winteraceae, Trochodendraceae, Tetracentraceae and Lardizalbaleaceae. The primitive genera are: *Alnus, Aspidocarya, Betula, Decaisnea, Euptelea, Exbucklandia, Haematocarpus, Holboellia, Houttuynia, Magnolia, Mangelietia, Pycnarrhena and Tetracentron* (Malhotra and Hajra, 1997). Takhtajan (1969) was led to believe that this region along with contiguous regions is the cradle of flowering plants. Furthermore, Janaki Ammal's (1950-1954) outstanding cytogeographic work has shown that northeast India, together with contiguous region of Chinese provinces of Yunnan and Schezwan, is a very active centre of organic evolution. This has now been confirmed by studies in South East China where an altogether new large mammal (*Muntiacus gongshanensis*) and four new genera (*Xizangia, Sinoleontopodium, Sindoxa* and *Tetradoxa*) of flowering plants have been discovered (De-yuan and Zheng-yu, 1995). Such is the biological riches of NE India and the adjoining SE China. This region needs special attention.

Although the two areas (North Eastern Himalaya and Western Ghats) are today disjointed having their own characteristic flora and fauna, the following species are common to both (Khoshoo 1992; Ali, 1981): *Ternstroemia japonica, Rhododendron arboreum, Hypericum hookerianum, Thalictrum javanicum, Cotoneaster buxifolia, Parnassia wightiana, Lonicera ligustrina, Gaultheria fragrantissima, Symplocos lauriana*, Himalayan and Nilgiri Tahr, Nilgiri Pine Marten,

laughing thrush (associated with genus Rubus), great pied hornbill, frogmouths, fairy blue bird, lizard hawk and rufous bellied hawk-eagle. The probable explanation for the presence of common species between the two disjunct regions is an indication of their being Pleistocene relicts. According to this view, during Pleistocene glaciation, temperate flora and fauna moved south. On retreat of the glaciation, temperate relicts were left at higher altitudes of the southern mountains and continuous distributionbetween northeast and southwest India was lost after the Pleistocene glaciation. This is the most plausible explanation.

According to Hora (1950), there is also resemblance in fish fauna between the two disjunct areas. However, he advanced Satpura Hypothesis, which envisaged movement of Assam flora and fauna through Satpura System to Western Ghats. Whatever be the explanation, the fact remains that the northeast and southwest floras and faunas have some degree of commonality. The common species listed above need detailed genetic study including genetic fingerprinting to establish the relationship between the two groups of disjunct biota in space and time.

In the Indian subcontinent, five sites have been recognized internationally that are not only rich but are also priority sites for data sheet treatment. These are: Agastyamalai Hills, Nallamalais, Nilgiri Hills, Namdapha, and Nanda Devi. Agastyamalai and Nilgiri Hills can be categorized as distinct floristic provinces, often covering a very wide area. Together these constitute a centre of plant diversity and/or endemism covering the whole region. For conservation to be effective, a network of smaller reserves needs to be established because it may be impracticable to protect the entire area. Namdapha and Nanda Devi are discrete geographical areas needing conservation.

Endemism and extinction

The most reliable work on endemism in flowering plants of India has been done by Chatterjee (1939). Most of the subsequent work has depended on this detailed study. According to him, there are 6,850 endemic species in India out of which 3,165 (about 50%) occur in the Himalaya. Among the largest genera in India are *Impatiens* and *Primula* with a high degree of endemism. The former has 189 species, about 112 of which grow in the Himalayan belt, while 77 species in Western Ghats, with only one species (*I. balsamina*) common to the two disjunct regions. *Primula* has 162 species out of which 148 are endemic. Endemic birds are found in western Himalaya, Indus valley, Western Ghats, eastern Himalaya, Nepal, Bhutan, Bangladesh, Assam Plains and Tirap Frontier with Burma. In higher vertebrates, the country has 12% endemism in mammals, 7% in birds, 40% in reptiles and 53% in amphibia. Andaman and Nicobar has 93% (75 out of 81 species) richness in endemic land snails. Overall, India has 90 species of mammals, 110 species of birds, 158 species of reptiles and 110 species of amphibians endemic in the Indian region (Mackinnon and Mackinnon, 1989).

Data on threatened species may be relatively more reliable. It appears about 1,336 species of flowering plants, 39 species of mammals, 72 species of birds, 17 species of reptiles, 3 species of amphibian and 2 species of fish are threatened.

Though no professional studies have been made on the extinction of biota India, the following species appear to have become extinct in India. These have not been sighted for a long time.

- *Rhodonessa caryophyllacea* (Pink Headed Duck) around 1935 possible cause has been over-hunting.
- *Athene blewiitti* (Forest owlet) around 1914.
- *Ophrysia superciliosa* (Himalayan Mountain Quail) cause was over-hunting. According to Salim Ali it was last sighted in 1876. There is however, a recent unconfirmed report of its sighting in Uttarakhand.

- *Rhinoceros sondaicus* (lesser one-homed rhino) extinct in India but occurs in Java.
- *Acinonyx jubatus venaticus* (Cheetah) extinct in India in 1939, but occurs in Central and Southern Africa and perhaps also in parts of Middle East.
- *Isoetes dixitii* (Isoetaceae) from Maharashtra. Extinct in 1868.
- *Isoetes sampathkumarnii* from Karnataka.
- *Lastreopsis wattii* (Aspediaceae) from Manipur.
- *Ophiorhiza brunonis* (Rubiaceae) from Kamataka and Kerala.
- *Ophiorhiza caudata* from Kerala.
- *Ophiorhiza radicans* from Kerala and Sri Lanka.
- *Wendlandia augustifolia* (Rubiaceae) from Tamil Nadu.
- *Trochetia parvijlora* (Sterculiaceae) from Meghalaya.
- *Sterculia khasiana* (Sterculiaceae) from Meghalaya.
- *Eragrostis rottleri* and *E. rangacharli* (Graminae) from Tamil Nadu.
- *Hubbardia hepataneuron* (Graminae) from Karnataka.
- *Dipcadi concanense* and *D. reidii* (Liliaceae).
- *Urginea polyphylla* (Liliaceae).
- *Corypha taliera* (Palmae).
- *Hedychium marginatum* (Zingeberaceae) from Nagaland.
- *Calanthe whiteana* (Orchidaceae) from Sikkim.
- *Prasophyllum colemaniae* (Orchidaceae) from Meghalaya.

Although the loss of foregoing 24 species has come to light, there may be many more species which have become extinct. A systematic study has to be initiated by BSI and ZSI involving the university system.

Centre of origin and diversity

All crop plants and domesticated animals can be traced to their wild ancestors. They have arisen both through inadvertent and deliberate selection by human being. The degree of dependence of these plants and animals on human being is directly proportional to the extent and nature of transformation that has taken place from the wild to the cultivated/domesticated condition. The crop plant genetic resources of the world can be assigned to specific centres of diversity as originally identified by Vavilov (1951).

Vavilov identified these on the basis of varietal diversity, homologous variation, endemism, dominant allele frequencies and disease resistance. The centres are located in different continents. These have also been referred to as Germplasm Treasures.

While Vavilov's basic conclusions have stood the test of time, there have been small differences about the number and location of centres of diversity. There is today a general unanimity about 12 centres of diversity (Zeven and Wet, 1982). India is one very important centre having contributed to world agriculture at least 167 plant species. Within the overall mega Indian Centre of Diversity as recognized by Vavilov, there are at least nine subcentres of diversity, where wild relatives of cultivated plants still occur (Arora and Pandey 1996).

One indeed marvels at the intuitive power of our very remote ancestors to have picked up these plants from the wild, and selected these unconsciously and consciously so as to make them far different and highly productive compared to the ancestral stock. Some of these are being cultivated world wide, e.g. rice, sugarcane, cucumber, egg plant, banana, citrus, ginger, etc. Among animals, the three important animals (chicken, cattle and pig) supporting world animal husbandry, chicken (*Gallus gallus*: jungle fowl) is India's contribution. The cultigens and domesticated types both in plants and animals have been crafted meticulously and are different from the ancestral species. Like cultural and developmental diversity, agri-biodiversity is also a part of the creative diversity of human being. All these diversities are mutually supportive and reinforcing.

There are secondary centres of genetic diversity which are environmentally different from the primary centres, where the crops were developed further by human ingenuity. Thus India is a secondary centre of diversification for several species which are very old introductions (may be even pre-Columbian) into the country. Such crops are grain amaranths, maize, red pepper, soybean, potato, oil palm, etc. Similarly, the Indian breeds of exotic

and domestic animals like horse, pony, sheep, goat, cattle, etc. are always in demand particularly for their disease resistance and hardy traits. The reason is that these animals are the result of hardiness, adaptation to heat, parasitic stresses, and availability of roughage with low nutritive value and, therefore, these are in demand for breeding purposes in Australia, USA and Latin America.

National Biodiversity Conseration Board (NBCB)

By their very nature, most Indians are peace-loving and vegetarian, and believe in non-violence which is enshrined deep into their psyche. Thus conservation is basically a part of Indian ethic. It is, therefore, not unexpected that in the historical past, India had a tradition of giving highest attention to wildlife. In the recent times, the country had a powerful Indian Board for Wildlife (IBWL) headed by the then Prime Minister of India, Indira Gandhi. This continued up to her assassination. After her, the Board has met only once. What it means is abundantly clear!

There is, however, no doubt that the concept behind IBWL has outlived its utility because there is a need to widen its scope and make it holistic. Even the World Wildlife Fund, from which many rich Indians have been drawing inspiration, was compelled to change its name to World Wide Fund for Nature by sheer circumstances of new and vastly extended knowledge on biodiversity. However, for the sake of continuity and convenience, they continued to have the same acronym: WWF. Theoretically, wildlife means all undomesticated plants and animals, but in practice it was restricted to large mammals, big cats in particular. This was so on account of a feeling that these animals were top of the food chain. The underlying rationale was: if big animals are conserved, *ipso facto* others below them are also conserved. This may not be correct under all circumstances and can, therefore, be a fallacious argument. In India due to the outstanding work of the late Salim Ali, birds have been studied very intimately. There has also been outstanding work done on algae, fungi, liverworts, mosses, fems, gymnosperms besides angiosperms. The same is true of different groups under the animal

kingdom. All this work is scattered and needs to be organized into a modern database.

Today, the concept of wildlife has widened considerably. It includes all biodiversity as a dynamic and interacting system, of which even the local human beings are also an integral part. It is not merely the number of microorganism, plants and animals, but the most important point is the interconnectedness, interrelatedness and interdependence of plants, animals (human beings included) and microorganisms existing as a system. There is also a very definite connection between biodiversity and cultural diversity, together with social, economic, historical, religious and philosophical dimensions.

Such a relationship is mutually reinforcing. Biodiversity is now looked upon as a major renewable resource and hence an important Earth Capital. If we take away biodiversity from the Earth, human beings cannot exist. Conversely, if we were to take away human beings from the surface of earth, biodiversity (except agri-biodiversity which has been created and crafted by human beings) will continue to exist, may be even flourish. Human race must realize this.

This country has done nothing worthwhile, although we made tall claims after signing the Biodiversity Convention at Rio in 1992 and thereafter. It may also be pointed out that biodiversity is not to be mistaken for mere animal welfare and such other populist measures, but there is whole range or scientific, technological, social, economic, ethical, moral and political disciplines involved in it.

Furthermore, throughout rural India, there are innumerable microenterprises at the village level using local biodiversity. The products from the same find their way to cities and even in international market. These are exotic and often exquisite items and are in demand. There have been very few dependable studies on such enterprises. There is need to document and analyse these

with a '*cradle to grave*' approach. With a little innovation, such studies can be linked not only provincially, but also nationally and some even globally. Sufficient attention has not been paid to these aspects except for the outstanding studies of K. S. Bawa and his colleagues. Their work has attracted world attention. As a whole this area is indeed uncharted and if work is done professionally, it would also give us an inkling about the economic value of the products obtained from our biodiversity. Regrettably, Indian biologists have not played their part well. The vacuum thus caused has been filled by a host of non-biologists. The professional biologist of the country must now take a lead lest the whole area of biodiversity should fall in wrong hands.

Another dimension is that there is considerable illicit trade in wild animal parts and plants, e.g. tiger bones, claws, skin of tiger and other cats, rhino horns, butterflies, orchids, herbal drugs and aromatic plants, sandalwood, etc. It is clear that animal and/or plant producing countries are in developing world in South America, Meso-America, Africa and South East Asia, but ultimate destination of the traffic in biodiversity is USA, Canada, West Europe, Japan, Middle East and China (UNESCO, 1994). On paper, India is neither a producing nor a receiving country, but considerable illicit trading in biodiversity comes to light once in a while.

Techniques like DNA fingerprinting can be used to identify such threatened and rare species. This technology has become very important because it enables unequivocal identification of the concerned species. Not only do target species need fingerprinting but also their adulterants. In addition, the diversity within the species needs to be charted and related to their chemical profile particularly in the identification of high-yielding strains of the concerned phytochemicals from drug and aromatic plants. Work on genetic fingerprinting has to be intensified and fingerprints obtained on most cultivated/domesticated and wild biota (human diversity included). All this information has to be collected in the form of a proper database and related to the uses of different

cultivars, ecotypes, chemotypes, etc. Such information together with species-specific and even gene-metabolite linked probes will also be of help in standardization of bio-pharmaceuticals and biodiversity-linked intellectual property rights, etc. For some critical species (endangered species like lion and tiger), such a technique will also give us an idea of the extent and nature of genetic variation so as to decide an effective strategy for its conservation based on principles of population genetics and breeding biology.

These sophisticated techniques need to be applied on a systematic basis to genetically, economically and trade-related biodiversity. Such a sophisticated database is going to be also critical to biodiversity conservation and utilization. Besides, it will have tremendous social, economic, ethical, and legal implications.

The foregoing aspects of biodiversity have to be accompanied by teaching and training in Conservation Biology: a new multidisciplinary subject which is becoming increasingly critical to the conservation and sustainable utilization of biodiversity particularly in developing countries. Advanced teaching and training in this discipline has to be started in some chosen conventional and agricultural universities and Wildlife Institutes so as to generate a cadre of well-trained and knowledgeable conservation biologists.

An important and an integral component of Conservation Biology will be a proper economic valuation of India's biodiversity. In fact it is a part of larger problem of proper economic evaluation of different forms of the Earth's capital (air, water, soil, minerals, etc.). Biodiversity has an indirect and a direct value. Indirect value pertains to the overall biological productivity of an ecosystem, fresh air and water, soil, regulation of climate, and ecotourism for shear greenery and fresh air and clean water and good viewing of wild animals and plants in their natural habitats. The direct value pertains to the level of community use of timber and whole range of non-wood forest products, genetic resources of crops and domestic animals and their ancestral and other related species. Putting a price tag on our

biodiversity will make its loss more understandable because it would be in fiscal terms. At present economic value of wild biodiversity (be it a medicinal or aromatic or fruit plant or whatever) is the cost of travel to collect the same, and no more. Those who make products, make the real money. However, it is the end-user and nature at large who pay the real cost.

Policy decisions regarding biodiversity have to be taken realistically, based on actual facts. Therefore, there is need to consolidate information and put it in the form of a major database commensurate with the biodiversity wealth of India.

Being predominantly a biomass-based country with largely bioindustrial pattern of development, India's stakes in biodiversity are indeed very high. Our performance in this area has been far from ideal. This is true even in its legal and political dimensions. At any rate, it is not commensurate with the extent and nature of bio-wealth that India owns. There are reasons for this. The result has been that biodiversity which is India's strength has been progressively going by default even when internationally biodiversity has assumed considerable importance. It is high time that Government and scientific and economic communities and responsible social scientists think about it very seriously. The least that can be done is to organize a competent and responsible organization so as to give proper importance and treatment to this wealth for the good of the country.

The information on biodiversity is very dispersed and needs to be consolidated so that the country can reap rich harvests from this important wealth. There is, therefore, a very urgent need of having a comprehensive and a professional National Biodiversity Conservation Board (NBCB) which can look at various aspects of biodiversity, ranging from environmental, to biological (including agricultural), social, economic, ethical and other related dimensions. The three broad functions are the establishment of database(s), and management and utilization of India's biodiversity. The National

Database(s) will store data on all the five kingdoms. Other equally important databases would deal with agricultural and industrial biodiversity. Here information of wild and human-created and crafted useful microorganisms, domesticated animals and cultivated plants together with their ancestors and related species and other relevant dimensions will be stored. It is indeed gratifying to note that this country already has a chain of very prestigious national bureaus of plant and animal genetic resources under the aegis of ICAR.

Indian Council of Forestry Research and Education (ICFRE) must take up the responsibility of conservation of forest tree germplasm, both under *in situ* and *ex situ* conditions in a meaningful manner (Khoshoo, 1996). Forest tree germplasm and lack of proper forest tree genetics and breeding programmes have been major lacunae in forestry research and development. This is why our wood productivity is indeed dismal, being the lowest in the world.

It may also be pointed out that the Ministries/Departments/ Organizations involved with NBCB would be Environment and Forestry, Agriculture, Industries, Commerce and their relevant Departments (DARE, DBT, DSIR, DST), ICFRE and those dealing with commodities like tea, coffee, jute, cotton, silk, tasar, rubber, cashew, coconut, arecanut, phytochemicals, biopharmaceuticals, biocosmetics, bioinsecticides, biopesticides, biofertilizer, etc. The total membership of the NBCB should under no circumstances exceed nine otherwise it will be only a talking body.

Of late, there has been a realization in the industrial countries that local technical knowledge of the indigenous people in the developing countries is not mere collection of myths and voodoos, but distilled knowledge accumulated over millennia. Such knowledge is based on large scale trial and error and intensive observation. Regrettably, this knowledge is regarded as 'ownerless' and is taken for granted as *Common Heritage*. There is now major effort by industrial countries to own all such 'ownerless' knowledge and resources. After its updating and refining, in industrial countries through the application

of relevant upstream S&T, this knowledge would be regarded as *innovation* and *intellectual attainment* and would become patentable. It would then be rewarded and awarded as private property and become available to only those who can pay the high price. All this has led to renewed emphasis on ethnobiology, ethno-medicine and ethno-pharmacology. This aspect of biodiversity has also opened up new vistas in ecology, biology, economics, micro-enterprises, anthropology, linguistics (particularly local languages), community development, conservation, etc.

In view of the foregoing, *the time has come that the country must declare biological diversity a National resource, its conservation and sustainable utilization a National goal and National priority.* The functions of NBCB have been worked out (Khoshoo, 1992) and need to be refined further. These need to be periodically looked at indepth and updated. An illustrative list of functions is given below:

- Formulate a National Policy on conservation and utilization of India's biodiversity and agribiodiversity together with a time-bound plan of action.
- Inventorize India's biodiversity.
- Establish minimal database(s).
- Review existing PAN (Protected Areas Network), identify gaps and draw criteria for identification of new protected areas.
- Examine tenurial security of PAN to ensure conservation in perpetuity.
- Prepare plans for management of PAN, ensuring stake and involvement of people.
- Support PAN with adequate number of genetic reserves, botanical and zoological gardens, arboreta and aquaria, and biological banks of organism parts including DNA.
- Draw plans for ecorestoration of degraded habitats.
- Draw plans for *ex situ* conservation together with rehabilitation of endangered species (e.g. tiger, rhino, lion, pheasants, butterflies, wild medicinal and other economic plants, etc.) based on genetic-evolutionary considerations.

- Draw criteria for endangerment of species leading to extinction together with causes for the same and suggest remedial measures.
- Draw conservation and sustainable utilization plans regarding hitherto neglected areas like marine biodiversity, forest tree genetic resources and microorganisms.
- Following principles of population and evolutionary biology and genetics and breeding, domesticate wherever necessary, wild biota that are in demand in trade, e.g. medicinal and aromatic plants, ornamentals, butterflies, fish, fur animals, botanical and zoological rarities and teaching materials.
- Draw plans for meaningful involvement of local people in conservation effort and in community biodiversity programmes.
- Establish centres for research and development, teaching and training and demonstration and extension in conservation biology, ecorestoration of habitats; economic value of ecosystems, species and genes; trade in biodiversity, particularly in endangered species; microenterprises at the village level; and indigenous people and their local technical knowledge.
- Build a cadre of PAN conservators and S&T specialists.
- Establish centre(s) of study for legal and policy aspects relating to conservation and utilization of biodiversity.
- Guarantee financial support.

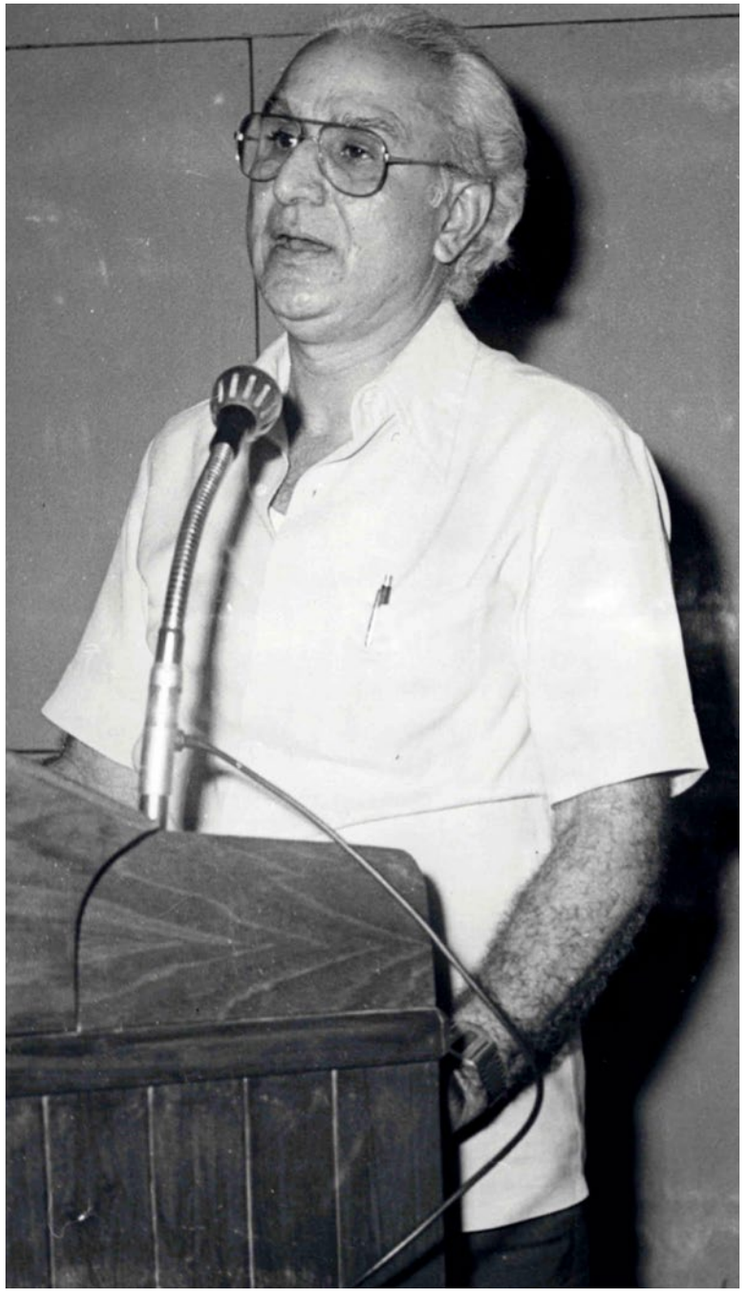
Finally, it may pointed out that in its wider context, the poor and struggling developing countries of the world in tropical/subtropical belt are particularly rich in biodiversity, but are very poor in its utilization using modem science and technology. There are definite reasons for this (Khoshoo, 1996). There is also an immediate need for an indepth discussion for forging ahead an alliance between all or most biodiversity-rich but technology-poor developing countries so as to deal with biodiversity-poor but technology very rich industrial countries in an effective and a gainful manner (Khoshoo, 1995).

If this is not done, the onslaught of concealed compulsions from industrial countries will keep developing countries (rich in biodiversity and local technical knowledge) in permanent bondage. Therefore, the most urgent need is to professionalize and technicalize the whole area of biodiversity, if not the whole area of environment.

Indian Bioresources Council

Over the years there have been suggestions made from India and abroad regarding organizing inter-ministerial and an all-encompassing Indian Bioresources Council (IBC). Bioresources as a whole are indeed very critical for the development of India, because, as pointed out earlier, this country is essentially a biomass-based and predominantly rural country, where the pattern of development has to be bio-industrial rather than purely industrial. There are already several Councils under Government of India dealing with bioresources (including human being), e.g. Indian Council of Agricultural Research, Council of Scientific and Industrial Research, Indian Council of Medical Research, Indian Council of Social Sciences Research, etc. In addition, there are Councils on Ayurveda, Unani, Siddha systems of medicine. The basic raw material for all these councils is biodiversity of sorts including human). These councils have rendered yeoman service. Having IBC over these, would, therefore, be adding a layer of administrative hassles. It would be counter-productive. However, a NBCB will be more pointed and focused organization to oversee in entirety conservation and utilization of the principal bioresource, i.e. biodiversity.

Khoshoo, T. N. (1996). India needs a national biodiversity conservation board. Current Science, 71(7), 506-513.



5
SUSTAINING DEVELOPMENT IN THE DEVELOPING COUNTRIES

Sustainable development entered in the environmental agenda in the second half of the eighties, more so when the book *Our Common Future* (Hurlem, 1987) was published in 1987 by the World Commission on Environment and Development (WCED). As of today, sustainable development is fast becoming a composite discipline and involves several major disciplines including science, technology, sociology, economics, ethics, trade and law. But defining sustainability in exact terms has proved to be difficult. This does not mean that the concept of sustainability is not relevant. One of the easiest ways to comprehend sustainability is that the rate of harvest from a renewable system must never exceed the rate of annual increment. If it remains within that limit, and, if there are no major environmental perturbations, the system can go on *ad infinitum.*

In 1992, that is five years after the publication of the above book, United Nations Conference on Environment and Development (UNCED) was held at Rio de Janerio with over 30,000 attendees. Thereafter the term sustainable development became very popular all over the world. Most people thought that these two words constituted a panacea for all the environmental ills and problems facing the earth. Considerable euphoria was generated on this account, and, during the last decade, an unusually large number of books and papers appeared on this subject. Increasingly it became clear that sustainable development was not a panacea for all the environmental ills. Furthermore, it also became fashionable to prefix eco or green- before every word or action so as to make such expressions (and sometimes even the tasks) ecologically respectable and thereby legitimize the same even when these are basically unsustainable.

