NATIONAL BIODIVERSITY STRATEGY AND ACTION PLAN (NBSAP)

Environmentally Friendly and Alternative Technologies

- Sub Thematic Reviews

Development Alternatives

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December 2003

OUTLINE

1.0 INTRODUCTION

India the second largest country in Asia and seventh in world, has a total geographical area of 329 million hectares with a coast line of over 7500 km. The great geographical expanse of the country has resulted into enormous ecological diversity. The diversity ranges from sea level to the highest mountain ranges in the world; hot, arid conditions in the west to tropical evergreen forests in North-East India and the western ghats; cold arid conditions in the trans Himalayan region to mangroves of Sunderbans and fresh aquatic to marine ecosystems. Thus, India has a representation of 12 biogeographical provinces, five biomes and three bioregion domains resulting into an array of habitats like forests, grasslands, wetlands, coastal, marine and desert ecosystems each with rich floristic diversity characteristics of its own. These biological attributes are further enhanced by the geographic location of the country at the confluence of three major global biogeographical realms *viz*. Indo-Malayan, Eurasian and Afro-Tropical, thus allowing the intermingling of floristic elements from these regions as well and making it one of the 12 mega biodiversity centers of the world.

As the modern technology advances, so does our ability to change our surroundings. Changes made on surface of the Earth today are more extensive and occur more rapidly than ever before. The ramifications of these changes have become more significant with the increase in world population, resulting in decline of available per capita land. Environment is loosing its resilience where the intensity of human interventions is high. However, the changes in the environment and consequently on the biodiversity are associated with demographic and economic changes. The continuing loss of India’s forests due to agriculture expansion, industrialization and technological advancements are leading to massive environmental disruptions, including an historical unprecedented rate of species extinction.

Much of the threat to the biodiversity of the country is due to habitat loss resulting from land degradation, industrialization and loss of prime ecosystems to meet the shelter needs of the burgeoning population. The richest repositories of biodiversity - the forests, rivers and oceans are under serious threat from industrial and technological developments in our country. From the ecosystem diversity point of view, floral, marine and aquatic biodiversity are facing the brunt due to intensive commercialization and industrialization.

As the National Biodiversity Strategy Action Plan initiative is working at different levels including ecological zones and geographical spread, in this paper we would primarily be looking at the impact of industrial and technological developments on biodiversity where it is densely concentrated and where it is the main source of direct and indirect livelihood for a large section of the country’s population.

2.0 BACKGROUND

Technology and industrial development have advanced enormously over the last few decades. These developments have an impact on biodiversity conservation and use. These impacts have enhanced the biodiversity in some cases (*e.g*. tissue culture have made it possible to propagate the endangered plant species), while it has negative impact on the others. As a result of the technological advancements, we now have the fast evolving information systems and genetic engineering. Similarly, there have been great advances in transport, sources of energy, food technology, medicine and construction *etc*. However, when we look at the environmental spheres it seems that the world is going backwards. The environment is still deteriorating, forests are diminishing and soils are eroding. The climate is changing, water availability is getting less, plants and animal species are still disappearing. The danger now is that as the advances in technology catch our imaginations in the virtual world of internet and in the published reports, at the same time we run the risk of forgetting and seeing what is happening in the real world. This has a great implication on the research (particularly in agriculture/horticulture field) as it is more of academic and theoretical in nature. There is need to conserve the traditional knowledge and integrate it with the current technologies. Technologies that can work to benefit of the environment can be classified into:

- Those which *reduce* the environmental damage by alleviating the direct pressure on natural resources or by reducing the pollution load through modifying the chemical or physical characteristics of work products.
- Technologies which *enhance* natural resources *i.e.* make them more productive or richer.
- Technologies that *save natural resources* and allow us to get more revenue from the same resource or to get the same from less.
- Technologies that *turn waste* into products by closing cycles.

India has witnessed rapid industrialization in its attempt to emerge as a fast growing nation. These have primarily been in the areas of construction - large scale dams, mega power projects, mining for minerals and other natural resources for internal consumption and export *etc*. Due to increase in population and subsequently to meet their demands for food, shelter and energy, has resulted in expansion of the agriculture, construction and exploration industries. However, this has affected the country's biodiversity. Industrialization with its thrust on exploiting biological resources as raw material has been destructive to the biological wealth of the nation. Hence present emphasis should be to develop environmentally and socially sound technologies (development/application/use of technology and industrial processes) which either do not cause damage or has less impact on biodiversity.

