BIODIVERSITY STRATEGY AND ACTION PLAN FOR KERALA

NODAL AGENCY

KERALA FOREST RESEARCH INSTITUTE
PEECHI – 680 653, THRISSUR, KERALA

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CULTURE, LIFESTYLE, LIVELIHOOD, TRIBAL AND INTELLECTUAL PROPERTY RIGHTS

Introduction

Kerala is a region of inhabitants with ancient cultural imprints. The aborigines in the mountainous regions of Western Ghats, numbering about forty groups of tribes, have the traditions of centuries old culture. Each tribe has distinct tribal features. The tribes living in tune with the nature have a very strong oral tradition encoded with a number of concepts for the preservation and enrichment of nature. Their art forms impart a lot of information about their contributions for keeping the biodiversity; and this forest lore about their surroundings was handed over from generation to generation. Their knowledge about the tuberous roots, medicinal plants and varieties of fruits is scientific. As Totemism connected with the concept of biodiversity was strong, its rituals and festivals were automatically transmitted. Animism was a strong concept and also a practice; and hence they had a devotional feeling towards land, animals, plants and the whole environment. They worshipped trees, forest, animals, hills and rivers; and their myths and songs are indicators of their intuitive knowledge about nature.

The construction of the houses and making of the household utensils were simple and congruent with the nature. Their food habits too have a concept of balanced diet with different varieties of honey, leaves, roots and fruits with seasonal emphasis and availability and this has the basic concept that is totally different from the present theory of 'exploitation of nature'. They had their own ways and methods of agricultural practices and notions of 'hill cultivation'.

The folk culture of the middle land has a lot of varieties and over 80 castes and sub-castes are identified with different systems embedded with distinct traditional vocations and rituals. Each tribe has its own tradition of music, ways of ritual practices, myths and this variety is accepted by all. *Theyyam*, the folk performance has at least 18 castes participating collectively. The art forms, apart from being art items, decide and mould the structure of the society and economy.

The Middle land culture is mostly agrarian. Tiny groups working in land collectively do various rituals most of which are connected with Mother Goddess concept and fertility. According to the source of availability of water, each place had invented methodologies of cultivation suitable and convenient for the society. About 120 varieties of paddy seeds and 40 varieties of intercrops, a number of tuberous roots, vegetables and fruits used to be cultivated; and the cooking pattern was also suitable

for the tropical climate. The local knowledge of agriculture, food gathering and preservation lie in their oral tradition and rituals, and their need to protect and preserve the seeds is seen in varieties of performances and rites.

The images, signs and metaphors in the local myths and art forms are imprints of their life and place of dwelling. It is obvious that local myths are more prominent than the high Myths, and the innate quality to create new local myths is very powerful in the folk. The structural form of the local myths is an indication of the philosophy of life of a tribe and also the meaning of the signs. Their songs are the documentation of local history; the ancient rustic songs, ballads praising heroes and uncombined individual songs are indicators of the local culture. Folk arts are the various documentations of the 'earth' they live in, and all of them invariably are the registered documents of bio-diversity. The local names of each variety, the spread and the distribution of each of them and even the intricate difference of each one's growth and behaviour can be read out from this orally transmitted knowledge.

The material structure of the life of the people who do the handicraft works is also diverse, and their position in the society is an indication of the importance given to nature and the needs of the people of the village, which is nothing other than the remarkable concept of self-sufficiency or *Gramaswaraj*. The material structure of the society was moulded by *Asari (Carpenter), Moosari (Metalcraft People), Thattan (Goldsmith), Kollan (Blacksmith), Kusavan (Clay worker), Parayan (Bamboo/cane worker)* and many other specialised groups. This shows the scientific division of specialised labour and technological tradition of knowledge. Keeping the conventional and traditional way of making things, each person was maintaining one's own speciality and style nurturing the diversity. This again maintained the balance of nature and life.

Issue 1. Depletion and degradation of wild biodiversity resources

Reasons

1. Shrinking of natural forests, mangroves and wet lands.
2. Neglect of active biodiversity conservation efforts and absence of a monitoring mechanism.
3. Expansion of the road network, agriculture and urbanization frontiers and conversion of natural forests into farm lands plantations, settlements and reservoirs .
4. Intensification of extraction of natural biodiversity resources.
5. Fire and spread of alien invasive weeds replacing native vegetation.
6. Fragmentation of agricultural lands and intensification of cultivation with mono crops by replacing the natural vegetation.

7. Disappearance of wild growth on the boundaries of homesteads, farm lands and plantations by replacement of natural boundary hedges/fences with stone and cement walls due to fragmentation of holdings and intensification of cultivation.
8. Degradation and depletion of traditional sacred groves in rural areas due to social and land use changes affects the people dependent and related to resource.
9. Degradation of ponds, wet lands, streams and coastal areas and land use changes. Wild growth on stream banks and shoreline being cleared for retaining walls and other construction activities due to unawareness, lack of policy guidelines or enforcement, lack of proven technological alternatives and commercialization.

Strategies

1. Identify the political, social and economic causes of replacement of natural vegetation by other land uses and seek ways of addressing them.
2. Include biodiversity conservation as a national development goal to be implemented by all so that biodiversity conservation does not remain a priority for the Ministry of Environment and Forests and conservation NGOs alone.
3. A credible fire prevention and management plan prepared after wide discussion that is both economic and transparent.

Actions

1. Research on processes that result in biodiversity erosion to identify the underlying causes and incentives leading to degradation of biodiversity resources.
2. Develop a participatory monitoring mechanism for biodiversity status inside and outside protected areas.
3. Draft a national biodiversity conservation policy to be implemented by all ministries, departments, agencies, institutions and the private sector and integrate biodiversity conservation with all natural resource management programmes.
4. Town and country planning rules should be amended to promote natural vegetation on river and stream banks. Construction should not be permitted within a specified distance from the waters edge.
5. Availability of social science research studies, media debates and discussion among stakeholders on ways to reverse depletion and degradation of biodiversity resources.
6. Policy decision to enlarge the area under natural vegetation while strictly conserving the remaining natural forests and wild vegetation.

7. Involve independent agencies at the local, national and international level to actively monitor the threats and actual changes in area under natural vegetation.
8. Documenting and investigating all fire incidences in forest and prosecution of offenders along with awareness creating within the community.
9. Research on the biology and ecology of weeds to be carried out to prepare and effective eradication program with emphasis on biological and mechanical control.
10. Awareness on biodiversity conservation in home gardens and farm lands should be created through regular school curriculum, state agricultural department, R and D organizations, agricultural universities, etc. Commodity boards like rubber, coconut, coffee, spices etc. should be sensitized and reoriented to help promote biodiversity conservation in farm lands.
11. Nature clubs should be promoted and fostered in all educational institutions, Government officers, industrial establishments and community organizations. Strengthen the existing NSS, VSS and NGC organization. Promote bird watching and convey the message that old trees and hedges permit birds to thrive and hedges host predators of crop pests. Promote awareness regarding biodiversity, environmental conservation, pollution, etc.
12. A programme to revive the health of the water bodies such as ponds, streams, rivers, wet lands and their banks. Waster disposal into water bodies to stopped.

Indicators

1. Periodic independent evaluations show that the area under natural vegetation is stable or increasing and threats are seriously evaluated and counter measures are being taken.
2. A scheme of training, including trainers training programme, for officials, and peoples representatives and NGOs and workshops on how best agricultural productivity and biodiversity conservation can co-exist.
3. Involve Gram Panchayat, local NGOs and community organization in sponsoring, funding or fostering sacred or secular groves.
4. Periodic review of forest status reveal decline in fire incidence and reduction in weed extend and intensity.
5. Annual action taken reports and review of their programmes reveal priority for conservation of biodiversity.
6. Periodic review of the state of sacred or secular groves in each district by the state biodiversity board and provide some motivation and incentives in the form of awards for the best preserved groves.

7. Nature clubs growing in number and activities.

Agencies to implement the programme

Research institutions, Universities, State Legislature, State Government Departments such as Forests, Fisheries, Agriculture, Irrigation, Power, Public Works, Health, Labour, Tribal organizations, NGOs.

Possible funding agencies

Government of India, Ministries of Environment and forests, Rural Development, Labour, State Government, Panchayat and other national and international funding agencies.

Issue 2. Decline in income and status of people depending on biodiversity resources.

Reasons

1. Decline in biodiversity resources due to intensive extraction. Gatherers of NWFP trying to forage a reasonable income from the sale of produce.
2. Degradation of natural forests due to fire and weeds.
3. Profits from trade and processing of NWFP are not shared equitably with the tribal collectors.
4. Development policy in agriculture, power, irrigation, roads, urbanization etc. is not sensitive to the need for conservation of biodiversity threatening the livelihood of the people dependent on biodiversity resources.
5. Decline in arts, crafts and handicrafts due to decline in natural resources. This affects the livelihood and traditional knowledge systems.

Strategy

Participatory research on how best support mechanisms can be provided / created to ensure sustainable utilization of resources and sustainable lifestyles for the population depending on them. Based on the findings, modify current policies and formulate appropriate packages for achieving the above.

Actions

1. Sponsor research studies on resource use pattern and lifestyles of people depending on biodiversity resources.
2. Research on criteria and indicators of sustainable levels of resource use that do not threaten the long term viability of the resource base.
3. Research on mechanism to provide incentives for sustainable use and effective systems to ensure equitable benefit sharing.
4. Tribal VSS (forest protection committees) to be charged with NWFP collection and management. They must be empowered to make local rules for resource conservation. Programmes for value addition to NWFP to benefit those depending on the resource.

5. Monitoring of the resource base of NWFP and conducting research on sustainable management by regulating harvest and closing areas for regeneration.
6. Employment creation in rural areas around forests in agriculture and infrastructure development to mitigate the unemployment problem around forests.
7. Enhanced investment in education and health care in rural areas adjoining forests to improve awareness of biodiversity conservation and improve employment opportunities and the quality of life o the people.

Indicators

1. The percentage of people depending on biodiversity resources for a living declines and the quality of life of those who continue to improve dramatically.
2. Availability of studies on the options available in tackling the issues and the methods and costs of alternate action.
3. Development projects are all screened for its impact on biodiversity conservation and local bodies and institutions become aware and sensitive to the state of biodiversity resources.
4. Reduction in unemployment in rural areas.
5. Improvement educational health care facilities in rural area. Home remedies, nature cure and healthy varied diet is practiced by increasing proportion of the people.

Agencies to implement the programme

Research institutions, Universities, NGO's, State Government Departments of Forests, Fisheries, Agriculture, Education, Health, Labour, Tribal Welfare, Power, Irrigation, Panchayats

Possible funding agencies

Government of India, State Government, Panchayats

Issue 3. Decline in diversity in food, agriculture, traditional resource sharing systems.

Reasons

1. Cultural erosion due to change in values fashions, media advertising and life style of social role models.
2. Intensification and commercialization of agriculture. Decline in intercropping. Decline in availability of natural organically produced food.
3. Urbanization, faster pace of life, changes in community cohesion and breakdown of traditional rural resource sharing systems.

Strategy

Traditional knowledge in food, medicine, agriculture, handicrafts, folk arts, traditional resource and information sharing system etc. to be documented and popularized as an alternative and ethnic life style, as a survival tool box, as a window to past and a tourism resource.

Actions

1. Enact the state legislation to protect the intellectual property rights over indigenous knowledge. Encourage documentation of tribal medicines and validate claims of effectiveness to get IPR protection. The national board as a custodian of IPR make it inaccessible to the tribals in case of litigation. A state authority would be more appropriate.
2. Biodiversity registers should be prepared and the local community should be given the right to market indigenous items.
3. Documentation and popularization of traditional diversity in lifestyles, food, medicines, handicrafts, folk arts etc.
4. Enhanced funding for documentation and promotion of traditional diversity in culture and lifestyles.
5. Promote of self help groups and community development initiatives. Support resource and information sharing programmes.
6. Recognise tribal medicine as branch of indigenous medicine by Government of India. The state government should promote dispensaries of tribal medicine in tribal areas.
7. Necessary legislation to be introduced to ensure benefits of research in tribal medicine should be passed on to the same community. Tribal medical practitioners to should be recognized and appointed as teachers to train new generation practitioners.
8. Artisans and crafts men living on biodiversity resources such as bamboo, reeds, canes, etc. should be supported by marketing information design development welfare schemes and organization support.
9. Conserving the fish resource from decline should protect the livelihood of traditional fishing communities.

Indicators

1. Formal education stream also appreciate the diversity in knowledge, culture and lifestyle.
2. Traditional physicians are being recognized; they enjoy a better status and are contributing to the health and knowledge fund of the community.
3. Rising quality of life for the population depending on natural resources, including tribals and traditional fisher folk.

Agencies to implement the programme

Research institutions, Universities, State Legislature, State Government Departments such as Forest, Fisheries, Agriculture, Irrigation, Power, Public Works, Health, Labour, Tribal Welfare, NGOs

Possible funding agencies

Government of India, Ministries of Environment and forests, Rural Development, Labour, State Government, Panchayat

Issue 4. Bio piracy and commercialization of traditional knowledge including product development, technology and benefit sharing

Reasons

1. Lack of proper documentation of traditional knowledge.
2. Lack of safe guarding mechanism of documented knowledge.
3. Lack of benefit sharing mechanism from the disclosure of knowledge to product development, technology transfer and commercial production and marketing.
4. Unwillingness of traditional practitioners to exchange/share their traditional knowledge for documentation.
5. Absence of effective legislation on the subject.

Strategies

1. Create an awareness among the people about the provision of CBD for protecting IPR and also provide awareness on documenting / safeguarding the traditional knowledge.
2. Framing laws and rules for recognizing and rewarding the IPR of local and indigenous communities subject to the proposed biodiversity Act 1999 and protection of plant varieties and farmers right bill 1999.
3. Introducing different kinds of benefit sharing mechanism right from the disclosure of the knowledge to the product development, technology transfer and commercialization.
4. Protection of traditional knowledge by introducing new *sui generis* system.

Actions

1. Documenting traditional knowledge in a standard format with safeguarding facilities.
2. Preparation of biodiversity register at Panchayat level.
3. Scientific validation of traditional practices / knowledge.
4. Establishment of digital libraries for disclosing knowledge to the users with a provision for benefit sharing.

5. To introduce benefit sharing mechanism at different level right from the disclosure of safeguard knowledge to product development technology transfer and marketing.
6. To standardize all the raw material trade and enact legislation to prevent bio piracy by selling live / dry plant and animal materials to unknown outside agencies.
7. List out endemic plants that can be protected through the geographical indicators.
8. Establish DNA fingerprinting of endemic plant species.

Indicators

1. Traditional communities gain returns commensurate with the profits of the trade.
2. Implementation of laws is satisfactory and law enforcement is effective.
3. Mechanism to safeguard traditional knowledge exists and it is known to all.

Agencies to implement the programme

State and Central Government, Panchayat Raj institutions, Research institutions, Universitites, NGOs

Possible funding agencies

Government of India, Ministries of Environment and forests, Rural Development, State Government, Panchayat

DOMESTICATED BIODIVERSITY

INTRODUCTION

Genetic resources of crops/livestock include both wild and domesticated gene pools. they are the reservoirs of new and valuable genes, which could be of immense help to the genetic improvement of domesticated varieties of crops and breeds of animals. this also includes millions of races, subspecies, local varieties and breeds of species. these can be domesticated varieties or breeds directly used by mankind or wild relatives as applied to crops or animals.

During the past three decades awareness was generated to identify, study, collect and conserve these fast depleting and irreplaceable resources for the good of the present and future generations. Only a fraction of these resources has been utilized so far in breeding programmes and not enough research or study is made to understand the nature and extend of diversity or variability with in these resources. However, the success of utilisation of genetic resources depends upon the characteristics and uniqueness of the conserved material to be used in the breeding programmes.

Genetic diversity is dynamic and changes continuously leading to diversification of species into subspecific categories of variability. Subspecific variations can be measured and expressed in variety of ways, including the number genetic strains within the species and the number of different agro-climatic ecosystems in which they occur.

Human society will continue to depend on biodiversity of wild relatives of cultivated crops or domesticated animals, including those that are already domesticated. In addition to this, dependence on biological diversity as such as a source of food, fibre, fuel, shelter, medicine and several other day to day necessities would be essential forever.

Maximum attention is given to the conservation of species diversity in nature. Variations within a species are not extensively conserved because of lack of understanding of the variants or uniqueness of the variations existing within a species either in the nature or in domesticated conditions. Genetic diversity existing within the individuals of a species allows populations of a species to adapt to varied environmental conditions.

Our livestock, fruits, vegetables, grains, pulses etc. are all derived from the products of diverse and healthy resources of our ecosystems. Wild plants and animals, which

have been diversifying thousands of years due to changes in ecosystems in which they are placed, survived the trials and vagaries of nature. While we are still cultivating or have domesticated some of those obsolete varieties (in the case of plants) and breeds (in the case of animals and birds), we are utilising some of those genes from diverse sources to improve the strains or breeds presently existing. Most of the improved forms today are synthetic or hybrid types derived by incorporating useful genes or selections made to produce better quality of produce or forms with longer shelf life or having better resistance to insect pests or diseases and adaptation to new or varied environments.

The wealth of genetic diversity presently available in the form of domesticated crops or breeds of animals together with their wild relatives, has immense potential, but these are non-renewable and are among the most essential of the World's natural resources and a nation's assets, worth documentation and utilisation. So it is essential that these be conserved either at species or crop or gene pool or ecosystem levels, for the use of present and future generations.

India has 50,000 plant and 80,000 animal species, which are already identified and described and documented in scattered literature. According to Vavilov (1926), about 160 species of domesticated plants and animals have originated in India.

Kerala State, being an integral part of the Western Ghats, has a wide array of crop plants, domesticated animals and their wild relatives. Plant genetic resources represent the sum total of diversity accumulated through years of diversification under domestication and natural selection. This assemblage of genetic diversity of economic plants and their wild relatives, including the medicinal and aromatic plants, presents an enormous wealth of genetic variation for use in the current crop improvement programmes and for catering to the unknown needs of the future. A gene pool of crop plants, livestock along with their local breeds, wild relatives, land races, bio-control agents and those offering vital ecosystem services such as pollination and nutrient recycling is known as agro-biodiversity which is an integral part of the total biodiversity (Renjith et al., 1996). In Kerala, there exists two unique systems of conservation of biodiversity in general but more specifically domesticated biodiversity in the form of homestead gardens and sacred groves. These are self sustaining and resource cycling. They have become integral part of livelihood of man kind. So far no scientific attempt has been made to understand the interdependence of each component of these systems with human beings. Not even the economic potential of these systems have been understood.

As many of the World's diverse life forms from microbes to higher plants and animals have a direct or indirect influence on agriculture, conservation of these organisms is essential for sustainable agriculture. Hence, they are to be maintained and utilised. However, the amount or value of diversity is not entirely known. This necessitates conservation, monitoring, determination of value and value addition for better use. The Indian subcontinent is the centre of domestication of over 12 crop plants as known from archaeological records (Dhillon and Kochhar, 2001). The erosion of crop biodiversity in relation to domesticated biodiversity is evident in the increased proportion of land devoted to high-yielding generally uniform varieties. In order to maintain productivity under varying climatic regime, all components of crop diversity needs to be conserved.