Much of it was only in words and little in deed. Thus in real terms, sustainable development still remains an enigma. For instance, what is sustainable development for the resource-guzzling industrial world in its megacities, or an eskimo living in the arctic circle, or the *ecosystem people* in the dense tropical forests of Africa, Amazonia or Andamans, or the very small hamlets in the Himalayan or Andean highlands, or people in deserts of Sahara, or the poor fishermen living in coastal areas, etc. The question arises that for such diverse situations, are there some common principles that would make development sustainable? Regrettably, so far the concept of sustainable development has been treated more as a socio-economic and political concept. Sustainable development would need tremendous inputs from many areas including science and technology. Another dimension of the problem is that sustainability in the ecological and economic systems has to be checked against a particular time-scale. It may vary between the life span of an individual, a species, or the earth itself.

The net result is that the concept of sustainability is becoming increasingly complex and amorphous. There is need for considerable thinking, debate, analyses and even modelling so as to define precisely the conditions and policies that help to confer sustainability in general, and in a specific ecological, socioeconomic, scientific, technological and industrial situation. Reconciliation between economic and biological systems is also one of the central issues. For instance, what should be the population of human beings in a given time frame with a particular resource-base available in a particular habitat against a particular socioeconomic, scientific and technological milieu? These are indeed difficult questions but need to be looked into in depth with a healthy and a positive approach. Thus the euphoria generated earlier has of late been gradually (but perceptibly) subsiding and scientists, technologists, economists, sociologists and others have begun to grapple with hard facts.

One year before the publication of the report *Our Common Future,* the present author, while presiding over the 73rd Indian Science Congress Session (Khoshoo, 1986), was among the very first to speak and write on *Environmental Priorities in India and Sustainable Development*. Perhaps this was among the very first research papers to paraphrase the concept of sustainable development as applied to a large populous country like India which is reasonably rich in resources but not so rich in technology, and essentially is a country of poor people. Twelve areas of work were identified that could help to confer sustainability in this country. This publication immediately became teaching material in India and abroad. Today there are a large number of definitions of sustainable development (some think the number is over 100).

Originally the WCED described sustainable development as development that ensures meeting 'the needs of the present without compromising the ability of future generations to meet their own needs'. It implies that the present generation has to impose voluntary limits on the use of resources as dictated by the present state of technology and socio-economics and the resilience of

biosphere to absorb the ill-effects of human activities. As a starting point this may be a reasonably good premise.

By the time the Rio Conference was held in 1992, a good deal of literature was generated on the subject. During the subsequent five years (1992-1997), this concept was debated threadbare, and in 1997 the UN General Assembly held a special session to commemorate Rio + 5 (years). The concept of sustainable development got a big jolt on account of the stand taken by the US President himself. This was notwithstanding the fact that there is a UN Commission on Sustainable Development which reports through ECOSOC to the General Assembly of the United Nations.

The Indian scene

India is a populous, fairly resource-rich and a reasonably science and technology rich country. Even if India exercises strict population control, its population will still keep on increasing for the foreseeable future because prospective mothers and fathers are already with us. This is true of most developing countries in Asia, Africa and Central and South America. So far priorities have been dictated by industrial countries. A time has come for reversal of roles, because the industrial countries (Northern consumers) are using resources far in excess of their requirement and the rate of renewal of the renewable resources. Furthermore, the developing countries cannot afford a situation where machines replace people. This will be counter productive. They need, what has been called labour-intensive industrialization, or, should we say, *humanization of industrialization*. There is only a very general and a casual appreciation of economic evaluation of Nature's services; therefore, there is a need to evaluate such services in social and economic terms. This alone will bring home to the developing countries the scientific, technological and economic value of ecological assets and help in their proper conservation based on S&T principles.

In general the western countries have been rather indifferent to making even modest alterations in their highly consumeristic

lifestyles. They give the impression that the concept of sustainable development would be a drag on their development. On account of such indifference of industrial countries, the 1997 UN meeting on environment has been summed up in the famous equation: Rio + 5 = 0. This equation conceals little but reveals a lot. The Kyoto Conference on Climate Change held in November 1997 and General Assembly of this Global Environmental Facility (April 1998) were not materially different. This is in line with the stance taken by industrial countries in several other conferences and meetings. One only hopes that there would be a real and lasting understanding between industrial and developing countries on this account.

The concept of sustainable development can still be a rallying point at least for the developing nations. There may not be total unanimity about the exact definition of the term, but its application can become widespread. One can hazard a reasonably good guess about the basic principles underlying such development which could confer sustainability no matter which habitat or people are involved. With proper policies and programmes there is a possibility of ensuring good degree of sustainable development in developing countries which have large populations and face a science and technology crunch.

In India there is yet another dimension to the problem of sustainability. Part of India's economic strength lies in the unusually large number of villages (5,76,000) and the habitations around the megacities. In terms of employment, the contribution of agriculture, animal husbandry, fisheries, village level small industry, vendors, rag and trash pickers, hawkers and the like of these is significant. Actually they are small-time producers who are unrecognized for their contribution to India's economy. No one has ever ventured to calculate in fiscal terms their contribution to the economy. Taken together they make a significant economic contribution. Though these are small vocations, these constitute the largest employment sector. With marginal technical and fiscal inputs, and with improved work and working conditions, their contribution to

economic sustainability can become considerable. This is also clear from the fact that each and every megacity in India is indeed a twin city: the megacity proper and the slums round it. The two are interdependent in ways more than one, but at present both are inherently unsustainable. While it is difficult to bring sustainability to the megacities on account of its resource-guzzling nature, the slums could be improved with marginal economic inputs, appropriate housing, sanitation and medicare. This segment of India's population can no longer be ignored in any consideration regarding overall sustainability of the country.

Due to overpopulation, our environmental assets (land, soil, water, air, forests, biodiversity, fisheries, etc.) are indeed highly stressed on account of over-extraction, over-utilization due to demand over stripping the mean annual increment or repairing capacity of these environmental assets. This indeed is not a healthy sign.

The root cause for unsustainability.

The present economic system is based on the Keynesian Model. The basic philosophy on which this model rests is clear from the words enunciated by John Maynard Keynes in 1930: *'For at least another hundred years we must pretend to everyone that fair is foul and foul is fair; for foul is useful and fair is not. Avarice, usury and precaution must be our gods for a little longer still. For only they can lead us out of the tunnel of economic necessity and into daylight'.*

There is now a need to rethink about the Keynesean economics, and blend ecological and economic objectives into a mutually supportive and an integrated system. This is possible when we calculate the real economic value of our natural resources. For instance, what is the value of components of the biosphere like fresh air, clean water against dirty and polluted air and water, fertile vs degraded land, forested vs deforested areas, or what is the scientific and economic value of our rich biodiversity, etc. Most environmental organizations do not take up work on such innovative and relevant topics. There is a strong case for an annual National Ecological Survey and National

Ecological Budget along with the National Economic Survey and National Economic Budget. The two have to be mutually reinforcing. Ultimately we need a methodology to calculate in realistic economic terms, both eco-decline and eco-regeneration. The two go hand in hand. This is only possible if we know how to cost natural resources realistically. We have today only a vague and a casual appreciation of Nature's services which now need to be costed realistically. It is here that considerable amount of S&T and economics would be involved. This will bring home to less developed countries (LDCs) the value of their assets and build a climate for sound resource conservation based on sound S&T and economic principles. It is here that studies like the one undertaken by TERI (Pachauri and Sridharan, 1998) have become most relevant. Such studies would need periodic updating not only by TERI but also by several other organizations dealing with individual subject areas.

The present economic system has evolved on a mistaken notion that natural resources are abundant, population is still not so high and ecosystem regenerability is higher than degradability. In addition, it is also due to the lack of a strong S&T base in developing countries. It is now abundantly clear that none of the foregoing assumptions is true and now one has to seriously ponder about it. The root cause for all these ills is the rising population and lack of S&T infrastructure in the developing world and overconsumption and wrong use of S&T in the industrial world.

The ground reality

Roughly 38% of the people in India live below the poverty line. They destroy the environment on account of their needs, while the rich destroy environment out of greed. To bring the former out of the present morass of poverty is one of the most important scientific, technological, economic and environmental challenges facing the country. For instance, firewood is still the only or the most important energy source in most, if not all, villages and even among poor sections in the megacities of India. Media always show head-loads of firewood and fodder collected from near-by forests and carried

by women, but never cycle-loads of firewood (little pieces of stray wood and fallen branches from trees) carried by poor men working in posh localities in the cities. Both these are common sights. This is so notwithstanding the fact that we have in this country all conceivable energy systems ranging from burning of cowdung/ firewood/trash to atomic power with everything in between. The poor in the villages still have to sweat and toil for food, fodder, fuel and water. This is particularly true for village women who have to toil to make their ends meet with the added burden of acting as childbearing machines. This is a reality, even though India has made a good deal of progress in development during the last 50 years. The problems of the poor have not attracted the attention of the scientific and technological community in India except in the agricultural sector. This is indeed most regrettable.

In agriculture, India has made spectacular progress through the Green Revolution. Here was an area where commitment of the political system was total when it said that in India *agriculture cannot wait*. Our agricultural scientists and technologists rose to the occasion. However, the tempo has not been kept up, and today there are signs of a *browning of the green revolution*. Given the wherewithal and the commitment of the agricultural scientific community, it should be possible to have a successful Second Agricultural Revolution. It is within their competence and comprehension. Agricultural diversification, application of relevant S&T including biotechnology and small-scale industry are the answer to elimination of the abject poverty in the villages. People need economic, social and technical support and facilities for credit and linkages with market. This would help marginal farmers and even landless labour.

The welfare of villages with development based on ecological and economic principles and gender equality together with access to education, health care, livelihoods, credit and decision-making are critical to the success of such eco-development. This would make women, who constitute 50% of the workforce, self-reliant

by offering opportunities for education, better skills, livelihood security, right to make decisions (including the number of children they need to have), generate microenterprises and have access to credit at the local level. They can then play an important role in alleviating poverty.

The local communities have to be adequately strengthened and empowered economically and socially. This would bring people into the mainstream of development. This applies particularly to the rural women. Not only their quality of life but also their access to resources have to be improved. It can happen only when they participate in decision-making through Panchayati Raj.

Any government, howsoever strong and efficient, cannot do everything by itself. Sustainable development in India can be a reality only when proper linkages are built to sustain such development on a participatory basis and decentralized governance. The overwhelming number of villages in India cannot be governed, managed or served from Delhi or even from the state capitals. Centralization has not paid dividends as is clear from 50 years of experience. Communities have to come forward to take up the challenge. Wherever decentralization has taken place in India (Khoshoo, 1995; Khoshoo, 1996), the results have been remarkable, because participatory management rests on decentralized governance, increased access to resources on a fairly equitable basis and generation of employment. Benefits in such cases have been reasonably equitable regardless of the social and economic status of the concerned community members. The net result has been that livelihood security of the rural communities has increased.

Communities have to come forward to take up such challenges. Decentralized governance has been the sheet anchor of such development. Any civil society has to guarantee a better future with long term security of its people. Therefore, in a developing country, sustainable development must generate economic and social growth that is equitable with no or manageable effect on

environment. It must also lead to empowerment of people. Such growth and development will widen the range of choices and opportunities for the people. Use of Panchayati Raj institutions must, therefore, be encouraged.

What will confer sustainability?

There is an urgent need to work out the carrying capacity of different systems in terms of growth of population, resource availability and use, and the technology used. These systems vary from the natural ecosystems where *ecosystem people* live, to agricultural systems (from subsistence to sustainable ones) and to a variety of industrial economic systems, and from rural and small scale, to urban and large scale industry. The idea is to help developing countries to reach the goal of sustainability, a concept which at present is still eluding them.

For bringing sustainability in the poverty-stricken villages of Bihar, MP, Rajasthan and eastern UP (the so-called *BIMARU* states) and Orissa, there are no reliable studies. Also, we hardly know the way we can bring even a reasonable amount of sustainability in industrial areas in the developing world let alone in the industrial countries. Most global environmental problems of the world actually emanate from the industrial countries. The latter have been overtaken by techno-optimists who care less and even advocate getting resources from other celestial bodies. Notwithstanding the inquisitiveness of the human mind, the situation prevailing today shows little attachment to Mother Earth at least in the industrial countries who exploiting the earth of its resources are now trying to reach other planets in our solar system. Even with all the uncertainties the concept of sustainability is still most useful to both the developing and industrial countries.

For making sustainable development a reality under varied environmental conditions, deep thinking is needed about what will confer sustainability under a particular scientific, technological, social, economic and cultural milieu. As we go along, these studies

can be increasingly refined and perfected. Obviously sustainable development is a function of a whole constellation of factors. As pointed out above, in 1986 the present author thought sustainability in India can be conferred by bringing an understanding of about 12 issues (Khoshoo, 1986), but today with better understanding and a wider perspective, the list has to be expanded to many interconnected, interrelated and interdependent issues. The list may expand further or even contract with better understanding about the complexity regarding paraphrasing of sustainable development in specific scientific, technological, economic and social terms. We therefore need critical studies on the following issues which are grouped under five heads for convenience:

1. **Sustainable management and utilization of natural resources**
   Stabilization and control of human population growth; integrated land-use management; conservation of water resources including its rational use; sustainable forestry for long-range ecological security and meeting rural, urban and industrial wood needs from plantations, and helping in ecological revival/ restoration; conservation and utilization of biodiversity and its linkages with cultural, economic, ethical and social diversities; sustainable agriculture, horticulture, animal husbandry and fisheries; protection of coastline and conservation of biowealth in the extended economic zone (EEZ); integrated and sustainable energy systems and augmentation of research, development and demonstration in solar and bioenergy systems with particular reference to rural areas; ecologically compatible housing and slum improvement; control of pollution of air, water (fresh and marine) and of land; waste and residue minimization (including hazardous wastes), and recycling of wastes so as to make industry environment-friendly; and sustainable development of island communities.

2. **Improving health and access to resources for weaker sections and women**
   Primary health care in rural areas; updating health services and

evolving strategies against disease-causing drugfast microbes and the AIDS epidemic; strengthening ecological, social and economic security of women and weaker sections of the society; free access to fertility control measures particularly to women from the weaker sections of society and harnessing women's power; and sustainable livelihoods for the poor.

3. **Economic and ecological efficiency and security**
   Proper economic valuation of natural resources; transition from ecologically insensitive to ecologically sensitive economy, and dovetailing economic, ecological and social goals: reducing then eliminating poverty by strengthening ecological, social and economic security; environmental costing of projects; building environmental accounting system(s) by making ecology and economy mutually supportive; strengthening ecological security at the national and regional levels; environmentally sustainable trade development; and generating employment and sustainable livelihoods.

4. **Making technologies ecofriendly**
   Transition from eco-unfriendly and consumptive, to eco-friendly and conservation technologies including eco-labelling of products; strengthening micro-enterprises; improving environmental information technologies including collection and dissemination of data; environmental education and awareness; environmental rating of projects; environment-friendly biotechnology; regional cooperation in environment; and strengthening scientific and technological bases of sustainable development.

5. **Participatory management**
   Decentralizing governance by appropriately blending top-down and bottom-up development patterns; encouraging participatory management; and periodic updating of legal support.

This is only an illustrative list of concerns which need to be updated and refined before taken up for implementation. By and large most of the foregoing issues are common to most developing countries because these countries are reasonably rich in resources but poor in technology. This group of countries need to take a hard look at abundant local technical knowledge and mini-local enterprises because many of these can confer sustainability at the local level, which would enliven this segment of the society. This would involve the use of S&T, sociology, economics, ethics, law and other cognate subjects. It may be pointed out that each developing country will need to work out indepth its own pattern of sustainable development in relation to its social, cultural, economic and religious milieu and availability of resources and the level of technology. For instance, what is true for USA may not be true for India because the former is about three times larger in area, with 3.5 times less population (Human Development Report, 1997; The State of World Population, 1997). USA is technologically a very advanced country, but is it doing enough to achieve sustainability?

Techno-optimists in USA have advocated that resources can be obtained even from neighbouring planets. Accordingly, the country is now racing to colonize Moon and Mars. It is not doing this only for scientific, technological and intellectual reasons but there appears to be a long-range covert agenda: once the resources of the earth are depleted, perhaps they would get the same from moon and/or mars. Hence USA is involved in geological prospecting (including water) of these celestial bodies. Furthermore, this programme also appears to be aimed at containing possible threats to USA from any country which may oppose it. It is, therefore, a deep-seated economic, industrial and military agenda with a guaranteed long-range investment from the US Government. This idea is to ensure flow of resources which in turn will ensure a particular lifestyle which is basically unsustainable. Thus this exercise is not only an exercise of scientific exploration but also an exercise to control resources that may be available in the celestial bodies nearest to the earth. History is repeating itself; only some five hundred years ago, Irish

and other Europeans set out to colonize and subjugate indigenous peoples of the Americas, Africa, Australia, New Zealand and parts of Asia including India. No doubt they were enterprising people and wanted to explore new pastures. The reason was that the British Isles and Europe were over-populated and diseases were rampant.

On the other hand, the pursuit for sustainability by a developing country like India is going to be straightforward: for providing reasonably good livable conditions to its teeming millions. Indians have nowhere else to go. In fact there are no uncolonized areas left on earth that are habitable. India has to ensure in perpetuity food, housing, energy, clothing, medi-care, education, vocations, etc. for its people. India also needs to chalk out a realistic agenda for sustainable growth and development. Therefore, the foregoing list of items that are critical for sustainable development of a developing country, need to be understood in depth and steps taken to translate these into action.

There is a need to prepare state-of-the-art papers, on the various areas listed above. This has to be done keeping in view the escalation in population. This task needs to be undertaken by organizations (government and non-government) which are conversant with the ground realities and adopt by-and-large a bottom-up approach. Some very good but isolated reports, such as the one by TERI (Pachauri and Sridharan, 1998) and the other on water by CSE (Agarwal and Narain, 1997) have been already prepared. These reports are indeed interesting and very important.

The approach has to be realistic but incisive. A lesson has to be learnt from what were acclaimed as great success stories of the economic development in South Korea and other Asian economic tigers (except Japan). These have now begun to show their covert unsustainable social and economic faces. Perhaps the story of Indonesia is an example of *what not to do*. The root cause is mankind's disregard for natural resources and economy. In this regard the recent forest fires in Mexico and Indonesia are only symptoms of

ecological and economic crises. These resulted in loss of virgin forests, and hot winds and smoke covered even the parts of the adjoining countries. Initially these were the result of unsustainable slash and burn by Indonesians and Mexicans themselves and then nature's wrath stepped in.

Opening a developing country's economy is good, as long as it follows a well thought out long-range policy, and avoids short-term populist measures. Our feet must be firmly on the ground all the time. Economic development is indeed a highly professional area and hardheaded economists and sociologists have to pool their intellectual resources to chart out a long-range path irrespective of which political party is in power. *Sustainability in development (like policies on defence and foreign policy) has to be an all party agenda, no matter which party is in power.* A parallel exercise is needed for environmental threats facing the country taking advantage of our strengths while guarding against some inherent weaknesses. All these issues are basically national, therefore, above politics.

While no one would like to mix politics with sustainable development, it is but certain that at some stage politics will enter in its working. Developing countries have to be careful regarding their cooperation with industrial countries because now it is no longer necessary to *actually* subjugate a country militarily as was necessary earlier. All that is needed is a covert economic agenda. Therefore, a developing country has to be clever enough to foresee and understand the after effects of such an agenda and guard against it. It is the small print of the agreements that has to be looked into very carefully. In this regard lessons have to be learnt from SE Asia.

Green technology

There is now worldwide thinking that more importance should be given to conservation technologies rather than consumptive ones. Clear criteria are needed for declaring a technology green. Equally important is the question of the carrying capacity of natural and habitats restored through eco-development.

The only answer to politics of development is self-sufficiency, self-reliance, complementarity and sustainable development: where a country's resources are put to sustainable use with the help of technology relevant to the situation.

From a unit of resource we should be able to get:

- maximum usable product;
- with minimum use of energy and cost of production;
- generation of minimum pollution;
- minimum cost of depollution;
- inflict minimal damage to environment during manufacture, transport and end use;
- generate minimum waste; and
- use packaging with short life.

Development should not involve:

- use of threatened/endangered species from threatened habitats;
- cause cruelty to animals and destruction of flora and fauna, or;
- affect other countries particularly developing ones which are essentially poor and fragile; and
- not endanger health of the user and the biosphere at large.

To achieve this would involve abundant use of relevant high quality S&T. Finally, there is the ethical dimension of sustainable development which cannot be ignored. In this regard the shining example before us is that of Gandhiji (Khoshoo, 1995). His role and relevance has increased because he has been a path-finder for India and the world at large. A combination of ecological security, economic security, equity and social justice are going to be the bed rocks of the future technology. Therefore, scientists and technologist have to leave their ivory tower approach and add the foregoing dimensions to their work.

Major leaps will be needed for enhancing productivity of food with no or manageable damage to environment including land and soil.

The same applies to health services, materials, transport, energy and information technology. Even in forestry a major jump is needed to attain sustainability. Here basic orientation has to change from mere management of natural forests and harvesting mean annual increment, to *designer plantations* with high yield per unit of area and per unit of time. No longer can we afford to continue to over-extract wood from natural forests in perpetuity. A forestry revolution is needed most urgently where we leave natural forests only for long range ecological security and get all our wood from man-made plantations as we do in agriculture. Such a transition took place in agriculture long ago. Human race no longer depends on naturally growing plants and wild animals for its food and other needs. This change was associated with the human race entering an agricultural society from a hunter and gatherer one. In view of the escalating population, there is need for a quantum jump in agricultural production per unit area/time because no new areas are available for cultivation. There is a need for a Second Green Revolution which will have to be highly productive minus pollution and labour displacement and depend on biofertilizers and biopesticides that are nonpolluting to land, water and air. Biotechnology will have to be used for enhancing production and productivity and storage.

There is thus an urgent need for high inputs of S&T to make Green Revolution-II and Forestry Revolution-I a reality. The goal has to be designer agriculture for enhanced food production and designer forest plantations for meeting the needs of firewood, timber, veneer, pulp and paper, etc.

Technologies that do not pollute land, water, and air and help in processing and storage will have to be developed. Special attention will have to be paid to human health. Disease control will have to be attempted on a very wide front and include drug-fast bacteria, AIDS epidemic/ heart diseases and hypertension, etc. These will

need special attention. India will need medicaments involving both high and low technologies in a proper mix because we have both diseases of affluence and of poverty. Technology whether in agriculture, forestry or industry has not to be labour-displacing but reasonably labour-intensive.

The energy scene in India is indeed very complex, we have most forms of energy in use. With enhanced affluence there is going to be enhanced energy demand. We need to update, refine and enhance production of all forms of energy from low-tech (firewood and biomass burning) to high-tech atomic energy, and everything in between.

Lastly, there is yet another dimension to green-technology. When one buys firewood, fish, medicinal herbs or water (all these are collected almost free from nature), we *only* pay for the cost of collection and delivery of these natural materials. Methods need to be evolved to calculate their intrinsic value so that we know the real cost of the natural materials. Thus it is not enough to have green technology but it has to be accompanied by green pricing, green economics and green-marketing.

Importance of individual action

One cannot minimize the importance of an individual in bringing about change towards sustainability. As individuals, we must think about our role and goal and the fact that in the ultimate analysis it is we as individuals who have to take decisions, and solve the problems of the environment. The reason is that a community, a nation and the world at large, are, in the ultimate analysis, an extension of an individual. A sustainable community can spring from interdependence between well-informed individuals. Thus sustainable lifestyles of the individuals can lead to sustainable communities, to sustainable nations and then to a sustainable world. Similarly, key to the solution of global environmental problems lies in local action (Khoshoo, 1998).

An individual is the starting point of environmental degradation. If an individual believes in need and not greed, and in comfort and not in luxury, and ponders about what is *enough* for a comfortable lifestyle, most of the problems would be solved. We have reports of influential individuals owning 3,000 pairs of shoes or over 700 sarees and what not. Regrettably, both these cases are from developing countries. What example do such individuals set for the society at large. Is it justifiable? One of the major root causes is undue thirst for resources which is particularly characteristic of the industrial world and the rich in the developing world. One can understand undue thirst for knowledge but not for resources.

Keeping the foregoing in mind, one can bring about sustainability in poor families in our *BIMARU* states and Orissa but equally important, if not more important, is to find ways to take to sustainability in the life of resource guzzling persons in the metropolitan cities in the developing countries and industrial world at large. Here each individual requires huge amounts of materials and generates equally large amount of wastes. Major environmental problems are created during collection of raw materials, manufacture of finished goods and finally during their utilization and generation and disposal of wastes.

The most critical input for bringing about sustainability in a gamut of social, economic and cultural situations is *education*. The important point is that today an average human being in the developing world is in socio-economic shackles, and follows value system(s) which leads to unsustainability. There is need to bring about a new value system that leads to sustainable development. The critical input for this change is also education, which gives us knowledge, information, understanding and above all stresses ethics and morality.