Being primarily agrarian country agriculture and fisheries have been the prime occupation and livelihood of several people of India and construction is another area where a large number of people are employed. While the first two are themselves components of the vast biological wealth of the country, the later is a major activity with adverse impacts on biodiversity.

3.0 BIODIVERSITY BASED INDUSTRIES

In the last few decades, industrial and technological developments have promoted both social and ecological disruptions. The impact of industrial and technological developments is felt most in areas where there is concentration of biological wealth. Many industries extract raw material from the natural resources and hence affect the biological diversity. Biodiversity based industries (*viz*. Agriculture, Fisheries, Forestry and others) are directly dependent on the the natural ecosystem resulting in the loss of biodiversity. The problem has been further aggravated due to the increasing population. In these areas there have been rapid technological developments to meet the increasing needs for food, shelter and livelihood.

3.1 Agriculture

The agricultural revolution has been the most fundamental innovation in the history of the cultural and socio-economic development of humankind. The term "Green Revolution" has come to be associated not only with the higher production through enhanced productivity, but also with several negative ecological and social consequences.

Expanding agricultural frontiers through centiuries for providing food and goods for an ever increasing human population is becoming intrinsically destructive of biological diversity. It has been observed that there is "fatigue of the green revolution" due to stagnation in yield levels and to a larger quantity of nutrients required to produce the same yield as in the early 1970s. "Super-rice", capable of yielding over 10 tonnes of rice per hectare requires a minimum of 200 kg. of nitrogen per hectare, together with other major and micro nutrients. Addition of such nutrients solely through mineral fertilizers will lead to serious environmental problems. Agricultural modernisation schemes introduce new and uniform crops into farmer's fields and destroy the diversity of local varieties.

Impending food crisis due to increasing purchasing power is leading to the consumption of more farm products, thus increasing damage to the ecological foundations of agriculture. To enhance the yield potential of major food crops from the declining land and water resources sound eco technological solutions are required to bridge the gap between demand and supply. Hence at this stage a paradigm shift is required in agricultural development that can help increase yield, income and livelihoods per unit of land and water.

The future belongs to small farm families taking to precision agriculture, involving the use of the right inputs at the right time and in the right way. Precision farming helps farmers to use inputs such as fertilizers, pesticides and water more efficiently. Like agro-ecological approaches, precision farming ensures sustainability. Biotechnology will play an important role in all the following six major components of integrated natural resource management and precision farming:

- Integrated Gene Management
- Efficient Water Management
- Integrated Nutrient Supply
- Soil Health Care
- Integrated Pest Management
- Efficient Post-Harvest Management

Eco-technology based precision farming can help cut costs, enhance marketable surplus and eliminate ecological risks.

3.2 Fisheries

Marine and aquatic ecosystems includes a range of diversity - wetlands, mangroves and coral reefs which besides being one of the most important and productive sources of food, protein, and livelihood for a large number of people of the country are an extremely rich repository of both floral and faunal diversity. Unfortunately, these very ecosystems are today under severe threat from industrial and technological advances including intensified fishing technologies, aquaculture, oil explorations and effluent discharge.

3.2.1 Mechanized Fishing

Following independence, India in its attempt to build its economy encouraged and promoted modernized western fishing technologies like bottom trawling and purse seining for large scale harvesting of fish. India with its 7500 km coastline and innumerable rivers, lagoons, lakes, reservoirs and ponds has one of the largest populations of fisher people over 12 million with two thirds depending on marine fishing and the remaining on fishing in a variety of inland water bodies.

The traditional fishermen who constitute majority of fisher folk community harvest a negligible quantity of fish. However, the small number of mechanized fish gear operators have been taking away the bulk of the catch (approximately 92%) thus adversely impacting the lives and economy of traditional fishermen in the country. To meet the highly competitive international market demand the mechanized operators have been employing various unsustainable means of fishing – including seines, stake nets, lines, bag nets, encircling nets and lift nets which has resulted he marine biological diversity of the oceans are threatened.

Trawling destroys sea bed habitats adversely affecting sea grasses and marine fauna such as the highly endangered dugongs and sea turtle habitats. Trawling and use of nylon mesh nets also results in the entanglement of marine turtles and dugongs resulting in high incidences of turtle mortality.

The use of dynamite to kill fish and toxic chemicals to capture either live or dead fish is a common practice in artisan fisheries. The industry sub sector has often employed very effective but destructive fishing gear and techniques.