Issue 1. Lack of a comprehensive inventory of domesticated biodiversity

Domesticated biodiversity comprises a wide range of natural resources including plants, animals, fishes and micro-organisms. These resources are distributed in diverse agro-ecological systems throughout India. The agro ecosystems range from humid coastal region to extremely arid conditions both in the plains and in the hills and they are spread throughout the length and breadth of India. There is need for systematic collection of available information , develop database at village , block, taluk, district, state and regional levels and to put the same in place for whole of India in each class of natural resources. A user- friendly format for information generation has to be developed and the data base documented and updated from time to time. For this there is need to develop computer programmes with facility for mapping and documentation of results. All the stakeholders involved in genetic resources utilisation and conservation are to be involved in this.

Reasons

1. Information available is scattered
2. There is no coordinating agency to compile the data base which is available with different agencies

Strategies

1. Generate information, at the grass root level on existing as well as extinct breeds and landraces in that particular area/ locality/region
2. Collate the information available with different agencies

Actions

1. Provide required research input to generate new information
2. Agency (ies) to be identified to collate the scattered information

Indicators

Availability of comprehensive information on inventory of domesticated biodiversity

Agencies to implement the programme

Kerala Agricultural University, State Agriculture and Animal husbandry departments, state and national agencies

Possible funding agencies

National and state funds

Issue 2. Loss/ verge of extinction of domesticated biodiversity

Farmers and NGOs who are prepared to safeguard and sustainably utilize the domesticated biodiversity are to be acknowledged , rewarded and compensated by the state/ central governments for which modalities are to be developed. State agriculture, veterinary and fisheries departments and the state agricultural universities have a leading role to play in this regard through their extension wings to create awareness on the significance of each variable/ diverse component of the domesticated biodiversity. Funds to be made available to these agencies, including the NGOs involved in this kind of work, by the State/ Central governments.

Reasons

1. Lack of awareness on the significance of the indigenous races
2. Conversion of agricultural and other farm lands & paddy fields into building sites
3. Introduction of HYVs of crops and breeds of animals, poultry and fish, including exotics, and replacement of indigenous/traditional races by these
4. Change in food habits

Strategies

1. Provide incentives to farmers for promoting the use of traditional varieties/breeds
2. Study and preservation of germplasm of indigenous/traditional varieties/breeds, etc.

Actions

1. Conduct awareness programmes on significance of conserving domesticated biodiversity among school children, farmers, etc.
2. Demonstration of local traditional agricultural practices in relation to sustainability and conservation of traditional varieties/ breeds, etc. at farmers' level.
3. Promote the quality and value of traditional varieties through value addition, thereby creating demand which will balance between HYVs and local land races in terms of sustainable use
4. Provide incentives to farmers growing traditional varieties/ breeds, etc.

5. Sourcing the availability of traditional varieties/breeds, etc.
6. Seeds of rare varieties of plant / native animals to be made available to farmers
7. Promote both onfarm and ex situ conservation

Indicators

1. Increase in use, awareness, availability and conservation of traditional varieties/ breeds etc.
2. Domesticated biodiversity is restored and sustainably managed.

Agencies to implement the programme

Kerala Agricultural University, State Agriculture and Animal husbandry departments, state and national agencies

Possible funding agencies

National and state agencies

Issue 3. Intensive monoculture of selected crops/breeds, etc.

There is increase in demand for food and industrial products, due to ever increasing population, as a result of which monoculture of selected crops, livestock, fish stocks, etc. is being practised at the cost of several components of domesticated biodiversity, for example rubber, tea, coffee, cardamom (Njallani) plantations. As against these, there exists two unique systems of conservation of biodiversity in general but more specifically domesticated biodiversity in the form of homesteads and sacred groves. This is an integrated system involving man, plants, livestock, and stocks of fish wherein the conservation, sustainable management and their utilisation to a great extent is being achieved through ages of human existence. These systems, especially homesteads is unique in Kerala. This gives opportunities for gainful utilisation of available resources in best possible way suiting to he varied requirements of homestead farmer/community time of women in the household. These systems are under constant threat due to changes in attitude, food habits, lifestyle etc. An in depth analysis of the merits of these systems, though well known and well appreciated, is lacking. Hence attempt should be made to study, understand and adopt the underlaying principles of these systems as models for conservation of crop – animal - fish based integrated farming system to the benefit of the mankind.

Reasons

1. Short term economic gains derived from monoculture
2. Subsidised support for improved varieties and technologies
3. Change in lifestyle including food habits, taste etc.

Strategies

1. Encourage traditional crops with crop/varietal combinations along with livestock/fish etc. suiting to the varying need of the farmer

2. The sacred groves and undisturbed natural habitat available around the household to be kept intact

Actions

1. Study and indepth analysis of the merits of the homesteads as a system from various points of view, especially in the effective conservation, sustainable management and efficient utilisation of different components.
2. Evolve homestead system models more specific to culture, lifestyle, food habit, resource availability etc.
3. Strengthen efforts to rationally integrate and conserve each component of these systems.
4. To adopt a system of farming incorporating all associated components for conservation, sustainable management and utilisation of all components of these systems.

Indicators

1. Conservation of each and every components of homestead and sacred groves which will ultimately provide livelihood security
2. Creation of a compliment niche for effective realisation of resources in a sustained and dynamic way.

Agencies to implement the programme

3. Kerala Agricultural University, State Agriculture and Animal husbandry departments, state and national agencies

POSSIBLE FUNDING AGENCIES

National and state agencies

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ECONOMICS AND BIODIVERSITY

Introduction

Biodiversity conservation helps economic development in several ways, probably the most important is that it provides livelihood security for many people and forms source of raw material. In addition, it is a potential source of many known and unknown goods and services that can be utilized not only by the present generation but also by future generations. Thus, biodiversity is a critical factor in securing the continued functioning of the life support systems and a pre-requisite for economic development.

Natural ecosystems, particularly forests, provide a variety of tangible and intangible benefits to the economy. Earlier, the valuation of forest ecosystem was carried out in terms of tangible benefits like timber, non-timber forest products, etc. Many natural ecosystems also provide various intangible benefits such as recreation, watershed benefits, ecological services, evolutionary processes, biodiversity etc. The economic value of intangible benefits are often underestimated or ignored by the policy makers. This led to unbiased decision in favour of a number of development projects such as construction of roads, industrial units, large dams, etc. The benefits gained by many projects have been overshadowed by the long-term ecological costs. As a result, many of the world's natural ecosystems have been severely damaged. An attempt is made here to discuss some of the issues relating to economics and biodiversity. Here, the main focus is on forests, one of the important biodiversity zones, assuming that the issues raised here can be extrapolated to other natural ecosystems.

Issue 1. Over-exploitation and degradation of natural ecosystems

Kerala is endowed with a versatile forest ecosystem, which covers an areas of 11125 km^2. The area under forest accounts for 27.8 per cent of the total geographical area which is higher than the national average of 19.50 per cent (State Planning Board, 2001). The major forest types found in the State are tropical wet evergreen (37.02 %), tropical moist deciduous forests (43.62 %), tropical dry deciduous forests (1 %), mountain subtropical (2 %), and plantations (16.36 %). Out of total forest area, about 1.88 lakh ha. are degraded with crown density below 40 per cent (State Planning Board, 2001).

There are several factors that contributed to degradation of forests and loss of biodiversity. Probably, the most important are: encroachment, submersion of forest areas by river valley projects, forest given on lease to private agencies, raising

plantations, etc. For instance, one estimate shows that about 23,990 ha. of forest area are under encroachment and about 115000 ha. of forests were diverted to various non-forestry operations during 1951-52 to 1972-73 (Prasad, 1986). Another study indicated that the area under forests in Thrissur district of Kerala, declined from 392.19 km^2 in 1930 to 300.69 km^2 in 1960 and to 151.62 km^2 in 1984, accounting for a total of 73 per cent (Menon, 1986).

Reasons

1. Lack of effective protection
2. Lack of information on conservation value of biodiversity
3. Lack of proper natural resource accounting

Strategy

Generate bio resource accounts and incorporate the environmental value of depletion of bio resources into the national income accounts.

Actions

1. Develop simple methodology for valuation
2. Create awareness among the policy makers and common people regarding prospective value of natural resources through workshop and training programmes
3. Studies on market and non-market benefit of the natural resources.

Agencies to implement the programmes

Research institutions, state planning board, central statistical organization.

Possible funding agencies

State, National and International agencies

Indicators

1. Methods of valuation available
2. Better policy
3. Better natural ecosystem health
4. Reflected in Gross National Products

Issue 2. Very few studies / Research on biodiversity valuation

Economic valuation is the process of estimating the appropriate monetary value for the identified goods and services. The value of biodiversity is the difference between the current or future value of a diverse range of genes/species/ecosystems and value of less diverse range. However, because of cumbersome procedure involved in the estimation, generally this is not attempted and hence value of biodiversity is discussed n the frame work of total economic value (TEV) (Bateman and Wills, 1999). The TEV of forests is the aggregate monetary value of all benefits from the goods and services provided by such areas. Conceptually, it is the sum total of *use values (*UV) and *non-use values* (NUV) of a natural system.

Majority of the studies on economic valuation of intangible benefits were carried out in developed countries. However, there are a few studies in the Indian context of which those by Murthy and Menkhuas (1993), Chopra and Kadekodi (1997) Hadker *et. al.* (1997) Manoharan (1996), Chopra (1997) and Haripriya and Parikh (1998) are important. One of the draw backs of these studies is that as these are micro level ones in different forest types, no generalization can be derived. There is hardly any comprehensive study on value of forests in Kerala.

Reason

Lack of institutional programmes for promoting biodiversity valuation studies

Strategies

Set up and strengthen appropriate agencies / institutions for promoting biodiversity valuation studies

Actions

1. Set up state level committee for monitoring biodiversity valuation
2. A district level co-ordination committee of the officers and scientists of concerned departments and Institutions involving of local Panchayats in the biodiversity conservation programme.

Indicators

1. More number of institutions and studies
2. Generation of knowledge base on biodiversity valuation

Agencies to implement the programme

State planning Board, State Forest Department and a district level committee under the supervision of the District Collector

Possible funding agencies

State and National agencies

EDUCATION, AWARENESS, TRAINING AND RESEARCH

Introduction

It is necessary to make adjustments in the individual and collective lifestyles of all sections of the society, particularly those who have privileged access to natural resources and to the decision making processes that determine the use of the resources to ensure biodiversity conservation. Biodiversity conservation needs to be one of the most critical issues in the management and utilization of all natural resources. It has to be integrated with all sectoral planning, including agriculture, forestry, water resources development, health, tourism, energy and infra structure. It also has to be integrated with issues such as empowerment, equity and gender. People having access to natural resources and who depend on these resources for their livelihood can contribute substantially in conserving biodiversity. Hence empowering these people in management and utilisation of these resources is vital. Equity concerns need to be taken care of to ensure due share of resources to the people belonging to marginalised and vulnerable sections of the community, as their full support is necessary for biodiversity conservation. Again, gender relations are highly influential in the utilisation and management of environmental resources. Women are often the potential forces in the maintenance of biodiversity. They are often repositories of vast amount of indigenous knowledge on local biodiversity accumulated over centuries of use and adaptation and transmitted through generations. They play an active role in biodiversity conservation as a part of their daily activities connected with the management of household. The sections of the society, who waste natural resources through ignorance or greed, can also play a crucial role. Hence to ensure effective biodiversity conservation all sections of the society need to be made aware of the urgent necessity of the resultant adjustment to be made in their individual and collective life styles. All available communication avenues need to be fully utilised for this purpose. Formal and in-formal education and training from grass root to the highest seat of learning should also get top priority.

Another area that needs urgent attention is the research issues involved in conserving biodiversity. Though a net work of research institutions, universities and colleges conducting research on various aspects pertaining to biodiversity exist in the State, scientific information on many aspects are still not available. Expertise and infrastructure for conducting research on various aspects are lacking. Efforts to link research results to field practice, extension activities to make research results available to the concerned and interested public and adequate linkage between

scientific research and indigenous knowledge are the other issues which have to be addressed.

Issue 1 Inadequate emphasis on biodiversity in educational curricula.

A perusal of existing educational curricula, right from nursery level to university reveals that the attention given to biodiversity related issues are far from satisfactory. To ensure integration of biodiversity conservation in the individual and collective lifestyle of people it is very essential to address this problem. The students can influence their family substantially. Besides today's children are future citizens. Hence, care in this aspect assumes special significance. Adequate attention to incorporate biodiversity related issues in the curricula to the extent required is an urgent necessity. To ensure this, making all concerned aware of the problem, building up the necessary infrastructure are of paramount importance.

Reasons

1. Lack of adequate understanding of the significance of issues related to biodiversity and its conservation.
2. Inadequate information regarding the topics on biodiversity to be included in the educational curricula of schools and colleges and the degree & mode of education required.
3. Lack of sufficient books and teaching materials covering the various aspects on biodiversity to be taught at different levels.
4. Lack of motivated teachers well versed with topics on biodiversity to be taught in schools and colleges.

Strategy

Promote introduction of biodiversity and its conservation as an integral component in the educational curricula of schools &colleges.

Actions

1. Creation of awareness among educationists and decision makers regarding the need for introducing biodiversity related topics in the curricula at various levels in schools and colleges.
2. Identification of topics on biodiversity to be included in the educational curricula of schools and colleges.
3. Evaluation of existing curriculae at various levels (primary, high school, college etc) in the context of adequacy of biodiversity related topics.
4. Introduction of biodiversity related topics in the syllabus of schools and colleges to the extent required.
5. Preparation of books and other teaching materials with adequate emphasis on biodiversity

6. Training to teachers at various levels on different aspects of biodiversity and its conservation.
7. Motivation and incentives to the teachers depending on requirement.
8. Monitoring the implementation of the above activities and adoption of measures to rectify the defects identified.

Indicators

1. Increased awareness among educationists and decision makers regarding the need for providing adequate emphasis on biodiversity related topics in the educational curricula of schools and colleges.
2. School and college syllabi covering biodiversity related topics to the extent required.
3. Sufficient teaching materials and books on biodiversity related issues.
4. Well trained & motivated school and college teachers fully equipped to teach different aspects of biodiversity related topics required to be taught in respective levels.
5. Increased conciousness and actions among students about the importance of biodiversity and ways & means of its conservation.

Agencies to implement the programme

State and Central Govt., UGC, NCERT, universities, colleges, schools,research organisations and NGOs.

Possible funding agencies

Local bodies, State & Central Govt, National and International agencies, Private enterprenuers.

Issue 2. Lack of awareness on biodiversity related issues.

Biodiversity related issues are yet to get adequate attention among general public.They are totally unaware of the need for conserving biodiversity.The importance of biodiversity for the social, economic, ecological and cultural well being of the present and future generations is not properly understood by most of the people who have access to natural resources and the decision making process connected with its utilization and management. For ensuring successful biodiversity conservation it is essential to rectify this lacuna urgently.

Reasons

1. Immediate and long-term importance of biodiversity is yet to get adequate attention of the public.
2. Inadequate understanding of the potential of biodiversity as a means for sustainable development.
3. Inadequate appreciation of relation of biodiversity to man’s cultural diversity.

Strategy

Create awareness about the significance of biodiversity and its conservation among all sections of society - Politicians, planners, administrators, media, academia, judiciary, industrialists and businessmen, farmers, students and the general public at large.

Actions

1. Highlight the importance of biodiversity conservation as a state policy through appropriate forums - among intellectuals, politicians, administrators, policy planners, social workers, academia and other decision makers
2. Organize seminars and workshops on biodiversity for different professional groups such as media, judiciary, medical, engineers, industrialists, managers and traders.
3. Proactive campaigns through varied forms of media such as national & regional (including vernacular) newspapers/magazines, TV, radio and cable networks on the significance of biodiversity on immediate and long-term quality of life of the people.
4. The potential of Information Technology should be fully utilized.
5. Create awareness in the public on biodiversity culture links and emphasize common household activities such as waste recycling, rain water harvesting, organic farming, sustainable agricultural practices, traditional food processing and eating habits, traditional first aid measures, folklore and their linkage to biodiversity conservation.
6. Involve various non-governmental and governmental agencies in promoting awareness to the maximum extent possible.
7. Involve people such as teachers, extension workers, social workers, gram sevaks, health workers, anganvadis and Kudumbasree units on biodiversity related issues.
8. Promote development of adequate publicity materials, literature, TV programs, documentaries and computer software highlighting the relevance of biodiversity and its conservation.

Indicators

1. Increased awareness among policy planners and decision-makers about the importance of biodiversity and the need for promoting awareness among different sections of the society.
2. Biodiversity conscious media, judiciary, engineers, doctors, lawyers, industrialists, politicians and administrators.
3. Sufficient availability of publicity materials, literature, TV programs multimedia and documentaries high lighting various aspects of biodiversity and its conservation.

4. More number of workshops, seminars, symposia, awareness campaigns tailored to suit the requirement of different sections of the society.
5. Increased awareness on biodiversity among various sections of the society.

Agencies to implement the programme

Media, Research institutions, Universities, State and Central Govt. departments, Non-Governmental Organizations and Local Self-Governments (LSGs)

Possible funding agencies

Central and State governments, Local bodies, Industries & business houses, NGOs and National & International agencies supporting biodiversity conservation.

Issue 3. Lack of adequate training among the different sections of the society about the various aspects pertaining to biodiversity conservation.

Reasons

1. Lack of adequate awareness among the policy planners and decision makers about the need for providing training on various aspects pertaining to biodiversity conservation to different sections of the society.
2. Absence of proper understanding of the target groups requiring training,aspects to be covered ,level and mode of training.
3. Shortage of adequate manpower, resources and other infra structure required for providing training to different sections of the society.
4. Lack of adequate appreciation among public about the need for getting trained in different aspects of biodiversity conservation

Strategy

To provide practical training to the people belonging to different sections of the society on various aspects of biodiversity conservation, bring positive attitudinal change and equip them for sustainable use of resources.

Actions

1. Identify the agencies and institutions capable of providing training on different aspects related to biodiversity conservation to different sections of the people.
2. Identify multilevel target groups to be trained by these organizations /agencies.
3. Identify the aspects on biodiversity to be covered and the approaches to be followed while providing training to different target groups.
4. Develop training materials suitable for different target groups.
5. Organize multi-level Trainers' Training Programs to provide sufficient resource persons for imparting training on various aspects of biodiversity conservation to different sections of the society.

6. Organize training programs for various target groups on different aspects directly or indirectly connected with biodiversity conservation on a continuous basis.
7. Make the training on conservation and sustainable use of resources as an integral component of various other related training programs and educational activities targeted to different sections of the society.

Indicators

1. Sufficient agencies and Institutions capable of providing training on biodiversity related issues to different sections of the society
2. Availability of adequate training materials on different aspects of biodiversity and its conservation.
3. Adequate number of manpower equipped to train the multi level target groups.
4. Availability of adequate number of agencies to fund and promote training on biodiversity to different target groups.
5. Availability of sufficient training programs on biodiversity related topics at various levels.
6. Availability of adequate number of people to come forward for attendng training on biodiversity issues and practicing the concepts and approaches learned, in daily life.

Agencies to implement the programme

Media, Research Institutions, Universities, State and Central Govt. departments, Non-Governmental Organizations and LSGs

Possible funding Agencies

Central and State governments, Local bodies, Industries and business houses, NGOs and International agencies.

Issue. 4 Lack of adequate research on different aspects pertaining to biodiversity and its conservation

Reasons

1. Inadequate understanding of the significance of different aspects pertaining to biodiversity and its conservation among policy planners, administrators and scientists.
2. Lack of adequte manpower and resources to undertake research.
3. Lack of sufficient time bound programs for conducting research on a priority basis.
4. Absence of timely transfer and application of research findings for biodiversity conservation at grass root level.

Strategy

To develop adequate infrastructrue , conduct research on priority areas and transfer the findings on a time bound basis.