If one follows the history of human species, there have been two distinct but over-lapping phases. The species began as having *reverence towards nature*. At that stage humans looked at nature with awe and respect, something that they did not understand. Then,

they began to, understand nature, there came a phase of *subjugation of nature* which led to all manner of deforestation, ecodegradation and pollution and rampant abuse of natural resources. This has been the phase when humans got the erroneous feeling of being all powerful, and looked *down* upon nature for being exploited with vengeance. Today the world is in the latter phase! However, of late there is the beginning of a phase where many voices are heard about *reintegration or a coalition with nature.* This change is the result of a phase in history when technology was used to the detriment of nature and ultimately to the detriment of the human race itself. The reason is that everything on earth is interconnected, interrelated and interdependent. Our salvation lies in not approaching nature with arrogance but with humility and respect. Most biological scientists are of this view, because they have an inkling of the intricacies of and fascination for the web of life. This is what scriptures of most religions teach. S&T need to be used for the good and the well-being of the earth and all its inhabitants.

Towards a *sarvodaya* (or a sustainable) society

The socio-economic situation in real life is indeed very complex. For convenience, we may consider four broad situations, two of which are unsustainable and the remaining two are sustainable (Table 1). Between and within each of these two extreme categories, there are many intergrading situations. One of the two extremes of unsustainability is found among the hunter-gatherers (lower left) who live in very harsh, fragile and unstable ecosystems such as the Sahara desert. These people are essentially nomads with hardly any worthwhile assets. Here climatic conditions are very harsh and resource base is very poor, there is dire need and abject poverty. They follow local wildlife for their sustenance. Technology used to capture or kill the wildlife is very primitive, e.g. stone tools, bows and arrows or traps. They make some use of fire. The other end of the unsustainable spectrum (upper left) is seen in the industrial societies of the world particularly in their metropolitan cities. Even in the latter (e.g. New York), the situation is uneven. Resources are abundant in opulent sections while for people living in poorer

sections of the city, resources are scarce. In the former, there is the vulgar show of wealth and abuse of resources. They are rich in technology, which, by and large, is misused for the so-called welfare of the rich. This is true of most industrial countries and megacities of those developing countries which have followed purely an industrial route to development. Between these two extremes of unsustainable development there are many intergrading types. The two corners are assetless people with abject poverty on the one side, and extremely rich on the other.

In the sustainable group (Table 1) one of the two extremes is constituted by the hunter-gatherers (lower right) living in stable ecosystems. They are the *ecosystem people* like the original inhabitants of Andaman and Nicobar or many places in the Central and South Americas. Left to themselves, they have sustainable lifestyles because resources are abundant. There is no monetary economy *per se* but nature's economy prevails. They barter goods and services. There is need but no greed. Their technologies are primitive, but their lifestyle is sustainable.

Some of the best examples of sustainable development are seen in the indigenous societies behind which is the time-tested robust common sense and local technical knowledge. Taking advantage of such knowledge, one could hazard a guess for sustainable society or what Gandhiji called *sarvodaya society*. The success of such a society depends upon inputs of science and relevant technology, and micro-enterprises based on local technical knowledge. These would give succor and bring them out of the morass of poverty and penury and transform the village communities.

At the other end of the sustainable group (upper right) would be a society where resources are sufficient, there is respect for nature, they believe in need and comfort but not in greed and luxury; they make good use of technology relevant to a situation. Their aim is to have welfare of the weakest (*antodaya*) which in the ultimate sense leads to welfare of all (*sarvodaya*). This is why one could call

these as *sarvodaya* or sustainable societies. The basic philosophy is to live and let live, and through frugality (i.e. more from less) and fraternity (getting in association with others) achieve sustainability. Herein lies the future of humankind. Such would be the societies of the future. Today these may exist in bits and pieces but not in sufficient numbers and certainly not on large scale. There are several individual attempts in this direction like the work of Chandi Prashad Bhatt in Gopeshwar, R. P. Misra in Sukhomajari (Haryana) and Chakriya Vikas Pramali (Bihar), Anna Sahib Hazare in Raligan Siddi and A. T. Ariyaratne in Sri Lanka. Such attempts are being made in other places as well. Table 2 summarizes the broad characteristics and the relationships between the four societal patterns and their developmental concerns.

Gandhian development

Notwithstanding the fact that Gandhiji earned India freedom with little bloodshed and became a Mahatma (a great soul) in his own life time; there is a growing opinion that the 20th century did not understand him. For some he was irrelevant and that he talked and believed in what was out-moded socially, economically and technologically. However, now there are many (all over the world) who believe that he was born at least a century ahead of his time. With his forethought and vision, he was actually a man of the 21st century.

When independence (*swaraj*) began to become a reality, Gandhiji was asked as to what pattern of development India would follow. At that point of time for a British Colony, such as India, the only model was the British Model. Gandhiji said: *'it took Britain the resources of half the planet to achieve this prosperity. How many planets will a country like India require!'* It is indeed a prophetic statement. He insisted on individual commitment because he felt *swaraj* (self-rule) does not mean independence from all restraints. It means we take from the earth what we *actually* need and no more. He stressed *non-violence* which means not to *exploit* anything including biosphere. Furthermore, one should not venture to take more than what one

Unsustainable development	**Sustainable development**
Industrial societies Metropolitan cities • Resources abundant or obtained from less developed countries at nominal price • Rich in technology which is more often misused • Resource-guzzling countries/people • Resources abused and pollution generated during manufacture • Vulgar show of wealth • Greed and luxury • Welfare of the rich • No real respect for nature • Economic victims	**Sustainable (sarvodaya) societies** • At present largely an utopia • Resources sufficient • Essenally biomass-basad (renewables) • Society using low pollution causing modem technology • Technology appropriate to the situation • Need and comfort • No vulgar show of wealth • Blending fruits of modemity with tradition • Respect for nature • Welfare of the weakest (antyodaya) leading fo welfare of all (sarvodaya) • Aiming at economy of permanence
Hunter-gatherer societies Harsh ecosystems e.g. deserts (Sahara); people mostly nomads • Resource base very poor • Access to resources limited • Very primitive technology used • Dire need • No exposure to modernity • Abject poverty and powerlessness • Prevailing superstition • No worthwhile economy • Ecological victims	**Hunter-gatherer societies Stable ecosystems: Ecosystem people (e.g. Andaman and Nicobar Islands; Amazonia)** • Original inhabitants • Supersitious. • Indigenous age-old technologies • Hardly any exposure to modemity • Nature's (non-monetary) economy: Barter • system • Need but not greed • Respect for nature • Economy of permanence

Table 2: Relationship between societal patterns and eco-developmental concerns

needs. His thinking is contained in his very famous quote which has gone into the annals of environmental literature: *'The earth provides enough to satisfy every man's need but not for every man's greed.'* Obviously he felt that nature produces enough for our legitimate needs and comfort, but not for our greed, luxury and vulgar show of wealth. Such a mad rush for materialism is not only irreligious but also a criminal act against nature and humanity and all creations at large. It is unsustainable and a pernicious disease. It is untenable scientifically and technologically in the long run.

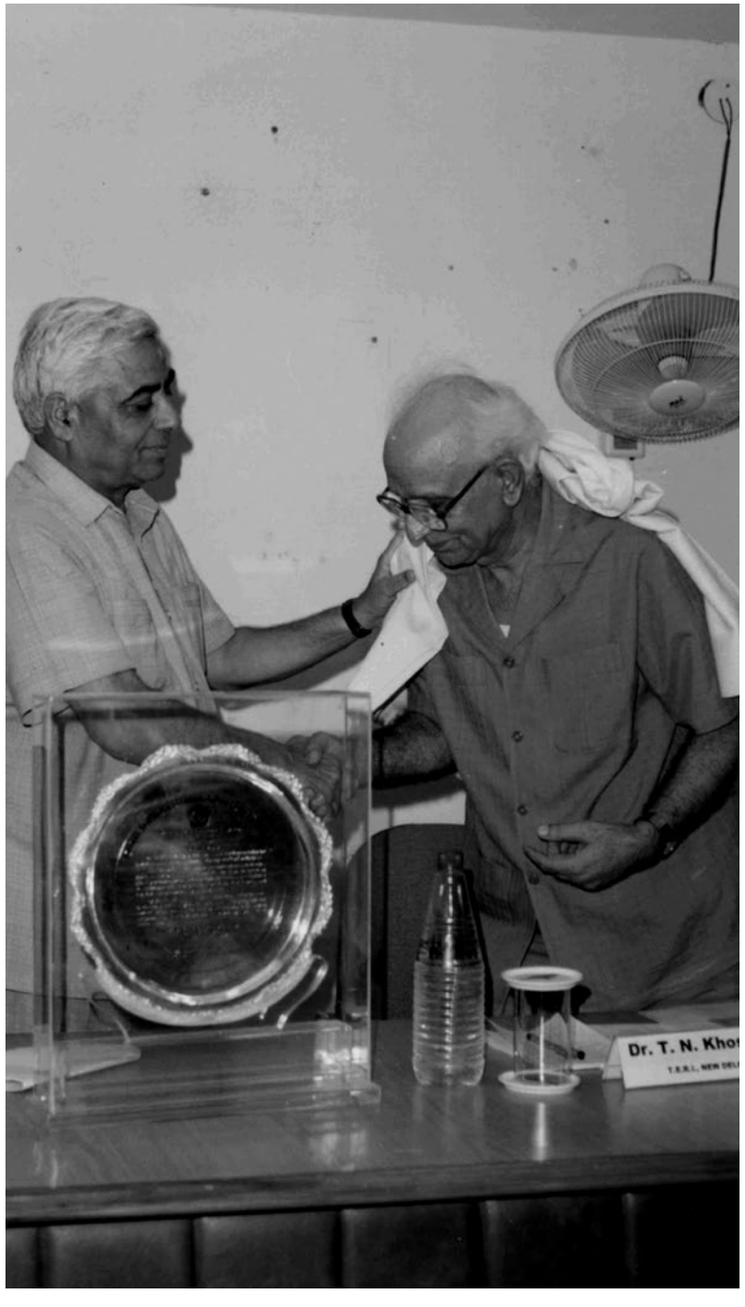
Gandhiji gave the world an acid test for sustainable development in order to help the poor who are indeed the weakest link in the socio-economic chain. His famous 'talisman' was: '*whenever you are in doubt or when the self becomes too much with you, apply the following test: Recall the face of the poorest and weakest man you may have seen and ask yourself if the step you contemplate is going to be of any use to him. Will he gain anything by it? Will it restore him to a control over his own life and destiny? In other words, will it lead to Swaraj (self-rule) for the hungry and spiritually starving millions? Then you will find your doubts and your self melting away.'*

If humanity would follow Gandhiji, there would be no poverty but there would also be no stinking-rich people. His life was a life of sacrifice. In material sense he was the poorest Indian but, in what he gave to the country and the world at large, he was indeed the biggest benefactor of the 20th century. His was a life of sacrifice, charity and penance *(yajna, dhana and tapas)*. Unfortunately, 20th century has seen more tormentors than benefactors like Gandhiji.

In view of the foregoing discussion, sustainable development under conditions of a developing country should be people centred and must lead to: environmental harmony; economic efficiency; resource (including energy) conservation; local self-reliance; gender equality; equity with social justice; cultural relevance; and peace and disarmament.

It should enable solving problems at the local level which will ultimately have impact at the national, regional and even global levels. It must aim at sensible, credible and implementable environmentalism and not eco-fundamentalism. The biggest challenge is concretizing sustainable development and translating it into actual action points so as to be in line with our social, economic, cultural, religious and ethical diversity. To make such development a reality, would involve a considerable amount of relevant S&T and inputs from economics, social sciences, ethics, law, etc. The academies and non-government institutions dealing with science, technology, education, social sciences, economics, law and ethics need to take up such studies and prepare status papers for the benefit of the Government. Finally, such sectoral reports need to be integrated into one connected whole, to ensure the creation of credible and implementable options that are relevant to the prevailing situation in India. We need to set our own house in order in the first place. Only then can we confront the northern consumers who use resources far in excess of the renewal rate. Environment in general and sustainable development in particular have to be on our national agenda, but these have to be above politics like the foreign policy, defence, agriculture and economy.

Khoshoo, T. N. (1998). Sustaining development in the developing countries. Current Science, 75(7), 652-660.



6
SOLAR, EARTH AND HUMAN CAPITALS, AND SUSTAINABLE DEVELOPMENT

The three capitals

All developmental activities are ultimately based on three types of capitals (Miller, 1996) which make earth habitable for human life in its present form. Broadly speaking these are solar capital, earth capital and human capital (**Figure 6**). The equatorial- tropical-subtropical belt receives the maximum solar energy throughout the year. This belt acts as the heat engine of the world and sets a temperature gradient from equator to poles with the associated climatic processes. Solar capital is one of the important ingredients of a deceptively simple process like photo- synthesis which uses this energy into making of actual usable materials. Photosynthesis takes place in phytoplankton in sea and other water bodies and on land in plants.

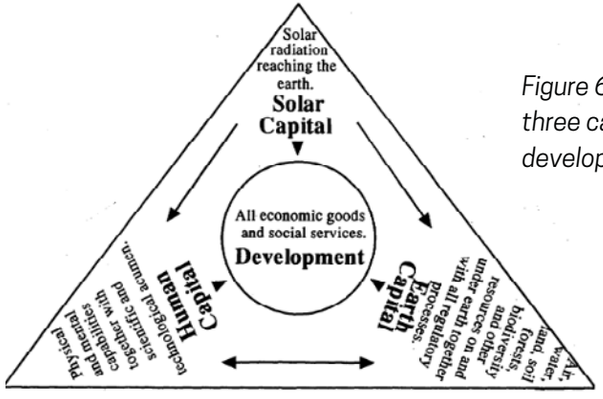


Figure 6: The three capitals for development

The earth capital (or what may be termed as natural resources) includes resources like air, water, land, soil formation and all that is on the land and under it: e.g. forests, biodiversity, grasslands, wetlands, oceans and metallic and non-metallic minerals (including oil). Among these, wind, water, geothermal heat and biomass are potentially renewable. The earth capital includes natural processes like detoxification, dilution, decomposition and recycling of vital chemicals like carbon, oxygen, nitrogen, phosphorus, sulphur and above all water. It also includes renewable energy of sun, wind, flowing water, geothermal heat and biomass. The earth system is not static but has been changing over periods of time. It has also the capacity of self- renewal and purification. Its biodiversity has capacity for evolution and adaptation to changing climatic conditions including natural pest and disease control.

The earth capital also has life-sustaining capacity and on account of several factors has been favourable to the origin, evolution and diversification of life ever since the first self-replicating DNA molecules arose over 3.8 billion years ago. The pinnacle of evolutionary process is the origin and evolution of *Homo sapiens*. There have been many species of microorganisms, plants and animals that have come and gone, but some have stayed on the earth ever since their origin.

Although a moot point, what if from today, sunlight does not become available to earth! Much of the life as we know will come to an end because of being directly or indirectly photosynthesis- dependent. Some forms of life may spread: e.g. the biota found deep down on the sea floor or that exist in and around volcanoes on the bottom of the oceans where there is no sunlight.

The solar and the earth capitals constitute the most important components of the life-support system of the earth to be used by all species including human, The solar capital gets converted into goods and services through photosynthesis. The human capital resides in the human ingenuity, diversity, ethnicity, and diversified history, culture, religion and philosophy leading to varied technologies and socio-economic systems.

From the interaction between earth capital and human capital (technology) there emanates the manufactured capital. It includes manufactured goods using tools, machinery and equipment, and physical and mental capabilities and talent of human being. In this system technologists evolve technology, managers put it to use and look after the manufacture of goods, and workers do the actual work. The entrepreneurs invest monetary resources and then reap the profits. Thus economics is basically production, distribution and consumption of goods and services to satisfy people's wants and needs. Therefore, the three capitals together are the major source of all economic development that takes place on the earth (**Figure 6**). If used judiciously and with thought and care, these capitals can reform the face of earth to the good, the benefit and the well-being of not only human species but also of all creations.

The impact of human capital

The story of human species on earth begins with its ancestors like *Australopithecus afarensis* (3.36 millions years ago). After about 2 million years, arose the genus *Homo*: first it was *H. habilis*, then *H. erectus* and finally *H. sapiens* (4,00,000-1,50,000 years ago) which along with its genetic diversity also acquired physical, mental,

social and cultural diversity (Khoshoo 1997: Weaver et al., 1985). *H. erectus* and particularly *H. sapiens*, colonized all the continents of the world except Antarctica.

H. sapiens (or the human being) has been the most intelligent and a thinking animal that the earth has hosted, and has reached the present state through three types of societies as a result of three major revolutions. The first revolution was the *Stone-tool Revolution*. Here the first resource was food (plants and animals), second resource was stone which the then human being used to defend itself and also to kill its prey and do other jobs. These resources together with fire-making ability gave the then human being a distinct edge over all other animals. It not only became a thinking animal but also had an innovative mind. At this stage it was essentially a society of hunters and gatherers: men hunted and women and children gathered.

Thanks primarily to women, imperceptibly there developed an agricultural society and then followed Agricultural Revolution. Soon land and water became important resources for cultivation and irrigation of crops respectively. These changes accompanied the invention of wheel, plough and domestication of crops and animals. This helped in insulation of the human being against vagaries of nature by ensuring supply of food. A fallout of the agricultural societies was that human being became a 'son of the soil' (*Bhoomiputra*). These changes took place during the last 6,000 - 10,000 years.

Around 1712 AD, two things happened; Firstly, wood began to be replaced by coal as source of energy; and steam engine was invented. This was the beginning of the third revolution: the *Industrial Revolution*. This revolution is only about 285 years old but has been a 'mixed blessing' inasmuch as living standards of humans improved but quality of environment deteriorated increasingly. Progressively there was greater damage to earth with lowering of the quality of environment on account of overpopula- tion, soil erosion, loss

of forests and biodiversity, pollution of air, water and land, global warming, ozone depletion, waste generation becoming a health hazard, etc. This led to environmental, developmental, economic and even political problems. At the root of this were the doings of just one species: the *Homo sapiens*. Thus from the biospheric point of view, the origin and association of human species with earth has been a 'mixed blessing'.

In this regard there are some important precedences. Some 6000 years ago, there were six flourishing contemporary civilizations which fell like house-of-cards. These were: European-Mediterranean, Babylonian, Nile Valley, Indus Valley, Huang Ho and Mayan. The principal underlying reason for their fall has been disrespect for environment. Progressively the human species became the most unnatural species that has ever existed on the surface of earth. But the basic fact is that human being is the only species that has power of intelligence to enable to modulate environment so that it may suite her/his convenience. Thus humankind is able to evade natural selection to a large extent through the application of science and technology in which there has been tremendous growth in knowledge. Such ingenuity led to creation of artifacts. Furthermore, a human genotype which may have congenital defects in her/his organs in the body can also evade natural selection and continue to live and, what is worst, even leave progeny. All she/he needs is enough money to buy the most modern medicaments and healthy organs to replace the defective ones. One can also change an ugly face into a beautiful one.

Human being invented or discovered drugs (e.g. antibiotics in mid-1940s) to control some of the vicious diseases. This era started with the discovery of penicillin which was hailed as a major step in disease control. Initially the results were miraculous. There was a spate of new antibiotics discovered. Soon a race began between microorganisms and the discovery of increasingly more potent and new antibiotics. The race has not ended. Today we have strains of pathogenic microorganisms which are not only drug- fast but, what

is worst, *feed* on antibiotics. This is most ominous: an altogether new race has begun between humans and the tiny microorganisms.

The moral is that by the use of science and technology we are trying desperately to perpetuate human genotypes which would normally have little or even no selective value in nature. In this process human being has pitched itself against the natural laws. Secondly humans have entered in a race against harmful microorganism, where the indications are that the battle is unequal and humans will remain pitched against these organisms perpetually. Their genetic system is simple and capable of countering what humans can do. In the long run, it is, therefore, an unequal battle and microorganism and even insects seem to have an edge over human beings.

Interaction between earth and human capitals

Earth has been regarded as Goddess by the Greeks (The *Gaia* concept), we in India regard her as Mother — we call her Mother Earth (*Dharti Mata*). The Gaia concept became popular thanks to Lovelock (1979), an outstanding atmospheric scientist. He concluded that earth is a 'homeostatic living organism' and felt that the Gaian concept could become a scientifically verifiable religion. There is, however, a difference between the two concepts. Goddess is generally put on a pedestal and one bows before her and worships her; but with mother we have an organic connection through an invisible but indelible and permanent umbilical cord, which lasts throughout ones life; we are her children in every sense, we seek her benevolence, we depend on her and draw sustenance from her. She also provides an abode for human race and meets all the needs. In fact this is true for all the living creatures be it plants, animals or microorganisms. Ultimately, mortal remains of all organisms return to Mother Earth. There is a subtle dis- tinction between concepts of Gaia and Mother Earth, but both are basically reverential in character.

Responsibilities of human being

With all the knowledge human being has, it is clear that so far there is no concrete evidence of life on any other planet in our solar

system except the earth. Thus earth is not only unique but is also indeed a 'miracle'. The human race has a major responsibility to save this miracle in space and time because human being has also vast knowledge and power at its command. It can peer at the earth both from outer space and also while sitting on the earth itself. The changes being made by human being may be subtle or obvious, but ultimately are fouling the earth's atmosphere, hydrosphere, lithosphere and biosphere. The subtle changes in quality of air, water and water bodies, movement of glaciers, vegetal cover, forests, deserts, soil, even individual species and biogeochemical cycles together with energy flow, can now be constantly followed and measured. What is equally important is that such information can be transmitted within seconds to any part of the earth. Never before had human being acquired such a power for instant gathering of data, instant analysis, drawing strategy and conclusions and spreading the message, and also have the feedback in record time from village to the country as a whole. Such information can also be used to evolve a repair strategy and save our country and the region from ecological damage. It can also help to evolve a local to global overview and have an attitudinal change from exploiter/destroyer to saver/helper.

The repair strategy is essentially slower than power of disruption and destruction. It takes millennia to reach a stage of a climax forest but only a few hours to destroy such a handiwork of nature with myriad species that have made it their abode over millennia. *There is now a need to question the very role humans have played on the surface of this planet in changing the biosphere.* Such a change has been more for the worse than for the good of all other species.

The human being has spread to all the continents except Antarctica. It is now trying to colonize Antarctica but for a different purpose. Therefore, the effect of human presence on the planet has made obvious and subtle changes in the life-support system. These are

not only local but some changes have had global implications. The extravagant lifestyles of the industrial countries are no longer a concern of only those countries but also of the developing countries, the reason being that local changes add up to become global changes. There is only one earth and we are all interconnected, interrelated and interdependent.

The damage to earth is increasingly overshooting its repairing capacity. This is indeed a matter of deep concern for all humanity. Therefore, it is high time that the entire human race irrespective of cast, creed, or colour joins hands to repair the damage it has already done, or is in the process of doing. For this, there is an urgent need to evolve a code of conduct for human race, because otherwise our only abode will cease to support us. For instance, we may have drawn so-to-say a moratorium on the nuclear activity but the nuclear haves have not abandoned nuclear arsenals. The world is unequal, not only regarding nuclear power but also the damage inflicted to the earth on several other counts (including over-use of resources).

Today we have knowledge and power to create wealth from waste; raise forests and improve their diversity or raise plantations to meet the wood needs in a matter of decades on denuded and abandoned land; conserve species; try to improve the quality of air, water and land; try to reverse pollution; harness energy from sun, wind and water; redesign crops with the knowledge of genetics, breeding and biotechnology; use microbes to do some beneficial tasks (e.g. manufacture of insulin and other products); take to use of natural products from medicinal and aromatic plants, natural oils, gums, dyes and what not, but we cannot recreate species already lost. We have controlled population of unwanted weedy species, so we also need to control our own unwanted numbers.

Thus human race has vast and myriad powers but we need courage to restrain and use these only for the good, the benefit and the well-being of our atmosphere, hydrosphere, lithosphere and biosphere of which we are an integral part. We have to be on the side of life and

the living biota and the life-support system but never ever on the side that kills the 'goose that lays the golden eggs'.

The present day crisis in environment and development is actually an outward symptom of a inner crisis in our mind and spirit about the type of society we are trying to build where human numbers are outstripping increasingly the diminishing resources of the earth, whose carrying capacity is in jeopardy, we are generating waste on an unprecedented scale, and the very security and functioning of biosphere is getting impaired. Is this the type of civilization we should build?

Furthermore, the doings of human being are such that the biosphere functioning is being impaired increasingly due to climate change, CO_2 increase, ozone depletion, etc. In every sense we are destroying and undermining our own future. Thus human race has unleashed a situation which may fast become out- of-control and human species is likely to be affected adversely.

Earth without humans

The question arises as to what happens to Mother Earth if by some chance the entire human race gets annihilated all of sudden, leaving behind all the artifacts (buildings, palaces, castles, roads, automobiles, aeroplanes, railways, industries, power plants, shopping arcades and all other infrastructure) that have resulted from human genius. Thereafter, what would be the scenario on the earth, say after 2 to 3 centuries.

All that was created by human being would have deteriorated. The buildings would have crumbled, all means of transport would have rusted, and all open spaces, roads, fields, agricultural land, parks, aerodromes, etc. would have been colonized by trees, shrubs and herbs and animals of sorts.

Most of the natural biodiversity including endangered species and forests would have flourished. However, all agribiodiversity crafted

by human being would have perished. Such diversity is essentially unnatural (created to fulfil needs of the humans) and therefore bizarre and depends on its sustenance of human beings. Reciprocally human being depends on it for its own survival. For instance, the 3 to 4 feet tall wild form of *Brassica oleracea* (commonly called wild cabbage), still growing wild in European Mediterranean coast, will flourish, but the six different vegetables (e.g. cabbage, cauliflower, brussel's sprouts, kale, broccoli and kohlrabi) selected and literally crafted by human being over a period of time would have ceased to exist because these are bizarre and highly specialized with no selective value whatsoever in nature. In cabbage the whole plant has become a gigantic bud, cauliflower and brussel's sprouts are highly condensed but large and soft inflorescences of very minute sterile flowers, broccoli has large auxiliary buds (mini cabbages), kohlrabi is a swollen, soft and leafy stem, and kale is indeed a very leafy vegetable.