3.2.2 Aquaculture

The expansion of industrial shrimp farming in India has been driven by soaring demand for shrimp in the United States, Canada, Japan, and Europe. Shrimp trawling is considered to be one of the world's most wasteful and harmful fishing practices. Today industrial shrimp aquaculture has spread to 50 countries. Shrimp farms have destroyed a million hectares of critical coastal wetlands including mangrove forests, disrupted and displaced traditional fishing communities, and contaminated freshwater supplies.

Intensive farming in ponds, pens, or cages produces organic matter that settles to the bottom of the pond or pen, or below the cages. Some of the suspended waste matter from excessive artificial feeding, fish excreta, and the application of chemicals is flushed out of the enclosures and pollutes adjacent waterways.

3.3 Forestry

The forests of India are a critical resource for the subsistence of rural people throughout the country, but especially in hill and mountain areas, both because of their direct provision of food, fuel and fodder and because of their role in stabilizing soil and water resources. Due to the use of these forests for commerce and industry, the flora and fauna of the region is deteriorating very fast. Compared to 1970s, India has been quite successful in cutting down the rate of deforestation and somewhat stabilizing the forest cover. But India's forests still face major challenges and threats mainly due to the increased population and industrialization.

3.3.1 Commercial Plantations

India has a forest cover of 20% (FSI, 1999) which is less than the goal of having 33% forest cover as enunciated in the national forest policy of 1952 and 1988. If we see the recent trends during 1980 and 1990 there has been increase in the forest cover of the country. However, this increase in forest cover is mainly because of the plantations.

According to the FAO report India has the world's largest area under the plantations. The total plantation area reported by 90 countries of the tropical zone amounted to 30.66 mha in 1990. Of this India alone had 43% of the tropical world's total. This has decreased the biodiversity of the forest ecosystem. In order to meet the growing demand for industrial requirements, there has been more focus on the plantations (mainly exotic species) with reduced rotation period.

Forestry development schemes introduce monocultures of industrial species like eucalyptus, which push into extinction the diversity of local species which fulfil the local needs. Monocultures of fast growing species and high yielding varieties are equated with increasing productivity and often justified as improvement and increased economic value. Technological transformation of biodiversity have different connotations at different levels of users. While improvement of a tree species and crop productivity mean one thing for a paper pulping industry and food processing industry, it means something else for a farmer requiring fuel, fodder and manure.

On one hand this has been successful in meeting the industrial and local (fuel and fodder) requirements, while on the other hand it has reduced the biodiversity due to monoculture.

3.3.2 Non-Timber Forest Produce (NTFP)

In India where economy is largely based on rain-fed agriculture, people rely on non agricultural or forest vegetation for subsistence during lean periods. The collection of NTFP changes with the seasons. Harvesting of NTFP is usually suspended during the monsoon when people are fully engaged in the field for ploughing and sowing the crops. Womenfolk constitutes the major gatherers of forest produce. While medicinal plants are by and large collected by a few knowledgeable men, all food and fuel items and material for preparing household articles both for domestic and market consumption are always collected by women. Often these are collected as a household activity. A household or non-household cottage industry may also be involved in processing of NTFPs by applying local skills and village level technology.

However, sustained development of NTFPs within the socioeconomic sphere of forest management in India offers challenging opportunities for forest managers to improve productivity from the forest. An understanding of resource use, flow and economic returns from various NTFPs is essential prior to arguing for a reorientation of the timber-dominated forest policy.

3.4 Pharmaceuticals

Forest plant species have served as a source of medicines for people for centuries. Due to the technological advancements in research pharmaceuticals has emerged as a major biodiversity based industry. Majority of the raw material for these industries is the wild plant species. While in India medicinal plants and herbs have been used by local communities and traditional healers for primary health care, the pharmaceutical companies have mainly focused on their collection and processing for commercial trade. As propagation of most of the wild species is still being researched hence, over exploitation has left several of these species either threatened or extinct.

4.0 INDUSTRIES IMPACTING BIODIVERSITY

Post independence has seen major technological interventions to speed up the process of economic development which has further diminished the natural wealth of India. With the growing need for communications, roads were built into the interior areas including those hilly and try tracts ---- of pristine natural areas. With the opening up of these areas the forests have been ruthlessly overexploited.

Rivers and dams have emerged as a major threat to natural forest areas in hilly tracts. Numerous dams in the Himalayas, western ghats and central highlands have been constructed. These are very sensitive regions where most of the forested areas of the counrty edists.

Mining activities pose yet another threat. Since independence India has witnessed phenomenal growth in mineral production. Nearly 40 contiguous distircts in central and easterns India account for more than half of all the national mining outputs of the country. These very areas are also the most richest in terms of forests and having large population of tribals dependent on these forests.

