Biodiversity in the Western Ghats: An Information Kit (IIRR, 1994, 224 p.)

1.1 About this information kit

WWF

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WWF - India mission thrusts

• Promoting India's ecological security, restoring the ecological balance.

• Conserving biological diversity.

• Ensuring sustainable use of the natural resource base.

• Minimizing pollution and wasteful consumption.

• Promoting sustainable lifestyles.

This set of information materials was produced through an intensive, 17-day workshop in January 1994. The workshop was organized jointly by the World Wide Fund for Nature - India and the International Institute of Rural Reconstruction, Philippines. The workshop and kit were funded by the Swedish International Development Agency and the British Council in Delhi. The workshop venue was the National Institute of Oceanography, Dona Paula, Goal The Goa division of WWF - India coordinated the workshop and distributes the information kit.

Over 250 participants, observers and reviewers registered for and participated in the workshop. A total of 77 topics were presented by 99 authors. The authors presented the materials, which were revised during the workshop itself on the basis of audience comments and suggestions. Artists, editors and desktop publishing services were made availiable during the workshop.

The information kit is designed for teachers, nature club leaders and others involved in environmental education and public awareness efforts. Journalists may also find the kit useful as a source book of ideas for adaptation or translation. It is hoped that teachers will use this kit as a reference material and as a tool for teaching about nature conservation. The materials can be copied or adapted freely. Please ensure that the authors, WWF - India and IIRR are credited in all reproductions and adaptations.

Collaborating organizations

World Wide Fund for Nature - India

The World Wide Fund for Nature - India is today the country's largest conservation non-government organization, with a network of 18 State and Divisional offices spread across the country. Its Secretariat is in New Delhi. Founded in 1969, WWF - India is one of 29 independent national organizations functioning worldwide. A coordinating International Secretariat, the WWF International, is located in Switzerland.

WWF - India started as a modest wildlife conservation organization with a focus on protecting particular species of wild fauna. Over the years, the perspective broadened to encompass conservation of habitats, ecosystems and support to the management of the country's protected areas network. WWF India's mission is to promote nature conservation and environmental protection as the basis for sustainable and equitable development. WWF's Goa office provides services to nature clubs in schools and organizes teacher training camps and workshops to encourage an appreciation and knowledge of the natural ecosystem among Goa's people.

International Institute of Rural Reconstruction

The International Institute of Rural Reconstruction is a nonprofit, non-government organization devoted to improving the quality of life of the rural poor in the developing nations of Africa, Asia and Latin America. Founded in l 960, IIRR focuses on development strategies that release powers of the rural poor to transform their lives. IIRR uses bottom-up, participatory, integrated strategies to address the interlocking nature of rural poverty. Staff in each of the Institute's five programme areas conduct field-based action research to test new technologies and rural development approaches. They communicate results through international training courses, publications and audiovisual materials. IIRR has collaborated with numerous partner organizations in conducting participatory workshops to produce information kits on a range on environmental topics.

International Institute of Rural Reconstruction, Silang, Cavite 4118, Philippines. Tel. (0969) 9451. Fax (0969) 9937.

IIRR programme areas

- Integrated community-based rural development

- Environment, natural resources and agriculture

- Community health, reproductive health and nutrition

- Rural enterprise development

- Institutional capacity building.

Information kit produced by

WWF-India, Goa division and the

International Institute of Rural

Reconstruction.

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Information kit produced by
WWF-India, Goa division and the International Institute of Rural Reconstruction.

1.3 Introduction to biodiversity

We are losing biological diversity at an unprecedented rate. The loss of species is not new. In the course of geological time one has only to recall the fate of the dinosaurs. By and large, however, the disappearance of species in past eras has occurred by virtue of natural processes within the context of evolutionary time scales. Today, however, human activities contribute more to the loss of biodiversity than any other factor.

Biological resources are renewable resources, but they are being exploited at rates that exceed their sustainable yield. Human destruction of habitats, whether exploited for commercial or subsistence reasons, is the greatest threat. The clearing of land for agriculture, overgrazing of grasslands, cutting and burning of forests, unsustainable logging and fuelwood collection, indiscriminate use of fertilizers and pesticides, overwatering of crops, overexploitation of fisheries, draining and filling of wetlands, poor water management, urbanization and pollution of air and water, figure prominently in the degradation of our biological resources.

Nobody knows how many species are disappearing (or being generated) on the earth. Probably fewer than 10% of species have even been given a scientific name.

India's biodiversity

India has about 45,000 plant species, including 15,000 flowering plants. 5,000 species of algae, 1,600 of lichens, 20,000 of fungi, 2,700 of bryophytes and 600 of teridophytes.

The country has about 75,000 species of animals, including 50,000 insects, 4,000 molluscs, 2,000 fish, 140 amphibians, 420 reptiles, 1,200 birds and 340 mammals.

The two richest areas of India in terms of biodiversity are the Eastern Himalayas and the Western Ghats.

India's biodiversity

-Botanical Surveyand Zoological Survey of India

What is biodiversity?

Biological diversity is made up of all species of plants and animals, their genetic material and the ecosystems of which they are part.

Genetic diversity refers to the variation of genes and genotypes between and within species. it is the sum total of varied genetic information contained in the genes of individual plants, animal and microorganisms. Diversity within a species gives the ability to adapt to change, whether in environment, climate and agricultural methods to the presence of new pests and diseases.

Species diversity refers to the variety of species within a given area.