Similarly, the ancestor of maize with only a few grains which are adequately protected (not naked like maize grain) and which can shatter, would flourish; perhaps so would modified teosinte whose grains were non-shattering but threshable. The cultivated maize having 'naked' grain without the hard casting of the ancestral species (Teosinte) evolved into a highly specialized type of cob specially crafted to fulfil the need for high yield. On account of this the modern corn would become extinct particularly because seedlings would have to penetrate the leaf-like sheaths protecting a cob. Then the seedlings would be densely clustered and compete for water, soil and nutrients and fail to reach reproductive stage (Myers, 1984). Maize is so specialized that it would become extinct without human intervention, because it does not have any selective value in nature. The same is true of other crops and domesticated farm and non-farm animals (e.g. many breeds of dogs selected from the wild wolf, *Canis lupus*) selected by human being over the years.

Human ingenuity has through successive breeding and selectoral cycles tampered with reproductive processes of the agricultural

plants and animals. The investment of their energy has been in reproduction leaving little for their defence and survival. The story of agriculture has been that from hardly any worthwhile yield per unit of area and time in the wild progenitors, there has been investment to boost the yields in cultivars, be it, wheat, rice, maize, potato, pig, cattle, chicken, etc. For instance, in chicken the egg yield per hen per year has shot up from about 13 per year in the wild to over 300 n domestic breeds, making chicken merely egg-laying machines.

All the cultivars/domesticates are over-specialized and thus have become over- dependent on human being having been evolved only to fulfil food needs of humans. Therefore, these cannot face natural selection and exist without the intervention of human being. Associated with such transformation there have been skeletal and a number of other deformities which, like cultivated plants, make the domesticated chicken totally unfit to face natural selection.

The marine life in coastal/mangrove regions and in deep sea would improve in absence of humans because there would be no extraction of edible marine animals, sea weeds and corals. Furthermore, there would also be no dumping of pollutants and wastes in these habitats. In addition, the natural environment would have improved, e.g. quality of air, water and soil would have become much better. The reason being that the sources of present- day pollution would have ceased to exist. However, the host of non-biodegradable synthetic chemical compounds that are alien to biosphere, but manufactured and used by human beings, would persist, unless some microorganisms begin to feed on them and degrade the same into elemental forms.

No doubt human being in its present form has become the most unnatural species existing on the surface of earth. This would be increasingly so in the future. All the elements that epitomize human culture and civilization (e.g. literature, art, music and all other finer things of life) would vanish in absence of human interest and creativity.

Increasingly, one gets a distinct feeling that the earth together with most other species will fare much better without humans, because humans have created a type of civilization that is leading to the destruction of the earth. We have, therefore, to change our ways if we want to be a part of the biosphere in perpetuity. We need to change our mindset regarding unlimited growth and development, jobs, consumption patterns and the politics of domination that is behind some of the unstated objectives. Furthermore, the general feeling that sustainable development can be achieved only with better technology, laws, agreements, treaties and enforcement is true only to some extent; because ultimately it is a question of ethics and morality behind resource use. There is no alternative to this change. We have to learn new values, new imperatives and move in a determined manner towards sustainable society. There is not even one action big or small taken after 1992 (United Nations Conference on Environment and Development) towards sustainability, notwithstanding the fact there is also a Commission on Sustainable Development. It is largely a business-as-usual situation.

The fundamental point is that we have to practice ethics and morality not only *vis-a-vis* humans but also for all other creatures (plants, animals and even most microorganisms). We must respect not only human life and affirm our responsibility both to our near and dear ones but towards all life and all creatures. Over-use of materials (living and non-living), in strict sense, also amounts to violence against nature as a whole.

Homo sapiens is indeed different from all other species, because it is a thinking animal: it can recall its past and gain from it if it wants to. Furthermore, it can *foresee* the future. But whatever decisions emanate will have to be moral and just. Transition to sustainability must become our moral and ethical obligation to generations that will follow us. Here each one of us has a role. Each individual and her/his action is indeed critical for society, because a society is an extension of an individual. *The bottom line is that biosphere does not need us, but it is we who need biosphere for our well-being.* Therefore, there is need for serious introspection. *The 'enemy' of environment is within each one of us.* Nature is very complex, we have not understood its ways fully, we must approach it with tremendous humility, awe and respect. We must accept the fact that environment is most critical for our ecological, social, economical, ethical and even military security. These are parts of one whole and cannot be delinked.

Towards sustainable development

As is clear from **Figure 7** the very foundations of all sustainable or unsustainable development rest on the use or misuse respectively of the three capitals. The agricultural development can be regarded as a major solar enterprise backed by the use of some earth capital (land and water). The industrial development involves a major use of earth capital. Both agricultural and industrial developments are backed by human capital. While earth capital is finite and limited, solar capital is indeed clean and infinite. It has yet to be used to a significant extent. This can be a major input in improving chances for sustainability.

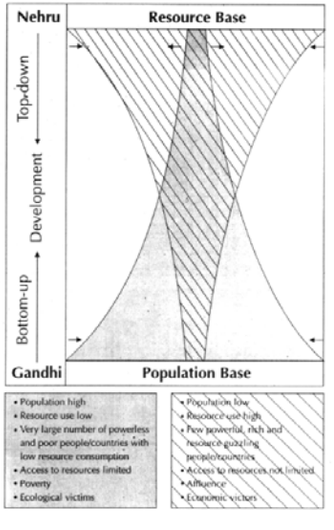


Figure 7: Relationship between population and resource use in developing and industrial countries

Furthermore, human mind has been very creative. During a relatively short span of time, it has created three types of diversity: agri-biodiversity, cultural diversity and developmental diversity. Agribiodiversity involved picking up the right kind of grasses and other plants and animals, followed by a meticulous domestication and selection process, so much so that it has not been possible for modern human being to add any totally *new edible economic species* even when powerful tools of science and technology have been at his command. One marvels at the meticulous work done by the so-called primitive human being. Based on the interplay of the three capitals, three types of human societies have evolved in a sequential manner.

Types of human societies

From the point of view of environment and development there are three types of societies. *A Hi-Tech or Throwaway Society and Economy, a Back-to-Nature or Subsistence Society and Economy, and a Sustainable Society and Economy*. The first two represent the two ends of the spectrum, while the third is indeed the 'middle path'. The Hi-Tech or Throwaway Society represents what one sees today in the industrial countries. They act as though the resources of the earth are unlimited and technology can help to do anything and everything. Such a society believes that developmental considerations are most important and subordinate to environmental ones. This pattern of life is unjustifiable and is not tenable on moral, ethical, economic and environmental considerations. The Back-to-Nature or Subsistence Society is regarded as primitive even though it may be sustainable. But it denies the fruits of modernity to the poor and the needy. This is unjustifiable and this segment has to be taken out of the morass of poverty and helped to enjoy at least some of the fruits of modernity. In fact this is their right.

Sustainable society

Can one hazard a guess about the shape of a sustainable society in a country like India? Basically it has to be a healthy blend of environmental, developmental and economic imperatives. The

underlying rationale has to be that ecosystems, agro-ecosystems and industrial economic systems have to be conserved and used in a sustainable manner. Furthermore, economic growth has not to be at the expense of ecological assets. The sustainable society has to aim at working in *partnership* with nature and conserve resources and energy, reduce waste, and avoid degradation of renewable resources. It must produce goods that are easy to recycle, reuse and repair after use. Sustainable economy aims at maintenance at a constant and sustainable level of both the number of people and quantity of goods. These should be in line with the carrying capacity of the concerned systems: ecosystems, agro-ecosystems or industrial economic systems. The basic needs of the people are met without any serious detriment to environment. *Need not greed, and comfort not luxury, should be the guiding principles.*

The method of growing food and raising livestock has to be. based on soil and water conservation, bio-fertilizers, biological control of pests and minimal use of non-renewable energy. There is needed extensive use of relevant biotechnology under sustainable society. Under this path of development, people must believe that resources of earth have to be protected and sustained not only for human being, but also for other species. *The approach to manage and sustain resources of earth is not centered around human being but around the entire life-support system.*

Sustainable society and economy is based on a firm belief that earth is finite in area both for colonization of species and utilization of resources, but human numbers keep on growing. It follows from this that there cannot be infinite and unlimited growth and development with finite and limited resources that earth has. Furthermore, the increasing population growth and production and consumption of goods and services, stress and strain the natural processes and renewability so as to maintain the life-support system (air, water, soil, flora and fauna) in a healthy state. It is, therefore, essential that environmental degradation and depletion of resources is prevented by working *with* nature. The aim is to reduce unnecessary use and

waste of resources (including energy) and not cause permanent extinction of species.

A sustainable society would largely be a solar/photosynthetic/ biomass society where solar energy and solar hydrogen together with whole range of renewables are used and aims at not wasting resources unnecessarily and avoid interference with other species. The idea is to reduce short term gains that have long term environmental and economic costs.

A sustainable society would insist that the national accounting system should take into account both the economic growth rate and the rate of ecological resource degradation and rehabilitation. The two together will give a correct picture of the state of the country's economy. This would ensure that the economic growth is not at the expense of ecological assets. Although India has rather a rich resource base, the majority of the people are essentially poor. The sustainable group must have faith in science and technology as a powerful instrument of social and economic change and must advocate the use of technology relevant to a particular situation with emphasis on local self-reliance. As indicated above, we need to believe in recycling and reusing materials and advocate adoption of all the technologies that help to conserve the life-support system of the planet without affecting its regenerability. This would lead to rational use of resources with minimum waste. The guiding principle is to satisfy the need and not greed of the people, ensure comfort not luxury, and above all bring about equity with social justice. Unlike the Hi-tech Society, which basically in its present form works against nature, the Back-to-Nature Society works in nature, and the Sustainable Developmental Society would work *with* nature.

The attitudinal difference between eco- fundamentalists and sustainable developmentalists can be seen from the fact that the former talk of ecocide, *ecodisaster* and *eco-catastrophe*, while the latter, taking note of the former, talk and plan through *ecotactics, ecotechnology and ecodevelopment*. Their roles could

be complementary to one another — the former use shock tactics to arouse interest, while the latter do something positive on the ground.

The twin goals of sustainable developmentalists are: restoration of the past ecological damage, and insulation of the country from the damage as a consequence of future development. The latter must entail minimum risk to environment. They recognize the fact that there is no form of development with zero-risk. To accomplish both restorative and preventive strategies, they advocate the use of science and technology in an abundant measure.

The most formidable task before a Sustainable Society is to achieve, in actual practice, sustainable development that will alleviate the condition of the teeming millions of India who have to be brought out of the present day morass of poverty, penury, want, illiteracy, disease and joblessness through the application of location-specific science and technology. It must firmly believe that our teeming millions in villages (including tribals and adivasis) are entitled to the fruits of modernity without affecting the resource base adversely. It is not ethical to keep them out of the mainstream of national development and advocate, as some eco- fundamentalists do, a Back-to-nature approach.

Panchayat Raj (governance through local Village Councils) shorn of its populist and political overtones, can be one major instrument of the much-needed socio-economic change at the grass roots for India's teeming millions. However, what we need is the right mix of development and environment to enable people to produce, protect and sustain resources so as to raise their quality of life. It would also generate employment and halt migration from villages to cities. The fundamental question is what pattern of development needs to be followed. The answer is simple; it has to be the bio- intensive form of development because foundations of our village society are biological: agriculture, animal husbandry, forestry and fisheries. These are all biomass-based vocations. Furthermore, there has

to be intensification and diversification of biomass production, processing and utilization. To ensure this would involve sophisticated science and technology including biotechnology. Further more, biomass production has not to be monsoon-dependent. Such a positive approach alone will help rural people to insulate themselves against future ecological and economic shocks, which otherwise would make them 'ecological refugees'.

For the success of bio-intensive pattern of development at the grassroots, two measures are very necessary. Firstly, land use planning and land-tenure, which though somewhat intractable issues, have to be solved in favour of people particularly the weaker sections. Secondly, our per capita land holding is very small, and with population increase it would become still smaller. We have, therefore, to get more and more biomass from less and less land. This is possible by involving environmentally clean science and technology, particularly genetics, breeding, pharmaceutical sciences and biotechnology, and advocating use of not only high-yielding varieties but also biofertilizer and bioinsecticides in order to make biomass production sustainable and continuing to maintain the tilth and health of soil.

Our very life and existence and economic system depend on solar, earth and human capitals. The technology to use the earth capital is generated by the human capital. We have also to respect not only human life but affirm our responsibility towards all life.

Thinking must become systematic, holistic and futuristic. We must anticipate consequences of first, second and even third order, and must redesign our behaviour towards people, government and business, and above all towards our atmosphere, hydrosphere, lithosphere and biosphere. These should not be abused and over-used because these alone will help to evolve sustainable societies.

Models of development: Broadly speaking, there are two models of development for India. The top-down Nehruvian model of development involves industrial development in which mostly non-renewable resources (including energy) are used. Generally, such development everywhere has been oblivious of the destruction of natural resources, which represent wealth in their own right. The prime indicator of this development is the increase in Gross National Product. This is essentially a human-made macro-economic indicator, which neither reflects the extent and nature of human well-being, nor the damage done to the environment.

The bottom-up Gandhian model is basically aimed at building self-reliance and self-respect in a villager, and poverty alleviation of region's teeming millions who are steeped in penury. Village is a socio-economic and cultural unit and not a geographic unit. This model involves enhanced biomass production, processing, and utilization. A large section of our society has to be served by this model which depends on renewable resources (both man-made and natural). The model is largely fuelled by solar energy (photosynthesis). The indicator to be used for estimating growth of such a model has to be the increase in the Gross National Resource Product, which should be sustainable and should cause the least or manageable amount of ecological damage to the production base. The basic principles (local self-reliance and equity with social justice) of the Gandhian model of development must become applicable to all situations from ecosystem to industrial societies. However, the top- down model of industrial development is relevant primarily to the industrial economic sector. This model needs refinement and has to be made sustainable.

The Gandhian model leads to decentralized economic planning and to an 'economy of permanence' while in top-down model of industrial economy there is the danger that the rich become richer, and poor poorer. Success will be measured not by homogenizing a heterogeneous situation, but by harmonizing diverse societies in which modernity is appropriately blended tradition, and where

man-made does not become destructive of the natural capital. Both models have their specific constituencies. *Thus, following a democratic path, there is need for a creative synthesis of the bottom-up (Ganndhian) and the top-down (Nehruvian) models.* Herein lies the salvation of this country.

In one model a small percentage of population uses an unusually large amount of resources. Globally this is also true of a small number of powerful industrial countries guzzling resources far out of proportion. The other model results in a large percentage of the population using a small amount of resources, as is true of a large number of populous (but rather powerless) developing countries. Equalization between the two models can only be possible by shrinking the use of resources in the first group, while enhancing resources use and controlling population growth in the second group. At present, both these are only pious wishes because, for instance, the USA has about 5 to 6 per cent of the population of the world, but is guzzling about one third of the world 's non-renewable resources. From the resource consumption point of view, its population actually constitu tes over 20 per cent of the world's popu lation. On the other hand, India h as 16 per cent of the world's population, but from the point of view of actu al resource-consu mption, i t represents less than 4 per cen t of the popu lation of the world (Khoshoo, 1997). The present situation neither reflects any form of equity nor social justice, and is indeed inheren tly unsustainable. It needs urgent attention, for otherwise it carries in it the germ of future confrontation between developing and industrial countries. *The advice from the later to the former regarding controlling their population will carry conviction only when industrial countries give demonstrable proof of reducing their resource consumption.*

The best option for our region with its very large rural population is *bio-industrial development*, rather than pure industrial development. The bedrock of such development is sustainable production, processing and utilization of biomass (to meet the needs of the unusually large rural sector), together with a commensurate amount

The Two Models	
Bottom-up Gandhian model	**Top-down Nehruvian model**
Intensification and diversification of agriculture, animal husbandry and forestry, i.e., biomass production processing and utilization i.e., renewable sources	Intensification and diversification of industrial development using mostly non-renewable resources
Photosynthetic / Solar Model: Use of solar energy and some non-renewable energy	Man-made Industrial Economic System: Use of non-renewable resources and energy. This model should not be accepted without Environment Impact Assessment and Environmental Management Plan
Labour intensive	Labour displacement
Caters to over 76% of population	Covers hardly 10% people
Poverty alleviation at subsistence level	Gap between rich and poor widening, rich becoming richer, poor poorer
Governance at village level through Panchayat (Village Councils): Bottom Up Approach	Governance centralized: Top down approach
Economy of Permanence: Sustainable	Economy of Impermanence Unsustainable
Rural Development	Industrial development
A creative synthesis of the two models is needed for achieving bio-industrial growth and development	

Table 1: The Two Models of development

of pure industrial development. Furthermore, the GNP needs to be recalculated on the basis of depreciation or appreciation in land and soil, forests, water, biodiversity, fisheries, extent of climate change and ozone layer depletion, and so on. These calculations must also include specific indicators of human development and well-being. This is where India in the course of time, can blaze a new rail by appropriately blending economics and ecology into one connected whole. Herein lies the future of India in fostering pluralism and not singularism. This is both a challenge and an opportunity for our country.

It is clear that India cannot be against industrialism *per se* but it has to have industrialism minus its negative impacts, for example, labour displacement and exploitation and environmental degradation. The important characteristics of the two models are summarized in **Table 1**.

Today, a major challenge as also an opportunity before the country is how soon can we move towards sustainability. In India, if we go the way we have been so far, centuries will continue to co-exist in future. We will continue to have a subsistence India of a large number of poor and dispossessed toilers and plodders who live in medieval times, and an affluent India of a small number of people who are jet-set and wealthy who may be poised to enter the twenty-first century with a bang. How soon we take even the preliminary steps to bridge the vast gap between the large powerless subsistence and the small powerful affluent India, will determine whether we can make it to a sustainable society where we have environmental harmony; conservation of natural resources (including poised to enter the twenty-first century with a bang. How soon we take even the preliminary steps to bridge the vast gap between the large powerless subsistence and the small powerful affluent India, will determine whether we can make it to a sustainable society where we have environmental harmony; conservation of natural resources (including energy); economic efficiency; local self-reliance; gender equality: equity with social justice; ecological, social and economic

security; sustainable consumptive ethic with cultural relevance; and peace and disarmament: the dream of Mahatma Gandhi (Khoshoo, 1995)

The governments in the developing countries, for that matter even in the industrial countries, have yet to evolve sensible, credible and implementable agenda for ensuring sustainable ecological and economic growth, development and security. We need a comprehensive ecological and economic code about responsibility of an individual (because a society is actually an extension of individuals), society at large and country as a whole, and, to the extent possible, even of the South Asian Region. We also need to evolve a regional approach to the global issues which has become very important on account of our shared history, culture, religion, philosophy and above all fostered by our guardian, a healthy Himalaya, without which India would have been altogether different, may be a desert.

Tasks ahead

Economy-ecology nexus: There is a close connection between economy and ecology. The former emanates from the ecological assets (the earth capital) with the help of technology (the human capital). Economy and ecology are intimately interrelated, interconnected and interdependent. India presents to the Parliament an annual *Economic Survey*, and then a week later announces an Economic Budget. It is high time that we also present an *Annual Ecological Survey* of the country followed by an *Ecological Budget* with ecological deficit in the form of pollution and ecodegradation of water, air and soil, deforestation, etc. Following preventive and restorative strategies, we can wipe out ecological deficit, and have an ecological surplus in the form of clean air, water, soil and the increase in forest cover, sustainable agriculture, etc. We have to make ecology and economics as two sides of the same coin in real terms Ecological and economic security are mutually reinforcing.

The major task facing the country is to set right the big environmental deficit created by past ecological damage, and to

ensure manageable or no. ecological damage from future economic development. *The most important point underlying sustainability is that we must live on the income (in the form of annual increment) from our life-support system and not on the capital.* With proper management it is possible to enhance the income. The idea is to evolve a portfolio of restorative and preventive environmental, social and economic strategies based on hard core science and technology. Examples of these are Ganga Action Plan, Wasteland Development (Khoshoo, 1986).

Ecotechnology

Equally important is the realization that the future development is going to be through the use of ecotechnologies. In fact enlightened industrialists in Japan and Germany are increasingly switching over to such technologies on account of the realization that *there is going to be far more money in conservation technologies than in consumpive technologies.*

Urgent tasks

The most important tasks needing urgent attention are: population stabilization; land-use planning in our land hungry country; water conservation; sustainable agriculture, horticulture animal husbandry and fisheries; conservation and sustainable utilization of natural forests and raising large scale man-made plantations in order to save our natural forests; conservation and sustainable utilization of biodiversity: ecologically compatible housing particularly slum improvement; control of pollution of air, water and soil; non-polluting renewable energy systems; minimization, recycling and utilization of wastes; green technologies; control of AIDS epidemic; environmental education and training leading to environmental ethics; periodic updating of environmental laws; blending ecological and economic imperatives; and ethical and moral dimensions of resource use.

Attitudinal change

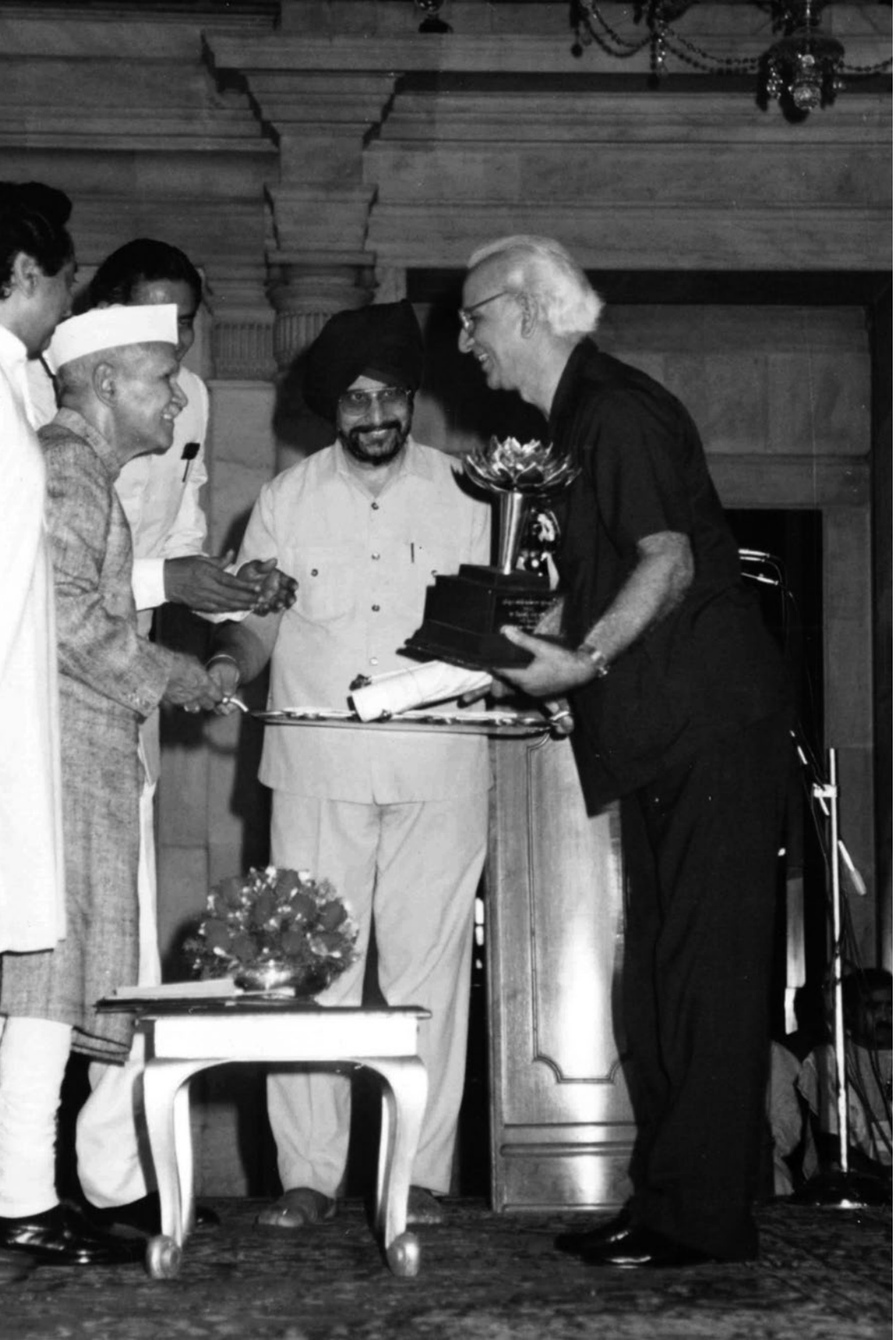
Finally, there has been a major change in the attitude of the human race from purely techno(logical)-economical consciousness to a

broader perspective of eco(logical)-economical consciousness (Skolimonski, 1991), of which technology is one of the components. The important characteristics of the new environmental thinking are that it must become holistic, qualitative, spiritual, reverential, evolutionary and participatory. Herein lies the salvation of human being notwithstanding the fact that it may soon acquire the capability to clone itself, even so it must remember that *death is a reality.*

Role of human being

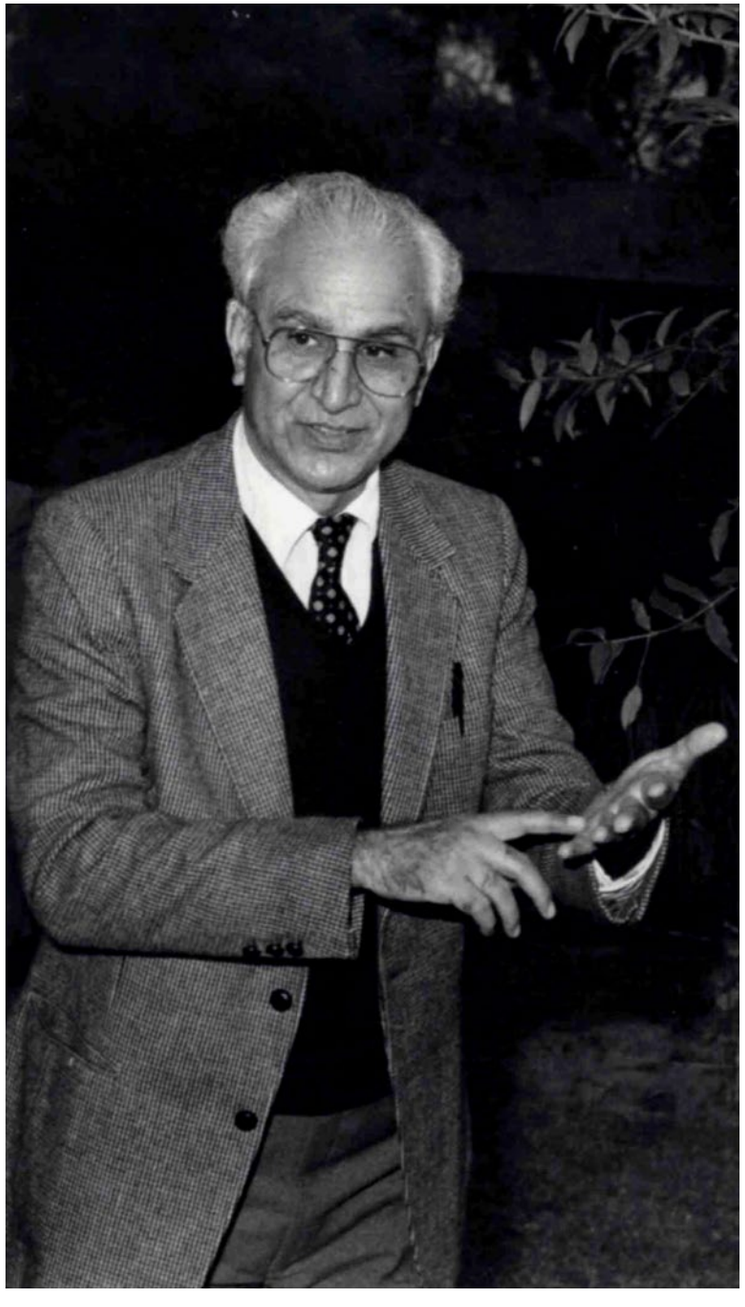
The foregoing tasks are more or less attainable, but human race has to take decisions about its future role. It is a part of the overall system which ranges from her/himself to universe in successively expanding horizons (Noss and Primack, 1993). This may look to be beyond one's comprehension, but it imposes an implicit responsibility on human beings. Firstly, there is a continuum from one's own self to the universe. Secondly, there is a progressive dwarfening of the human being. Someone has put this idea differently: collect all the sand grains on the surface of earth, these will give some idea of the number of celestial bodies floating in the universe. Take just one of the sand grains, that would be our Mother Earth. Imagine one's own self standing on this grain: one among billions of people and countless other organisms (plants, animals and microorganisms) living on the earth. Obviously, one feels humbled and miniaturized beyond recognition. Lastly, the fundamental point is that human beings must realize that it is not a co-creator. No doubt it is a species gifted to think, recollect and foresee, and added to this is the power of science and technology. This power must not be misused and abused. Therefore, human being must become a responsible species: scriptures talk of such a responsibility.