Several activities, have over the years have grown into major industrial activities which has helped the nation to keep pace with developemnt. The process of economic and social development of a country always involves industrialization, which in turn is linked with core sector growth. While on one hand these activities have provided livelihood and material comfort to the people, on the other had it has major implications on the natural resources. Rapid developments in mining, transport, construction of dams and manufacturing etc. have resulted in environmental problems like deforestation, pollution, and climate change.

4.1 Mining

The exploitation of mineral resources through open cast or strip and underground mining has caused wide ranging environmental problems such as land degradation, loss of biological wealth, air, water and noise pollution and displacement of local communities. The multiplier effect of mining has acted as a catalyst for urbanization and industrialization. Open cast mining on catchment slopes has drastically reduced the water resources which subsequently has a significant impact on biological diversity.

The development of infrastructure and core sector is directly linked with increased production of minerals, like coal for power sector, iron ore for steel sector, limestone for cement for housing and infrastructure development. The open cast mining technology is adopted for quick and economic extration with higher percentage of recovery.

According to an estimate in 1997-98, nearly 106 million tonnes of lignite, 70% million tonnes of iron ore, 6 million tonnes of bauxite, 23 millino tonnes of lignite and 78% of coal production came only from open cast mines. Coal based power plants supply nearly two thirds of electricity in the country and this is expected to go up in the years to come. These activities basides having severe consequences on the biodiversity of the area also cause problems of air and water and noise pollution.

Mining is important for the development of the country as it provides the materials required to sustain quality of life. However, most of the mining activities are carried out in ecologically sensitive areas. Abandoned mining sites result in toxic dumps which remove the top fertile soil resulting in loss of native flora and fauna. Hence, appropriate eco-technologies for mining should be developed to reduce the impact on environment.

4.2 Manufacturing

Growing pollution of rivers and streams poses a serious threat to the fish populations. Dams and canals constructed for harnessing water resources apart from preventing migration of fish, have serious implications on fish genetic resources, allowing intermixing and breeding of different genetic strains of species which were earlier isolated due to geographical and ecological boundaries.

Water bodies are the global sinks for many pollutants from both land-based (untreated domestic and industrial effluents) and water-based (oil spills, shipping waste) industries. Almost all forms of water pollutants diminish the capacity of water bodies to support aquatic life if they reduce the amount of dissolved oxygen. Chemicals in polluted waters also affect fish populations adversely. The contamination of aquatic species with pollutants, primarily with sewage and toxic substances, and the occurrence of toxic algae blooms have also rendered them unfit for human consumption.

4.3 Infrastructure and Construction

To facilitate fast movemnet of people and goods there has been a major thrust on the construction of road networks in India. Most of the inaccessible and remote areas (eg. North East) have been connected to rest of the country by the road network. Road building has resulted in destablising of the slopes and removal of forest cover.

The construction of hydroelectric dams and subsequent submergence of forested valleys have resulted in large scale deforestation. This has a significant impact on the local flora and fauna.

4.4 Transport

Modern means of communication and transport has resulted in greater movement of people and goods. The improved connectivity has led to sometimes accidental transport and introduction of 'alien species' into new environments. Alien species are very hardy, aggressive and quickly become established in a new environment often posing a serious threat to the native flora. Alien introductions are often more out of ignorance and require awareness and strict quarantine enforcement.

5.0 ECO-TECHNOLOGIES

Industrial advancement and technological developments are essential for a nation to progress globally and are essential to meet the increasing demands of the increasing population. However, there is an urgent need for bringing “sensitivity” to environmental concerns which are the very life-support systems and source of livelihoods for millions of people in the country.

Technologies are intended to bridge the gap between nature’s resources and human needs. Science and technology do not automatically translate into development. Ecological and economically inappropriate science and technology often are the causes of underdevelopment and casue of poverty.

Technological process often lead to higher withdrawls and consumption of natural resources and higher addition of pollutants than ecological limits permit. These contribute to underdevelopment through destruction of ecosystems.

The need for eco-technological solutions has been felt for sometime and a few sporadic and scattered innovations and efforts are being made silently in the areas of agriculture, mining and fishing for mitigating the adverse impacts.

The successful adoption of alternative eco-technologies depend upon their integration into the existing livelihood systems. Stakeholders are both the experimenters with and potential beneficiaries of alternative systems. However, given the diverse environmental, economic and social conditions in the areas, not all strategies are applicable universally. Hence, development activities that work with and through indigenous knowledge and organizational structures have advantages.