Actions

1. Increase the awareness among decision-makers on science policy about the importance of biodiversity and its conservation.
2. Identify areas on biodiversity and its conservation requiring research and prioritise them with the active involvement and participation of various specialist groups and stakeholders.
3. Mobilise resources and develop adequate manpower and other infrastructure for undertaking research on prioritised areas in a time bound manner.
4. Prepare research programs on priority areas and conduct research on a timebound basis.
5. Effective monitoring regarding the progress of research and implementation of corrective measures where ever required.
6. Timely transfer of research findings for field application.

Indicators

1. Sound understanding regarding the priority areas of research on biodiversity and its conservation.
2. Awareness among decision makers about the priority areas of research.
3. Availability of adequate funds, manpower and other infrastructure for conducting research on thrust areas.
4. Availability of adequate time bound research programs in priority areas.
5. Enhancement of knowledge in priority areas and reduction in knowledge gaps
6. Timely application of research findings.

Agencies to implement the programme

Media, Research institutions, Universities, State and Central Govt. departments, Non-Governmental Organizations and LSGs

Possible funding agencies

Central and State governments, Local bodies, Industries and business houses, NGOs, National and International agencies

HEALTH AND BIODIVERSITY

Introduction

It is estimated that about 20,000 species of plants are used as source of medicines in the third world countries. In India, about 7000 species are used for medicine along with a few minerals, metals and animal products. Among the Indian systems of medicine, Ayurveda, the most prevalent system in the country, uses about 700 species of plants. Other systems like, *Sidha* uses 500 species of plants, *Unani* 400 species and *Emchi* or *Tibetan* system about 300 species. The Folklore systems play an important role in meeting the health care needs of the rural community in India and use more number of plants than in the Indian systems of medicine.

Kerala has a rich tradition in Ayurveda from very early period and contributed much to the development of this system of medicine. Apart from trained Ayurvedic doctors from institutions, there are a large number of registered as well as unregistered medical practitioners in the state. According to FRLHT, Bangalore there are 7000 A class and 6000 B class medical practitioners in Kerala (Pushpangadan *et al*, 1998). The number of unregistered medical practitioners (Folklore System) is about 5000. There are 750 licensed Ayurvedic medicine manufacturing units and about 1000 unregistered units in Kerala. These medicine manufacturing units as well as practitioners of Local Health Care System use a substantial quantity of medicinal plants and they are collected mostly from the wild.

About 450 raw drugs are used in the manufacture of 500 Ayurvedic medicines on a commercial basis. The annual trade in Ayurvedic medicines is about Rs.200 crore in Kerala (Sasidharan & Muraleedharan, 2000). Among the raw drugs used, only 7 per cent is obtained from cultivated sources. Forests are the main source of raw drugs, which are collected by the Tribes and Local Communities. The demand for drug plants is increasing every year. The increased demand has lead to the over exploitation of these valuable plants resulting in depletion of many species from several forest areas. Though the demand for medicinal plants has been increasing every year, there is no precise data regarding the requirement of raw drugs for Indian Systems of Medicine and Folklore System of Medicine. Efforts are needed to cultivate the drugs which are in short supply in their suitable habitats. An inventory of bioresources used as food and medicine is also an urgent necessity. Lack of standardisation of raw drugs is affecting the quality of herbal medicines. Therefore, establishing the correct identity of the raw drugs and their phytochemical

characterisation are to be taken up. Lack of proper documentation may lead to the piracy of traditional knowledge on bioresources. Preventive measures are also very important than treatment with medicines. Efforts are needed to make awareness among the people in the biocontrol of disease causing organisms as well as carriers through their predators. There has been a decline in the use of traditional food items among the people, mainly due to the preference to use food items, which are freely available in the market. There is also decline in the cultivation of traditional food items.

Under the theme health and biodiversity suggestions are given on strategy and action plan to address the issues.

Issue 1. Scarcity of raw drugs for Indian Systems of Medicine and Folklore Medicines

Reasons

1. Over exploitation from the wild
2. Unsustainable extraction
3. Habitat loss
4. Lack of resource inventory

Strategies

1. Generate data on annual requirement of raw drugs for Indian Systems of Medicine and Folklore System of Medicine
2. Promote studies on sustainable harvesting and post harvest storage
3. Encourage studies to standardise cultivation practices of medicinal plants, their habitat requirements and marketing
4. Popularise good conservation practise by establishing gene banks of medicinal plants at village level
5. Introduction of good collection and storage practice for medicinal plants

Actions

1. Preparation of resource inventory of raw drugs
2. Make it mandatory for the medicine manufacturing units to declare their annual raw drugs requirement
3. Assess the resource, which have become rare or fast depleting.
4. Promote cultivation of medicinal plants in wastelands, homesteads, government lands, forest plantations, etc.
5. Include medicinal plants for raising in “Smirithivams” in memory of National leaders

6. Permit the user agencies to go in for captive breeding of animals of medicinal importance subject to rules and regulation

Indicators

Improved availability of raw drugs

Agencies to implement the programme

R & D Institutions of State and National level

Possible funding agencies

State, National and International agencies

Issue 2. Lack of standardisation of raw drugs and prepared medicines in Indian Systems of Medicine

Reasons

1. Often quite unrelated plants are used as the source of one raw drug.
2. Regional availability and preferences for certain raw drugs.
3. The medicines prepared and marketed under a trade name differ in composition as well as properties, which affects the effectiveness of medicines.
4. Knowledge on the correct identity of raw drugs is eroding from the practitioners as well as the public.
5. Restriction on collection of rare and endangered medicinal plants from the wild.

Strategies

1. Generate data on raw drugs, which are being substituted.
2. Create awareness among practitioners and public.
3. Encourage raising plantations of medicinal plants by medicine manufacturing units in private lands.
4. Effective implementation of good manufacturing practices
5. Ensure the therapeutic efficacy of raw drugs through pharmacological and clinical studies adopting both principles of traditional systems of medicine and modern methodology

Actions

1. Establish the correct botanical identity of raw drugs and their phytochemical characterisation.
2. Formulate rules/laws so that only genuine raw drugs can be sold by raw drugs dealers and sellers.

3. Promote pharmacognostic studies of raw drugs

Indicators

Ensures availability of genuine raw drugs

Agencies to implement the programme

R & D Institutions of State, Central and Ayurveda colleges

Possible funding agencies

Department of Science and Technology, Medicinal Plant Board, Ministry of Health and Family Welfare and other acceptable international funding agencies.

Issue 3. Biopiracy and commercialisation of traditional knowledge

Reasons

1. Lack of proper documentation of traditional knowledge.
2. Unwillingness among traditional practitioners to share their traditional knowledge for documentation.
3. Absence of effective legislation.

Strategies

1. Create awareness among the people about the provisions of convention on Biological Diversity for protecting IPR and the need for documenting traditional knowledge.
2. Formulation of laws relating to IPRs and provision of CBD on benefit sharing.

Actions

1. Documenting traditional knowledge in a standardised format
2. Evaluate the traditional practices and test their usefulness
3. Preparation of biodiversity register at Panchayat levels
4. Preparation of a Digital Library on traditional knowledge

Indicators

Scope for claiming right for IPR and countering Biopiracy

Agencies to implement programme

Research Institutions, NGOs, KIRTADS, Ministry of Health and Family Welfare

Possible funding agencies

State and National agencies

Issue 4. Decline on the use of traditional systems of medicine and food resource among the people

Reasons

1. Preference for using food freely available in the market.
2. Decrease in the cultivation of traditional food crops.
3. Habitat loss, use of pesticides, lack of space in homesteads.
4. Lack of knowledge on traditional food resource and their value among younger generation.
5. Preference to approach modern system of medicine
6. Introduction of exotic food crops.
7. Lack of awareness on meeting primary health care requirements by utilising locally available bioresources

Strategies

1. Promotion of traditional food resources among people and their conservation.
2. Introduce and popularise the holistic approach on primary health care linking with biodiversity and indigenous knowledge.

Actions

1. Create awareness among people on traditional systems of medicine and food resources and their importance.
2. Create awareness among the people on the role of home remedies on primary health care, provide training for the preparation and use of home remedies
3. Create awareness on pros and cons of GM foods as compared to traditional foods
4. Ex situ *conservation of traditional food resources*
5. Generate data on food resource from communities, which mainly depends on traditional sources.
6. Research to improve cultivation, processing and manufacturing of traditional foods.

Indicators

1. Increase in popularity and use of traditional food.
2. Empower people to meet their primary health care requirement using locally available bioresources

Agencies to implement the programme

Research Institutions, Agriculture Department, NGOs, Tribal Welfare Department, Forest Department

Possible funding agencies

Ministry of Environment and Forests, Forest Department

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MICRO-ORGANISM DIVERSITY

Introduction

Microorganisms have contributed substantially towards the original biosphere of Earth. Not only have they made conditions suitable for the evolution and existence of macroscopic life forms, they also continue to drive and profoundly influence many of the essential bio-geo-chemical processes. Furthermore, most of the present-day biodiversity among the eukaryotes is microbial, being generated by the protists, algae, fungi and bacteria, so the consequence is that 'the tree of life is largely a tree of microorganisms with the plants and animals appearing as small, terminal branches. Even though, this fundamental importance of microorganisms can hardly be doubted, little emphasis has been given to understand the diversity of microorganisms and their conservation. Microbial diversity plays an important role in both natural and man-made ecosystems. Besides the species diversity of microorganisms, spectacular functional diversity of microorganisms such as aerobic, anaerobic, facultative, phototrophic, chemotrophic, autotrophic, heterotrophic, etc. and diversity of interspecific relationships such as commensalism, synergism, mutualism, amenalism, competition or parasitism, etc. also occur. These complex relationship among plants, animals, insects and microorganisms and among microorganisms themselves constitute the key to health and growth of all organisms in general and maintaining the environment and the whole ecosystem clean.

Human lives are more closely intertwined with microbes than with any other organisms. However, there is general ignorance about the degree to which our daily life depends on the beneficial activities of many microbes from sewage sludge through to agriculture, and making bread and butter and antibiotics, and other life-saving drugs. In the field of agriculture, functional characteristics of microorganisms like nutrient supply and growth promotion for the plants (biofertilization), antagonism, competition, and mycoparasitism relative to plant pathogens (biocontrol), and degradation of pollutants in the environment (biodegradation), litter decomposition, nutrient cycling, etc. deserve special attention. Microorganisms offer an array of microbial products for agricultural purposes including crop improvement and crop protection. Anaerobic digestion is an effective method for treating many organic wastes and diverse anaerobic bacteria participate in the degradation process and produce innumerable intermediate metabolites as well as products such as methane, carbon dioxide and ammonia. In the medicine and food industries,

microorganisms play a major role and genetic modification of key microorganisms is also applied to improve the quality and quantity of the final products. Thus, the enormous diversity of microorganisms provides the foundation for biotechnology in the areas of agriculture, pharmaceutical industry, food and beverage industry, and chemical industry. Usually, microbes evoke negative feelings because they are also associated with diseases and spoilage. Moreover, microorganisms rank so low on the kinship scale, the demise of a microbial species is not an emotional issue for humans.

The driving forces of microbial diversity include the genetic constitution of these organisms, the environment in which they are found, and ecological interactions with other components of the biosphere. The result is an extraordinary richness of microbial diversity, most of which remains to be explored.

Issue 1. Inadequate information on microorganism diversity in different ecosystems

Microorganisms (bacteria, fungi, actinomycetes, cyanobacteria, virus, protozoans, etc.) thrive in all environments and provide essential services for the biosphere by regulating the composition of the atmosphere, controlling the structure and fertility of soil, quality of water, regulating the pests and diseases, maintaining the health in plants, animals and humans and increasing the productivity. The fundamental importance of microorganisms and the tremendous impact they have made in shaping human history can hardly be questioned. The human lives are more closely linked with microbes than with any other organisms. The critical role they play in maintaining the health and growth of plants, insects, animals and welfare of human beings confer on them an exceptional status in the context of conservation and use of biodiversity. Biological diversity today is getting decimated more rapidly than ever because of the various anthropogenic pressures. Habitat degradation and fragmentation are a few fundamental causes of species extinction. Comprehensive studies on the impact of habitat change or alteration on species diversity are scanty. Inadequacy of knowledge on species distribution and biology restrains decision makers from taking appropriate steps for species conservation contributing to the loss of biodiversity. Also conservation plans without proper understanding of species biology would be futile especially microbes are concerned, as they have restricted ranges and specific microhabitat requirements. At present available information on microorganism diversity is meagre.

Reasons

1. Lack of studies on microorganism diversity
2. Lack of microbial taxonomists
3. Shift in academic programmes towards molecular systamatics

4. Lack of funding on studies related to microorganism diversity

Strategy

Development of human resource and infra-structure

Action 1. Development of data base on microorganism diversity

University departments and research institutions have generated valuable information on microbial diversity, especially knowledge of certain groups of fungi and bacteria in different ecosystems. These information generated mostly as a requirement for research degrees or through short-term research projects is scattered and there is a need to collate the available information.

Actions

1. Retrieval of taxonomic database from assorted sources like reports, thesis, journals and miscellaneous publications from various research organizations and universities.
2. Consultation of research personnels in various research organizations and universities and collection of unpublished information pertaining to microorganism diversity.
3. Collation of the available information and its synthesis into a electronic database.

Action 2. Intensification of research on microorganism diversity

Research programmes dealing with microorganisms diversity have to be intensified. Certain areas of research like microbial ecology and diversity in rhizosphere have received a great deal of attention, while phyllosphere has been described as an ecologically neglected milieu. Natural forests, water bodies, aerosphere, etc. are the other ecosystems least investigated. Usually research programmes dealing with microbial diversity are rarely funded because of a low priority and value judgement placed upon it than is applied to similar biodiversity research on animals and plants groups. This attitude has to be changed and importance of microorganisms has to be recognized sufficiently to assure equitable funding for the study.

At present we do not have the sufficient numbers of experts needed to make serious contributions to the knowledge of microbial diversity in different ecosystems quickly to conserve those group of species. The depleted rank of classical microbial taxonomists has to be augmented by giving training to interested young researchers.

2.1. Development of microbial taxonomic expertise

Microbial taxonomists are scarce because of a shift in academic programmes towards molecular systematics and biotechnology. At present only a very few taxonomic experts of microorganisms are available. While fungal taxonomists are available in a few institutions, taxonomic experts of other groups of microorganisms, especially, actinimycetes, bacteria, viruses, protozoans, etc. are still meagre. Only a few research institutions are handling work on microorganism diversity and this situation mainly owes to a lack of encouragement given to this field and also lack of opportunities, funds and support from sponsoring agencies. A directory of taxonomic expertise in various groups of microorganisms available and research organizations involved in carrying out microorganism diversity studies needs to be prepared.

Actions

Preparation of a directory of microbial taxonomists and experts in Kerala and institutions carrying out microorganism diversity studies and linkages developed.

1. Talented employed scientific professionals to be trained and taxonomic expertise for each group has to be developed along with mechanism to retain the trained manpower.
2. More importance has to be given for microbial taxonomy in the curriculum at college/university level.
3. Provision of opportunities and recognition at national level for those who need to opt for a career in microbial taxonomy.
4. Creation of interactive CDs on all taxonomic groups.
5. Strengthening molecular and genetic taxonomy along with classical taxonomy

2.2. Establishment of research centres for microorganism diversity studies

Research centres exclusively for carrying out microbial diversity in different ecosystems and allied research activities have to be established. At present, research activities on microorganisms diversity at University departments and research institutions are mainly depended on personal initiatives and interests. Undoubtedly, the basic research undertaken in Universities provides the knowledge base necessary for understanding the diversity of organisms and is basis for the biotechnology and related industry, providing critical understanding of genetic and cellular mechanisms and thereby allowing application of biotechnological principles to the improvement of human condition. However, these information is meagre and microorganism diversity study can be strengthened by establishing research centres dealing with distinct groups of microorganisms and separate ecosystems. Research programmes on microbial diversity have to be given high priority and skewed funding policy towards microorganism diversity study taken by many funding agency has to be discouraged.

Actions

1. Research Institutions dealing with different groups of microorganisms, viz., fungi, bacteria, algae, viruses, protiozoans, etc. associated with different ecosystems have to be established.
2. Long-term microorganism biodiversity projects have to be implemented.
3. Microbial research in university departments and other research institutions has to be strengthened.
4. Importance of microorganism diversity studies has to be recognized and equitable funding for its study has to be assured.

2.3 Characterization, conservation and cataloguing of microorganisms, especially beneficial microorganisms

Microorganisms have to be characterized employing modern tools and techniques and then potential candidates can be used for developing various microbial products and also for genetic modification of organisms. Cataloguing of microorganisms have to be carried out and a knowledge base of important metabolic products of the microorganisms or microorganisms themselves can be utilized for the human welfare have to be made. Conservation measures for beneficial microorganisms have to be made. Conservation measures can be both *ex situ* and *in situ* and appropriate niche can be identified and maintained for preservation/conservation of particular group of microorganisms.

Actions

1. Identification and characterization of fungi, bacteria, actinomycetes, viruses, protozoans, etc. from different ecosystems has to be carried out to reveal their full potential.
2. Microorganisms which offer potential in utilization in crop improvement (nitrogen fixing, phosphate solubilizing, nutrient mobilizing, etc.) and crop protection (biological control), etc. have to be properly conserved.
3. Microorganisms which offer potential in utilization in anaerobic digestion (sewage and effluent treatment), pharmaceutical industry, food industry, biotechnology, etc. have to be conserved.
4. Microorganisms which offer potential in utilization in environmental protection (heavy metal fixing, oil and plastic degrading, etc.), have to be conserved.

2.4. Establishment of national repositories

National repositories of microorganisms have to be established to cater the needs of the researchers, industry, etc. Facilities have to be developed to maintain microorganisms belonging to different groups. A specialists' group on microorganism

diversity has to be formed to oversee the activities related to microorganism diversity and allied studies. A linkage of allied institutions has to be developed to strengthen the microbial diversity research and development of data base.

Actions

1. Establishment of authentication centres and reference collections of all groups of microorganisms.
2. Form a specialists group on microorganism diversity
3. Impart training to young scientist in microbial systematics and molecular and genetic taxonomy.
4. Extend identification services to other agencies / institutions involved in microbial research.

Indicators

Increased knowledge base on microorganism diversity in different ecosystems

Agencies to implement the programme

State and Central Government agencies, Universities and Research Institutions

Possible funding agencies

State, Central Governments and Non-government agencies

Issue 2. Micro-organism diversity under threat

Micro-organisms seem to be tolerant to almost any set of conditions thrown at them. Also, they appear to have reproductive capabilities to generate populations of truly astronomic numbers within a very limited time. However, that is a superficial understanding and any belief that microbial species are not threatened is simply wrong. The general phenomenon is that microorganisms are threatened when their ecological niche is threatened. Our knowledge of microbial diversity is so meagre that we do not yet know if and when most species are threatened. So far, we have described only a few species of microorganisms from different ecosystems and many species may be threatened whose existence is still unknown. Our very inability to answer the question of threatened microbial species cries loudly for the need for microbial systematics and ecologists to begin to address the exciting challenges regarding our knowledge of the extent of microbial diversity on Earth.

The main threat and cause of decline of microorganisms can be categorized as resulting from global or specific or local problems. Air pollution, considered globally, may influence fungi through the green house effect producing a slow climate change, as well as existing an indirect effect through modification of vegetation. Such changes might threaten climate-sensitive species and /or forms the development of more thermophilic taxa which could in turn acts alien competitors against native species. The balance between parasites and their hosts might also be changed.