Khoshoo, T. N. (1997). Solar, earth and human capitals, and sustainable development. Current Science, 72(9), 612-621.



ECOSOPHY FOR A SUSTAINABLE FUTURE

Professor Khoshoo was deeply impressed by the Gandhian approach to life. He interpreted Gandhiji's principles in a refreshing manner, particularly in relation to ecological sustainability and development. While Western philosophers like Félix Guattari and Arne Næss were championing the ideas of 'Deep Ecology' and 'ecosophy', Professor Khoshoo reintroduced the Gandhian perspective to emphasize environmental conservation and sustainable development in rural India, underscoring the importance of bottom-up approach. The following chapters provide a glimpse into Professor Khoshoo's contributions to eco-philosophy and his vision for a sustainable future for the planet.



1
MAHATMA GANDHI: AN APOSTLE OF APPLIED HUMAN ECOLOGY

Although during the lifetime of Mahatma Gandhi, there were no wide-ranging debates on environment and development *per se*, he was nevertheless much ahead of his times, on account of his being deeply conscious of the very environmental concerns we perceive today. It shows his forethought and vision. This is abundantly clear from his statements and writings, and above all from the very simple and sustainable personal life style that this great socio-economic and political reformer followed all his life. He renounced all luxury, and willingly experienced the pangs of deprivation, even though he came from a wealthy family, and, as a barrister-at law, could have led a very comfortable life. He identified himself with the poorest of the poor (*daridranarayan*) in this country. Indeed, he had a holistic

approach towards all such problems. His strongest point was that he preached what he practised. His hermitages (*ashrams*) stood as testimony to this. These were located in open and rustic rural setting and were based on self-help (including cleaning latrines by inmates themselves), local self-reliance, participatory management, gender equality, etc., the importance of which has been realized only now. According to N Radhakrishnan.

The ashrams or the communities Gandhi founded, both in South Africa and in India, were meaningful centres where Gandhi demonstrated with convincing success how each member of this community could live in harmony with nature. The community life Gandhi was developing consisted of manual labour, tree planting, agriculture, simple life, and crafts. In short they were attempts at self sufficiency without invoking the blessings of the temptation from outside. While they could be described to be bold experiments, but by no stretch of imagination could anyone say they were utopian ideals. The running and recurrent principle of the community life was to live according to the rhythm of nature and in harmony with nature with minimum needs and not to exploit nature beyond taking what nature offers.

Gandhiji's underlying philosophy *was need but not greed, and some comfort but no luxury*. In the final analysis, these are the goals of sustainable development. Environmentalism was a part of his daily routine, or, should we say, a part of his ethic. In every sense he had foreseen the environmental crises that were in the offing. The environmental problems of the earth began with its very birth some 4.6 billion years ago. If one were to compress into 24 hours the time scale from 3.6 billion years onwards (when origin of life on earth took place), then the ancestors of the modern human being arrived only two seconds before midnight. Homo sapiens came only one second before midnight; agriculture came about 0.25 seconds before midnight, and industrial revolution only about 0.0001429 seconds before midnight (Miller, 1994). But there has been considerable damage to the earth system (including its atmosphere) during

the very short time-span of the human existence on earth; far-reaching changes have taken place, and landscapes have been changed beyond recognition. These changes began in the middle of the eighteenth century when the steam engine was invented in England, and coal was firmly established as an energy source. As energy consumption increased, so did economic growth and distribution of goods and services. Thereafter, environmental degradation has been associated with most human endeavours leading to changes in the chemistry of air, ozone hole, deforestation, soil loss, desertification, water scarcity and its pollution, urban sprawls, toxic wastes, unsustainable energy use, species loss, ecological refugees, etc. All these can be traced to the ecologically unsustainable human development. The human being has thus become according to John *McHall, the most dangerous organism that the planet has ever hosted.*

In the history of earth system there have been six major episodes of mass-extinction but all these were followed by evolution of new flora and fauna. However, today, renewals are not in sight; and this makes human-made destruction of landscapes and extinction of species very ominous, and a cause for great concern.

Awareness about these changes has been growing, particularly during the last 50 years. Thus, during the 1950s, emphasis was on conservation of mega-animals (like lion, tiger, rhino, crocodile, even some birds, etc.) and public health engineering. This was the legacy that the British left us. In the decade of the sixties the emphasis was on pollution of air and water, particularly by synthetic chemicals which leaked into the biosphere leading to their bio-magnification. This was summarized in the book *Silent Spring* by Rachel Carson (1962). Then followed the decade of the seventies, and the publication of the book titled *The Limits to Growth* (Meadows et al., 1972). This book brought out the dilemma facing humankind as a whole: while the planet and its resources are finite, the human population is growing exponentially, and so are its demands on the biosphere. Thus there dawned a realization: that unlimited and

infinite growth and development cannot take place with limited and finite resources. This was followed by the UN Conference on Human Environment in 1972 at Stockholm. Apart from the host (Olaf Palme, Sweden), only one world leader of significance (Indira Gandhi) attended this conference. Her intervention brought forth the fundamental truth that *poverty and need are the greatest polluters*. Thus the horizon of environment widened to include social, economic and ethical aspects. She also talked of peace and disarmament being critical to environment. In 1973 there was the energy crisis. Except for the oil exporting nations, all nations were affected adversely. What was more important, the world realized, for the first time, that it was living in a Petroleum Society. With this, energy issues together with their environmental effects entered the arena of environment. During the decade of the eighties, the global implications of environmental degradation and energy-use became clear. The possibilities of climate change, ozone depletion, and sea-level rise were discussed and deliberated upon. In 1982 a meeting on the energy crisis was held. Another major event was the publication of the report of the WCED (World Commission on Environment and Development) in 1987, and with this a realization dawned, that the human race has a *common future*. Earlier, similar conclusions were arrived at by commissions headed by Willy Brandt and Olaf Palme, who talked of problems of *common crisis* and *common security* respectively facing all humankind.

Finally came the decade of the nineties, when the historic UNCED (United Nations Conference on Environment and Development), with over 30 000 attendees, was held at Rio de Janeiro. Contrary to the 1972 UN Conference, this event saw most Heads of State/ Governments making a bee-line to UNCED so as to make an appearance and a statement. The result was the release of five documents, the principal one being Agenda 21 (Environmental Agenda for Twenty-first Century). It is a blue-print for the future. Even a cursory glance at this document shows that it contains almost everything in it. Thus, environment has assumed tremendous importance, leaving almost no compartment of human life and

endeavour un-affected by it. Today, the subject has become all-encompassing.

To define environment, with its all-pervading role, is indeed difficult. There are as many definitions as there are people who have defined it. I have found a definition given in McGraw Hill Encyclopaedia on Environment (1975) which is simple yet comprehensive and holistic. It states thus: *environment is the sum total of all conditions and influences that affect the development and life of organisms*.

Although the foregoing definition talks of organisms, in practice *Homo sapiens* has literally taken control of the earth system, as though humankind is the only species present. Ethically, all species have a standing, and all have equal right to live. The human species has forgotten that it is only one species out of the 16 04 000 described so far (World Conservation Monitoring Centre, 1992). This means that, as a species, *Homo sapiens* constitutes only 0.0000623% of the total living species on the planet, even though the population of humankind is close to 5.7 billion. The total number of species on the planet is likely to go up to 122 50 000 and in turn the percentage of Homo sapiens, as a species, falls to mere 0.0000082%, even though its population may touch the seven-billion mark by ad 2000. Furthermore, all the species that occur on the earth today constitute only about one per cent of what have existed during the history of the earth. Taken in this light, the percentage of humankind as a species, would fall still further. Human beings have to keep this in mind, and recognize that the biosphere constituted by plants, animals and microorganisms is an interacting system and a web of life in which the human race is only one strand, although an important one because of its being a thinking species—intellectually at a significantly much higher plane.

There is another dimension to the above argument. If one visits the Andaman and Nicobar Islands or even the interior of Madhya Pradesh or Orissa, and tries to understand their tribal societies, one finds that these are an inseparable part of Nature. Some are

almost in total harmony with Nature. They take from Nature what they actually require and not more. They generate little waste, all of which is biodegradable; and waste of one species is food for others, resulting in no accumulation of waste. Here the human being is but one of several species in the ecosystem. The latter is auto-sustainable and self-regenerating, with sunlight as the only input from outside. The other extreme is what one finds in the metropolitan cities of India, where the human being is the most dominant species. In fact, in these cities, it appears that humankind is the only species that matters. It generates enormous quantities of waste during production, processing and utilization of goods and services. Some of the waste is non-biodegradable, resulting in accumulation of pollutants in air, water and land which consequently leads to environmental degradation. These are the two extremes in India, with many situations in between.

Essentially, the two extremes represent *harmony* with Nature on the one hand, and *conflict* with Nature on the other. However, if we look into our past and see the type of conservation ethic that comes to us from Vedic times, the truth becomes abundantly clear from the very first stanza in *Isho-Upanishad*. It says

The whole universe together with its creatures belong to the Lord (Nature). No creature is superior to any other, and the human being should not have absolute power over Nature. Let no species encroach upon the rights and privileges of other species. However, one can enjoy the bounties of Nature by giving up greed.

Alas, we Indians have forgotten this basic ethic and taken to assaulting Nature and thus come into perpetual conflict with it on account of exploitation (and not *utilization*) of natural resources. This approach stems from a feeling of supremacy over Nature, from the false notion that the human being is a co-creator with Nature. Basically, this thought is alien to Indian culture. Indians have not been exploiters but utilizers of natural resources. This is indisputable; for had it not been so, this country would have presented a vastly

different scenario, being one of the few countries which has been under the influence of human beings and agriculture for over 10,000 years. The underlying factor is compassion for both animate beings and inanimate materials and co-existence with Nature, which is ingrained in our history, culture, religion, and philosophy.

There is now a global thinking that humankind is indeed an integral part of the biosphere. Furthermore, *the human species has to realize that Planet Earth with all its life forms can exist without human beings, but human beings cannot exist without earth and other biota. Earth is our only home.*

There is, therefore, no doubt that *Homo sapiens*, being a *thinking species*, has to be a responsible species and act as a guardian of other species.

The importance of Gandhiji lies in the fact that he talked in his lifetime about many of the foregoing issues now being discussed under environment. He was no doubt a profound environmentalist, like Mahatma Buddha and Ashoka the Great.

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GANDHIAN ENVIRONMENTALISM - AN UNFINISHED TASK

Mohandas Karamchand Gandhi was born on 2 October 1869 at Porbandar, the capital of a small princely state in Gujarat. His father Karamchand Gandhi was the Chief Minister of the State of Porbandar. Putlibai, Gandhiji's mother was a pious and deeply religious person. The family was *Vaishnavite*, which is a sect of Hindus who worship *Lord Vishnu* (The Creator). Gandhiji was a strict vegetarian. He was also a believer in fasting as a means of self-purification and religious tolerance.

In his lifetime Gandhiji was regarded as a *Mahatma* (a Great Soul) by the people of India. He became the principal architect of India's Independence and nationalism and set his head and heart to stop the blatant exploitation of India's people and loot of natural resources. He advocated the use of the same for the good, the benefit and well-being of the teeming millions of India. After Gautam Buddha, he has been the Prophet of Non-violence (*ahimsa*), Truth (*satya*) and sticking to the truth (*satyagraha*) even under the greatest provocation. He was the unquestioned apostle of applied human ecology. Using non-violent means, he set in motion a process that led to the Independence of India and many nations in Asia and Africa and elsewhere. These countries, like India, were under an alien rule before. Thereafter they were in control of their own destiny and free to come out of the quagmire of abject poverty and penury.

Very early in life he set for himself two objectives: near-term objective of political Independence of India following the path of ahimsa and satyagraha, and long-term objective of economic Independence for India's teeming millions based on social, economic, environmental equity and ethical considerations. While he achieved the former in his life time, the latter is still a dream even after 50 years of Independence of the country.

As is borne out by his life and work, Gandhiji was much ahead of his time. Few could have made such futuristic statements on environment and development, particularly when, at that time the environmental problems were either not too obvious, or at best were only in their incipient stages. It needed the Mahatma's mind and eye to discern these, and talk and write about the same. This only shows his forethought and vision of the shape of things to come.

Yoga and Ecology

Even a cursory study of his life shows that Gandhiji was indeed a practicing yogi, although he never claimed to be so. Yoga, in simple words, is discipline and control over body and mind, through physical practices (*Hat Yoga*) and ethical code of conduct (*Raj Yoga*). In the

latter, there are eight formal disciplines, and first two (*yamas and niyamas*), pertain to environment and ethics of resource use. These were actually first practiced and then preached by Gandhiji.

The *yamas* are ethical commandments relating to human behaviour in relation to other humans and living creatures and non-living resources. Essentially these are a set of don'ts, the five yamas are: non-violence (*ahimsa*) towards all animate and inanimate creations; truth (*satya*); shunning the use of materials obtained by illegitimate means and avoiding destruction and vandalism (*asteya*); celibacy (*brahmacharya*) because humans need to keep their numbers in check, otherwise demand on resources will increase; and lastly, not coveting or amassing materials and wealth beyond requirement (*aparigraha*).

The five *niyamas* are self-based codes of conduct: these prescribe what a human being should do, and relate to cleanliness/ sanitation (*shaucha*) of one's mind, body, and the surroundings - for a human being is essentially dirty animal which, unlike other animals, generates considerable waste and garbage, often non-biodegradable in character and as such pollutes the environment. Shaucha also includes ridding oneself of undue lust including sexual desire (*kama*), anger (*krodh*), greed (*lobha*), undue attachment (moha) and conceit and vanity (*ahankar*). Other niyamas are contentment (*santosh*); austerity (*tapas*); introspection on the self (*swadhyaya*); and prayer and meditation (*ishwar pranidhan*) for any dereliction of duty towards yamas and niyamas and towards Nature and components of the biosphere of which humans are an integral part. A yogi controls himself by himself, and thus becomes humane. Gandhiji practiced all the *yamas* and *niyamas* without claiming to be a yogi.

He encouraged indigenous capability and local self-reliance (*swadeshi*); self-rule and local self-governance (*swaraja*) at the level of village; and welfare of the weakest (*antyodaya*) leading to welfare of all (*sarvodaya*). His chief 'weapons' were non-violence (*ahimsa*)

and sticking to the truth (*satyagraha*) which he used to rid India of the British rule and the plunder of the country's resources.

Most of the commandments enumerated above, though essentially personal moral codes, were converted by Gandhiji to a socio-economic and political movement to galvanize India and Indians into a cohesive force to drive the British out. Essentially it was conversion of environmental, socio-economic and ethical principles into political movement. It was only his genius that could accomplish this. In short, he blazed a new trail: Non-violent Method of Conflict Resolution, which before him, was seldom, if ever, accomplished.

Widening Horizons of Environment

During the last five decades, after Gandhiji's assassination in 1948, there has been an ever-widening circle of environmental concerns and strategies, starting with conservation of the big cats and ending with ethics of resource use and everything in between. The earth is regarded as the Universal Mother (*Dharti Mata or Greek Gaia*) which harbours her 'brood' of a very large family of living organisms (*Vasudhaiva-kutumbakam*). Humankind is only one out of millions of species described so far. Being a thinking species, it is no doubt different from others.

Gandhiji believed that there is divinity in all life, and that there is thus a fundamental unity in diversity. His faith in non-violence and vegetarianism made him a votary of conservation of all diversity including all forms of life, societies, cultures, religions, traditions, etc. His argument for conservation of biodiversity was indeed simple: since a "*human being has no power to create life, he has, therefore no right to destroy life*". Further, Gandhiji felt that there cannot be any ecological movement designed to prevent violence against nature unless the principle of non-violence becomes central to the ethos of human culture.

Gandhiji was particularly concerned about women, who have actually been traditional conservators and far more committed to conservation than men. Historically, women have been gatherers, and not hunters and killers of life like men. Woman by her very nature creates, cares and shares. At the subsistence level, woman's plight moved Gandhiji. He eulogized women for their role at various social levels and considered them equal to men in all respects. He "*worshipped women as an embodiment of the spirit of service and sacrifice*" and helped them to take up national reconstruction. It is only now that the world has focused its attention on women and children and begun to talk of gender equality.

Gandhiji was equally concerned about sanitation and also the liberation of scavengers. He called them *Harijans* (God's People) because of the great service they were rendering to the society at large, a service which no one else was prepared to render. He did a lot to remove their drudgery, led movements against Hindu orthodoxy to admit them in temples, and reuse the rich night soil as a source of manure and energy, which was otherwise a potential environmental hazard: Breeding ground for and spread of highly infectious diseases of poverty.

Equally important for Gandhiji was the role of an individual, which he regarded as of utmost importance because a society or a government is only extension of individuals. Hence, environmental perceptions of an individual are of critical importance. He was very concerned about inequities/disparities in resource-use of various sections of the society and said: "*Man's happiness lies in contentment. "He who is discontented, however much he possesses, becomes a slave to his desires*". Here then lies his basic ethic behind resource use. If implemented, the downstream environmental degradation that follows overuse of resources could also be controlled if not eliminated altogether.

Acid Test of Development

Gandhiji's personal life style was the most sustainable one. He identified himself with the poorest in the country who were irresistibly drawn towards him. His strength came from the fact that he preached what he practiced. He experimented first on himself and then shared his experience with others. Gandhiji's choice was clear: He was for the poorest of the poor: The *Daridranarayana*. In fact his advice to everyone was that, before embarking on any project or programme, he or she must use a simple talisman: Recall the face of the poorest and the weakest man you may have seen and ask yourself if the step you contemplate to take is going to be of any use to him. Will he gain anything by it? This has to be the acid-test of all development.

Gandhiji was a votary of basic education of the village level. He was very particular regarding educating children about their surrounding environment and availability of resources, together with giving them a thorough grounding in self-help and self-reliance through productive crafts. According to him, education must be aimed at children being integrated with environment, and must have "*strong pupil teacher relationship and appreciation for Indian culture*".

As a result of his first hand experience at the grass-roots level, there emerged a definite Gandhian Model of Rural Development which meant concentrating on villages (over 5,76,000 in number) and villagers. It is here that 76 percent of India's population resides in abject poverty. He was for a proper legally-binding empowerment of the poor and women in our society. The model envisaged that development and governance should be bottom-up and not top-down; goals should be self-defined and not stranger-defined; production should be aimed at basic goods to fulfill basic needs to use-values, and not at non-basic and greed-oriented luxury goods; the process of production should be by masses and not through mass production; and the whole approach should be holistic and not sectoral. He felt that unless India focuses on the economic development of villages and the villagers, which are the weakest link

in the socio-economic chain, the country cannot become strong in the real sense of the world. His chief aim was to strengthen political independence with economic independence of sustainable kind.

He was opposed to following Western industrialism blindly because of the associated environmental, social and economic problems. The principal reason was that such industrialism is based on an assumption that resources are unlimited which is actually not the case. The biosphere does not have unlimited capacity to hear the eco-degradation resulting from unsustainable development. While our planet's resources do not grow, population and wants grow exponentially. This means that there cannot be unlimited and infinite growth and development with limited and finite resources. He was not averse to industrialism per se as long as it was not resource- and energy-intensive and did not displace small cottage industry and labour. Cottage industry, according to him, has a future in the Indian context. It would help the villagers generate marketable goods. He advocated that we should not become slaves to unlimited desires for material growth.

If we do not follow an austere path, there would follow an ecological backlash which may engulf the human race, with nowhere else to go. Therefore, the delicate, and holistic balance that exists in Nature has to be respected and maintained. Gone is the time when environmental protection was synonymous with caring for the big cats; today, on it depends the well-being of the Planet as a whole, together with all its inhabitants (including human beings) and non-living resources. There is a tremendous connectivity and interdependence among various components, like natural living and non-living resources, with considerable social, economic, historical, cultural, philosophical, ethical and moral dimensions. All these aspects are now under purview of environment. Thus a healthy economy cannot flourish in an unhealthy environment. The reason being that in final analysis, economy depends on resources available on earth and the incoming solar energy coupled with human ingenuity (technology).

The enemy of our environment is within each one of us because we want more and more at the expense of nature and consume more than our share of materials. Furthermore, ecological security is equally, if not more, important than economic security. Today the human race is at the cross roads: The present eco-degradation and pollution are the result of greed of the rich, need of the poor to eke out an existence, and careless application of technology.

The Way Out

The right choices have to be made by the human race. Having already attained a certain level of quality of life, the North needs to aim at non-material growth; but the South needs to profit from the past mistakes of the North and aim at sustainable material growth to a reasonable extent together with stringent population control.

Years ago Gandhiji was asked if he would like to have the same standard of living for India's teeming millions as was prevalent in England. He quipped: "*It took Britain half the resources of the planet to achieve this prosperity. How many planets will a country life India require!*" Behind this statement lies his life's experience of dealing with environmental and developmental issues. Following Gandhiji, the human race, in both industrial and developing countries, has to exercise a deliberate restraint on resources use. Here then comes the question of what is enough for a need-based comfortable living. He advocated that industrial countries must bring down resource use in their own countries. Mercifully, thinkers like Mahatma Buddha, Mahavira and Mahatma Gandhi in the south, have not only been talking about resource conservation, but also do practicing it since the dawn of human history.

It is against such a background that one would like to define development, i.e., which leads to economic development based on ecological principles of environmental harmony, economic efficiency, resource (energy included) conservation, local self-reliance and equity with social justice. Such a revolution has to be guided by need and comfort, and not by greed and luxury. The

basic principles of Yogic practices in ecology, environment and sustainable resource use have to be emulated in our daily lives. In this connection it is very pertinent to note that Gandhiji had thought about this much earlier when he said: "*The earth provides enough for everyman's needs but not for everyman's greed.*" This statement of his has gone in folklore and environmental literature.

The basic principles (local self-reliance and equity with social justice) of the Gandhian Model of Development must become applicable to all situations - from ecosystem to industrial societies.

The Nehruvian Model of Development involves industrial development in which mostly non-renewable resources (including energy) are used. Generally, such development everywhere has been oblivious of the destruction of natural resources, which represent wealth in their own right. The prime indicator of this development in the increase in Gross National Product (GNP). This is essentially a human-made macro-economic indicator, which neither reflects the extent and nature of human well-being, nor the damage done to the environment.

The Two Models of Development

The Nehruvian Model of industrial development is relevant primarily to the Industrial Economic Sector. This model needs refinement and has to be made sustainable. The Gandhian Model, in the words of J.C. Kumarappa, leads to decentralized economic planning and is actually "*Economy of Permanence*", while in the Nehruvian Model of industrial economy there is the danger that the rich may become richer and poor poorer. India's success will be measured not by homogenizing a heterogeneous situation, but by the success with which diverse societies can be harmonized and can co-exist and become mutually reinforcing and supportive; where traditions and modernity are appropriately blended, and where man-made capital does not become destructive of the natural capital. Both models have their specific constituencies in India. Thus, following

a democratic path, there is a need for a creative synthesis of the Gandhian and the Nehruvian Models (Refer Table 1).