Much of the biological diversity is in the custody of farmers who follow age-old farming and landuse practices. Hence they are the excellent conservators of biodiversity. However, due to the increasing demand for food, fodder and other natural resources there is a need to develop the eco-technologies (as they are the blend of traditional knowledge and modern technologies).

5.1 Community/Household Level (Case Studies)

The Watershed Development and Soil Conservation Department of the Government of Rajasthan has facilitated the formation of 15,000 watershed users groups, with at least three million hectares under sustainable practices, such as strips of vetiver and other grasses on the contour and regeneration of common lands with shrubs and trees. Sorghum and millet yield has more than doubled to 400-875 Kg. /ha (without addition of fertilizers); and grass strips have improved yields by 50-200% to 450-925 Kg. /ha.

The Sikar district of Rajasthan is dry (annual rainfall is 25-50 cm.) so establishing the trees is very difficult. People grow pearl millet, pulses, sorghum in the monsoon and wheat, chilly, gram, onion, fennel, cummins and fenugreek in the winters on the irrigated plots. In 1978-79, the Forest Department of Rajasthan launched a tree-planting scheme on irrigated lands. People planted the seedlings on irrigated and the dryland. The survival rate on the dryland was very low (10-15%). After a training course at Indian Agricultural Research Institute (IARI), people started experiments to establish trees on the dryland. They found that below the depth of 30 cm. Soil has sufficient moisture for the survival of plants provided evapo-transpiration was controlled by removing the weeds. In 1983, towards the end of monsoon they planted *Dalbergia sissoo*, *Zizyphus* spp., *Acacia nilotica* and *Ailanthus excelsa*. The success rate was more than 90%. Several officials, social workers and foresters *etc*. visited the village and appreciated their efforts and predicted a possibility of another green revolution in dry lands, provided the technology is scaled up.

The National Innovation Foundation has been set-up with the aim to recognize and support creative potential of innovators at the grassroots level as a way to make India self-reliant and a leader in sustainable technologies. The first competition was held in 2000. One of the prize winners in the first international competition, organized by the International Fund for Agriculture Development, was Maniam Sitaraman who developed a biological control of the rice hispa pest (*Dicladispa armigera*). It causes immense losses of yield in South ands South East Asia. Maniam Sitaraman, a tribal farmer from Andhra Pradesh in India, uses a poisonous plant called 'kodisa' (*Cleistanthus collinus*) found in abundance all along the Eastern Ghats.

Alarmed by heavy soil erosion and land degradation in the Shiwaliks, the Punjab government decided to construct check dams and carry out catchment area treatment on the pattern of Sukhomajiri. Nada (village in Ropar district, Punjab) was chosen after a detailed soil, land and socio-economic survey of the area. Before the project started the villagers agreed to participate social fencing and stopped taking their animals, mainly goats to the forest for grazing. The hilly catchment area of 125 ha was severely denuded. A massive afforestation programme was undertaken by the forest department the local communities. To reduce the burden of grazing on the forest, an exchange scheme sponsored by the World Bank and implemented by the animal husbandry was extended to the farmers. A major benefit came by the increased food grain production. The impact on the village life was visible. There is an increase in the household income and the pressure on the forests has been reduced.

With the setting up of the community biogas plant (under an ICAR sponsored all India Coordinated Research Project, the scenario at Islampur village in Bhopal changed. About 21 quintals of cow-dung thoroughly mixed with an equal quantity of water is fed into the plant everyday. The gas yield has been reportedly varying from 45-67m3 per day depending on the season. The gas is supplied to the local people for domestic cooking twice a day that is equivalent to saving 112 tonnes of fuel wood/agro-residues per day while the digested slurry is used for cultivation.

Extensive field trials revealed that about 50% of the recommended dose of inorganic fertilizer can be replaced by biogas slurry without significantly affecting the crop yields. Besides application of the spent slurry along with inorganic fertilizers resulted in better soil health. Thus the plants have been helping conserve precious forest and chemical fertilizers and reduce pressure on the environment.

5.2 Industrial Level (Case Studies)

5.2.1 Technologies for improving grain yields

New technologies that help conserve agricultural resources in rice and wheat cultivation has been evolved by the Rice-Wheat Consortium (RWC). RWC is a collaborative body which is the outcome of the heads of the premier of agricultural bodies of Bangladesh, Nepal, India and Pakistan. Deterioration of soil quality and water depletion, among other things has resulted in decline in yields. The Consortium's thrust is to promote different technologies that help conserve the resources and which are economically and environmentally advantageous. RWC has promoted surface seeding, zero tillage, reduced tillage and bed planting, collectively called resource conservation technologies (RCT) with potential multiple benefits for the user.