Elevation of sea level could also become a problem for microbes in coastal ecosystems. Another global problem widely recognized to be of paramount importance in the decline of fungi world-wide is the destruction of habitats and the dramatic felling of forests. Air pollution affects many microorganisms, especially fungi; deposition of various pollutants and accumulation of metals leading to soil modification also affect the microorganisms considerably. Fragmentation of habitats makes it difficult for some species to maintain normal population. Deforestation, urban extension, land use changes and change of agricultural practices which employ high input of fertilizer, herbicides and pesticides also threat the diversity of microorganisms. Another possible threat may be due to introduction of genetically modified microorganisms (GMMO) in the ecosystems for controlling the indigenous pests.

Reasons

1. Habitat destruction
2. Changes in land use
3. Replacement of native forest species with exotics
4. Improvement, abandonment and afforestation of semi-natural grasslands
5. Soil, water and air pollution
6. Impact of intensification of agriculture and high input of agro-chemicals
7. Introduction of genetically modified microorganisms (GMMO)

Strategy

Protection of environment

The most satisfactory manner in which to conserve the micro-organisms is through protection of environment and thereby the natural community itself. In some cases, species of microorganisms on verge of extinction or those strictly confined to very limited or threatened habitats can be conserved by growing them in culture media.

Action 1. Generating basic information on biological and functional diversity of microorganisms

Microbial taxonomy is problematic and our understanding of species is very limited. Appropriate biochemical tools have to be developed and deployed to supplement the classical microbial taxonomy. Computer has to be made use to generate database as well as exploit the database for speedy and correct identification and confirmation. Various methods and techniques are in vogue to assess the status of a particular microorganisms. Although many bacterial species can be cultured on media, majority are not easily cultured or are unculturable by present methods. Consequently, we have little idea of the true morphological and functional diversity of all microorganisms.

Appropriate techniques have to be evolved to assess the microbial status correctly and to study their population dynamics in different ecosystems.

Studies have to be carried out to develop functional approaches to determine population dynamics, develop habitat based models to predict species presence and future potential habitat for rare microorganisms and explore and develop methods to survey for rare species of microorganisms.

Basic information on biological and functional diversity of various groups of microorganisms has to be generated. Roots, stems, leaves, flowers, fruits, and seeds of plants, insects and animals, all provide suitable habitats for microbial populations. Numerous microorganisms like fungi and bacteria occupy cortical pores and vascular systems of many plants (endophytes). Similarly, various groups of microorganisms are associated with insects and animals in different ecosystems. Besides the species diversity of microorganisms, spectacular functional diversity of microorganisms also occurs such as metabolic diversity and diversity of interspecific relationships. More information on microbial diversity in natural and man-made ecosystem has to be generated.

Actions

1. Biochemical tools can be developed and used for identification/ confirmation of identity of particular groups of microorganisms.
2. Techniques employed for studying the microbial status in different ecosystems are inefficient in assessing the status and population dynamics of microorganisms. New techniques have to be evolved or the existing ones should be modified.
3. Exhaustive inventories in different ecosystems to be carried out.
4. Systematic studies pertaining to biological and functional diversity have to be initiated.
5. More emphasis should be given to least explored and unexplored habitats of different ecosystems.

Action 2. Enhancing the knowledge of ecology and geographical distribution along with status

Information on ecology and biology of microorganisms has to be generated. This area consists of diverse issues related to taxonomy, systamatics, phylogeny, understanding and documenting microbial communities in space and time, examining

effects of natural and anthropogenic disturbances on the ecology of microorganisms, and exploring important ecosystem functions of microorganisms, particularly their role in ecosystem resiliency and health. Geographical distribution and status of microorganisms also required.

Actions

1. Systematic studies on ecology and biology of microorganisms in various ecosystems.

2. Systematic inventories and mapping programmes to generate data on geographic distribution and status.

Action 3. Afford legal protection to the microorganisms in industry, medicine and agriculture

Microorganisms are very seldom legally protected and all the known and yet to be known microorganisms from this region should be legally protected. Red Data lists for microorganisms are not so far prepared. Red Data lists species that are considered threatened or susceptible to certain area. In agreement with the guidelines of IUCN, five categories of threatened species are distinguished: extinct, critically endangered, vulnerable and susceptible or rare. Most of the wild edible fungi which produce macroscopic reproductive structures are threatened by anthropogenic interventions. Large-scale commercial harvesting of wild mushrooms has to be curtailed. Any attempt of illegal transactions of microorganisms have to be stopped. Exhaustive inventories, mapping programmes, etc. have to be carried out. Red Data lists of microorganisms have to be prepared. Introduction of genetically modified microorganisms (GMMO) in different ecosystems to control the indigenous pests has to be restricted. As widely admitted, microrganisms cannot be protected individually like plants or animals. However, the microorganisms used in medicine, industry and biotechnology have to be legally protected and any substratum containing known or unknown micobes should not be allowed for illegally transaction.

Actions

1. Status of the microorganisms in a particular ecosystem to be ascertained by intensive inventory and Red Data lists to be prepared for important groups of microorganisms.

2. Overexploitation of, as well as destruction, illegal transactions to be avoided by ascertaining legal protection to certain groups of microorganisms.
3. Restricted introduction of genetically modified microorganisms (GMMO) in different ecosystems

Indicators

Increased microflora

Agencies to implement the programme

Research Institutions and Universities

Possible funding agencies

State, national and international funding agencies

NATURAL AQUATIC ECOSYSTEM

Introduction

Kerala state is situated in the extreme tip of the Indian peninsula and it lies between 8^{o} $18^{'}$ and 12^{o} $48^{'}$ N latitude and 74^{o} $52^{'}$ and 77^{o} $22^{'}$ E. longitude. The total area of the State is 38,864km^2 and the population as per the 1991 census was 2,90,11,237. Physiographically, three natural zones have been recognized in the state *viz*., low land, middle land and high land. The backwaters such as the Vembanad and Ashtamudi, the 'kole wetlands' of Trichur, pokkali fields of Ernakulam and 'padasekharams' of Kuttanad are unique to the lowlands of Kerala (CWRDM, 1995). The midland constitutes the major productive area of agriculture and sustains the agro-economy of the state. Highland is endowed with the mighty Western Ghats rising from low altitudes up to 2,000m. Most of the protected areas and the reserve forests are situated in the highlands. The important peaks are Anamudi is the highest peak (2690m) of south India is located Eravikulam National Park in Idukki district. The ghat region supports different types of vegetation such as the tropical wet evergreen, semi-evergreen, moist and dry deciduous, shola forests and grasslands. In addition to these, sacred groves with almost similar vegetation types met within the forests are also preserved in Kerala.

Drainage system

From the Western Ghats of Kerala, forty-four rivers of the state find their origin. Of these, Pambar, Kabbini and Bhavani flow eastwards and ultimately empty into the Bay of Bengal whereas the rest empties into the Arabian Sea. Periyar River has got the maximum length of 244km followed by Bharathapuzha (209km). Pookote of Wayanad district and Sasthamkotta of Kollam district are the only two major natural freshwater lakes in the state. The man-made reservoirs for irrigation and generation of the hydel power spread to a total area of about 30,000 ha (Sugunan, 1995).

Backwaters

Kerala is also endowed with vast inland water bodies in the form of Kayals (backwaters), canals and ponds. There are thirty backwater ecosystems extended over

the state having a total area of about 2.65lakh ha. The most prominent brackishwater lake is the Vembanad Lake with an area of 21,050 ha. followed by Ashtamudi lake in Kollam district.

Marine ecosystem

Kerala has got a coastal length of 590 km, which is almost one tenth of Indian coastline. The state has got 220 landing centres including two major fishing harbours, one at Kochi and another at Sakthikulangara, Kollam District. Kerala occupies the foremost position in the marine fish production in India with a figure of approximately 5.7 lakh tonnes accounting to almost a quarter of the total landings (2.4 million tonnes) from Indian waters. About 97% of the state's fish production is from the marine sector and out of inland fish production of 3%, only 0.3% contributed by reservoirs.

Aquatic resources

Altogether 210 primary freshwater fishes (excluding marine forms visiting freshwaters) are found in the inland waters of Kerala of which 53 species are endemic to the state (coming to 25.24% of the total freshwater fish fauna). The endemic forms include interesting forms like *Lepidopygopsis typus* (confined to the Periyar lake), the blind cat fish (*Horaglanis krishnai*) known only from the subterranean wells on Kottayam district, southern Kerala, dollar minting ornamental species such as *Puntius denisonii, Horabagrus brachysoma*, *H.nigricollaris*, cute little puffer fish, *Tetraodon travancoricus* and cultivable species like *Gonoproktopterus periyarensis*, *G.curmuca*, *Labeo dussuemieri*, and *Neoslissocheilus wynaadensis*. However, there is no consolidated information available on the lower faunal resources inhabiting the freshwaters of the state like the shellfishes (crustaceans-crab, prawns, *etc*. and molluscs). We are reluctant to comment on the freshwater aquatic plant wealth due to lack of information as well as expertise.

A total of about 165 species fin and shellfishes have been listed from the backwaters of Kerala (Kurup *et al*., 1989). Most of them contribute immensely to the fishery and thereby the economic sustainability of the local inhabitants. The most important ones are the fin-fishes like *Mugil cephalus, Liza parsia*, *Lates calcarifer, Etroplus suratensis, Chanos chanos*, *Gerres filamentosus, Silago sihama, Tachysurus*

maculatus and shell-fishes like *Penaeus indicus, Penaeus monodon, Metapenaeus dobsonii, M. monceros, Macrobranchium rosebergii, M. idella, M. latimanus, Scylla serrata, Portunus pelagicus, Villorita cyprinoids* and *Paphia malabarica*.

The marine landings of the state can be divided into two major groups namely the pelagic and demersal. About 650 species of the total 2000 fin and shellfish species reported from Indian seas are being exploited from the Kerala coast. The pelagic group comprises fishes such as oil sardine, lesser sardines, *Stolephorus* spp., ribbonfishes, carangids, mackerels, seer fishes, tunas, barracudas and mullets. The demersal groups comprises fin-fishes such as elasmobranchs, cat fishes, perches, sciaenids, silver bellies, *Lactarius*, pomfrets and 115 crustaceans like shrimps and lobsters; molluscs like green and brown mussels, cephalopods, whelk (*Babylonia spirata*, *B. zeylanica*,), sacred chank (*Turbinella pyrum*) and ornamental molluscs. Nearly 400 species of marine ornamental fin-fishes and 5 species of commercially important echinoderms are reported from the Southern Kerala (Vizhinjam) coast.The "Karikkadi" prawn (*Parapenaeopsis stylifera*) fishery is important only from the Kerala coast. The mudbank ('Chakara' in local parlance) formation during the southwest monsoon season is unique to the marine environment of the state. Nearly 127 species of seaweeds (marine algae) are reported from Kerala coast of which, 100 species have been identified up to species level (Nair *et al*., 1986a,b). Thirty species belong to chlorophytae, 13 phaephytae and 57 rhodophytae. Most of them are economically important as agarophytes, alginophytes and edible sea grasses. Nearly 9 algal species are recorded from the estuaries of Kerala. Recently, Kaladharan *et al.*, (CMFRI, per. comm.) has reported new distributional record of seaweed (*Graciliariopsis lemoniformis*) and a sea-grass (*Halophila baccarii*) from Kerala coast. The total biomass production of seaweeds from Kerala coast is estimated to be 1000 tonnes (wet weight) of which 150 tonnes are economically important (Chennubhotala *et al.*, 1988). Marine mammals as a group require special attention. Of the 32 species of marine mammals recorded from Indian seas, 14 species are reported from the Kerala coast. The information on marine reptiles like sea turtles and sea snakes from Kerala coast is rather scanty. Stray occurrence of 5 species of sea turtles is recorded from Northern Kerala coast *viz*., *Eretmochelys imbricata, Chelonia mydas, Caretta caretta, Lepidochelys olivacea* and *Dermochelys coriacea*.

CONSTRAINTS

The water bodies of the state have been continuously subjected to alterations due to various anthropogenic factors. As a result of these, the life forms are under severe stress. An example to cite is the case of the freshwater fishes. Out of the 98 species evaluated for the status (based on IUCN criteria), all of them were threatened and 15 species were on the verge of extinction. Indiscriminate exploitation of endemic ornamental species like *Puntius denisonii* (Day), *Tetraodon travancoricus* and loaches (Family: Balitoridae) has lead to the condition of endangerment of these species. There are no recent reports of distribution and abundance of the critically endangered blind catfish (*Horaglanis krishnai*),which has found a place in the red data book. In addition to these, the fish disease (Epizootic ulcerative Syndrome (EUS) prevalent in the state has led to the decline of erstwhile abundant species like *Channa micropeltes, C. striatus, Clarias dussumeiri, Horabagrus brachysoma* and *Heteropneustes fossilis*. Introduction of alien species like Indian Major Carps (IMC), Chinese carps and Tilapia has resulted in decline of native species like *Gonoproktopterus curmuca, Labeo dussumeiri, Tor khudree* and *Gonoproktopterus periyarenesis.* In the marine sector, catches of the white fish (*Lactarius lactarius*) and *Tachysurus* (*=Arius*) spp. dwindled drastically (James, 1994) mainly due to over-exploitation. Habitat alterations has also led to the decline of brackish water resources such as *Meretrix meretrix, M. casta* (clam species), fishes like *Trachynotus ovatus, Mugil cephalus* and *Lates calcarifer* (Kurup *et al.*, 1989).

NEED FOR A STRATEGY

The pre-requisite for the biodiversity conservation/preservation as well as the sustainable tapping of the resources is the up-to-date information on the status, distribution and abundance of the species. A critical review of the history of exploration of the freshwaters of Kerala reveals that several workers have contributed to the knowledge on the fishes of Kerala though not comprehensive. Apart from the century old publication of Day (1865; 1875-78), the information on the fish fauna of the state is rather scanty. The recent new descriptions (see Pethiyagoda and Kottelat, 1994) indicate that several forms await a new name. A perusal of the literature shows that several species is 'missing' (Easa and Shaji, 1997) even in their type locality (the place where they were discovered) alarm us to make through study and regular monitoring. However, the recent listing of the species from the State (Gopi, 2000) as well as from the Protected Areas (PA) (see Biju *et al*. 1999; Ajithkumar *et.al*., 1999)

substantially contributed for the assessment of the faunal wealth. As mentioned earlier, these surveys/inventories lack information on the status (based on any criteria) and thorough discussion on any ground). Similarly in the marine sector, a comprehensive list of species including economically unviable occurring along Kerala coast is lacking. Very few attempts are being made to study the brackish water ecosystem as such except in the case of Vembanad and Ashtamudi lakes (Kurup *et al*., 1989; Unnithan, 2001). An atlas of the backwaters of the state giving details of habitat parameters and resources is urgently required to adopt the management strategies to conserve these continuously shrinking habitat.

Issue 1. Lack of adequate knowledge on freshwater and marine biodiversity

Reasons

1. Inadequate information and lack of proper documentation
2. Lack of specialists in certain areas

Strategy

To generate and document the required information

Actions

1. **Continuous monitoring the health status of fauna and flora of the estuarine, marine and freshwater ecosystems.**

Justification

The aquatic systems in the State are in severe stress due to multitude of reasons. The major ones are the obstruction of the river course and regulation of the water flow rate. This has resulted in the salinity intrusion, invasion of the estuarine species and shrinkage of the habitat of the highly adapted stream faunal community. Sand mining in the rivers and indiscriminate trawling in sea result in the removal of the benthos from these ecosystems. The loss of canopy cover along the riverbanks resulted in the increase of water temperature that subsequently led to the mass mortality of the stream communities (Kottelat *et al*., 1993). The deforestation has resulted in high-level soil erosion making the habitat less or fully unsuitable for the adapted micro-macro fauna. Pollution and continuous reclamation of the backwaters resulted in the loss of habitat and disappearance of the species. In the above context, following specific action plans have proposed.

Specific action plans

1. Proper documentation of existing information
2. Monitoring the distribution and abundance of the aquatic fauna of the state with special emphasis on endemic ones.
3. To maintain the viability of the habitat

Inventory surveys

The inventory of the aquatic fauna and flora is very essential for the sustainable utilization and long-term conservation of resources. The only available compilation of the resources is mostly inadequate, a century old and needs updating. A large number of new species have been reported recently. To cite a few, *Garra surendranathani, Mesonemacheilus menoni, M.remadeviensis, Monopterus roseni, Horabagrus nigricollaris, Travancoria elongata and Puntius muvattupuzhaensis*- these indicate that more efforts are required to assess the faunal wealth. Many species were reported to be endangered (Anon, 1998). The extermination of another native species in the wild (see, *Clarias dayi* and similar other species from the Nilgiris quoted by Francis Day during the period of 1865-1889) calls us to make the re-survey. The Kerala Forest Research Institute has carried out in-depth surveys of most of the streams and rivers of the state. Recently, NBFGR under the NATP has funded for the detailed habitat inventory of the freshwater habitats of Kerala with a view to conserve the threatened species and to identify selected areas of rivers as potential sanctuaries (Ponniah and Gopalakrishnan, 2000; Gopalakrishnan and Ponniah, 2000) The College of Fisheries, Cochin under an ICAR funded project has initiated a programme to enlist all the freshwater crustaceans found in the state. From the secondary information, the NBFGR has prepared a database of all freshwater fish species of the Western Ghats including state-wise lists giving emphasis on the endemicity, distribution, abundance and conservation status of these species (Ponniah & Gopalakrishnan, 2000). The CWRDM has enlisted floral and faunal wealth of Pookote lake and Kottoli wetlands in Kerala. An in-depth survey of the Vembanad backwaters has been carried out by Kurup (1989) and Kayamkulam and Vellayani lakes by the Aquatic Biology Department of Kerala University. Detailed inventory of other brackishwater lakes and mangroves of the state is yet to be carried out. Similarly a complete list of all the marine species including uneconomic ones inhabiting the Kerala coast is also lacking. Based on this, following specific action plans are proposed.

Specific action plans

1. To prepare an atlas of brackish water and estuarine resources of the state with special reference to faunal and floral wealth.
2. To prepare an inventory of marine fauna and flora and freshwater crustaceans and molluscs

3. Create the repository of information on freshwater and marine biodiversity

The biological wealth of the nation or bio-geographic area is partly or fully contributed by the systematic exploration by experts of the field concerned. This task requires the collection, preservation, establishment of museums/repositories and functional organizations or institutions for the dissemination of the information. At present, the referred collections of valuable fauna of the state are deposited elsewhere (Paris, Australia, UK or in ZSI at Calcutta) and not available for the ready reference. Establishment of the repositories will avoid duplication of collections on behalf of research/studies. A centralized institution will be useful for co-ordinating information on a particular flora or fauna. The lower phyla (Molluscs, Annelids, Arthropods) need more attention as they contribute much to the diversity but it is poorly documented apparently due to lack of experts. Endemic species of the state should be given adequate priority in such repositories aiding in their conservation programmes. The establishment of the repository is essential to prevent bio-piracy and to safeguard intellectual property rights (IPR).

Specific action plans

To create referral museum on freshwater and marine bio-diversity

Indicators

Database on the status, distribution and abundance of fauna and flora of aquatic ecosystems helpful in the management strategies

Agencies to implement the programme

***National*:** NBFGR, CMFRI, ZSI, BSI, FSI

State: STEC, Universities, Research Institutions, NGOs

Possible funding agencies

International: US fish and wildlife services, Canadian fish and wildlife services, UN agencies, GEF, World Bank (WB).