A Creative synthesis of the two models is needed for achieving sustainable bio-industrial growth and development. The Gandhian Model is basically aimed at building self-reliance and self-respect in a villager, and poverty alleviation of India's teeming millions which are steeped in penury. This Model is primarily based on enhanced biomass production, processing, and utilization. The larger section of our society to be served by this model depends on renewable resources (both man-made and natural) and the Model is fueled largely by solar energy (photosynthesis). The indicator to be used for estimating growth of such a Model has to be the increase in the Gross National Resource Product at the village level, which should be sustainable and should cause the least or manageable amount of ecological damage to the production base. The basic principles (local self-reliance and equity with social justice) of the Gandhian Model of Development must become applicable to all situations - from Ecosystem to Industrial Societies. However, the Nehruvian Model of industrial development is relevant primarily to the Industrial Economic Sector. This model needs refinement and has to be made sustainable.

In industrial development generally a small percentage of population uses an unusually large amount of resources. Globally this is also true of a small number of powerful industrial countries guzzling resources far out of proportion. The rural development model results in a large percentage of population using a small amount of resources as is also true of a large number of populous (but rather powerless) developing countries. Equalization between the two models can only be possible by shrinking the resource use in the first group, while by enhancing resource use and controlling growth of population in the second group. At present, all these are only pious wishes.

USA has about 5 percent of population of the world, but is guzzling a large amount of resources. From resource-consumption point of view, it population is actually over 20% of the whole world; while India has 16% of the world population, but from actual resource - consumption point of view it represents less than 4% of population of the world. The present situation neither reflects any form of equity not of social justice, and is indeed inherently unsustainable. It needs urgent attention, for otherwise it carries in it the germ of future confrontation between developing and industrial countries. The advice from the latter to the former regarding controlling their population will carry conviction only when industrial countries give demonstrable proof of reducing their resource consumption. Gandhiji was indeed concerned about the inequitable development that the country had under the British Raj. Most unfortunately, the situation is no better after 50 years of Independence. As early as 1944 he had opined about this question in the following words: "Economic equality is the master key to non-violent independence. Working for economic equality means abolishing the eternal conflict between capital and labour. It means the leveling down of the few rich in whose hands is concentrating the bulk of the nation's wealth on the one hand, and a leveling up of the semi-starved naked millions on the other. A non-violent system of government is clearly an impossibility so long as the wide gulf between the rich and the hungry millions persists. The contrast between of New Delhi and the miserable hovels of the poor labouring class cannot last one day in a free India in which the poor will enjoy the same power as the richest in the land. A violent and bloody revolution is a certainty one day unless there is a voluntary abdication of riches and the power that riches give and sharing them for the common good. I adhere to my doctrine of trusteeship in spite of the ridicule that has been poured upon it."

The precepts and concepts of the Gandhian Model of Development are based on biomass production, processing and utilization, and are relevant to almost all situations at the grass roots. It leads to "Economy of Permanence" which can be sustainable under most

circumstances. All development must prevent man-made capital becoming destructive of the natural capital. Herein lies India's future role of blending ecology and economy in one connected whole; this is both a challenge and an opportunity for us.

Gandhian Economics

At the outset it may be pointed out that Gandhiji was not an economic theorist but an economic reformer. The major characteristics of his economic ideas can be summed up in the following twenty points:

- Economics is untrue if it ignores or disregards moral values.
- Everyone has a right to earn his own livelihood.
- The life of a labourer, whether a tiller of soil or a craftsman, is a life worth living: Dignity to Labour.
- Every individual should be provided equal opportunities and resources.
- Every individual must earn his livelihood by his own labour.
- Labour should not be regarded as a discommodity to be minimized.
- Welfare of the poor (Antyodaya) will lead to welfare of all (Sarvodaya).
- Co-operation is a better principle than mere competition to out-do people.
- Cottage industry must produce marketable goods.
- Aim at small surplus and not large profit.
- All occupations are important.
- Decentralization is conducive to progress, centralization leads to abuse.
- Political independence must be strengthened by economic independence of the right kind.
- Both bottom-up and top-down development and governance are needed.
- Objectives should be self-defined and not externally defined.
- Production of goods for basic needs and not luxury goods.
- Development has to be need-oriented and not greed oriented.
- Not Economic Dictatorship but Economic Partnership is needed.

- Good economics is conducive to the good of all, including the environment; and
- Healthy economics cannot flourish in an unhealthy environment, because economics ultimately depends on resources which come from Mother Earth.

Gandhian Environmentalism

The important elements of Gandhian environmentalism are:

- Human beings should act in a manner that it is a part of Nature rather than apart from Nature.
- Materials available on the earth are not used with an element of greed.
- Human being practice non-violence not only towards fellow humans but also towards other living organisms and inanimate materials because over-use of such materials also amounts to violence.
- Women are respected, and are made partners in and given their rightful place in all spheres of human endeavour.
- Bottom-up shared view is preferred over the top-down totalitarian overview.
- Conservationist and sustainable life-saving approach prevails over the unsustainable consumerist self-destructive approach.
- Human care for and share with the poor and the destitute in the society as a moral obligation towards them.
- The human race thinks about how much is enough for a simple need-based, austere and comfortable life style.
- All development as far as is possible leads to local self-reliance and equity with social justice; and
- Ethics and self-discipline in resource use is an over-riding criterion of development.

Gandhiji's entire life and work is an environmental legacy for all humanity. This was not because he wrote a big treatise on environment, or led a movement to stall a dam or some industry, or clean a river, or whatever. This was because he was a practitioner

of sustainable development in the real sense of the word. His strength came to him on account of his spirituality and practice of non-violence and truth. Taken in a wider sense, these are the very critical elements for the success of sustainable development. In brief, his whole life was his message and a lesson on environment and development for Indians and the world at large to follow. Gandhiji's environmentalism amounts to being pro-nature, pro-poor, pro-women and pro-job generation. He combined social, economic, environmental, equity and ethical imperatives for obtaining political independence and economic salvation through rural development for the teeming millions of India. To achieve this, he considered the path of love, co-operation and peace more sustainable than hate, conflict and war. Furthermore, in 1920 in Young India, he wrote thus: "We want to organize our national power not by adopting the best methods of production only, but by the best method of both the production and distribution."

Bio-industrial Development

The best option for India with its very large rural population (40 percent below poverty line) is Bio-industrial Development, rather than pure industrial development. The bedrock of such a development is sustainable production, processing and utilization of biomass (to meet the needs of the unusually large rural sector), together with a commensurate amount of pure industrial development. Furthermore, GNP needs to be recalculated on the basis of depreciation or appreciation in land and soil, forests, water, biodiversity, fisheries, extent of climate change and ozone layer depletion, etc. These calculations must also include specific indicators of human development and well-being. This is where India, in the course of time, can blaze a new trail by appropriately blending economics and ecology into one connected whole. Herein lies India's future in fostering pluralism and not singularism. This is both a challenge and an opportunity for the country.

It is clear that Gandhiji was not against industrialism per se but he wanted industrialism minus its negative impacts, e.g., labour

displacement, exploitation, environmental degradation, etc. He envisaged co-existence of shipbuilding, electric generation, steel mills, machine making in cities with handicrafts in villages. He felt that nothing should be produced in cities that villages can produce so that migration of villagers as "*ecological refugees*" is halted. As stated earlier, the enemy of environment is within most of us, because we want more and more at the expense of Nature. We are at war with Nature to varying degrees.

Environmental Priorities for 21st Century

Keeping in mind the type of environment that Gandhiji thought and practiced, one can make a fair list of environmental priorities for the next century. These are:

- Population stabilization;
- Land-use planning in our land-hungry country;
- Water conservation;
- Sustainable agriculture, horticulture and animal husbandry;
- Conservation and sustainable utilization of natural forests and raising large-scale man-made plantations in order to save our natural forests;
- Conservation and sustainable utilization of biodiversity;
- Ecologically compatible housing particularly slum improvement;
- Control of pollution of air, water and soil;
- Non-polluting renewable energy systems;
- Minimization, reuse, recycling and utilization of wastes;
- Green technologies;
- Control of AIDS epidemic;
- Environmental education and training leading to environmental ethics;
- Periodic updating of environmental laws;
- Blending ecological and economic imperatives and
- Ethical and moral dimensions of resource use.
- Human Being in Universe

Being a practicing yogi, Gandhiji had tremendous control over his body and mind. He realized both the significance and insignificance

of human being. The latter has attracted the western mind as well. One way it has been expressed is the place of human being in the universe. This is depicted in the following diagram. A few points emerge from this diagram. Firstly, there is a continuum from one's self to universe. Secondly, the expanding circles from one's self to reveal the progressing dwarfening of the human being. Someone has expressed this idea differently: collect all the sand grains available on Mother Earth. These would give an idea of the celestial bodies floating in the Universe. One of the grains from this heap is Mother Earth. Imagine one's own self standing on this grain, one among billions of human beings, and one among the countless plants, animals and microorganisms. The result is dwarfening, better still miniaturization of human being. Can we really recognize ourselves! Lastly, the question arises, whether human being is a co-creator. This question is relevant because westerners think so. The oriental viewpoint is that human being no doubt can think, recall and foresee, but he is not a co-creator.

It is this basic difference that distinguishes the Western and Eastern thoughts, i.e. an arrogant versus a reverential attitude towards the Mother Earth and then Mother India. This is also the basic lesson that can be drawn from the Gandhian environmentalism.

Summing Up

The foregoing code of human ecology would help humankind to enter into a *dhrmic* or a *yogic* phase of environmentalism where human being not only controls himself by himself, but, in that process, also becomes truly human. Gandhiji was a person who was in harmony and peace with environment and with himself, although for his whole life he was locked in an unequal battle with the then mighty British.

What are the important elements of Gandhian environmentalism? One has to base the answer to this question on his utterances and writings and above all on the very life style he adopted, and then try to echo some of his ideals and ideas. First and foremost, he would have wanted us to follow the path of a robust left-of-the-centre

social democratism where empowerment of women and weaker/poorer sections of our society was guaranteed. Secondly, he would have liked us to link environmentalism with some basic social, economic and ethical tenets. He would have also liked the society at large to take the full responsibility of carving its own future within the framework of a robust, sensible, credible and implementable environmentalism. Gandhiji's expectation about India was: "*I have not pictured a poverty-stricken India containing ignorant millions. I have pictured to myself an India continually progressing along the lines best suited to her genius. I do not, however, picture it as a third class or even a first-class copy of the dying civilization of the West.*" Furthermore, a year before his assassination, Gandhiji expressed the following wish: "*Independent India, as conceived by me, will have all Indians belonging to different religions, living in perfect friendship. There need be no millionaires and no paupers, all would belong to the state, for the state belonged to them. I will die in the act of realizing this dream.*"

Albert Einstein has said: "*Generations to come will scarcely believe that such a one as this, it may be ever in flesh and blood walked upon this earth... The moral influence which Gandhi has exercised upon thinking people may be far more durable than would appear likely in our present age, with its exaggeration of brute force. We are fortunate and grateful that fate has bestowed upon us so luminous a contemporary, a beacon to generations to come.*"

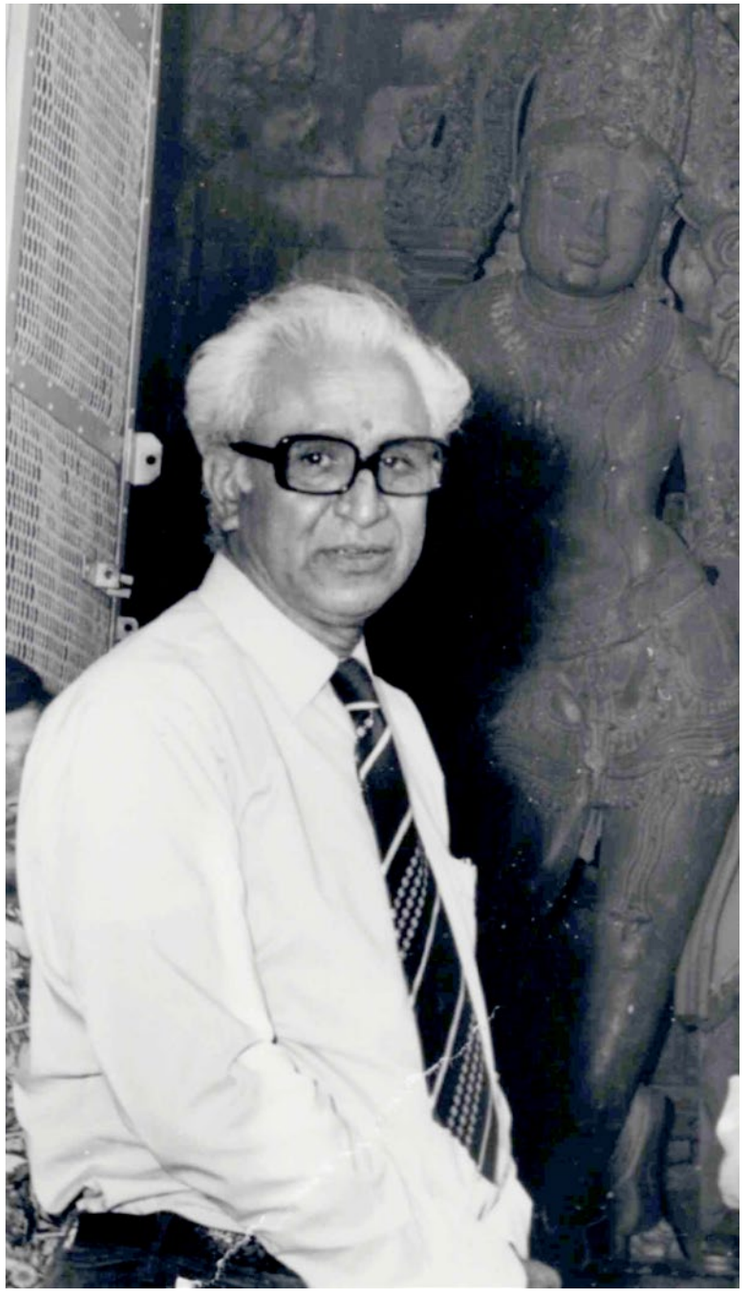
The twentieth century was dominated by Hitler, Stalin, Mao and Gandhi. In contrast to the first three, Gandhiji was not a tormentor but a pacifist and a benefactor. He believed that "*he who is unable to rule over self, can never really succeed in ruling others.*" We Indians killed and like Mahatma Buddha, we forgot him only to come back to us today, half a century later, via the West. This also happened to Sanskrit language which came back to us thanks to Max Muller and other German scholars.

Despite his differences with Gandhiji regarding the pattern of development to be followed in free India, Jawaharlal Nehru acknowledged Gandhiji's greatness in glowing terms. He said it was clear that "*this man of poor physique had something of steel in him, something rocklike which did not yield to physical powers, however great they might be. And in spite of his unimpressive features, in his loin cloth and bare body there was a royalty and kingliness in him which compelled a willing obeisance from others... His voice clear and limpid would purr its way into the heart and evoke an emotional response.*" Finally, Nehru said: *"Gandhi's words, his use of pious phrases, may sound platitudinous, but make no mistake, there is power behind his words. Gandhi came to represent India to an amazing degree and to express the very spirit of the ancient and tortured land. To the millions of India he was India."*

The impact of Gandhiji can be seen from the deliberations and declarations of a plethora of conferences and meetings under the aegis of the United Nations and other international and national bodies on problems of population, women, children, labour, human rights, tolerance, environment together with the associated social, economic, environmental and political dimensions. The impact of Gandhian ideas is seen everywhere. Though not being with us physically, today his silence speaks louder than his words; and initially his wisdom constituted philosophy, but now it has become common sense. Still there are doubts about the way the country can make Gandhian environmentalism work. The way out is that the emerging society has to be based on the village reconstruction or what A T Ariyaratne calls Sarvodaya Society. According to him, this would be the best tribute to the Mahatma. A country can be self-reliant only when villages become self-reliant. The bottom line is that there is an urgent need for a transition in human consciousness from techno (logical)-economical to eco (logical)-economical.

In the present times, the central message about environment comes to us in the words of the living apostle of ahimsa. His Holiness the Dalai Lama said: "*If we care for Nature, it can be rich, bountiful and inexhaustible sustainable.*" Finally P.N. Haskar, a noted Indian thinker of our times, has said: "*There is need to reiterate Gandhian values and instead of merely garlanding the portraits of Gandhiji, Indians must translate his ideals into real life.*" Let us then resolve and dedicate ourselves to complete the unfinished tasks in whatever field we may be working. Gandhiji's precepts and concepts have global implications. Let his memory guide us to the right path.

Khoshoo, T. N. (1997). Gandhian environmentalism: an unfinished task. IASSI Quart, 16.



3
HUMAN RACE AT THE CROSSROADS

History of the Earth is replete with examples of cataclysmic changes leading to the rise and the fall of entire floras and faunas. Ever since the human being arrived on Earth, the planet is facing twin burden: one on account of natural changes, and the other as a result of human activities. Being a thinking species, the human being has been living in contrived environment. A question arises: will the human being continue to successfully circumvent nature and natural laws for its own benefit! In order to ensure its survival, there is a need to rethink about the developmental pathway(s) that it must follow: avoiding unnecessary greed of the rich but ensuring necessary needs of the poor. There has to be a basic qualitative change from the present philosophy, to what we may call

as ecophilosophy so as to usher a pattern of development that is ecologically secure and sound, and developmentally sustainable. Methodology for anticipatory strategies is one area that the human being needs to learn and think seriously.

At present the human race is living in a totally contrived environment, avoiding, to a very large extent, the harsh realities of natural environment that other species face in the world. This has raised some basic questions about the very future of the human kind on this planet, e.g. is humanity destined to self-destruct (Caldwell, 1999)!

Accompanying the change from nomadic to settled life style(s), the human being became largely a son-of the-soil (*bhoomiputra*). It got attached to land as there was need for assured food supply as against an uncertain nomadic life of hunters and gatherers. With this change there was a need felt for enhanced and assured food production. This in turn ultimately led to increasing population pressure, and to a change from the traditional low input and low output, to commercial agriculture with high inputs and high outputs. Such a change accompanied two other changes: firstly, the original stock of economic plants and animals was genetically highly diverse and was with low productivity per unit of area and per unit of time. Secondly, the rapidly growing human numbers made demands for higher and more assured productivity. There was a need felt for high-yielding varieties. Therefore, while biodiversity in general is the gift of nature, the agribiodiversity is the result of human genius and effort. Initially this effort was subconscious but later it was deliberate and goal oriented on account of the application of genetics, breeding and other allied disciplines. This has enabled transition from low productivity to high productivity in both quantitative and qualitative terms.

How natural is today's human being?

Nature is tremendously benign, yet it is very harsh and ruthless because the basic rule in nature is 'survival of the fittest'. But the

human being through its contrived environment has consistently avoided the harsh realities of natural selection (Johnson, 1993; Demonick et al., 2000). Peeping in the past, one finds that there have been three major revolutions in human history. The Stone Tool Revolution was followed by Agricultural Revolution and finally, some 288 years ago (in AD 1712), there was the Industrial Revolution in Great Britain when steam engine was invented and coal became the source of energy. The industrial revolution has been a mixed blessing inasmuch as it has helped to enhance the standard of living, but it has degraded the quality of environment on account of progressive pollution and ecodegradation. The result of the industrial revolution has been progressive ecological degradation of the planet so much so that it is today a major issue threatening the very future of humankind and the planet. The ultimate result is that human genotypes that would have no survival value under natural conditions continue to live on account of human genius. This has helped in creating an environment of its own which among other things includes better food and living conditions, better and increasingly effective medicines, etc. The underlying thought is: *survival anyhow and somehow.* Looking at this problem in another way, one finds that there are long-term costs involved in the type of life we live, away from the harsh realities that other organisms face in nature. The basic question arises: can human species survive in time and space by continuously avoiding natural selection? Is human species destined to continue to remain and act differently than other species?

It is high time that the human race makes a long-term assessment of what has been achieved and what needs to be achieved. Then think whether these achievements are in consonance, or, are at cross purposes with the Natural Order! Are we jeopardizing our own future by following paths we have followed so far? In fact the fundamental question is: should humans behave as though they are co-creators and masters of Mother Earth? There is a mis-match between the way humans have 'developed' by ignoring the natural laws/regimes that most of the other species face. Is it justifiable?

What is our defence against any cataclysmic and other changes emanating from deforestation, ozone hole, CO_2 build-up, climate change, species loss, etc. Most of these changes are the result of human interference. The basic fact is that humans always *manage* environment to their *own* advantage at the *expense* of other species. The fundamental question is whether the future of human species is guaranteed for under the climatic and other changes whose beginnings we now see on the horizon? As a result of this, will there be any long-term disadvantage to human species to be far removed from all other species existing on the Earth? How can we have long-range security in the present situation which is largely artificial and totally contrived with very little natural environmentalism! These are indeed questions with serious implications. When one raises such questions, one is not necessarily a doomsayer.

In this context, let us remind ourselves that the six flourishing civilizations, namely the Nile Valley, the Babylonian, the Mediterranean-European, the Indus Valley, the Huang Ho and the Mayan fell like a house of cards on one count: not being environment-friendly. The reason was deforestation and elaborate irrigation channels, leading to climate change, drought and failure of agriculture, followed by wars. Their fall is a testimony to the destructive environmental role humans have played. All this is well known, but humans must draw lessons from past events.

In view of the foregoing, why do we think that human being in its present form is there to stay permanently? How long, is the question? Does this species, bereft of scientific and technological support, have the total genetic wherewithal to face adverse climatic change(s) in future? Individuals here and there may have, but not the species as a whole. Further, history teaches us that unfettered growth and development have never been longlasting.

Lone voices are heard today, about halting the march of human beings set on such a destructive path. One such voice is that of Caldwell (1999). Therefore, there is a need to rethink and ponder

seriously over the pattern of development that needs to be followed in future so that we warranty and guarantee the survival of the system on a long-term basis. There is also a need to think deeply and evolve a strategy so that the human species is saved in space and time. This is also the lesson one can draw from the story of life on Earth. Time has come to pool all the intellectual resources and think collectively and draw a set of short- and long-term strategies at local, district, country, regional and global levels.

The impeding crisies

During the last 50-75 years considerable advances have been made in the area of agriculture, medicine, health, sciences, engineering, etc. which have enabled population growth to take place virtually to explosive limits, together with degradation of air, water, land, flora and fauna and accumulation of hazardous wastes. In our race to develop, we did not foresee the negative aspects of the pattern of our development. We thus have a legacy of outstanding economic successes but at substantial ecological costs which we did not anticipate.

Today we are faced with both positive and negative impacts of past development which should put us on guard for the future with regard to the limits of growth and development. Many warning bells have been sounded ever since Club of Rome (1972) raised the first alarm. The lessons to be learnt from the past are that we need to broaden our understanding of the real-life situations as also make indepth analyses of the natural systems. Methodologies for anticipatory strategies is one area that the human being needs to learn and think seriously.

Although the human being has evolved as a part of the biosphere, our innate level of understanding of the dynamics of the biosphere itself is not much. Computer modelling is now being used for solutions to our real life problems. One is not sure about the level of computer intelligence and its independent thinking because a computer is dependent on what we feed it with. The choice of

policies, therefore, will remain an area within the human ambit which has many dimensions: population pressure, material consumption, availability of resources, effect on environment, infrastructure development, job creation, commerce, etc.

Growth cannot continue forever although there may be considerable emotional resistance to this idea. Many environmental problems can be traced to behaviour of the humankind, since most environmental disasters have been, in reality, accidents that happened due to human failure and total defiance of nature. Although the extent and nature of energy use is a sign of prosperity and advancement, most of the forms of energy have their inbuilt ecological and economic advantages and disadvantages. The goal of using a low cost (affordable by the poor), non-polluting, low risk and abundant form of energy is still a distant dream. One of the outcomes of the present-day abuse of the environment is the global climate change which affects atmosphere, oceans, freshwater, soil, forests and biodiversity.

The next question arises as to whether human being can make environmental predictions (regarding, say climate change, etc.) with certainty. Since there are underlying uncertainties, one may only paint general scenarios because the human being is endowed with the capability to recall and foresee. Based on this, can human species evolve a portfolio of anticipatory strategies to lessen the brunt, or altogether avoid the ill-effects of the impending dangers? For avoiding catastrophes or at least lessening their ill-effects, definitive skills have to be developed in measurable terms.

The dominant concerns in future

One cannot hazard a guess for the world at large or even a country as complex and as diverse as India, where ages and epochs still co-exist in different parts of the country and sections of the Indian society. We have a large and powerless subsistent India with not much worthwhile assets being controlled by it, and a small but powerful India controlling much of the assets. It is a continuum from

stark subsistence to vulgar abundance and show of wealth. This is so notwithstanding the fact that India is a functional democracy. The country has to go a long way to have genuine equity with social justice. Today this poor country is harbouring a large population of essentially poor people. Yet it is a democracy, tending to take to market economy. To make such a transition, it has to be very careful. As a species, the future of human race is primarily in its own hands. It has many advantages over other species and it can accomplish some of the challenging tasks enumerated below (Khoshoo, 1980).

While population control and its stabilization remains the prime environmental concern for most developing countries, we fail to recognize the basic fact that for the poor, a child is *two* working hands but only *one* mouth to feed. Very few of us talk about the unlimited desires of the rich among us which results in driving us towards expanding the material economy that ultimately puts our environment under stress. Human race is overshooting the sustainable state both on account of the unnecessary greed of the rich individuals and nations, and the dire need of the poor. This has social, economic and environmental impacts. Though a socially vexing problem, it is no doubt resolvable. Under the present circumstances, the population in the developing world will continue to grow because the prospective mothers and fathers are already with us.