In the surface seeding - method the seed is place on top of the soil surface without any land preparation such as tilling. The process helps contain soil erosion and does away with the costs of tilling. The practice has been promoted in eastern parts of India and the low-lying lands of Nepal.

In zero tilling system - on the other hand, the seed is placed in the soil by a seed drill with limited prior land preparation. The tilling and soil preparation is carried out only in the rows where seeds are to be sown and not the entire piece of land under cultivation.

This technology has been promoted in the higher yield, relatively more mechanized areas of India and Pakistan. The results of adoption of technologies have been encouraging in Haryana and Punjab in Pakistan. Farmers in Haryana user zero tilling method on 8000 ha of soil and direct drilling with locally manufactured drills was used to cultivate 5000 ha in Punjab, Pakistan. The area under zero tillage has increased three-fold in the last three years and should continue to expand, as the equipment becomes easily available to the farmers. According to ICAR the farmers have saved about Rs. 2000/- per hectare, reduced irrigation requirements by 30-5-% , advancement of sowing time, lower prevalence of weeds and increase in yield by 200-600 kg per hectare. The advancement of sowing time is crucial as it enhances the yield and provides scope for an extra crop and also helps the farmer retain casual labour at the farm, which reduces the cost of tilling.

5.2.2 Biofertilizers and Rice Production

Nitrogen fixing micro-organisms convert about 139-170 million tonnes of nitrogen every year into fertilizer nitrogen for which the energy bill is paid by the nature. The fact that the total world biological nitrogen fixation is three times that of industrially produced nitrogen, demonstrates the significance of biological nitrogen fixation in agricultural and nitrogen cycles. Nitrogen fixing systems offer an economically attractive and ecologically sound means of reducing external inputs and improving internal resources.

Immobilization of nitrogen fixing cyanobacteria under rice field conditions can be done with solid matrices such as polyurethane foam, polyvinyl foam, sugar cane waste, paper waste and rice husk. The immobilised cyanobacteria could continuously excrete the ammonia extra-cellularly which could be used for continuous supply of nitrogen to rice crop. The immobilised cyanobacterial system in solid matrix when inoculated in rice field is like a mini in situ fertilizer factory which produces ammonia continuously. The accumulation of ammoniac nitrogen in the flood water as a result of immobilised cyanobacterial inoculation will reflect on the growth and yield of rice.

5.2.3 New Mining Technology for Mining

The process of open-cast mining scars the landscape, disrupts ecosystems and destroys microbial communities. Apart from unsightly impacts, the degraded environments created in the aftermath of open-cast mining often cannot support biomass development. Put another way, extensively mined land usually does not possess sufficient surface soil to anchor plants, and the plant growth that does take place is inhibited by the presence of toxic metals. Over the long term, open-cast mining reduces forest productivity, damages aquatic and atmospheric ecosystems and sometimes leads to substantial alterations in microclimates. Such changes, in turn, carry adverse economic and social impacts for nearby communities whose residents depend on the region's natural resources for large portions of their incomes.

The National Environmental Engineering Research Institute (NEERI), Nagpur, India, has developed a sustainable eco-friendly technology that reclaims and rejuvenates the "soil spoils" left behind by open-cast mining. The strategy, which experts have labeled the integrated biotechnological approach (IBA), involves the use of diverse organic materials (for example, such industrial wastes as pressmud, a by-product of sugar mills, and treated sludge, a by-product of paper mills) to build soil productivity. These organic materials, which nourish the depleted soil, are supplemented by the planting of saplings that contain specialized cultures of endomycorrhizal fungi and such nitrogen-fixing bacteria as *Rhizobium* and *Azotobacter.* IBA has increased the survival rate of plant species found on land that is scarred by open-cast mining to more than 80 percent. At the same time, it has boosted the species' growth rate by a factor of five. Barren, eroded slopes – hard rock of a deep brown color – have been transformed into lush-green tree-lined environments. Equally important, the areas' biodiversity is slowly being regenerated. In fact, IBA forests ultimately produce commodities of high value, including timber, fruit and gum. In addition to these long-term environmental benefits, over the short term the strategy generates jobs and income.