National: Ministry of Environment and Forests; ICAR, CSIR, Science and Technology Department, DBT, DOD

State: State fisheries department, NGOs, STECH.

Issue 2. Loss of marine and freshwater biodiversity

Reasons

1. Habitat loss
2. Over-exploitation
3. Pollution
4. Introduction of exotics
5. Diseases (Epizootic Ulcerative Syndrome & others) in the wild

Strategies

1. Conserve marine and freshwater biodiversity
2. Mangrove ecosystem should be brought under Protected Area category

Actions

1.Reclamation of the wetlands should be stopped

The wetlands of Kerala encompass paddy fields, kole wetlands, mangroves, etc. other than the riverine ecosystems. The wetlands are being reclaimed in the state for various developmental works. This has far reaching ecological as well as economical effects. The functional diversity of the kole wetlands is diverse. The study on the kole wetlands indicates wide animal groups use this habitat especially the migrant birds. They play very important role in the refilling or recharging the aquifer (ground water table). The paddy fields and Kole wetlands act as a breeding ground for fish species like snakeheads and freshwater sharks and they contain floodwaters.

2.Need for effective legal measures and their implementation

At present the fishery sector in India is regulated by large number of rule both at central and state level. There is a need for a revision of all fishery related rules and their integration into one fishing regulation act. This would provide more effectiveness in implementation. In addition, the gap between the policy framers and policy users are too vast. It is also recommended that steps should be taken to translate all these acts and practices into regional language supplemented by visual illustrations. Innovative measures need to be employed in the extension services of the state fisheries department so that the rules are understood by the stakeholders and adhered to it in letter and spirit. Effective implementation of rules to prevent capture of marine mammals, sea turtles in areas like Thiruvananthapuram and marine sponges and whale sharks to be made.

3. **Indiscriminate capture of fish spawners during monsoon to be stopped**

During the monsoon period, freshwater fishes of low lands (*Channa sp., Labeo dussumieri, Puntius sp., Clarias dussumieiri, Heteropneustes fossilis*, *etc.*) migrate to the inundated paddy fields and shallow areas of the river for breeding activities and such migrations are called as "*Oothayilakkom*" in Malayalam. Indiscriminate capture of the brooders of these species using the harpoons and traps has led to drastic decline of these species, leading to their endangerment. The public are not aware about the consequences of this activity; hence attempts to be made to check the massive collection of fish spawners during the "*Oothayilakkom*".

4. Captive breeding and re-stocking of threatened species

Attempts have already been initiated by the Cochin Unit of NBFGR (National Bureau of Fish Genetic Resources) to replenish the endemic freshwater resources of the

Western Ghats by *ex-situ* conservation and captive breeding. The techniques of milt cryopreservation and captive breeding have been perfected for two native species namely, *Horabagrus brachysoma* and *Labeo dussumieri* in collaboration with the RARS Kumarokom. In a NBFGR funded project, RARS, Kumarakom was also successful in perfecting the captive breeding of the native catfish, *Clarias dussumieri*. Similarly, the college of fisheries, Cochin under NATP – NBFGR Project became successful in the breeding of native ornamental fishes like, *Nemacheilus triangularis*, *Puntius fasciatus, P.filamentosus, Garra menoni* and *Pristolepis marginata* under captivity. Attempts are on the way by NBFGR Cochin Unit to breed *G. curmuca* under captivity and to carry out river ranching and species recovery programme of stocks of *Clarias dussumieri, Channa micropeltes, C. leucopunctatus* and *Labeo dussumieri*. However, more threatened and endemic species are to be considered for captive breeding and river ranching programmes by other organisations.

5. Endemic species to be given top priority in aquaculture practices with incentives

With the introduction of the alien species like Tilapia, IMCs, and Chinese carps, local species like Thooli, Kooral, Manjakoori and Kuyil were totally neglected in aquaculture practices leading to their decline even in natural water bodies. Owing to the fast growth rate of the exotics, their replacement with the native food species will not be preferred by the fish farmers. However, the native popular food species showing better growth rate and better returns may be incorporated in aquaculture practices giving incentives to the farmers. Their artificial propagation techniques also may be developed to be used in the aquaculture practices. The ideal native candidates for the culture practices have been enlisted by Gopalakrishnan and Ponniah (2000).

6. Declare mangrove area as Protected Areas and entrust their restoration and management with local bodies.

Mangroves are the most fragile ecosystem along the west coast. Most of the mangrove areas fall under private land. The shrinkage of this system is at an alarming rate in the state. The mangroves are the breeding grounds of the estuarine as well as the marine fish species. Two thirds of the total marine species breed in the mangrove and spend their early stages of their life in the mangroves. The vegetation in the mangroves is highly adapted and unique. They serve as filters of the heavy metals from entering the seawater. More over they act as a barrier from the seacoast erosion. No concerted efforts have been taken to study the ecology of the mangrove ecosystems, their functional diversity and conservation. For better conservation, they may be brought under PA and managed by local bodies.

7. Exotic aquatic species should not be introduced

As in other parts of the world, several exotic species have become a menace to the native fauna in Kerala also. Exotic common carp, Tilapia and African catfish (*Clarias gariepinus*) have resulted in the decline of local species in several water bodies in Kerala (Kurup *et al*., 2001). The above exotic species and the non-native IMCs and few ornamental fishes like green sword tail, *Pangassius sutchi* and *Lebistes reticulata* are continuously caught from the wild water bodies in the state indicating their gradual establishment in the rivers and streams. Even the most dreaded, carnivorous red piranha (*Pygocentrus nattreri*) is available in aquaria all over the state. So far, there were no guidelines even at national level for controlling the clandestine introduction of exotic fish species. Recently, NBFGR has formulated the guidelines to control the introduction of exotics aquatic species, which is going to be released as an ordinance/bill by the Govt. of India. Any proposal for introduction of exotic species even for ornamental purposes to be viewed seriously for the conservation of native fauna and wherever possible, equally good native species may be given priority *vis-à-vis* its exotic counterpart.

8. Declare bar-mouth areas as no-fishing zones

Bar-mouths are important for migratory species such as mullets, prawns and other fishes through which they migrate to sea for breeding activities. Indiscriminate fishing activities in the bar-mouth areas would lead to decline in the number of spawners and hence fishing activity in bar-mouth areas needs to be banned.

Indicators

Preservation/conservation of the biodiversity

Agencies to implement the programme

National: NBFGR, CMFRI, CIFRI

State: Kerala Forest Department, Fisheries Department, Local bodies, ADAK, KAU

Possible funding agencies

International: WB, GEF, US Fish and Wildlife Service

National: MoEF, ICAR, DOD.

State: Fisheries Department, KFD

Issue 3. Inter-state / eco-regional problems

Reasons

Political boundaries sharing same eco-regions but policies differ between states**.**

Strategy

Activities/ (eco) developmental projects/forestry operations should be viewed on the ground of the ecological disaster/impact on the contiguous ecosystems in the neighbouring state.

Actions

A panel of experts from neighbouring states to monitor the eco-regional issues to advise the policy makers.

JUSTIFICATION

The major habitats especially the rivers and forested area share the political boundaries so that a consensus while making policies is very crucial. The laws as well as its amendments should be in such a way that the participation of the stakeholders both regions must be ensured. As south Indian states concerned, the major rivers originate from one state but pass through another one. Any habitat alteration, pollution, etc. in the upper reaches of the rivers/streams will have an adverse effect in the lower reaches of the river in adjacent state. The netting in Kabini river in Karnataka region hindered the upstream movement (towards Kerala portion) especially the spawners. This has also resulted in the decline in catches in Kerala part of the river. Similarly, habitat alterations in Mahe region of the Union Territory have adversely affected the mangrove ecosystem of Thalasserry and Kannur of Kerala.

Indicators

Mitigation the interstate eco-regional socio-ecological problems

Agencies to implement the programme

Interstate: State Forest, Agriculture and Fisheries Departments, Tribal Development Agencies, Irrigation Departments, Tribunals for the interstate river disputes, MoEF, Researchers from premier organizations.

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NATURAL TERRESTRIAL ECOSYSTEM

1. Ecosystem Profile

Kerala state is a narrow segment of land in the southeastern part of Peninsular India extending over a distance of 560 km along the west coast sandwiched between the Lakshadweep sea (Arabian Sea) and the Western Ghats. The area of the state is 38,863 sq. kms. (Resource Atlas, 1984). The state has a very high density of population. This state with a total area slightly over 1 % of the total area of India supports about 4 % of country's population.

1.1 Physiography

Physiographically the state can be divided into low land (<8m) midland (8-75m) and highland (>75m) from west to east. The altitudinal variation from west to East within a short distance (maximum < 120km) from msl to over 2500 m plays a vital role in the terrain condition contributing to diversity in fauna and flora. This elevation difference influences the climate and distribution of vegeation. The coastal stretch falling within the low land region shows a few isolated scattered hillocks and rocky cliffs. Within this low land are distributed a string of 34 kayals (lagoons or estuaries), the largest among them is Vembanad lake, 205 sq. kms). Generally, the low land lying close to the seashores negligible undulations and comprise beaches and strand plains with beach ridges and swales trending roughly parallel to the present day shoreline. Most of the rivers show regular meandering channels in the coastal zone. The entire coastal zone is covered by coconut trees, paddy, extensive wetlands isolated remnants of mangrove vegetation etc.

The midland region form the inter junction between the coastal plain and the highland region consisting of deeply weathered and dissected hills generally showing a laterite cover.

About 40% of the state falls within the highland region above an altitude of 75 m forming part of the western slopes of Western Ghats. A major part of this spectacular ranges is dissected by numerous west flowing rivers resulting in varied land forms. These mountain ranges are essentially plateau remnants forming plateau land forms called plantation surfaces of three of more altitudinal ranges of which the major ones with regional extent are identified around 1800m, 1200m and 600m. These plateau land forms have very steep side slope with major slope breaks between older and younger plantation surfaces. These abrupt elevation differences reflected in the river profiles are utilized for the hydroelectric power projects. The Palghat Gap having a width of about 30 km is a major natural discontinuity within the Western Ghats. The elevation in this part is below 300m. This major discontinuity in the continuous stretches of Western Ghats is considered as a tectono - erosional land form.

1.2 **Drainage (Rivers/stream).**

The drainage network in this part of the country consists of 44 short and swift flowing streams all originating from Western Ghats. Generally these streams show a high gradient in their course through high land with youthful characteristics. They are having broad valleys with depositional landforms only in their course through the low land region. The steep gradient of the rivers permits swift and speedy surface flow with low rate of percolation. As a whole the river system contributes to active erosion and slope retreat in the high land region resulting in erosional or denudational land forms with depositional land forms restricted only to the low land region. The development of drainage network is the focus for the interacting processes, which carry water and sediments out of a drainage basin leading ultimately to shape the landscape. Drainage basin/watershed reveal many details about streams and their geologic and geomorphic set up which forms the basis of evolution of diverse eco systems.

1.3 Slope of terrain

The land surface from the summit of hills to the base of valleys is bounded by a sloping surface of the slope. The complexity of form and multivariate nature of processes that act on it makes its evaluation important not only in all anthropogenic activities but also in the evolution of diverse conditions supporting individual ecosystems. Based on slope of terrain the following physiographic units can be identified in the state. The eastern most unit forms the Sahyadris and adjoining midland having an altitude of more than 300m. The dissected segments and high level plateau remnants (>600m) of Western Ghats are characterized by highly sloping segments. The plateau edges are highly indented having 70 to 100 % slope. Palghat gap is the only interruption within this unit. West of this unit lies the midland area of moderately to steeply sloping ridges having an altitude range of 50 to 300m. The slope ranges from 55-66%. The topography is highly dissected due to intensive fluvial action. Valleys are deep and narrow. The ridges especially in the northern part have flat tops with laterite cappings. Change in slope from the eastern unit to this region is evident from the adrupt slope breaks (Knick points) in the profile of rivers. The above unit is succeeded towards west by a transitional zone of slope range 10-20% with isolated hillocks. The extreme western part is nearly level to very gentle sloping coastal plains falling below an elevation of 10m which is mostly depositional developed by fluvial as well as marine action. Features like alluvial plains, lagoons, coastal dunes, and mudflats indicate preponderance of aggradational process compared to the other eastern units.

1.4 Geology

Geologically the major part of this state is covered by Precambrian crystalline comprises chiefly Charnockites, Khondalites, Granite gneisses. Dharwar schists and Granites traversed by younger basic dykes. Occurrences of sedimentary rocks belonging to Cenozoic age is found as discontinuous outcrops along the coastal stretch with its basin extending into the offshore part. Laterite of presumably quaternary age is seen over the sedimentaries and also on the crystallines in the midland region. Recent sediments are represented by soil and alluvium along the valley sections of coastal and midland units.

1.5 Groundwater

The above geological setup indicates that 90% of the total geographic area of the state is occupied by Precambrian crystallines and the rest by sedimentary rocks. Generally, the crystallines are poor aquifers from a groundwater point of view. The upper weathered portion of crystallines wherever it is deep and located in favourable topography supports open wells. Fractured zones in crystallines some times supports high yielding borewells. The thick laterite cover in the midland region is a rich source of ground water and usually supports the domestic wells found throughout Kerala. Ground water in sedimentaries occur both under water table and confined condition. Cenozoic confined aquifers in the deeper horizon located in the south and middle areas of Kerala coastal zone are highly potential. Coastal alluvium has a fresh water zone in an unconfined condition. However, this aquifer is very sensitive and over exploitation and mismanagement can lead to saline intrusion and pollution.

1.6 Soils

In general the soils of this state is dominated by lateritic soil and forest loams. Other soil types have developed in certain areas due to local physiographic factors. Based on the physico chemical properties and morphological features they are classified by the Soil Survey Unit of the Department of Agriculture, Govt. of Kerala into 10 Soil Groups which could be identified with thirteen Great Groups of soil taxonomy.

1.7 Climate

The State falls in a region of tropical climate. The coastal location of the state and abrupt change of elevation within a short distance from the coast due to the disposition of Western Ghats influence the climatic condition of this region. While most of the areas are under tropical dry and wet condition with high maritone influences, certain areas in the eastern parts experience sub tropical type of climate.

The period March-May is the hottest when temperature reaches a maximum ($>32^0$c). From June it gradually comes down due to heavy monsoon. Again an increasing

trend is noticed in October and November followed by lower temperatures (<27^0c) in December and January. The seasonal and diurnal variation of temperature are not uniform throughout the state. The stations located near the coast are influenced by land and sea breezed and the seasonal and diurnal variations are almost of the same range (5^0 c to 7^0 c). At Palghat the mean seasonal variation is less than the diurnal variation but in high ranges which are typically subtropical the diurnal variation is very high (15^0 c in some months). This is a typical example of a par-humid area where the tropical climate has been remarkably modified by the higher altitudes (Resource Atlas, 1984).

The area receives a high rainfall amounting to an annual average precipitation of about 300 cms (Resource Atlas, 1984). The following seasons are identified. South west monsoon (June-September), North-east monsoon (October-December) and Pre-monsoon (January-May). An analysis of rain fall data for the period 1901-1950 and 1961-1980 by Sampth *et.al.* 1989 indicates the following. The total rain fall in the coastal tract received during south west monsoon steadily increase from Trivandrum (863 mm) in the south to Kasaragod (2936 mm) in the north. The co-efficient of variation on the other hand, decrease from south (Trivandrum, 31) to north (Kasaragod, 17). This indicates that the variation in rain fall from year to year is less as we move northward. The percentage contribution of south west monsoon to annual rain fall also increases from south (Trivandrum, 46%) to north (Kasaragod, 83%). The coastal area north of Palghat, gets more than 80% of the annual rain fall from south west monsoon. The north-east monsoon shows a larger variability from one year to another. The percentage contribution of north-east monsoon varies from 9% in Kasaragod to 33% in Trivandrum indicating a significant high level in the region south of Palghat Gap. The pre-monsoon contribution ranges from 260 mm to 619 mm and significant in the region South of Cochin. The characteristics of rain fall in the midland region below an altitude of 600m are similar to that of coastal tract.

The high land region above an altitude of 600 m above msl receives an annual total ranging from 2100 mm to 4200 mm with the north-east monsoon and pre-monsoon contributing to about 20 & 37% respectively. Since these two monsoon periods have a large co-efficient of variation, the total rain fall in this region will exhibit a large variation from one year to another. The variation in rainfall both in its spacial distribution and local intensity due to the orographic effect of Western Ghats is poorly understood and the present network of weather situation is inadequate to make a complete assessment of rain fall variation in this region.

1.8 Vegetation

The natural vegetation in the form of forests are confined to parts of highland and midland zones falling within Western Ghats and its foot hills. As per records of the forest department the total forest area, which includes plantation comprise 24% of the total geographical area.

The vegetation types includes Wet evergreen and Semi evergreen, Moist deciduous, Dry deciduous, Montane subtropical and temperate, Plantation and others. The forest types like reed, bamboo and grasslands form part of these major types of vegetation. Evergreen forests are generally confined to the rugged slopes of Western Ghats. Evergreen, semi-evergreen and moist deciduous forest types are located in the rain fall zone of 200-300 cm with temperature more than 20^0C. Most of these areas fall above an elevation of 300m. The dry deciduous forest is confined to the rain shadow region where the annual rainfall is about 100 cms and temperature in winter season is considerably low. The sub tropical or Montane sub-temperate evergreen forests commonly known as temperate shoal, occurs in valleys of the high ranges. Grasslands are seen as isolated patches. Extensive grasslands are confined to the plateau land forms of Western Ghats.

Forest plantations include teak, eucalyptus, softwood and others in their order of extent. There are over 500 species of identified medicinal plants a part from many varieties of orchids etc., prevalent in this part of Western Ghats.

The climate variation especially temperature due to presence of sea in the west and high relief in the east has endowed the state with a unique agro-climate favourable for cultivation of a wide variety of crops. The highland region (>1000m) with colder climate favours plantation crops like cardamom, tea and coffee but the low land and midlands with warm humid climate sustain a variety of tropical crops including rubber.

1.9 Land use

The land use distinctly dependent on physiography and climate of the state. There are five broad categories of land use distributed in this state (Resource Atlas, 1984). It is seen that arable land forms a continuous stretch along the entire state extending from the coast to the inland up to 100m above msl and further east only along the river valleys. Both irrigated and un-irrigated land fall within this category. The next important group is the forest land, the western limit of which can roughly be marked by 300m contour. The entire eastern part of the state, except in the vicinity of Palghat

Gap, is forest land. Forest land has been used for developing many plantations. The high altitudes plantations in Periyar-Idukki and Wynad plateau are mainly tea, coffee and cardamom while the plantation along the western fringes of the forest land are mostly rubber. Grasslands are noted throughout the state in isolate patches. Extensive waste lands formed of hard laterite as plateau lands unsuitable for cultivation are found in the northern parts of the state.

Due to high pressure of population on land, most of the land is put to use for some productive purpose or other. Permanent pastures and grazing land are therefore, very limited in the state. The land put to non agricultural use includes areas under settlements, water bodies, roads and other cultural uses. The districts having major portion under lowland record higher percentage of areas under this category.

Issue 1-Land degradation

Reasons:

Accelerated soil erosion

Major part of the state falls on the western slope of Western Ghats which is an area undergoing severe fluvial action and consequent erosion as well as slope retreat. Improper land use causes accelerated erosion contributing to degradation of terrestrial ecosystems by removal of precious soil cover which is generally thin in the high land region. Even under thick vegetation cover of forests the thickness of soil is hardly more than a few meters which except in plateau land forms rests directly cover the Precambrian hard crystalline rock basement.