Land degradation and deforestation have caused considerable damage and affected water regimes. Human settlements are unsustainable for a variety of reasons. No longer can we afford to dump wastes in landfills and in water bodies. These are a source of pollution and have become health hazards. Human settlements, especially slums, have not attracted the attention of environmental engineers so as to make these environmentally benign. It is not possible to altogether remove slums, any such attempts will become counterproductive.

The developing world has not taken adequate measures to

control pollution of air, water and land. Air quality and water quality and quantity are progressively falling. Serious programmes to rehabilitate rivers like Ganga, Yamuna and Kaveri were taken up in India. Regrettably no worthwhile results have been achieved so far. Associated with this is the pollution of air. There has been much talk, but no tangible results have emerged from the control measures and the air and water quality is still below the acceptable levels.

Waste generation remains one of the very potent sources of pollution of water, land and even air. But it is also a source of small-time vocations for the poor in developing countries by recycling a good part of it. Even so, waste is a potential health hazard. Recycling wastes and residues for energy and other products has not received the attention that it deserves. Waste can in reality be converted into wealth.

Environmental education, although receiving considerable attention, is still in infancy. There is scope for academia to evolve education programmes for various sections of our society, including the illiterate majority.

To ensure climate stabilization and water availability for agriculture and drinking purposes, there is a need for a good and permanent forest cover. At the same time there is a need to meet increasing demand for wood from plantations so as to leave the natural forests for ecological security by keeping our permanent forest cover intact.

Some of the developing countries like India are important mega-biodiversity centres. It is most imperative to take long-range measures to conserve the biodiversity, particularly when these countries are the centers of origin of several important crop plants and have considerable genetically important germplasm growing wild.

The mainstay for energy in the developing countries is wood and biomass of sorts together with coal, electricity and gas. The

alternative sources of non-polluting energy (including solar), have as yet not been tapped meaningfully to meet the energy crisis. At present energy sector continues to be one of the most polluting sectors of human activity.

Technology is the result of the human genius, which can be benign, beneficial and constructive, or could even be harmful and destructive. Today there is tremendous inflow of information, but there is no method to sift which one will prove to be for the good, the benefit and the well-being of the biosphere and all its components, including human beings, particularly the poor of the developing world.

National security is one issue which people in the developing world look at only militarily. This may be understandable and justifiable taking into account their particular geo-political location. But long-range ecological security is now an integral part of the national security. This is being undermined all the time. There is need to recognize that national security is no longer confined to threats across borders but also emanates from environmental degradation which happens all the time. Initially, such insecurity starts as scarcities of natural resources (both living and nonliving) and then ends up in economic stresses (like inflation, unemployment, etc.) which convert into social unrest and sometimes even lead to political instability. Therefore, the new dimensions of national security are not confined only to what is happening on the borders, but also include the long-range ecological security which is being undermined unwittingly all the time by the people, either on account of dire need or greed. Consciously and unconsciously, we all degrade environment in one way or the other. Therefore, the *enemy* of the environment is within each one of us.

The human species has proved to be a very adaptable species as can be seen from its distribution from northern Arctic circle (eskimos) to the equator to the southern hemisphere, and now involving even the Antartica. Thus given the genious, humans may

avoid rigours of climate change, and build their own world even in the harshest climates. Even so, there are people who take a dismal view and feel convinced about the fact that human race is set on a wrong course. They feel demographic, environmental, economic, social and political problems will surely overtake humans. The fact is that such changes may happen imperceptibly and creep in slowly but surely. One may not be overtly conscious of such changes while these are taking place.

How rosy is our future?

Time and again, many warning bells have been sounded about the future of the human being, particularly because its actions have been largely insensitive to the environment and towards generations that will follow. Although some thinkers before Rachel Carson (Carson, 1963) talked of the impeding environmental dangers, she has been generally credited with ringing warning bells worldwide against the ill-treatment meted out to Mother Earth by the human species. Her book *Silent Spring* created ecological ripples around the world, and, it is for the first time, that the world as a whole took note of the impeding dangers that the deteriorating environment posed to humanity at large. In fact this book has been regarded as a watershed in environmental history, even though warning bells were rung as early as 1864 by George Perkins Marsh and several others. In addition, there have been many papers presented in conferences wherein modern society has been blamed for environmental degradation. Some authors even set specific time tables for the impeding catastrophes and destruction, which did not prove to be right. The result was that whatever was written, was taken as over-statement regarding the impeding dangers. There then followed many books for and against the impeding catastrophes .

It was soon realized that the environment by itself is very complex. Climate change is an example. If humanity as a whole takes to rectification of the damage done to the environment and makes the present economic system environment friendly, then a fair chance exists for humanity to defer the doomsday.

There are definite signs of the impeding danger, and long-term future of humanity is at risk. There may be disagreements regarding the calendar and intensity of future events, but the general conclusion is that at present humanity as a whole is not on a proper path, and there is need for change. What then is the way out? The answer lies in ethics.

Ecological ethics

There are two views about the relationship between humankind and nature: one is of arrogance with an underlying co-creator attitude. The result of this has been *conflict* with nature. The other view is of reverence and an underlying partnership, leading to *harmony* with nature. In the coming years it is certain that ecological ethics will get added importance because it offers the way out from the present mess in which the human race has landed itself over the past decades/centuries.

A lot of useful literature is now emanating, particularly from the western world about the ethics of resource use because, more than the East, the West has realized that their present-day pattern of development is not sustainable. The West is eager to hear the views of orientalists about the environment, because this subject has been a part of ethos of the latter from time immemorial.

Following are some basic principles underlying the ecological ethics which were discussed earlier by Khoshoo (Khoshoo, 1996): protecting and augmenting the regenerability of life-support system; fair sharing of the resources, and means and products of development between and within nations of the world; reducing the disparity in resource use; promoting awareness regarding the hidden social, economic and environmental costs of consumerism and overuse of resources with particular reference to its impact on the developing countries; adopting willingly, sustainability as a way of life by encouraging frugality (i.e. getting more from less), and fraternity (i.e. getting it in association with others); meeting genuine

societal needs and legitimate aspirations of the people by blending economic and environmental imperatives so as to alleviate poverty; and halting and then reversing the overuse of resources and armament build-up for ensuring sustainable environment, peace and security.

Connected with the subject of ecological ethics is the fact that the human race has had a common origin in Africa, followed by a common past. Then there was divergence, and the human being colonized all the continents because it was the first intelligent, inquisitive and thinking animal 15. In course of time, there followed population explosion, multiplication of needs, undue demands on and progressive destruction of components of the Earth system (namely atmo-, hydro-, litho- and biospheres, including biodiversity). The net result has been that the Earth system as a whole became progressively endangered: some of its parts more than the other parts.

There began a global realization about the impending dangers associated with serious environmental deterioration. Then came the Stockholm Conference (1972), followed by the Rio Conference (1992), and a plethora of other conferences. In this process, the humanity as a whole jumped from the *Common Origin* to the concept of *Common Future*. There has been talk of globality of environment, and connectivity between local and global environments. Yet there are no worthwhile global or regional strategies or even national strategies for achieving sustainability. Therefore, while *Common Origin* is a fact, *Common Future* is still a myth, because, as M. S. Swaminathan has said, humanity has yet to reconcile about a common present? The latter is still an open question and an enigma! Practical steps need to be taken in this direction.

The only way left is that the human race has not only to work out solutions to local problems, but also has to rise above the local issues and think about the repercussions of its action at national, regional and global levels. Furthermore, it has to work overtime to

give all such strategies a practical shape. It is indeed a two-way traffic: local to global and *vice versa*. Understanding the dynamics of this two-way traffic will actually lead us towards real sustainability in development. The important elements are that: Earth is a finite system, both in resources and in its carrying capacity; future economic growth cannot be sustained if it is at the expense of long-range ecological security; environmental insecurity ultimately leads to economic, social and political insecurity; sustainable development for intra- and intergenerational human well-being has now to be an integral part of the future composite world culture; and sustainability in development is a global concept and every living being, as a member of the Global Family (*Vasudhaiva Kutumbakam*), has a role to play.

There is an urgent need to translate these lessons in to reality. There is also a need to understand scientific and technical complexities of nature, and develop a good measure of reverence for nature for the vast bounties it provides. In this connection, we must also learn from the tribal societies, which have developed an approach of harmony with nature. This can still be seen in the interiors of the Andaman and Nicobar Islands and Amazonian forests. As stated earlier (Khoshoo, 1980), it is the *common threat* to our long-range ecological security that will bring the human race closer despite diversities of sorts. Thus, for our sustainable future, we have to move towards globality on the one hand, so as to correct the past environmental follies, particularly of the industrial countries and on the other hand, we need to meet common local threats. There is a need to develop a culture/ethics/code for Ecological *Dharma* (Khoshoo, 1999) at all levels, starting from the individual up to a country or region and the entire Globe, so as to practice the cult of sustainability in development. It is only then that we will have a situation, as put by Rene Dubos: 'think globally but act locally'.

A basic question arises: are we ready to move towards a sustainable society? This indeed is a major challenge as also an opportunity before the entire human race. Regrettably, if we go on the way

we have been so far, centuries will continue to co-exist. We will continue to have a subsistent India of a large number of poor and dispossessed toilers and plodders who live in medieval times; and an affluent India of a small number of people who are jet-set, powerful and wealthy. The latter may be poised to enter the 21st century with a bang. How soon we take even the preliminary steps to bridge the vast gap between the large but powerless subsistence India, and its small but powerful affluent section, will actually determine whether we can make it to a sustainable society, where we have environmental harmony, economic efficiency, resource conservation, gender equality, equity with social justice, and local selfreliance. To practice this, we need to draw inspiration from Mahatma Gandhi who basically was a social, economic and an ecological *Apostle*. Keeping this in mind, earlier the present author discussed the relationship between welfare ecology and welfare economy as backed by ecological and technological assets, which are mutually supportive and reinforcing. Furthermore, a survey of the important religions of the world from an environmental point of view reveals a measure of divide.

The western religions give an impression that the human being is a kind of a sovereign, while the Eastern religions regard human being as a constitutional partner with underlying reverence and harmony. The latter believe in the Holy Trinity: the creation, the preservation and the destruction, or should we say birth, development and death. In the Hindu tradition, these three elemental processes are assigned to *Brahma, Vishnu* and *Mahesh*, respectively. These underlie the origin, evolution and extinction, which in turn are backed by mutation, recombination and selection. The key to sustainable development is based on knowledge, information, understanding, ethics and morality. Therefore, a qualitative change from the present value system to a new value system is needed, where we make a transition from disharmony to harmony, illiteracy to literacy, poverty to economic independence, large family to small family, ill health to good health, inequity to equity (including gender), social injustice to justice, cultural irrelevance to relevance, resource

wastage to conservation, blind faith to self-reliance, etc. Science and technology has to play a major role in such transitions.

All in all, a transition from the present-day philosophy to what we may call as ecophilosophy is needed. The humanity needs to adopt ecophilosophy which must be wise both economically and ecologically. Such a transition has become necessary if the human race has to move towards sustainability in the real sense of this much-abused word. It is obvious that there has to be a strong under-current for change based on science and technology.

Concluding remarks

The foregoing account is a general survey of environmental problems of countries (like India) that are developing and developed at the same time. Such countries are developing compared to industrial countries, but are developed when compared to under-developed countries. This sounds paradoxical but is nevertheless true.

Given the good S&T base that a country like India has, it is possible that it can come out of the serious environmental vortex if it follows a sustainable pathway where we combine our age-old environmental ethics with modern S&T. But the biggest problem is resistance to change. There is a need to come out of the present morass of poverty in which large sections of the society are deeply immersed. The choice has to be made now because almost all the elements (particularly intellectual) are in place. All that is needed is to put the human and other resources to proper use with a major thrust on population stabilization and then its control, which is the one single-most environmental, social and economic problem of the developing world, particularly of India.

Nature can be very benign, but it can also be very ruthless. Response of the genetic system of a species to environment is what counts: if unfavourable, the species is destined to be on its way to extinction. Natural systems are ruthless and do not tolerate inefficiencies.

In the past, nature evoked awe and respect on the human mind, but today that attitude is gone. Regrettably, human beings often believe that nature is for their wanton use, because human being happens to be on the 'top of the evolutionary ladder'. The question is, does human being want to be a super-species above natural laws, where natural selection is not allowed to operate on account of contrived environment? Or, does the human race want to be a species which understands and respects nature and natural laws and aims at need but not greed, at comfort but not luxury and is not unnecessarily wasteful. If the human race sticks to the latter, many of the environmental problems will resolve by themselves. There are isolated sane voices all over the world which say, halt and ponder about the reckless path that the human race is following.

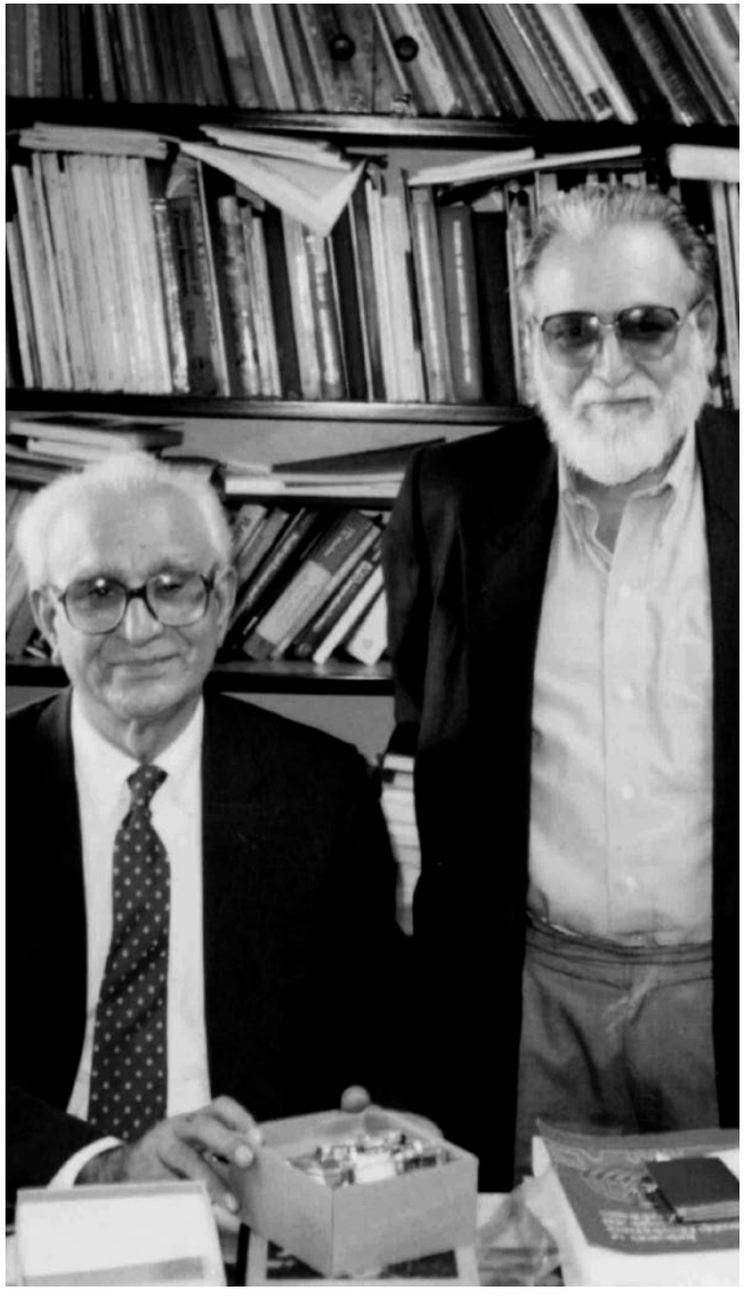
One would like to hazard a guess as to how different citizens of tomorrow should be from citizens of today. A major qualitative change in our present value system is needed. The new value system has to be based on knowledge, information, understanding, ethics, economics and morality. Unless there is a qualitative change, there is no hope for ushering a development which may be sustainable in space and time. Today's human being is caged. The new value system is likely to free the human race from the shackles in which it is bound and confined. This would help usher sustainability.

At the end of the 20th century, the human race is at the crossroads. The species has to think seriously about shape of things to come. The scenario is not too optimistic, but at the same time all is not lost. The situation can be retrieved and life on Earth will continue unaffected. What distinguishes humans from all other life, is ethics, morality and spirituality. This is so because it is a thinking species. These are not values of the bygone eras, but today there is a far greater need to ponder on these issues which are relevant. Abandon

greed and take to need. This is going to be the biggest mantra for the 21st century. If we all stick to this, the next century would be different. It would become environmentally liveable, economically sustainable and socially benign.

A society is an extension of individuals; if individuals are 'greened' then, in course of time, the society as a whole will follow suite. Therefore, the human race has to make a firm resolve in this direction at the individual level, only then the battle can be won.

Khoshoo, T. N. (2000). Human race at the crossroads. Current Science, 79(10), 1428-1435.



4
THE *DHARMA* OF ECOLOGY

The concept and scope of ecology is ever-widening and becoming all encompassing. The ecological crises facing the world are basically an outward expression of inner crises in the mind and the spirit of human race. This species has changed landscapes on earth beyond recognition for its own `good'. There is now a realization about interdependence between welfare ecology and welfare economics. Both have to be fortified by ecological and technological assets. Ecology is becoming a moral issue and will a deep interconnection with *dharma*. Proper interface among ecology, economy and technology will lead to welfare of biosphere of which human being is an integral part along with all other living creatures and non-living materials.

Ecology: A moral issue

The word *Dharma* enjoys universal acceptance having been included in all the standard English dictionaries. Now it is as much an English word as it is a *Sanskrit* word. It is derived from the Sanskrit root '*dri*' which means to 'uphold, sustain and support'. In simple language it means to 'hold together the different aspects and qualities of a being'. Associated with it are also righteousness, morality and duty. In short, it embodies all that is universally and eternally true. Without *dharma* nothing can make sense. Therefore, it is a part of the very nature of every thinking human being about all situations and problems (including ecology) that confront humanity at large. *Dharma* is, therefore, enshrined in any orderly life, society and environment. Implicit in it is that human beings have to control themselves so that their actions do not endanger the ecology which surrounds them, and on which they depend for sustenance all the time. Also implicit in *dharma* is that one should not inflict on surroundings and other living beings anything which is disagreeable to one's own self. Thus, there is a deep inter-connectedness between *dharma*, ecology and environment that surround all forms of life all the time. In view of this, it is not surprising that ecology and environment are fast becoming moral issues and a moral responsibility of the human race which has the capability to think and foresee about the end-result of human actions. Nature (*Prakrati*) and human being (*Purush*) are two major elements recognized in the scriptures, which, if antagonistic, can bring doom and gloom to the Mother Earth.

Normally nature by itself does not degrade environ-ment. If, however, natural cataclysmic changes happen, there may follow environmental degradation. Left to Nature, there starts a process of ecological rehabilitation. and reconstruction of the deteriorated habitats, and, more often, a new ecological regime sets in, which may even bring status quo ante in course of time, or even a new balanced ecological state. There is, therefore, tremendous resilience in Nature, because of the inherent capacity to reconstruct and rehabilitate. Nature is also not static,because there is an inherent capacity in it to change,

refine and update. Those of us who visit natural habitats see these phenomena occurring all the time.

On the other hand, market forces, more often than not, depend on short-term gains and profits. These are oblivious of the responsibility of setting right the damage created by their short-sighted policies. Regrettably, at present making profits is the *dharma* of industry, but losses regarding generation 4 of wastes/pollution is governmental and societal responsibility. Even at the individual level, eating food every day is a personal matter, but disposal of wastes therefrom is societal and/or governmental problem. Environment is the source of all raw materials which everyone is out to grab, but environment is also the sink for all wastes. A question arises as to how moral are such attitudes? Therefore, benefits and costs must become part of all environmentalism.

The world is not united on the question of sustainability of the Earth system including a concern about growing human numbers. However, most scientists are worried about the shape of things to come. They advocate understanding the basic questions scientifically and evolve technologies to combat the impeding dangers. Earth being a finite entity, does not grow in size. Thus there is a need to combat realistically the problem of increasing human numbers, and their wants and desires, and qualitative and quantitative dwindling of resources and above all the very health of the Earth system.

The basic question is, can we raise the carrying capacity of the Earth system to cope with demands of *one* species (*Homo sapiens*) which happens to be the pinnacle of organic evolution! Using technological innovations, this species having spoiled the Mother Earth, no doubt has also the technical capability to stop endangering the health of the Earth system! This sounds paradoxical, but is nevertheless true.

The above are some inconvenient but real-life questions for which we have to find answers: sooner the better. Here then is a combined challenge for scientists, technologists, economists, sociologists,

and those who deal with ethics of resource use. The basic question arises as to what will confer sustainability! Some thinkers (including this author) have attempted to answer this, but there is need for a more concerted attention of an expert group so that a necessary policy frame-work can be drawn for this purpose.

To save our planet with all its living and non-living manifestations and to ensure the diversity that has been its strength, there is an urgent need to adopt a Code, which may be called *The Dharma of Ecology*. Without following *dharma* nothing can make sense. Human being is a thinking species, therefore, *dharma* has to be part of its very nature including the ecology that surrounds it. Although this word is an oriental coinage, it is universal in approach and application. It is connected with human conduct and is enshrined in all religions of the ward in one form or another (Khoshoo, unpublished). The important point is that all living and non-living resources in the life support system are held in an intricate balance and have a value. These resources are to be held in trust. Thus human action should not inflict on other species (*including other human beings*) anything that is disagreeable to one's own self including the surroundings of a particular individual be it plant, animal or microorganism.

Some basic principles

The following are some basic principles underlying the dharrna of ecology:

- Protecting and augmenting the regenerability of life-support system. This has to be accomplished by rationalized husbanding of all resources. Among other things, this would involve nurturing and protecting renewable resources; conserving non-renewable ones together with prolonging their life by recycling and reuse; avoiding waste; and benefiting from the economy of scale.
- Fair sharing of the resources, and means and products of development : between and within nations of the world. This would reduce the disparity in resource-use, leading to a significant reduction in resource-use in the developed countries and increase in resource-use with little or no environmental degradation in the developing countries.
- Promoting awareness regarding the hidden social, economic and environmental costs of consumerism and overuse of resources with particular reference to its impact on the developing countries.
- Adopting willingly sustainability as a way of life by encouraging frugality, i.e. getting more from less, and fraternity, i.e. getting it in association with others.
- Meeting genuine societal needs and legitimate aspira-tions of the people by blending economic and environmental imperatives so as to alleviate poverty.
- Halting and then reversing the overuse of resources and armament build-up for ensuring sustainable environment, peace and security.

We need a firm commitment to the *dharma* of ecology at the individual level, because a society or a government is only an extension of an individual. The common threats to the long-range ecological security will bring nations of the world together. The Earth as a whole is also a Civilization Reserve not only for humankind but also for all the living beings: be it plants, animals or microorganisms. Therefore, as citizens of the world, the human race must rise above the local and national ideologies and narrow economic systems, and owe allegiance to the life- support-system as a whole.

Global family

Never before, has there been a greater need for application of the concept of Global Family (*Vasudaiva-kutumbakam*) as is today. Environmental crises facing the world are actually an outward manifestation of an inner crisis in mind and spirit of human beings. Environment can no longer be treated as bits and pieces and dealing only with wildlife, ecodegradation, pollution and the likes of these. In the larger context, environment encompasses the whole well-being of all life on our planet. In the developing countries, poverty

is the biggest polluter, a statement made by the late Indira Gandhi. Poverty degrades environment and thereby accelerates the pace of poverty in the developing countries. Their dire need is a survival strategy. On the contrary, in the developed world, it is the prosperity and unlimited greed which causes environmental degradation. Even though the developing countries harbour over 84% of the people, their contribution to ecodegradation and pollution is far less than that by 16% of the people in the developed countries, who consume nearldy 80% of the world's resources.

If history of human being is traced ever since its origin in Africa, it is clear that, from the environmental and socio-economic points of view, there were three major societal epochs discernable: the Hunter—Gatherer Societies, followed by Agricultural Societies and the more recent Industrial Societies. We may now examine the broad contours of each of these.

Hunter and gatherer societies

The human being has been hunter-gatherer for 99% of its time span. It is only during the last ten to twelve thousand years that it has taken to agriculturization and industrialization. During the hunting-gathering stage, the human being was largely nomadic, and acted as one of the species in the concerned ecosystems. The environmental impact was strictly local and small, and due to the natural process of eco-repair, ultimately there was little or no damage. Hunter-gatherers have performed the biggest trial-and-error experiments for the humanity as a whole. The latter has to be ever-grateful to the former.

Agricultural societies

The early agricultural societies domesticated livestock for food, clothing and for carrying loads. They also began selecting and cultivating plants as food in 12 centers of origin and domestication in the world, one of which is in India. Except for some microorganisms, humankind has not added to the list, and has been using the same animals and plants that were selected and domesticated by its

primitive ancestors. However, with the invention of the plough and the wheel, agricultural societies were involved increasingly in clearing forests for cultivating crops, raising livestock and making dwellings. With rather assured food supply, population began to increase and food supply had to keep pace with it. Thus irrigation helped in settled and enhanced agriculture in turn leading to significant increase in population and permanent settlements in the form of villages, some of which in the course of time became towns. Some of the towns grew into cities.

Together all these factors resulted in the establishment of civilizations. Associated with the latter was enhanced need for food, leading to enhanced rate of· degradation of forest cover, and considerable increase in irrigation systems. The latter began to become clogged due to siltation and associated environment and human health problems followed.

Since, by now, population had begun to increase and agriculture had extended considerably, there was need for labour both for agricultural and desilting operations. This gave birth to a landed class who owned land, and a landless slave or labour class who put in hard work. The small and localized environmental impacts gave way to larger impacts on account of forest clearances for agricultural purposes and grasslands for domesticated cattle. The human being still depended on its muscle power and that of the domesticated animals.