5.2.4 Application of Remote Sensing and GIS in Biodiversity Conservation

Tropical deforestation and the loss of biological diversity have raised major concern among ecologists during the recent years. The loss of biodiversity has been attributed to the destruction of habitat, isolation of fragments of formely contiguous habitats and edge effects within a boundary zone between forest and deforested areas. A Geographic Information System (GIS) has been used to spatially model the disturbance regimes and to integrate the ground based non-spatial data with the spatial characters of the landscape. The various parameters (viz. Patch shape, patch size, number of patches, porosity, fragmentation and juxtaposition) have been analyzed on the landcover maps to spatially represent the disturbance regimes. A spatial model incorporating ground based biodiversity attributes of the landscape elements, landuse change patterns, disturbance regimes of the landscape and terrain complexity have been used to delineate the spatial pattern of the biological diversity. Habitat evaluation using ground based data and their spatial organization have been found to provide the reliable information on the biodiversity distribution pattern. The present approach for prioritizing the biodiversity rich sites have the advantage of integrating spatial, non spatial information and horizontal relationships. The approach will facilitate conservation prioritization, systematic inventory and continuous monitoring. The project is jointly funded by Department of Space and Department of Biotechnology for Biodiversity Characterization at National Level and is being executed by Indian Institute of Remote Sensing (IIRS), Department of Space, Dehradun.

However, there is need to prepare detailed plan using GIS and maps should be prepared jointly by local communities and professionals to foster an integrated approach to forest conservation and sustainable and equitable use to meet the following needs:

- Conservation of prime forests.
- Commercial forestry to meet the needs of small and large industries.
- Community forestry to meet the fuel wood, fodder, fiber, fruits and other needs of local communities.
- Zoning and identification of industrial sites with minimum impact on biodiversity.

5.2.5 Turtle Excluding Devices (TEDs)

A TED is a fishing gear device, which is inserted into an existing trawl and functions as an escape hatch to allow turtles that are caught up in a trawl net to be released and at the same time, releasing a significant amount of intended catch. Slanted bars guide sea turtles and other large objects out of a net through a trap door, while smaller fish swim through the bars on the device to escape the net. Early TEDs excluded 97% of the entrapped sea turtles, retained most shrimp, increased trawling efficiency, and reduced finfish catch by 50-60% as well. They were heavy, however, and proved unwieldy and undesirable for most shrimp fishers. By the late 1980s, a lightweight, collapsible TED had been developed, spurred by laws in some states requiring the used of TEDs.

There has been a growing international acceptance of the use of TEDs. Some foreign governments have shown an interest in acquiring TED technology and in developing national TED programs. The U.S Department of State and the National Marine Fisheries Service have worked to provide training in the use of TEDs, and to promote the transfer of TEDs technology. Orissa is the first state in India to get TED technology, to reduce turtle casualty and unintended catch during fishing by trawlers.

6.0 RECOMMENDATIONS FOR ACTION PLAN

Technological and Industrial developments are essential and important for the economy as well as livelihoods. However, there is a need for environmental consciousness and responsibility through action. There is a need for spreading awareness, promotion and revival of certain traditional “practices” and promoting measures, which could mitigate the impact of the technological developments. Existing eco-technologies are few, but require to be researched, field-tested, promoted and disseminated on a large scale.

Most policies have focused too narrowly on short term solutions rather than on long term sustainable methods that maximize local resources. In most of the cases the better results come from using indigenous knowledge and science to build on traditional systems, better use of local renewable resources and external inputs. This requires research and development by greater collaboration of various stakeholders and development agencies with more access to credit.

Formation and establishment of an **Ecotechnology Alliance** for promoting Eco-technological solutions for Biodiversity Conservation is suggested.

The Alliance would bring together diverse representatives of concerned stakeholders for:
Assessment for increased knowledge base – traditional practices and innovative technologies in use by local communities as well as the efforts being made towards eco-technological alternatives in specific areas related to mining, fishing, construction, and other areas where the the impact are very adverse and affect a large pristine and ecological sensitive areas.

Adaptive Management - Identification of sustainable management practices and technologies as well as policies that promote positive and mitigate negative impact of agricultural advancements on biodiversity. Promotion of adaptive management practices, technologies and related policy and incentive measures.

Capacity Building – Promoting participation of different stakeholders for understanding and learning from traditional practitioners for sustainable management and biodiversity conservation practices.

Mainstreaming – Adapting an integrated approach for including biodiversity concerns in all important sectors of planning for development.