Improper Land use

The state has a high density of population and land available is at a premium. This promotes improper land use practices which are non-sustainable and are only of temporary economic advantage. The way in which a part of the landscape serves a functional purpose defines its land use. The land is recognized as constituting both a commodity and a resource which requires adequate conservation policies for its proper utilization by the society. Natural features on surface of earth undergo continuous change. Anthropogenic activity/land use practices some times can accelerate the process involved so as to make these changes sudden or abrupt reaching hazard producing status. Land use and land cover classification systems have to be evolved based on the physiographic and climatic aspects of terrain.

Destruction of Natural vegetation

Surficial and mass stability of slopes are significantly influenced by vegetation cover. The protective role of vegetation ranges from mechanical reinforcement of soil by the root system, rain drop interception by foliage and soil moisture control by evapo-transpiration. Major part of Kerala is falling within the highland region of Western Ghats. However, the last few decades witnessed large scale human migration into this region resulting in the conservation of natural vegetation into mono cultural plantations and seasonal crop areas. Further, the continuous stretch of natural vegetation were cut down into unsustainable patches by various developmental activities like roads, canals, power projects etc. This whole process of degradation of natural vegetation and consequent land cover changes made the western slopes of Western Ghats environmentally fragile and physically unstable.

Inappropriate management practices of forests and revenue land

There is no definite policy guide lines or appropriate authority for management of forest/revenue land based on scientific principles. Even a proper evaluation of the terrain characteristics for desirable management strategy is not feasible due to lack of relevant terrain data on a large scale. Watershed based management may be appropriate. Definite policy decisions and political will to implement these are necessary with long term management options which are socially acceptable and suitable to the terrain/climate conditions and at the same time economically viable to improve the quality of life of inhabitants.

Non-sustainable developmental activities

Many developmental activities takes into consideration only short term benefits. Some of them are non sustainable and their implementation politically motivated. Many projects implemented prior to 1975 were done without assessing their adverse impacts on terrain system. Proper environmental impact assessment of developmental activities is essential. It is time curb the tendency of giving high weightage to political and regional consideration over environmental issues.

Introduction of Exotics

Introduction of alien species of flora can disrupt equilibrium of the terrestrial ecosystem. This introduction may be accidental or intentional. In Intentional cases it is for short term and temporary economic benefits. In both cases such introduction of exotics in most cases plays havoc on the local terrestrial ecosystem.

Man made and natural calamities

Natural calamities are events that occur suddenly and swiftly causing heavy damage to life and property. Floods, earthquakes, landslides, wild fires are some of them. Even though most of them are natural phenomena, in some cases like floods, landslides etc., the human activities accelerate the processes that lead to the natural calamities. A typical example of such phenomenon is the devastating landslides in the Western Ghats during monsoon.

Strategy

Develop and follow appropriate land management practices so as to reduce/minimize land degradation.

Actions

1.Generate information on site-specific landuse planning

The Geological and geomorphic peculiarities of terrain falling between Western Ghats and Lakshadweep sea encompasses the flat coastal terrain, laterite covered deeply weathered highly dissected midland region and the high sloping erosion prone high land region having a thin soil cover. Apart from these the severe monsoon rains and elevation difference from m.s.l to over 2500m within a short distance from coast present diverse terrain conditions with varying soil, water and climate conditions supporting habitats which are unique. Such terrain information on a larger scale is essential for planning sustainable land use. Terrain information on such scale is lacking in the state which need be generated as a first step.

2.Create awareness regarding sustainable use of land resources

The presence of population and impact of developmental programmes force man into relatively virgin environments. Such invasion involves tampering with landscape and disturbing the habitats of the flora and fauna. It is recognized that unscientific developmental activities has resulted in severe environmental degradation and a steadily declining quality of life for people. An awareness at all levels especially among the local community on environmental preservation can go a long way in that it can ensure active people's participation. Another important factor to be ensured is the creation of awareness among the planners and administrative executives to appreciate the need for land resources conservation and management in all developmental work. Environmental preservation to provide assured quality of life to the inhabitants should be the long term strategy of all planning processes.

3.Increase vegetation cover and initiate action for reduction of soil erosion

The area falling on the western slopes of the Western Ghats forming the major part of the state in the recent past was covered mostly by natural vegeatation. The human activity during the last few decades is reducing this natural vegetation cover at an alarming rate. The natural vegetation is destroyed, degraded or being replaced by mono-cultural plantations, seasonal crops or converted as settlement areas. This trend is not only to be stopped but if possible reversed. The remaining patches of natural vegetation has to be preserved and protected at all cost. The degraded area as well as areas without vegetation cover are to be subjected to afforestation schemes to enhance the spatial extent of healthy vegetation cover. Such activity can protect the soil and water these by preserving a healthy terrain ecosystem. Watershed based developmental planning is a viable proposal which can be effectively adopted.

Indicator

Better ecosystem health and increased productivity

The monitoring of the eco-system is essential. Once the strategy is implemented its effects will be reflected in improved ecosystem health and there by enhance productivity. Ultimately the inhabitants quality of life forms an indicator

Agencies to implement the programme

State, National and International agencies.

Possible funding agencies

State, National and International agencies

Issue 2. Degradation of river basin

Reasons

1. River pollution due to industry, tourism, agriculture, urbanization etc.

Rivers in Kerala are very small compared to the major rivers in other parts of the country. The high density of population and concentration of urban centers near rivers cause untreated solid as well as liquid waste reaching rivers. Waste treatment facilities are inadequate in the industries which causes direct entry of untreated industrial waste into the river system. Similarly pesticide pollution from agriculture is another factor urbanization is causing direct influx of urban waste into the rivers and

water bodies like estuaries. During the lean flow period most of the rivers have inadequate water flow to wash out the pollutants.

2. Sand, clay mining and quarrying.

Sand mining in rivers of Kerala has reached a stage of affecting the existence of the river system causing lowering of ground water level thereby reducing the contribution of ground water to the rivers to maintain the summer lean flow. The natural profile of the stream is destroyed causing imbalance in stream development. Clay mining activity is disturbing the flood plain areas and affects the river regime.

3. Adverse, Impacts of hydropower and irrigation projects.

The artificial reservoirs influences the sediment load in the stream causing shortage at lower sections. Some times inter basin transfer of water causes major ecological changes due to shortage of water in affected sections. Such reservoirs often affects the natural flow of stream sections. The effects of projects on the catchment is an important aspect to be taken into consideration.

4. Reclamation

This problem is more severe in the coastal and midland section. Almost all the flood plains of rivers are converted into settlements by filling and reclamation reducing the effective flood cushioning area. Further, such reclamation of low land reduces residence time of monsoon water in the terrain causing less input into ground water.

5. Salt-water intrusion

Salt water intrusion into river system increases when lean period flow becomes insufficient to counteract entry of salt water from sea. This happens both through river channel as well as through subsurface flow due to lowering of water table when river flow is hampered.

6. Weed growth in river /water bodies

This is especially alarming in the coastal stretches in the estuarine and lagoonal areas. The weed growth completely chokes the water bodies and destroy the quality of water making it absolutely impossible for any life form to survive.

7. Destruction of wetlands

These are the first causalities in reclamation. Since population is very high and most of the urban centers are concentrated along the coastal land, there is demand for land for settlement and agriculture. These wetlands maintain the surface water-ground water balance to maintain the lean flow. Further, they are an unique ecosystem by itself like the mangrove vegetation which is being eliminated at a very drastic manner.

8. Lowering of water table

Lowering of water table is caused by over exploitation, sand mining, loss of flooding low lands, low percolation from rain etc., has its effect on the river flow. In the normal setup river flow contributes to ground water in the rainy season while water table supports streams during summer months. This balance is disrupted by lowering of water table resulting in drying up of streams immediately after monsoon.

Strategy

Scientific river basin management

Actions

1. Reduce catchment degradation due to uncontrolled and improper landuse, deforestation, grazing etc.

This is a major aspect in the river basin management. Degradation of catchment zone reduces the water holding capacity of terrain and the entire water goes as surface flow with reduction in base flow. Degradation of catchment finally destroy the perennial nature of the river system. Since almost all the catchment of rivers in Kerala falls in the Western Ghats, this essentially involves the strategy of managing the fragile ecosystems falling within the western slopes of Western Ghats. Curbing improper landuse, protection of existing natural vegetation, revival of degraded vegeatation, aforestation of areas devoid of vegetation with appropriate local species, maintenance of grasslands and similar natural ecosystem, controlling encroachment of forests preventing uncontrolled grazing, providing soil erosion protection measures in degraded catchment, idenfication of critical zones which are prone to mass movements and their management are some of the aspects on which action need be initiated based on a scientific terrain evaluation of the catchment concerned. Such action can convert many seasonal streams of Kerala into perennial streams and also improve the ground water availability in many watersheds down streams.

2. Control of river pollution

Pollution of rivers mainly happens in their course through urban centers due to discharge of urban waste into the rivers. Discharge of industrial waste is another area which needs immediate action. Pollution from pesticides used in plantations pollute the upper reaches. While the same used in the lower wet land paddy and seasonal crops affect the lower reaches. Proper urban waste management can contribute significantly to the river health condition. In many cases improvement of lean flow by proper catchment management can bring down the intensity of pollution through dilution. However, river pollution is an area which needs immediate effective preventive action as it is observed that with time the situation is continuously deteriorating.

3. Regulation of mining activities along river and its environs (sand/clay)

Sand mining in the river bed, sand mining in flood plains and palaeo channels, clay mining within minor watersheds feeding main streams, clay and limeshell mining in lagoons and estuaries are some of the aspects which needs thorough evaluation to assess their influence in the degradation of the river basin and its environs.

4. Weed control

The pollution is acute in the lower reaches and in the lagoons and estuaries. This affects the usual flow of rivers and also degrade the quality of water thereby degrading the river health.

5.Introduced watershed management practices

Each river basin consists of several water sheds of varying dimension. If all these watersheds are managed in such a way so as to improve the retention capacity of the substratum and at the same time preventing soil erosion the entire basin will show dramatic improvement. With a little effort many seasonal streams can be changed to perennial ones especially if their course through midland laterite area is properly treated with water conservation measures. Implementation of an appropriate program on this lines can almost eliminate the water shortage especially of drinking water in some parts of Kerala during summer months.

Indicators

Improvement of the health of the river system

On implementation of action points the improvement of health of river system can be observed by increased lean season flow, seasonallaty gradually changing to

perenniability, improvement of quality of water, improvement of ground water condition in the river basin etc.

Agencies to implement the programme

State, National and International agencies, Central Board of Irrigation and Power

Possible funding Agencies

State, National and International agencies, Local bodies, Panchayat, State Government

Issue 3. Issues related to ground water

Reasons

1. Lowering of ground water table

This is caused by over exploitation, reduction of recharge due to destruction of basinal catchment area, reclamation of low land area, destruction of surface water bodies, removal of natural vegetation, excess surface evaporation due to exposure, uncontrolled mining activities etc.

2. Land use and land cover changes

Any type of land use which increases overland flow and reduces percolation will adversely affect the ground water condition.

3. Over exploitation

In some parts over exploitation causes lowering of water table. Such areas to be identified and drawl controlled. This is a problem in some coastal alluvial squifers causing saline intrusion. In some cases proper conservation measures can give more yield.

4. Degradation of river system

The influence of river system on ground water regime is well understood. In water management unless the approach is a combined one for surface as well as subsurface or ground water it can not provide the desired results in a sustainable way.

5. Soil profile destruction

Soil is the medium through which water enters from into the ground. In the hydrologic cycle soil plays an important role and their destruction will adversely affect the ground water condition of an area

6. Mining (sand and clay)

This type of deposits occur mainly along river channels and also in the palaeo channels and low lying areas near rivers. Sand mining can lower the base level of streams exposing basement rocks thus lowering the water table. Mining as a rule disrupts the natural landscape, affects the water table level and thus the percolation rate in the river basin.

7. Pollution (Saline water intrusion effluence from industries, sewage disposal)

Saline water intrusion into ground water is a common feature in the coastal alluvium in cases where over exploitation happens. Similarly salinity influx in rivers due to decrease of lean flow can also cause salinity influx in the phreatic zone. In the coastal alluvium pollution from sewage is almost seen in all places with high density of population and inadequate sanitation facilities. This is true in laterite areas also industrial effluence entering surface water is another pollutant of ground water. So far no pollution has been noticed in the semi confined tertiary aquifers. However, the possibility of their future pollution from the possible midland lateritic recharge zones needs investigation. Increase of saline influx in streams and rivers due to reduced lean flow can affect the recharge zones. Similarly urbanization of recharge areas can possibly cause quality deterioration of these potential aquifers. Pollution of deep seated fracture zones in Precambrian aquifers is not reported except in areas near coast, but this aspect needs further research and evaluation to understand them

8. Urbanization

Apart from the pollution effects of urbanization other important aspect is the increase of built up area causing excess run off and lowering of percolation. Concrete paving and landscaping with storm drainage arrangements decrease exposed surface area for ground water recharge. Reclamation and reduction of wetlands (paddy fields), reduction of vegetation etc., are also results of urbanization adversely affecting ground water condition.

Strategy

Sustainable utilization of ground water resources

Being a state having a highly sloping terrain condition, the residence time of rain water on land is minimal causing shortage during non-monsoon and summer months. Any strategy for water management in this state should involve both surface and ground water since both are mutually complimentary. Decrease in quantity or deterioration in quality of one will in course of time affect the other also. Unless this aspect is taken into consideration, and the present trend of different agencies dealing exclusively the management of surface water and ground water is curbed effective management of water resources of Kerala is not possible. A sustainable use of ground water resources once achieved, the water shortage in Kerala can be eliminated in addition to making many seasonal streams perennial.

Actions

1. Proper and continuous qualitative and quantitative ground water resources evaluation

Large scale monitoring network is to be established throughout the state for ground water monitoring. Recharge areas are to be closely monitored to assure both quantity and quality. A proper monitoring of the various stages of the hydrologic cycle active in the area in its broader aspect is essential. A combined resource evaluation of surface and ground water to understand their mutual contribution and dependability need be appreciated.

2. Evolving proper management strategies.

On the basis of resources evaluation a proper combined management strategy for surfaces and ground water for the state is essential taking into consideration the Geological, physiographic and climatic peculiarities of the state.

Indicators

Improved quality and quantity of ground water

Agencies to implement the programme

State, National and International agencies

Possible funding agencies

State, National and International agencies

Issue 4. Pollution

Reasons

1. Mining

Unscientific and inappropriate mining activities affect the landscape, surface and subsurface water condition etc., resulting in degradation of terrain ecosystem health. This will also affect the vegetation cover also.

2. Unplanned industrial activities.

Industrial activities in areas near major water resources, recharge areas vegetation zones etc., if they are not properly planned to contain their adverse impacts can create havoc to the health of terrestrial eco system. Recycling of waste, proper shortage of end products, treatment of toxic effluents are some of the aspects to be planned and implemented during the establishment stage. EIA for all industrial projects are to be made mandatory irrespective of their size but depending on the degree of fragility of the terrestrial ecosystem on which the establishment is planned.

3. Urbanization

Urbanization leads to influx of more urban waste in the form of untreated sewage into terrestrial eco system affecting its quality. The current trend of increased introduction of anon biodegradable plastic waste is a very alarming situation which needs immediate tackling. Urbanization in general increases the stress on terrestrial ecosystem above its carrying capacity.

4. Agrochemical inputs

Introduction of new techniques of chemical manuring often reaches a stage that the terrain became toxic to many endemic species. Same is the case where excess use of pesticides causing eco system deterioration due to pollution.

Strategy

Reduction of environmental pollution by proper management of terrestrial ecosystem

Actions

1. Create awareness among the public and concerned administrators and planning officials.

Public has to be made aware of the consequences of pollution and the need for preservation of environment. For this, proper awareness programmes are to be planned and executed. The awareness creation at administrative and planning level is as essential process so that even at planning stage required safeguards could be insisted upon. Further, this will ensure prioritization as per environmental preference rather than on regional, political or even economic issues.

2. Enforcement of law against polluting agencies

It may be mentioned that laws are in existence at present to take action against agencies, industries, individuals etc., responsible for any action contributing to pollution of environment. However, implementation of rules is not seriously taken up effectively by the concerned authorities. This is due to various reasons like socio economic, political, economic etc. It s time to make a rethinking of the whole issue to see that the existing laws are strictly enforced. The Government will have to show the required will and interest for enforcement of rules concerning environmental pollution.

3. Implementation of clean technologies

Clean technologies are to be adopted for new industrial projects. Existing industries are to be modernised with clean technologies to eliminate toxic end products or wastes which pollute the terrain elements. Continuous research and development should be a part of any industry to upgrade the technology for recycling, elimination of toxic waste products etc.

Indicator

Aesthetically and qualitatively acceptable environment.

Agencies to implement the programme

Local and State Government

Possible funding agencies

State, National and International agencies

Issue 5. Coastal Erosion

Being a coastal state with about 560 kms of coast line with a highly populated coastal zone forming the economic backbone of the state coastal erosion is an important aspect to be tackled.

Reasons

1. Anthropogenic influences

An evaluation of coastal erosion in Kerala shows that it is neither uniform throughout the state nor induced by the same processes at different locations. Generally, erosion is observed during monsoon as part of an erosion/accretion cycle at many locations. In some of these places anthropogenic influences superimposed on this seasonal cycle cause net erosion.

2. Sediment shortage in rivers

Net erosion near river inlets or mining sites may be due to sediment deficiency. Sediment shortage in rivers caused by improper basin management affects the sediment budget of many stable coastal areas adversely.

3. Destruction of coastal vegetation

Coastal vegetation especially mangroves are excellent coastal protection measures. In Kerala coast vast stretches of mangroves were destroyed. Only a few healthy patches are now available.

4. Lack of proper coastal zone management

Government of India has come up with CRZ regulation to regulate the human activities along the coastal zone and to protect the fragile and critical areas aimed at ecosystem preservation. However, these are only regulations preserving permissible or non permissible activities in the zones defined at various distances from the high tide line. What is lacking is an all pervasive coastal zone management policy or authority to enforce and implement such policy whose sphere of activity will be within the whole width of the coastal plains falling between the midland and the open sea.

Strategy

Coastal zone management

Actions

1. Evolving a coastal zone management plan and its implementation

The coastal zone of the state is thickly populated and almost all the urban centers are located within this. Even the most important industrial and commercial activities of the state are also localized within the coastal zone. Many agencies and departments are active in collecting information both socio-economic and scientific as well as implementing development projects and programmes in their relevant fields. However, a proper co-ordination among them is lacking. To make the situation more alarming none of these agencies consider biodiversity issues with the credence they deserve. It may be difficult to establish a supreme authority to co-ordinate all activities of all agencies in the Coastal Zone, but at least the establishment of Coastal Zone Authority primarily responsible to deal with biodiversity issues is necessary. This authority can evolve a Coastal Zone Management especially to deal with biodiversity issues.

Indicators

1. Effective coastal protection with consequent low rate of net erosion

2. Over all improvement of coastal eco systems

A proper management of coast can bring in an equilibrium condition whereby the health of the coastal ecosystem like, mangrove, estuarine, wetland, rivers etc., can be sustained thereby the natural sediment budget of coast restored.

Agencies to implement the programme

State, National and International agencies

Possible funding agencies

State, National and International agencies, Department. of Ocean Development

Issue 6. Unplanned tourism development

Kerala is endowed with a terrain set up which is aesthetically appealing and this natural aspect of this Gods Own Country attracts many tourists. Tourism is now accepted as an Industry and the state Government is taking all steps to promote tourism development throughout the state. This is identified as one of the thrust areas of development like the information technology. However, tourism promotion activities unless pursued with due consideration of the biodiversity aspects it will initiate gradual degradation of terrestrial ecosystem.