Next came the Agriculture-based Urban Societies, which led to further increase in population. Moreover, while some villages produced food, the larger villages grew into towns and larger towns into cities. In the latter case, people depended on food produced in the villages. In their spare time in cities, people took to small industries like tool-making, weaving, pottery, hand-made goods, etc. Six such contemporary civilizations appeared on the Earth; these were Nile Valley, Babylonian, Greek & Roman, Indus Valley, Huang Ho Valley, and Mayan & Aztec. While these civilizations contributed

materially to literature, art, music, science, etc., there were two classes in each: the haves, who constituted a small section but had large assets and were powerful; and the have nots, who were a large section, with little or no assets and were powerless being involved in producing food and doing all the dirty work and rendering services all the time.

Earlier, fights between groups took place for possession of more and more livestock, but now fights began about the ownership of land. This led to the springing up of leaders with armies of followers who controlled large areas. Wars began to be fought for possession and control of· land and ecological assets. There was scant respect for assets like -water, forests and land which were poorly managed and overgrazed, resulting in soil erosion, blockage of irrigation systems and increased number of slaves to clear the silt. The cities had a lot of waste generated by people, leading to infectious diseases and parasitic attacks. Habitats began to be altered beyond their carrying capacity, and, for the first time, there was significant ecodegradation. In this process, some empires became weak and wars became frequent. All this resulted in further degradation of the environment. Such ecological, economic and social reasons led to the collapse of the six civilizations enumerated earlier. In short, the prime reason for the collapse of·civilizations has been disrespect for forests in particular and environment in general.

Industrial societies

Starting from England, in the Western Europe was born the Industrial Revolution, with many inventions involving coal-based steam engine systems followed by the internal combustion engines. Thereafter, horse carriages and wind- powered ships were replaced by engines using fossil fuels. This was the period of European expansionism into Asia, Africa and the Americas. In this process, the indigenous peoples were either largely annihilated or subjugated. Even agriculture now began to be based on coal and oil in place of human and animal energy. Production increased and there was migration of former farmers to towns and cities. They now took

jobs in mechanized factories. With the two world wars, fought in the 20th century, many inventions were made in the area of science and technology. After the wars, these led to mass production of useful products at affordable prices and a 'high' standard of living with higher GNP per capita. With the application of modern science and technology, there have been major gains in the yield potential of the domesticates. There also was improved life expectancy, better living conditions, education and old age security. The environmental impacts of the industrialized societies were tremendous, be it agriculture, industry, mining, etc. All these led to degradation of land, forests, water, biodiversity and air through the release of noxious chemicals and cutting down of forests. Most cities became twin cities, the mega-component with all the facilities, and the slum-component where ecological refugees live. Most cities in the world are still stuck with such a situation. There also developed the regional problems of acidification and global build-up of carbon dioxide and depletion of ozone.

In fact, industrialization has been a mixed blessing. There was considerable economic growth with per capita increase in GNP and overall standard of living. However, all this progress and benefits have been at tremendous environmental costs. Furthermore, for some time past, lifestyles in the developed countries have also affected the resource base in the developing countries. The classical cases are that in return for food and financial aid by the developed to the developing countries, the latter destroyed their forests by supplying timber, growing cash crops and producing cheap meat for consumption in the developed world. In this regard the well-known case is the Hamburger Connection where Norman Myers showed that 40% of the forest cover in Central America had been destroyed for making pasture land available so as to supply beef at cheap rates to North America. The present- day cost of beef does not reflect the true cost of its production because huge environmental costs are not added to it. This example stirred the conscience of the whole world. The developing countries also use obsolete and dirty technology supplied by the developed countries,

thus degrading the environment further. In return for financial aid, some developing countries have even offered sites for burying and dumping noxious wastes. All such aids are in fact concealed compulsions and, in practice, amount to acts that threaten the ecological security of the poor developing countries.

Thus, in the developed countries the causes of eco- degradation and pollution are their prosperity and greed, while in the developing countries the causes are poverty and need. In the latter case, it is matter of very survival. The most profound aspect of the industrial era has been the arrogance of humankind to consider itself the most superior organism in the biosphere, and a growing feeling that everything is subordinate to human needs, and a feeling of being a co-creator.

Today the World is rather divided into two camps: a few (26) developed countries mostly located in the temperate regions of the world and a large number (107) of developing ones in the tropical, subtropical and hot temperate belt. The former consume far more resources (over 80%) than the latter. The underlying feeling of undue exploitation of resources by the developed countries exists in the developing ones. This causes tension and friction. However, in the recent years, the developed countries, confined mostly to the temperate regions, have realized the criticality of tropics and subtropics for their own survival and well-being. This has led to a trend to swap the debts of the countries in the tropics, for conservation of tropical forests. It is indeed a healthy sign, because environmental interconnectedness and interdependence between the rich and the poor nations is becoming increasingly clear. No nation however rich or poor is safe if its environment deteriorates significantly.

Environmental problems are thus the result of inter- action between complex and poorly understood social, economic, technological and political factors. However, it is also clear that although developing countries suffer from problems of over population and lack of

resources, the net quantum of eco-degradation and pollution in their case is far less than the less-populated developed countries. Furthermore, pollution in the developing countries is mostly biodegradable, while that in the developed countries is mostly non-degradable.

Ecological ethics

In the coming years it is certain that ecological ethics will get added importance. The Western religions (Judeo- Christianity, Islam and Zoroastrianism) have by and large looked at the relationship between humankind and Nature with a measure of arrogance and an underlying co-creator attitude: A notable exception being St. Francis of Assisi. The result has been conflict with Nature. On the other hand, the Eastern religions (Hinduism, Buddhism, Jainism, Sikhism and Taoism) have overwhelmingly viewed environment and Nature with reverence and an underlying partnership, leading to harmony with Nature. Most orientalists start their day with prayers to Nature and the bounties it offers. The two components Nature (Prakrati) and humankind (Purush) are partners which must work harmoniously.

A lot of useful literature is now emanating from the western world about the ethics of resource use because, more than the east, the west has realized that their present- day pattern of development is not sustainable. They are eager to hear the views of orientalists about the environment, because this subject has been a part of ethos of the latter from time immemorial.

Connected with the subject of ecological ethics is the fact that the human race has had a common origin (in East Africa) and also a common past. Then there followed divergence, and human being colonized all the continents because it was the first intelligent, inquisitive and thinking animal. In due course of time, there followed population explosion, multiplication of needs, undue demands on and progressive destruction of components of the Earth system (namely: atmo-, hydro-, litho-, and biosphere including biodiversity).

The net result has been that the Earth system as a whole became progressively endangered: some of its parts more than the other parts.

Then there began a global realization about the impeding dangers associated with serious environmental deterioration. Then came the Stockholm Conference (1972), followed by the Rio Conference (1992), and a plethora of other conferences. In this process, humanity as a whole jumped from Common Origin to the concept of Common Future (**Figure 8**). There has been talk of globality of environment, and connectivity between local and global environments. Yet there are no worthwhile global or regional strategies or even national strategies for achieving sustainability. Therefore, while Common Origin is a fact, Common Future is still a myth (**Figure 8**). Some years ago, M. S. Swaminathan raised a very pertinent question: How can there be a common future without a common present? The latter is still an open question and an enigma! Should not humanity do something tangible about it? This is a moot question which needs to be addressed to very seriously.

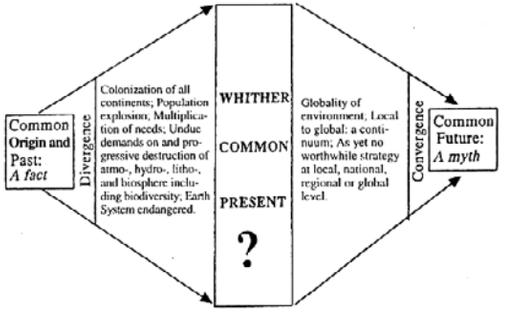


Figure 8: Transition from common origin to common future

The only option left to the human race is to not only work out solutions to local problems, but also to rise above the local issues and think about the repercussions of these at the national, regional and global levels. Furthermore, it has to work over-time to give all

such strategies a practical shape. It is indeed a two-way traffic. Understanding the dynamics of this two-way traffic will actually lead us towards real sustainability in development.

Apostles of ecological *dharma*

Regrettably during the 20th century, the human race has seen more tormentors (at least four) but only one benefactor (Mahatma Gandhi). In recent times, three Indians who, in every sense, preached and practised the *Dharma* of Ecology are: Mahatma Gandhi, Vinoba Bhave and Mother Teresa. The former two were Indians by birth but the last one was by her voluntary adoption. In fact all the three belonged to the whole humanity. The first two were devout Hindus, the last a devout Christian. But all the three followed identical paths and reached similar conclusions: to care for the poor, the dispossessed, the deprived and the destitute or, as M. S. Swaminathan has said in a different context: reaching the hitherto unreached. Thus, it was sheer simplicity that these three great souls wore. Here then are ideals in sustainability for the whole humanity.

The lessons one draws from the past experience are loud and clear and there is considerable realization about the following:

- Earth is a finite system, both in resources and in its carrying capacity;
- Future economic growth cannot be sustainable if it is at the expense of long-range ecological security;
- Environmental insecurity ultimately leads to economic, social and political insecurity;
- Sustainable development for intra- and intergenerational human well-being has now to be an integral part of the future composite world culture; and
- Sustainability in development is a global concept and every living being, as a member of the World Family (*Vasudaiva kutumbakam*), has a role to play.

There is an urgent need to translate these lessons into reality through the *Dharma* of Ecology. While we must understand

scientific and technical complexities of nature, we must not do so with arrogance of conquering nature, but working in close harmony with it. We must develop a good measure of reverence for nature for the vast bounties it provides. In this connection, we must also learn from the tribal societies, which have developed an approach of harmony with nature. This can still be seen in the interiors of the Andaman and Nicobar Islands and Amazonian forests.

If there is any one thing that is going to bring nations of the world together, it is the common threat to our long- range ecological security. Therefore, before we talk of common future, there is need for common concerns, approaches, strategies and actions for our common present. Thus, for our sustainable future, we have to move towards globality on the one hand so as to correct the environmental follies, particularly of the industrial countries; and on the other hand, we need to meet common global threats. There is need to develop a culture/ethics/code for Ecological *Dharma* at all levels starting from the individual up to a country or region and the entire globe so as to practice the cult of sustainability in development. It is only then that we will have a situation as put by Rene Dubos: 'think globally but act locally'.

A basic question arises: Are we moving towards a sustainable society? This indeed is a major challenge as also an opportunity before the entire human race. In India, if we go on the way we have been so far, on 1 January 2001 like today, centuries will continue to co-exist. We will continue to have a subsistence India of a large number of poor and dispossessed toilers and plodders who live in medieval times, and an affluent India of a small number of people who are jet-set and wealthy. The latter may be poised to enter the 21st century with a bang. How soon we take even the preliminary steps to bridge the vast gap between the large but powerless subsistence and the small but powerful affluent India, will actually determine whether we can make it to a sustainable society, where we have environmental harmony, economic efficiency, resource conservation, gender equality, equity with social justice, and local

self-reliance. To practice this, we need to draw inspiration from Mahatma Gandhi, Vinoba Bhave, and Mother Teresa.

Future prospects: Welfare ecology

Thanks to Dhrubajyoti Ghosh an all-encompasing term, welfare ecology, has now been introduced in ecological literature (Selected Essays on Welfare Ecology, Centre for Sustainable Living, Calcutta). This is a sequel to Amartya Sen's welfare economics, who, for the first time, talked of economics of the weak, the dispossessed, the deprived and the destitute which constitute the dumb majority in any developing country. The strength of a chain is its weakest link, and, therefore the poorer section in any society must receive special attention. Once the teaming millions come out of the morass of poverty, penury, illiteracy, hunger and dire want, then only a developing country can progress as a whole. Therefore, welfare economics has to be backed by welfare ecology. A basic premise is that economy springs from the use of ecological assets (atmosphere, hydrosphere, lithosphere and biosphere) coupled with human ingenuity in the form of technology (Figure 9).

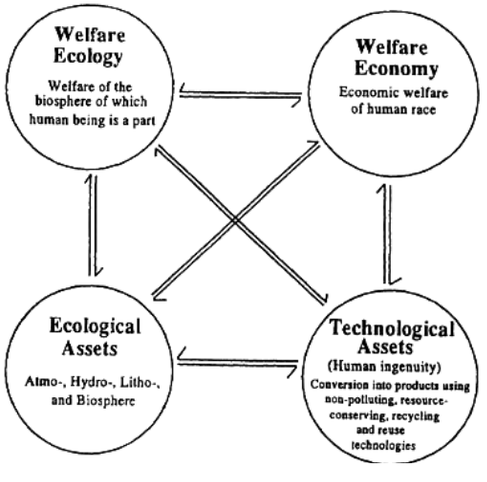


Figure 9: Inter-relationship between welfare economics, welfare ecology and ecological and technological assets

It may, however, be pointed out that technology is not only a human attribute but many other organisms make use of it intuitively. For instance, one has only to have a mind and an eye to see how meticulously and efficiently bees are organized socially and build their hives, how birds build nests, or how a beaver (an amphibious broad-tailed soft-furred rodent) builds a dam in a gushing stream of cold water. A bee-hive is an example of one of the most perfect and articulated organization. Each bee knows its job which it does selflessly. These are marvels of technology, division of labour and perfect coordination and articulation, in no way less than human ingenuity, if not better because there is no element of personal greed. Thus welfare economy and welfare ecology are mutually supportive. Gone is the time when ecology meant only study of plants and animals in their habitats, more often such discourses included human being very marginally.

Human ecology is now an important subject. There is a deep interconnection between human needs, wants and aspirations which in the wealthier sections of any society are in reality unlimited. Therefore, there is an urgent need for the human race to address itself to a serious question like: what is enough for a simple but comfortable lifestyle avoiding ostentatious and vulgar show of wealth which causes undue stress on environment and waste of materials? Welfare ecology is relevant to all living organisms including human being. It embraces the whole biota, because the health of whole will determine the health of the part, and vice-versa. Therefore, welfare ecology has a very wide meaning and application. Inherent in it is the basic minimal requirement for a simple and comfortable lifestyle which can be permanent with no long- or short-range ill-effects on the environment in which an organism lives. Sustainability will become a reality only when one lives on the mean annual increment (MAI) of the basic ecological-economic capital.

Thus there is a deep interconnection, interdependence and inter-relatedness between welfare economy and welfare ecology. The two are mutually supportive. On such a mutuality depends the future

of humankind on a sustainable basis. Proper interface between ecology, economy and technology, will lead to welfare of biosphere of which human being is an integral part along with all other living creatures and non-living materials. We need to face ecological challenges of the 21st century with the joint message of welfare ecology backed by welfare economics and vice versa.

Economics, energy and ecology are also interrelated, and one of the major causes behind India's environmental problems can be traced to their bad management. At present only economics plays an overriding role even when ecology is actually regarded as biological economics and energy as a currency of life. As of now three major | questions confront humanity. These are: How can the huge ecological deficit already with us be wiped out without | adding to the present-day ecological problems? How can the future development be made sustainable? How can | aims and objectives of environment and economic development be reconciled and be unified?

Conclusions

Although a Sanskrit word, *dharma* is now universally | accepted, it has a deep interface with ecology. Among the important findings of this century is the fact that the Earth is the only planet in our planetary system that supports life as we know. It is our only home. All the living beings (plants, animals and microorganisms) on Mother Earth constitute one Global Family. Furthermore, the 20th century has been one of discovery and expansion of human activities, resulting also in considerable environ- mental destruction. On account of this, the human race by its action has been responsible for extinction of some of the life forms. A question arises whether the next century will be one of continued and rapid environmental destruction, or of environmental reconstruction so as to save as many life forms as possible and the Planet Earth as a whole? Humankind has to make up its mind about becoming more humane and less selfish. There

is an urgent need to ensure continued regenerability of the life support systems, to be followed by fair-sharing of resources and their products, and practising frugality, fraternity and sustainability. Adopting such a course of action would help answering a basic question: how much is enough for a simple need-based comfortable lifestyle? In turn it would also help stall the ecological decline that has already set in, which if unheeded would in turn lead to economic decline followed by social disintegration. History has been a witness to such a course of events. Before any civil society talks about common future, it has to ensure a sustainable present. To attain the latter would need inputs from all sciences, technology, socio-economics, ethics and law. There is, therefore, a need for an indepth thinking on these issues.

We need to draw lessons from the decline of once flourishing civilizations in the medieval times, and avoid disrespect for Nature at all costs. We also need to conserve not only the natural heritage, but also the intellectual heritage. In the natural heritage is included the Mother Earth itself with all the biomes, ecosystems and populations of all living species (including the human being). In the intellectual heritage is included all that has been crafted and created by human genius for the good, the benefit and the well-being of humanity at large. It would also include human settlements, science and technology, history, culture, religion, philosophy, art, literature, music and dance, handicrafts, myths, etc.

The civil society needs to be commited to make innovations in development possible and thus ensure a better life for the generations to follow and help in sharing and caring. Herein lies a dual responsibility for each one of us: one to the biosphere and the other to humanity and all life forms on a collective basis. In short, there is need to guarantee a healthy Earth by itself, and the life on Earth in all its manifestations.

To conclude, sustainability is not only a scientific, technological, social, and economic issue, it also has major moral and ethical dimensions. Welfare economics backed by welfare ecology together hold the key to human survival on a sustainable basis. Therefore, determined efforts have to be made to avoid crossing the thin line dividing sustainability and unsustainability. To achieve this, there is also a need for evolving a unique 'technology' for the 'inner' development of human kind itself so that misuse of resources and creation of unsustainability is avoided. To the present author, these are some of the basic and dharmic responsibilities of humanity as a whole.

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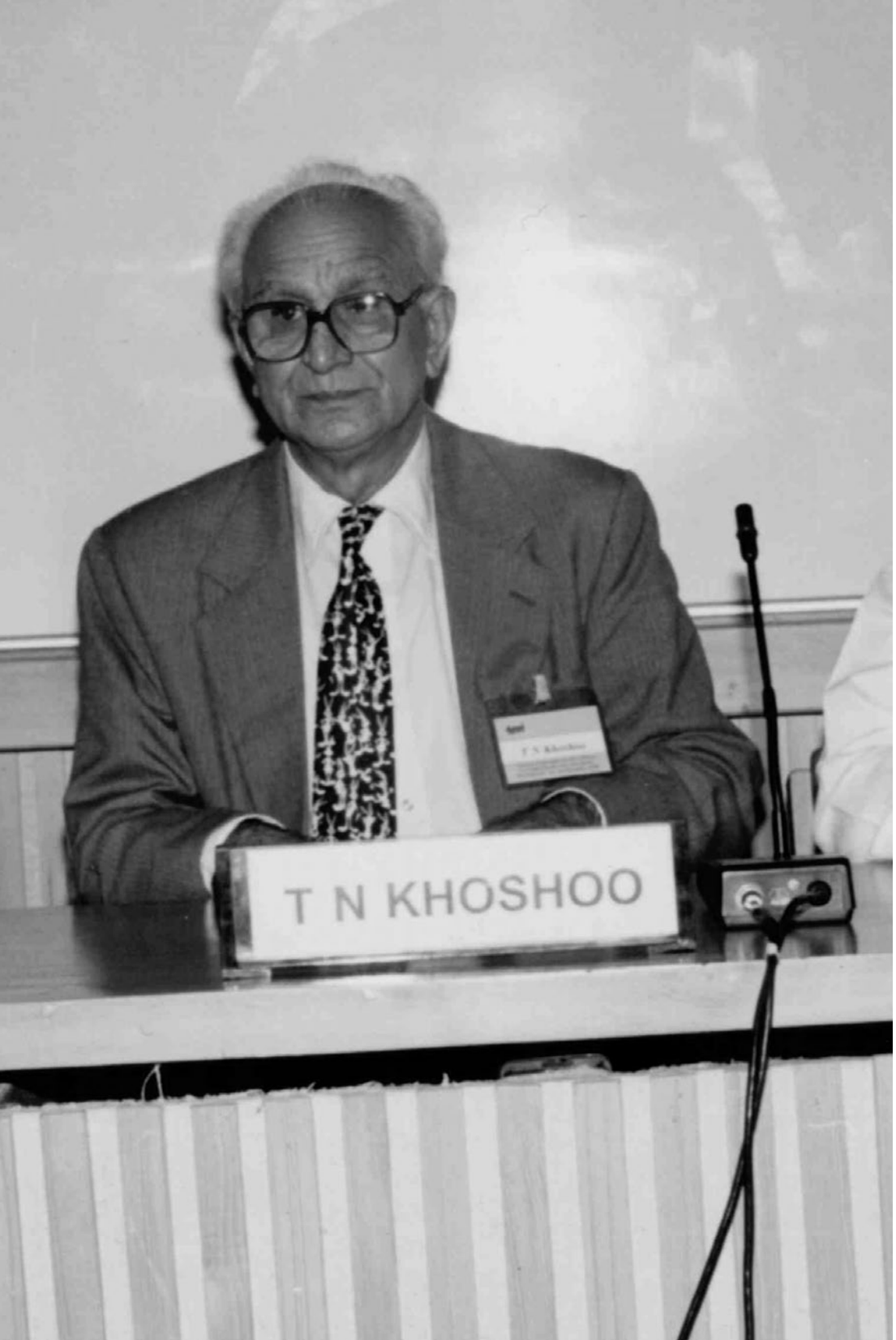

"Gandhiji's entire life and work is an environmental legacy for all humanity. This was not because he wrote a big treatise on the environment, or led a movement to stall a dam or some industry, or clean a river, or whatever. This was because he was a practitioner of sustainable development in the real sense of the word. Here then was a Man who was in harmony and peace with the environment and with himself, although, for his whole life he was locked in an unequal battle with the mighty British. His strength came to him on account of his spirituality and practice of non-violence and truth. Taken in a wider sense, these are the very critical elements for the success of sustainable development. In brief, his whole life was his message and a lesson on environment and development for Indians and the world at large to follow."

-T. N. Khoshoo

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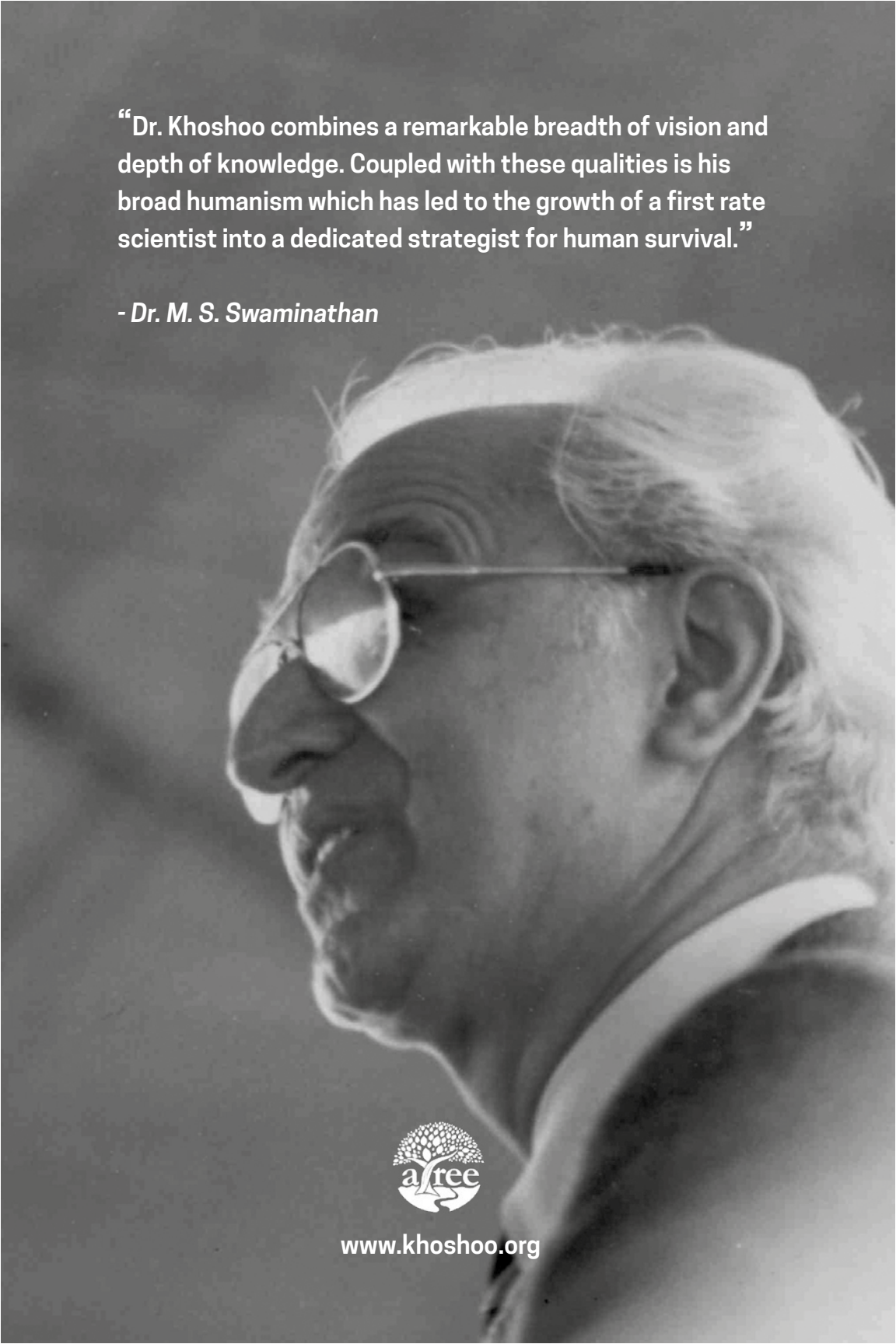
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