1. Establish networks /forums for increasing awareness and conscious ness towards the need for incorporating biodiversity conserns in technological research and development
2. Policy advocacy for support of cleaner, ecologically less harmful technologies
3. Increased awareness on traditional sustainiable practices and their encouragement and propagation
4. Multi-disciplinary and multi-sectoral teamwork in economic development projects and programs
5. Developing population, food and energy policies consistent with community interests and biodiversity conservation
6. Flexibility in laws allowing local level decisions to decide, set policies
7. Integration of biodivesity conservation in policies for all relevant sectors including agriculture, forestry, industrial development, energy suppoly and involving inter-agency responsibilities for biodiversity matters
8. Sponsor prevervation and support of traditional agroecological practices
9. Include economists, political representatives, natural and social scientists in planning
10. Investment in research for developing technologies for conserving biodiversity especially in vulnerable eco-systems, endemic forest ecosystems and for conserving populations of threatened and endemic fauna and flora.

6.1 Research and Development

Despite massive input of public funds into technology development, still there are very few eco-technologies. Most development planning programmes have ignored the real (natural) resource issues, since the the term ‘resource’ in planning practice has generally come to refer only to the amount of money available.

The NGOs play an important role by providing a window on the real world for the biological conservation. NGOs can assist in the process of identifying knowledge needs because they are often in a position to listen to the needs of stakeholders and policymakers more directly than the scientist. Also they can assist in identifying the local innovations that can be refined and can be used at a larger scale.

6.2 Building Institutions

At the local and national level we need new forms of institutions that are capable of fulfilling social objectives. At the national level, a full scale commitment is needed to set up institutional machineries to place the scientific development of sustainable and eco-technologies at the centre of the country's agenda. In essence, we propose that a completely autonomous institutions be established, which will comprise a network of local units throughout the country, capable of dealing with geographically or topically relevant societal and natural resource management problems. In terms of coverage, the concept can be modelled after the CSIR network of national and regional research laboratories. However, in scope of work, mode of operation and linkages with the economic sectors it deals with, its structure and functions will be entirely different from that of CSIR.

It will employ a 'corporate research and development' approach to identify and solve basic societal problems. This means that, it will not only undertake laboratory and prototype-level research and development, but will go all the way through productionizing and proving commercial viability by actual operation of model enterprises.

This will facilitate partnerships with the private sector and engage with businesses and market structures. This will also channel financial resource to network partners and help them develop their own resource mobilization efforts. It will also aim to promote and help facilitate the implementation of new organizations. Many of these actions are and will continue to be undertaken by other institutions, donor organizations and bilateral arrangements.

6.3 Building Alliances

The primary goal of building alliances is to create a network of institutions engaged in the pursuit of the mission described above. Formulating a South Asia Biodiversity Conservation Agreement would facilitate more detailed assessments, mapping and delineation of protected areas; revival of traditional conservation knowledge; curtailment of bio-piracy; setting up of domestic and joint venture manufacturing units; and facilitate trade in finished products rather than raw materials.

6.4 Promotion and Support for Innovation

The consortium should be open to and encourage the development of new and innovative eco-technologies such as Precision farming, Information technology and Remote Sensing & GIS. The communities should also be involved in the process so that the local traditional knowledge can be promoted.

Both in situ and ex situ conservation has been part of cultural tradition in India. However, the tradition has been drying out in the country. In national integrated gene management these conservation methods should receive adequate and concurrent attention and support. By providing explicit recognition to the pivotal role of community conservation will be strengthened in revitalizing these traditions.

Hence at this stage a paradigm shift is required in agricultural development that can help increase yield, income and livelihoods per unit of land and water. The green revolution was triggered by the genetic manipulation of yields in crops such as rice, wheat and maize. This can be further improved by triggering farming systems that can help produce more from the available land, water and labour resources without either ecological or social harm.

6.5 Resource Mobilization

Recognizing NBSAP as a national facilitator for a range of eco-technologies, one of its most important objectives will be resource mobilization to enable grassroots and support activities in various parts of the country. Resources will also be required to support the creation of new institutions.

6.6 Equity Issues

Despite women's vital role in environmental management, they are excluded from most environmental or development decision-making. Too few lines of communication connect international and local organizations, limiting women's ability to influence development planning and implementation.

Eco-technologies enable the adoption of ISO 9000 and ISO 14000 standards of environmental management. Building technical competence and providing institutional incentives for conservation of diversity have to go hand in hand. Much of the technologies for conservation or accessing or value addition in biodiversity may require an optimal combination of institutional structures and incentive measures. In past, incentives without institutions led to excessive biodiversity extraction. Large number of companies even in the *ayurvedic* drug sector pursued their business without any self-regulation or institutional constraints. The future gain in technology depends to a great extent on the way information technology is applied. Unless networked information system exists, best use of diversity may not be possible.