Reasons

1.Opening up of relatively undisturbed terrain

This is specially relevant in the high land region especially within forest land. Sometimes places like Munnar and its suburbs, Wynad plateau and simila areas are opened up for tourist influx in such a way that it exceeds the carrying capacity of the area. Such relatively undisturbed areas thus are subjected to ecological strain raising biodiversity related issues.

2. Exploitation beyond carrying capacity

Irrespective of the location whether they are in high land region or in the coastal zone, based on economic consideration, exploration of the terrain resources lead to degradation of terrestrial ecosystem. It is necessary to limit the development within the carrying capacity of the area so that ecostrain imparted by such development can be within the assimilative capacity.

3. Socio - economic and cultural changes (change in traditional trade, cultivation, animal rearing, life style etc)

Change in the traditional trade and cultivation results in change in life style of the local inhabitants. Traditional cultivation practices change or even become extinct due to economic considerations by diverting human effort as well as land and water resources for tourism related activity. This leads to the extinction of many traditional activities, practices and products. Same is the case of rearing traditional animal stock which will be gradually replaced by animals which can support demands of the industry. This processes will have adverse effect on the local biodiversity preservation. On the whole, the life style of the local inhabitants changes due to the influence of tourists and the accompanying temporary economic boom. The important aspect to be considered is the degeneration of traditional values and its impacts on the biodiversity related issues.

Strategy

Promotion of planned tourism

Tourism development should be based on a long term programme. Always the carrying capacity of the terrain is to be assessed before implementation. Care should be taken so that the accompanying socio economic changes will not at least entirely eorde the traditional practices adversely affecting biodiversity.

Actions

1. Development of site-specific tourism policy based on carrying capacity assessment.

As indicated tourism development happens either in backwaters, coastal plains, high sloping high land region or in the high altitude plateau lands. Each has its unique geomorphological, cultural and climatic set up and needs different types of development. This calls for a policy to always stress the need for site specific assessment of carrying capacity and not to go for uniform tourist programmes throughout the state. The tendency is always to adopt strategies even from outside the country for promoting tourism without consideration of the terrestrial ecosystems involved.

2. Creation of public awareness

Public awareness can create a sense of responsibility among local population to ensure protection of the natural ecosystem and its relevance in sustainable tourism development. The administrators and planners are to be made aware of the probable consequences of eco-degradation when biodiversity issues are not given the desired importance when long term tourism development projects are implemented.

Indicators

1. Improved environmental quality

2. Sustainable tourism development

It is reasonable to assume that tourists are attracted to an area only when that area acquires certain special aesthetic appeal due to its inherent ecosystem characteristics. Unless this aesthetic appeal is preserve through protection of the environment, tourism development in that ecosystem is not sustainable.

Agencies to implement the programme

State and National Tourism Departments

Possible funding agencies

State, National and International agencies

Issue 7. Adverse impacts of surface transport network

This is an area where large scale development is taking place in the country. New networks of surface transport in the form of roads and railway are coming with every plan project. All these transport networks are laid across different types of terrestrial ecosystems raising many biodiversity related issues.

Reasons

1. Possible landscape changes

Laying of surface transport network requires extensive landscape modifications which adversely affect the involved terrestrial ecosystem. Many hill slopes are to be cut down, low lands with unique ecosystem to be filled. Some times the continuity of the terrestrial ecosystem is interrupted by transport network splitting them into patches of no sustainable size. Laying of roads along fragile slopes initiates landslides. In many cases such activity disrupts both surface water flow as well as subsurface water flow.

2. Drainage interruption

In terrains such as Kerala which has numerous small streams, whenever a transport network is laid, it is always necessary to interrupt, divert or some times even block many natural drainage channels. Such blocking or diversion of drainage channel irrespective of their size always affects the terrestrial ecosystem. Usually, the major causalities in this are the seasonal channels and hollows on steep side slopes which are meant for natural storm drainage during high intensity rains. Their blocking destabilizes critical slopes. Improper design of culverts, tunnels, canals etc., stagnate streams and even cause flooding.

3. Socio economic changes

The transport network in an area provides more access to that area thereby changing the life style of the inhabitants. This affects the traditional cultivation practices, animal rearing etc. Sometimes the access through new proper road network opens up virgin forest areas for exploitation

Strategy

Development of transportation facilities with least adverse impacts

Actions

1. Long term planning based on systematic terrain evaluation.

It is necessary to conduct a proper terrain evaluation before planning any transport network in an area. Just like any other projects an EIA is an absolute requirement for a transport network planning.

2. Alternate transportation systems

Based on an EIA and a detailed terrain evaluation the best alternatives in transport systems are to be selected for an area. Kerala has a potential for developing a water transport system details of which has to be explored in detail. The transport system which imparts least stress on the ecosystem is to be opted for.

Indicators

Improved transportation facilities with least adverse impact.

Development of transport facilities is a prime requirement of modern society. However, a balance has to be maintained between this development and the health of the ecosystem through which such facilities are developed. The network should have the least adverse impact on the terrestrial ecosystems it transgresses or cut across.

Agencies to implement the programme

State and Central agencies

Possible funding agencies

State, National and International agencies, Govt. of India and Govt. of Kerala

POLICY LAWS AND INSTITUTIONS

Introduction

Law is one of the key instruments of social regulation. This is achieved through the establishment of norms of conduct and the creation of the required machinery with their accompanying empowerment for ensuring that such norms are effectively complied with. Legal evolution is often a result of an important interplay of socio-economic and political factors. The last two decades of the twentieth century witnessed the increasing use of legal and judicial processes by Indians to protect the environment. The Courts responded with a range of pro-environment judges.

We have around forty legislations relating to bio-diversity starting from 1871 to 1987. Biological diversity is not a new concept. We confuse it with biological resources. The convention on biological diversity reaffirms the sovereign rights of the nation over their bio-diversity and each nation must take appropriate steps towards inventorying, monitoring and conserving bio-diversity as a part of the integrated development planning. Various components of bio-diversity may fall within the jurisdiction of the states or the Central Govt. or the list of concurrent subjects. The relevant legislative entries are the Union List entries (14,52 and 57). Concurrent List entries 1and 2 and state list entries 5,6,17,21,24 and 25. Forest, Wildlife and population control were subjects on which the states had exclusive powers to make laws but now the Concurrent List enables both the Centre and the States to make laws on these areas (Refer Seventh Schedule List 3). States already have powers to make laws relating to public health and sanitation, agriculture, land and fisheries within state territory. They are subjects on which only the states have powers to make a law. Water also comes under the State List. Atomic energy, oilfields and resources, mines, interstate rivers and valleys and fishing in territorial waters are subjects related to Environment Protection and are in the Union List and therefore subjects for Union.

Issue1 Loss in Biodiversity

Reasons

1. Intensification of agricultureDiversion of forests to other land usesUnscientific extraction Regularization of encroachmentsNew highways and roadsUrbanization of settlementsRenewal of leasesCardamom hill reserve –

dual ownershipLand reforms / Land ceilingGrow More Food Campaign Loss of wetlands

Strategy

Strengthen the present legal machinery (laws, enactments etc) with an emphasis on biodiversity and provide new, wherever necessary in conservation of biodiversity and also implementation at the lower level.

Actions

1. Amend forest acts and laws to suite the present conditions and demands (Revision of Indian Forest Act of 1927).
2. Activate the present forest tribunals and establish more if necessary.
3. Stop issuing tenure rights and pattas in forest area.
4. Repeal the land ceiling laws.
5. Conduct detailed EIA and more transparent and sensitised public hearing.
6. Consistent Environmental Policy
7. Indicator:
8. Maintenance /enhancement of ecosystem functions

Issue 2 Lack of adequate legal literacy on biodiversity at Panchayat and People levels

Reasons

1. Non-availability of rules and regulation in simple local language.
2. Non-compliance of the constitutional provision of right to know.
3. Non-availability of legal experts on environmental issues and related topics at local level.

Strategy

Develop a mechanism for imparting legal literacy.

Actions

1. Establish legal literacy missions
2. Translate documents into the local language
3. Provide advisory clinics for local institutions and affected persons.
4. Create Lawyer's Fora for environmental awareness.
5. Popularise the existing remedies available at local level.

Indicators

Biodiversity related cases are settled at the local level.

Agencies to implement the programme

Law colleges, Universities, NGOs, PUCL, Lawyers' For a

Possible funding agency

Ministry of Environment and Forests, State Science and Technology Department, UGC, WWF etc

TECHNOLOGY, INDUSTRY AND BIODIOVERSITY

Introduction

Technology and industry are to be considered as relevant to biodiversity both for the benefits that can accrue from its judicious utilization as well as for its attributes that are detrimental in nature and needs remedies

appropriate technology without doubt has the potential to help industry overcome the damage being done to environment by a host of activities. the issue is perhaps of cost-effectiveness of the shift to newer technology by the concerned industries. in the absence of pressure from regulatory authorities there is reluctance to comply with existing rules or invest in the appropriate clean technology.

industry directly involved or dependant on biodiversity will be the first to integrate any conservation measures if they made aware of the long-term benefits in terms of sustainability. In the case of the flora or fauna being used as the basis of a manufacturing or utilizing process the medium-term sustainability should be of concern to the users. Like the pharmaceutical manufacturers, particularly of herbal drugs used in the traditional systems of medicine who depend for their raw materials on collection from wild but are not greatly involved in any activity that can conserve the resources and ensure sustainability.

Research efforts need to be focused on development of appropriate technologies that can work in tandem with existing technology or replace them where necessary to help in the sustainable utilization of biodiversity. The broader perspective of ecosystem level conservation needs to be considered along with specific elements of relevance to the industry. Recent developments in biotechnology needs to be evaluated for its potential impact on biodiversity in different situations since a debate is still unresolved as to its merits/demerits.

The increased awareness of the detrimental effect of older and often obsolete technologies on the environment and health will contribute to making alternate technologies a viable option. Organic farming produce is expected to find wider market thereby making it cost-effective as well as being conducive to a shift to a environmentally benign forms of agriculture.

The recent perception of the state as a prime eco-tourism destination is based on the unique landscapes, wildlife, spices and traditional herbal medicine all of which are deeply moored to rich biodiversity of the region. An assessment needs to be done to integrate this newfound opportunity into the broad development strategy for the state.

Issue 1. Over exploitation by the industry leading to depletion of biodiversity

Reasons

1. Overexploitation of industrial biomass (Paper/pulp and matchwood industry utilizing softwoods, bamboo/reed) without consideration for the livelihood of the traditional tribal and rural collectors, the ensuing local shortage of resources or sustainability .

2. Herbal drug industry (ayurveda, herbal extracts etc) utilizes biodiversity unsustainably endangering some species and resulting in shortages and bringing about use of spurious plant material.

3. Absence of appropriate pharmacognosy standards for raw drugs and finished products effects marketing of raw drugs by cultivators in the face of spurious and alternative raw drugs.

4. Monoculture plantations is typically raised through forest clearing damaging biodiversity and increasing risks of soil erosion and landslides. Uncontrolled use of chemical fertilizers, plant protection chemicals have a deleterious effect on biodiversity and human health.

5. Aqua culture both freshwater and brackish water farming for prawn and fish culture is the cause of destruction of mangroves and ingress of salinity in adjacent areas has resulted in several areas.

6. Clay mining for tile/brick/china clay, sand mining for construction has adversely affected the water table and safety of bridges and damage to terrestrial and aquatic biodiversity, wasting of potential agricultural land etc.

7. Under utilization by industry of the potential of local biodiversity and landscapes while favouring industries less suited to local topography and demographic factors. Scope for eco-tourism, bio-prospecting (introduction of local wild ornamental and useful plants/animals to trade wherever suitable, value addition of medicinal and ornamental plants) .

Strategies

1. Research efforts to be encouraged for efficient, sustainable use of biodiversity, value addition and conservation of biodiversity using modern technology including biotechnology.
2. Pharmacognosy standards to be developed for authentic raw material and finished products in herbal drugs. Enforcement of such standards and certification also is essential.
3. Promotion of cultivation of plant species that are overexploited in wild and ensuring appropriate marketing avenues and remuneration for cultivators, incentives to manufacturers for products made from raw materials raised in plantations
4. Promotion of technologies more suited for the topography and climate of the State and the highly literate manpower available e.g. Eco-tourism Biotechnology, Information technology, Floriculture including exploring potential of local ornamental plants and fauna.

Actions

1. Brainstorming meetings to be held with experts, policy makers and stakeholders on specific issues in sustainable utilization of biodiversity, value addition (preprocessing, storage), research needs and application of available technology.
2. Sponsored research projects aimed at sustainable use of biodiversity, value addition, development of pharmacognosy standards by improved amalgamation of modern analytical tools and digital documentation
3. Drawing up of schemes with involvement of the stakeholders to promote cultivation of the wild plants of interest to the industry and in short supply and regulating collection from wild resources.
4. Research projects focused on alternative technologies, bioprospecting

Indicators

1. Assessment of the growing stock of important plant species serving as raw material for industry and market surveys to understand the availability.
2. Improved efficiency of utilization of biodiversity and value addition in the industry.

3. Market studies, research/scientific reports and articles in journals. (CD produced by 'Jananithi,' Thrissur on the clay mining is an example)

Agencies to implement the programme

Forest Department, Industries, Commodity Boards, Farmer and tribal Societies,Universities, Research Institutes, STEC, R&D wings of industries.

Possible funding agencies

National and international funding agencies, private funding by Industry

Issue 2. Pollution and inefficient waste disposal affecting biodiversity

Reasons

1. Aerial Pollution and water pollution from cement, paper/pulp, distillery, metal and mineral processing and other industries and granite quarrying in the form of particulate matter, gaseous discharge, , heavy metals, untreated waste water and solid wastes causes damage to biodiversity and health problems.
2. Solid waste such as municipal wastes, wastes of coir, herbal extracts and drugs, plastic non-biodegradable wastes, recyclable waste paper, glass and plastic, dry cells, petroleum based products currently disposed into dumps without processing causes pollution of ground water and accumulation.
3. Lack of awareness or interest on eco-friendly alternatives for packaging materials (paper/biomass based bags, cups, plates) that can utilize local resources and generate employment.
4. Insufficient awareness of available technology for waste disposal and pollution control and dissemination of information by pollution control authorities also insufficient .
5. Indiscriminate use of pesticides/weedicides/plant protection chemicals pollute soil and water bodies.
6. Noise pollution from industrial units and automobiles deter birds.

Strategies

1. Strengthening of existing laws relating to diversity utilization and pollution and their scrupulous implementation is an urgent necessity.

2. Segregation of severely polluting industries from non-polluting ones and relocation from thickly populated or ecologically sensitive areas (in a phased manner), to take advantage of centralized pollution control systems, disaster management units etc.

3. Equipping statutory bodies like pollution control authorities with infrastructure for information dissemination and transfer of technology by linking with research Insitutes, NGO's.

4. Shift to eco-friendly technologies for packaging materials using plant products or biodegradable polymers.

Actions

1. Sensitization of policy, law making and implementing bodies, industry, local governments through dissemination of information interaction with experts, NGO's etc.

2. Identification of industrial belts, nature of pollution, effects on biodiversity, segregation of polluting units, potential mechanism on relocation etc.

3. Regular monitoring by statutory bodies and NGO's of air and water quality and pollutants throughout the State and studies on impact on flora, fauna and human health and remedial action

4. Building up the infrastructure and software for effective dissemination of eco friendly technologies and state of the art pollution control measures to the industry and local governments by links between statutory bodies, research Institutes and NGO's.

5. Utilization of alternate eco-friendly technologies and sponsorship of research for development of newer technologies.

Indicators

1. Various pollution indices for different locations in the state as indication of pollution abatement.

2. Timely legislation passed by law makers on relevant issues and legal action taken throughout the state .

3. Improved awareness level about pollution among people and industry and compliance with regulation.

4. Newer eco-friendly technologies contributing to lower pollution, wastes and improved air/water quality.

Agencies to implement the programme

Pollution Control Board, Industries, R&D wings of industries.

Possible funding agencies

National and International agencies, Private industry

WILD ANIMAL DIVERSITY

Introduction

Kerala lies between 8^0 17' and 12^0 45' N latitude and 75^0 11' and 17^0 20' E longitude. As per the data available, out of the total geographical area of 38,863 km^2 of Kerala, the extend of forest cover is 24 per cent. The forests of Kerala include evergreen, tropical moist deciduous, tropical dry deciduous, shoals and mangroves.

Protection of wild animal diversity in general, is limited to the protected areas. However, it is a fact that many of the endangered or rare animals are also found outside the protected areas. There is lack of information on the distribution of many of these wild animals in different areas, especially with respect to their ecology and habitat requirements. Basic facts with respect to the abundance and distribution of individual species are also not available and there is a need to reorient the research programmes in wild animal diversity to make available useful data on the above lines. It is estimated that 81 species of mammals, 47 species of birds, 3 species of amphibians, several other species including butterflies, are all on the verge of extinction.

The Western Ghat is a storehouse of rich and diverse flora and fauna and is one of the hotspots identified in India. The Kerala part of Western Ghats is also rich in wild animal diversity and harbours several endemic and endangered species of animals.

Many factors contribute to the loss of animal biodiversity, out of which the human factor is the most important. Habitat destruction in various forms accelerate the process of erosion of diversity. It may be remembered that the loss of unique genetic strains, let it be plant or animal, will be a loss for ever.

Thus, the overall scenario on the Wild Animal Biodiversity points towards developing and implementing suitable conservation strategies for the benefit of posterity. While considering the intrinsic value of the biodiversity, their optimum utilization in a sustainable manner for human welfare should also get the desired attention. Four major issues have been identified and the course of action to be followed in each is provided.

Issue 1. Lack of adequate and comprehensive information on wild animals

Although information has been generated with respect of larger mammals, birds etc. there is a need to generate data on other wild animals. Comprehensive studies are lacking mainly due to the lack of taxonomic expertise in various groups of animals. In addition to the generation of data, there is also a need to update the same from time to time and also to disseminate the information to the needy in a user-friendly format.

Reasons

1. Comprehensive studies are lacking
2. Due to the lack of motivation, there is also a lack of specialists available to identify various animal groups.
3. There is difficulty in getting permission from the Forest Department to carry out inventory studies, especially in forest areas.

Strategies

1. To generate the required information at Panchayat/Block/District/State levels.
2. Encourage taxonomic studies as done in the past so as to develop experts in various animal groups to get the correct identity of animal species.
3. The importance of the topic – 'biodiversity' to be projected and included in the curriculam at school/college/University levels.

Actions

1. There is an urgent need to prepare inventories on different animal groups.
2. To establish centers of taxonomic studies for various groups of animals.

Indicator

1. The information generated by way of publications in journals, scientific reports, monographs etc.

Agencies to implement the programme

1. Various Research Institutes
2. Universities and Academic Institutions
3. NGOs and other voluntary organizations in collaboration with Academic Institutions.

Possible funding agencies

National and State funding sources

Issue 2. Man-wildlife conflicts in and around Protected Areas (PAs)

There has always been a conflict between man and wildlife in several areas. One major problems identified in one of the public hearing was the problem posed by wild boar in damaging the crops of farmers living in the neighbourhood of forests. There is lack of information as to how developmental activities clash with the interests of wild animals. It is necessary that innovative methods have to be developed to reduce the human-wildlife conflicts with the active environment of local people.

Reasons

1. Encroachment by man into the Wildlife territories
2. Because of the above reasons and also due to several other developmental activities, there is considerable degradation of the wildlife habitat.
3. Changes in the attitude of the people together with changes in cropping pattern have resulted in man-wildlife clashes.

Strategies

1. Create public awareness on a serious scale to discourage encroachment by man into wildlife territories.
2. Encourage conservation activities through people's participation to prevent habitat degradation.
3. Take a co-ordinated approach to solve controversial problems with representatives of local people/local bodies/forest officials/NGOs.

Actions

1. Conduct periodic meetings, workshops etc. in vulnerable areas to increase the awareness of people and to reduce tense situations.
2. The core areas to be further improved in terms of habitat management for the survival /feeding of wild animals, so as to reduce their movement to marginal areas in search of food.
3. Sustainable utilization of animal resources as mentioned in the case of wild borer.

Indicators

1. Reduction in the number of compensation claims
2. Reduction in the number of details, either human beings or wild animals.
3. Habitat improvement through vegetation monitoring.

Agency to implement the programme

1. Local bodies
2. NGOs
3. Forest Department
4. Tribal Welfare Department
5. Forest Research Institute/Academic Institute

Possible funding agencies

1. Ministry of Environment and Forests
2. Kerala Forest Department
3. NGOs

Issue 3. Lack of conservation efforts outside protected areas such as Revenue land/Private land

It is very evident that all the conservation activities related to wild animal are mostly restricted to protected areas in the forests. However, several hundred square kilometers of private/revenue lands, adjacent or in the midst of protected areas are available. These areas are of high conservation value because – 1) such areas harbour several species of wild animal populations 2) many animals make use of these areas for the survival during adverse conditions in the protected areas. The question of bringing these areas under protection may also bring in legal issues. However, a

strategy for bio-diversity conservation outside the PAs through people's participation and awareness programme offer better scope.

Reasons

1. So far no attempt has been made to document the wild animal diversity which occur in revenue/private land close to or amidst protected areas.
2. Legal measures are not available at present to implement conservation activities in these areas.
3. There is lack of motivation on the part of the stakeholders.

Strategies

1. Motivate the stakeholders by providing adequate incentives to conserve the wild animal biodiversity outside the PAs
2. Establish biodiversity parks/museum with help from local bodies/educational/research institutions
3. Frame or modify laws so as to bring these areas also under the purview of protected areas.

Actions

1. Better interaction amongst the various governmental departments such as revenue, forests etc.
2. Create public awareness and encourage the local bodies to prepare biodiversity registers of such areas.

Indicator

1. New knowledge/information on wild animal diversity generated from areas outside the PAs

Agencies to implement the programme

1. Kerala Forest Department
2. Revenue Department
3. Local bodies
4. NGOs
5. Educational/Research Institutes

Possible funding agencies

National and state level funding sources.

Issue 4. More animal species becoming threatened or endangered.

There is an urgent need to assess the PAs in Kerala in order to find with the information gap in terms of threatened or endangered animal groups. It is estimated that over 150 animal groups belonging to mammals, birds and several other lower groups of animals belong to the threatened category. Thus identifying the threatened species assumes greater importance.

Reasons

1. Degradation of habitat, poaching etc.

2. Introduction of exotic species as well as over exploitation of indigenous species, especially in the case of fishes.

Strategies

1. Take adequate measures to improve the habitat
2. Discourage introduction of exotics

Actions

1. Maintain habitat continuity
2. Detailed studies on impact of exotics on native species

Indicators

1. Reduction in the number of endangered/threatened groups of animals.
2. An increase in the number of native species.

Agencies to implement the programme

1. Various government departments
2. NGOs
3. Academic/Research Institutions

Possible funding agencies

1. Government Departments
2. Local bodies.

WILD PLANT DIVERSITY

Introduction

India is the 12th mega biodiversity centre out of 18 such regions recognized throughout the globe, and with in India, Western Ghats region where in Kerala State is situated is one of the hot spots of biodiversity in the country. The State is located between 8^0 18' N latitude and 74^0 52' and 77^0 22' East longitude, and covers an area of 38,863 km^2. The State has a coastal boundary of 560 km, from where the altitude rises to about 2400 m above msl at Anamudi, traversing the midlands and hilly uplands culminating in the highlands. The phytogeographic zonation of the State is one of the major reasons for the rich plant diversity of the State, coupled with its location in the humid tropics.

Plant diversity is expressed as Species diversity, Genetic diversity and Ecosystem diversity. Species diversity is the most significant component of floral diversity, which is demonstrated by the marvelling variety of living plants - unicellular to the complex flowering plants - expressed as species and infraspecific taxa. Species diversity is accounted in floristic inventories which are area specific, plant group specific or prepared as detailed taxonomic accounts of families or genera. Genetic diversity, expressed within the species as chromosomal variations, is either demonstrated or suppressed in plant characteristics, without disturbing the concept of species. Ecosystem or habitat diversity of plants is mainly divisible into two, namely terrestrial and aquatic. In the terrestrial ecosystem, vegetation types in large or small areas and plasticity of habitats with regard to any specific plant group, demonstrates this category.

Habitats of wild plant diversity in Kerala

The 38,863 km^2 of the geographic area of the State is divisible into four zones, viz. coastal belt (<8m above msl), midlands (8-75 m above msl) and hilly uplands and highlands (> 75 m above msl). Floristically, the coastal belts is dominated by mangroves and strand vegetation, midlands by sacred grooves and remnants of past flora, hilly uplands by natural vegetation intermingled with plantations of teak, eucalyptus, etc. and hilly uplands and highlands rich in wild flora assembled into different forest types and also the grasslands with limited plant diversity, which are partially converted into plantations. It may be mentioned here that the coastal mangrove vegetation, floristically very rich in the past, had been subjected to much degradation and transformation, and at present, the extent and diversity of the vegetation type have drastically declined to isolated patches and that too with poor plant diversity. Strand vegetation of the coastal belt is also in the same state of affairs and increase in human population coupled with various developmental activities

ignoring the significance of the floral wealth is the reason behind this. Situation is also not much different in the case of midland areas, where intensive agriculture, extensive construction activities for the making of dwelling and other structures coupled with population exploitation and extensive growth of cash crops like rubber are the major constrains which devastated or restricted the natural flora to sacred groves or similar isolated patches which are also under constant pressure. So, for all practical reasons, the hilly uplands and the highlands are the physiographic zones of the State with maximum amount of wild flora and in fact, the hilly uplands are also partially in the grip of agriculture, plantations and settlements at the cost of wild plant diversity. Therefore, comparatively, the highlands zone is the abode of maximum wild plant diversity of the State and are more pristine in conservation status as compared to all other physiographic entities identified for the State.

Forest as the major habitat of wild plant diversity

In Kerala, the major forest types available are the evergreen, semievergreen, moist deciduous, dry deciduous and the shola forests, interspersed with extensive grasslands. Also, transitional types like subtropical hill forests are seen in the ghat region, floristically related to the adjoining dominant forest type, namely the evergreens, with few of the species characteristic to the sholas above also descending into the forest formation. Area-wise and plant-diversity wise, moist deciduous forests top the different forest types (4100 km^2) and the evergreen (2400 km^2), dry deciduous (94 km^2) and sholas and grasslands (88 km2) are comparatively less represented in both area and species content. On the other hand, it is the moist deciduous forest areas that are subjected to maximum loss of plant diversity due to conversion of extensive areas into plantations of teak and also various other degradation factors acting on the forest type which is more closer to human habitations. Of course, a part of the high altitude grassland belt of the State is already converted into eucalypt plantations at the expense of wild flora.

Status of knowledge on wild plant diversity of Kerala

Among the three categories of plant diversity - species, genetic and habitat - it is the species diversity, which is maximum studied and understood for the State, and genetic diversity is something least explored to in this context. Recording of different plant species occurring in the State was initiated since the middle of 17^{th} century AD and its continues even now with more and more areas intensively explored and more and more taxa added to the existing enumerations or taxonomic accounts by way of new taxa or new records of plant species already known from other parts of the country or the globe. The development of knowledge on the floristic diversity of the State is

dealt with here. While doing so, only major contributions in the field are mentioned, which are representative of different plant groups like algae, fungi, lichens, bryophytes, pteridophytes, gymnosperms and angiosperms.

Towards the close of 17th century, the first account on the flora of the northern part of Kerala, ie. Malabar, was made by Commelin (1696). This was followed by van Rheede (1779-91) almost after a century, even though Linnaeus (1753) also included many taxa from this part of India in his monumental work *Species Plantarum* dealing, with not only plants but also animals and minerals, which were classified and arranged in the binomial system of nomenclature, followed even now in botanical nomenclature. Almost during the same time, Linnaeus (1771) studied the fungal flora of India where several species of the lower plant group from Kerala were also included. After the publication of the last volume of van Rheede (1791), there was no remarkable contribution in the field of plant diversity of the State till the middle of nineteenth century, when several exhaustive floristic accounts, not only for the State but for the country and the world, were prepared.

During 19th century, concerted attempts to explore the flora of the State and documentation of all available information and preparation of floras were made. During this period, Wight and Arnott (1834), Wight (1831, 1833, 1838-53) and Beddome (1869-74) made remarkable contributions to the flora of the State, by species enumerations and also illustrated accounts of plants to facilitate their identification. While, the above mentioned contributions during the century were dealing with only the flowering plants which actually dominates the wild plant diversity, several contributions to the knowledge on diversity of lower plants groups like ferns, fungi, etc. were also made in the second half of the century like Beddome (1866) on ferns of India, Cooke (1880) on fungi of India and Beddome (1863-73) on South Indian ferns. Floristic documentation during the century culminated with the publication of *Flora of British India* by Hooker (1872-96), where, more than 17,000 taxa of angiosperms were enumerated and described from the former British India covering countries like India, Sri Lanka, Burma, Malaya, Java and Sumatra, which belonged to the then British Indian colony.

During 1900-2000, there were innumerable contributions in the field of floristic diversity of the State, region or the country and many of them pertain to the State, resulting in the present status of knowledge on the plant diversity of Kerala. In fact, it is Hooker's (1872-96) *Flora of British India*, which triggered the enthusiasm among scientists to prepare regional, State or district floras, and in most of the cases, Benthem and Hooker's (1862-83) system of classification was followed in line with

the arrangement of various herbaria, where specimens authenticating such enumerations were deposited. Bourdillon (1908), Rama Rao (1914) and Gamble and Fisher (1915-31) were the major contributors among them and there are also several enumerations, new distributional records and new taxa, published during this period. Nair (1997) attempted to assemble all the such references pertaining to the flowering plants of the State with a view to facilitate the preparation of a State flora and also to identify the knowledge gaps that exists, in order to avoid duplication and also encourage future endeavours in this direction. As the floras mentioned before were dealing with the region or the State, most of the subsequent attempts were to prepare District or Forest Division floras resulting the publication of floristic accounts like Ramachandran and Nair (1988) for Cannanore, Manilal and Sivarajan (1982) for Calicut, Manilal (1988) for Silent Valley, Vajravelu (1990) for Palghat District, Babu (1990) for Malappuram District, Sasidharan (1996) for Trichur Forest Division, Nair and Muktesh Kumar (1993) for Malayattor Forest Division, Nair (1988) for Pooyamkutty forests, Vivekananthan (1981) for Idukki District, Antony (1989) for Kottayam District, Mohanan (1984) for Quilon District, Mohanan (1984) for Trivandrum District, and so on. In fact, hundreds of checklists, new records and new taxa were also reported during this period which were published in journels and other periodicals. In order to link such publications with our knowledge on the plant diversity of the State, Nair (1987) and Nair and Soniya (1990) prepared additions to Gamble's *Flora of Presidency of Madras* (1915-31) from the States of Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. Part of Ernakulam and Alleppey districts are the only two areas on which exhaustive, floristic accounts are not available in the State and based on all available information, an exhaustive account on the angiosperm flora of the Kerala State is yet to be prepared.

During the second half of twentieth century, several accounts on the non-flowering plants of the State, region or the country were also prepared. *Fungi of India* by Vasudeva (1962), Mukerji and Janeja (1974), Sarbhoy *et al.* (1975) and Bilgrami *et al.* (1991), *Fungi of South India* by Rangaswami *et al.* (1970), *Fungi of Kerala* by Hosagoudar *et al.* (1996), *Fern Flora of Malabar* by Nayar and Geevarghese (1993), *Polyploid Ferns of South India* by Nampy and Madhusoodanan (1992), *Fern Flora of South India* by Nampy and Madhusoodanan (1998) are some such consolidated accounts dealing with the fern and fungal floras of the State.

Elaborating the floristic inventories were also prepared detailed taxonomic accounts for various plant groups in the State. Examples of such contributions may be mentioned FAO (1978), Nair (1990), Sharma, *et al*. (1985), Nair (1986), Muktesh kumar (1990), Renuka (1992, 1996), Muktesh kumar (1995), Seethalakshmi and

Muktesh kumar (1998), and so on. There were also plant resource inventories prepared for Kerala covering the topics like medicinal plants (Nambiar, *et al*. (1986), non-wood forest produce plants (Nair, 1996) and Palms (Renuka, 1999a).

Estimate of wild plant diversity in Kerala

According to a vague estimate by Nayar (1997), so far, a total of 10,035 taxa of plants are recorded from the State of Kerala. The details of representation of different groups are given in Table 1.

Table 1. Plant - groups and number of species reported (after Nayar, 1997).

Plant group	**No. of Species**
Angiosperms	3800
Gymnosperms	4
Pteridophytes	236
Bryophytes	350
Lichens	520
Algae	325
Fungi	4800
Total	**10,035**

Recently, there is an addition of more than 200 species to the total figure of plant taxa given in Table 1, making it 12, 750 as a latest estimate. This estimate is also not exhaustive and there will be many more additions by conducting more intensive field explorations.

Conservation of plant diversity

Several attempts were made in the past to conserve the wild plant diversity of the State. As examples of this, efforts like germplasm establishment of Dalbergia, Canes and Bamboos, seed stands of Rattans, live collections of medicinal plants, orchids and ferns, preservation plots established in natural forest areas and rehabilitation of wastelands and forest areas using indigenous medicinal plants may be mentioned, executed mostly by Institutions like Kerala Forest Research Institute and Tropical

Botanic Garden and Research Institute. There is also much conservation related literature published on the natural flora of Kerala and contributions of Basha and Nair (1991, 1992), Bhat and Padmaja (1991), Binoy, *et al*. (1991), Joseph (1991), Mohanan and Balakrishnan (1991), Nair and Bhargavan (1981, 1982, 1985), Nair (1990), Nair (1986, 1992, 1993), Nair and Basha (1991, 1995), Philip Mathew and Sivarajan (1982), Renuka (1987, 1998a,b; 1999b), Sanjappa (1991), Sasidharan *et al.* (1996), Shetty and Vivekananthan (1991), Zachariah, P.K. (1991) and many others is worth mentioning in this context.

Therefore, it may be mentioned here that, even though more and more data on the wild plant diversity of Kerala State is generated, year after year, the following data gaps also exist at present:

i. There is only very little information generated on the genetic diversity of wild plant species.

ii. There is an urgent need to complete inventorization of under-explored areas and less studied plant groups, especially the lower plant groups like algae, fungi, lichens, bryophytes, etc.

iii. Species in the endangered state are to be prioritized for conservation programmes based on evaluation of their natural population.

iv. Data on autecological and reproductive biological aspects of endangered taxa needs to be generated to chalk out effective conservation programmes.

v. Threat factors operating in the ecosystem/habitat where rare/threatened species are surviving may be identified and rectified. Wherever necessary 'protected areas' for plant species may be established for the *in situ* conservation of endangered wild flora.

vi. *Ex situ* conservatories of different categories shall be organized and such facilities may be used to preserve wild plant species, their propagules or germplasm.

Therefore, wild plant diversity of the State, not fully known, not fully utilized and not fully conserved, is unique for its variety and variability. This natural heritage is in the threshold of exploitation and destruction on one side and inventorization and conservation, on the other. What is desired is to understand what is not known, to

conserve what is endangered and to retain the remaining wild floral diversity of the State for the sustained utilization of it, not only by the present generation but also the future generations to come. The following issues, strategies and action-plans are evolved as part of the NBSAP programme to address the problems faced by wild plant diversity of the State.

Issue 1. Lack of comprehensive information on wild plant diversity

Strategy

Complete inventory of wild plant diversity has to be prepared with details on species, which need protection

Actions

1. Exhaustive surveys, including population biological studies, especially for imperfectly known wild plant groups.
2. Consolidation of all available data on wild plant species of the State.
3. Generating details on rare and endangered species with information on the causes of rarity.

Agencies to implement the programme

Research Institutions with expertise in plant taxonomy, and population and reproductive biology of various groups

Possible funding agencies

State, National and International agencies

Issue 2. Loss of plant diversity due to excessive exploitation from the wild

Strategy

Regulating unsustainable exploitation of wild plant species and their products

Actions

1. Gathering details on the availability and growing stock of species, excessively exploited.
2. Generating data on natural populations of species, which have become very rare.
3. Regulations to be framed and executed effectively to check further depletion of natural populations
4. Promoting regeneration, sustainable utilization and research for alternate source species through bio-prospecting

Agencies to implement the programme

1. Details on population, regeneration and alternate species to be generated by researchers.
2. Regulations to check further depletion of species to be framed and executed by the State/Central Governments.

Possible funding agencies

State, National and International agencies

Issue 3. Loss of species and their ecosystems

Strategy

Implementation of species and ecosystem conservation programmes.

Actions

1. Identification of wild plant species and their habitats, which require conservation actions.
2. Identification of causes of depletion and strategies to mitigate such negative impacts.
3. Standardization of protocols for the conservation of endangered species and their natural habitats.
4. Execution of effective education programmes to conserve the wild plant diversity of the state, especially on species which deserve protection from people, domestic animals, etc.

Agencies to implement the programme

1. Data requirements shall be met by Research Institutions and Universities.
2. Execution of conservation strategies by concerned agencies in collaboration with the research organizations and universities.
3. Student community at various levels can be involved in the awareness programmes.

Possible funding agencies

State, National and International agencies

Issue 4. Loss of fragile ecosystems and specialized habitats

Strategy

Execution of micro-level action programmes to save wild plant diversity in specialized habitats like mangroves, strand flora, fresh water lakes, sacred groves, Myristica swamps and so on.

Actions

1. Generate data on the wild plant content of fragile ecosystems and methodologies to protect them.

2. Initiate location-specific action plans with the involvement of voluntary groups, student community and local plan implementing bodies.
3. Researchers can act as resource persons for the execution of various protection activities.

Agencies to implement the programme

1. Inventory and methodology for protection shall be generated by research organizations and universities
2. Local action groups can be formed for execution of the programme with the involvement of researchers.

Possible funding agencies

State, National and International agencies

Issue 5. Need for documentation and protection of wild relatives of useful plants

Strategy

Collection and documentation of data on wild relatives of useful plants

Actions

1. Survey and detailed documentation of wild relatives of useful plants
2. Implementation of suitable conservation programmes to protect them

Agencies to implement the programme

Research institutions, universities and colleges

Possible funding agencies

State, National and International agencies

Issue 6. Lack of exhaustive and interactive information exchange mechanism

Strategy

Organization of a complete, interactive and dynamic data base

Actions

1. State Biodiversity Board to take leadership in the establishment of a centralized data base facility.
2. Research institutions, universities, colleges, etc to ensure free flow of data.

Agencies to implement the programme

State Biodiversity Cell and research institutions, colleges, etc.

Possible funding agencies

State, Central and International agencies