Ecosystems consist of interdependent communities of species (complex mixes of diversity between and within species) and their physical environment. The extent of the ecosystem or habitat is imprecise a single ecosystem may cover thou- sands of hectares or just a few. They (include major natural systems such as grasslands, mangroves, coral reefs, wetlands and tropical forests, as well as agricultural ecosystems that, while depending on human activity for their existence and maintenance, have characteristic assemblages of plants and animals.

Not just an environmental problem

Loss of biodiversity is frequently presented as an environmental problem, but the underlying causes are essentially social, economic and political. The excessive and unsustainable consumption of resources by a small but rich minority of the world's population, combined with the destructive impacts of the world's poor and hungry in a desperate bid for survival, have destroyed or overexploited habitats worldwide.

Genetic erosion

Genetic erosion-the reduction of diversity within and the main cause of extinction of a species-is a global threat to agriculture. The greatest loss of crop genetic resources results from the introduction of modern, uniform plant varieties in place of a mix of traditional ones. The Green Revolution introduced high-yielding varieties of rice and wheat to the developing world, but displaced traditional varieties and their wild relatives on a massive scale. In India, for example, agronomists predict that just ten varieties will soon cover three-quarters of the total rice area where once over 30,000 different varieties were grown. In the United States, over 85% of the 7,000 or so apple varieties grown in the last century are now extinct.

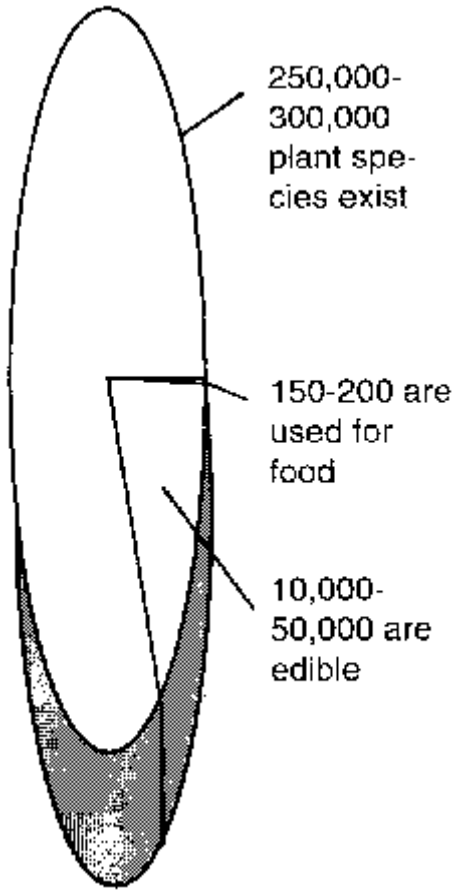
The same is true for animal genetic resources.

The introduction of a very few modern breeds that are better suited for the high input-output of industrial agriculture is displacing the diversity of indigenous livestock breeds. In Europe, half of all the breed of domestic animals (horses, cattle, sheep, goats, pigs and poultry) that existed at the beginning of the century have become extinct. A third of the remaining 770 breeds are in danger of disappearing within the next 20 years.

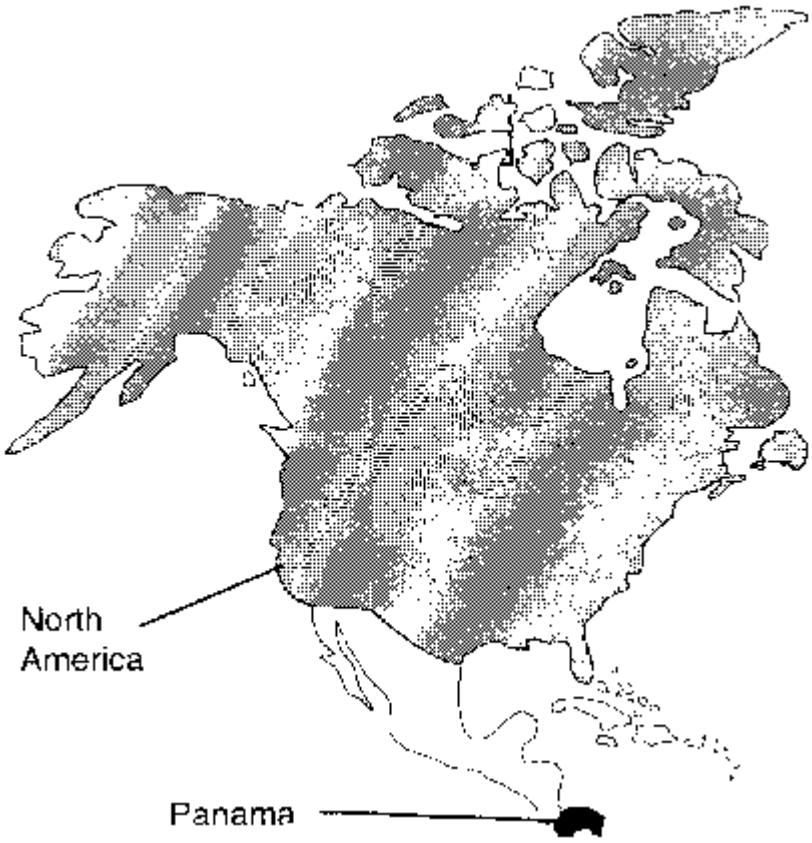
The rural poor depend on biological resources for an estimated 90% of their needs.

Unexploited biodiversity

Several thousand plant species have been used for human food in history, but now only about 150 are cultivated. Just three (rice, maize and wheat) supply almost 60% of the calories and protein derived from plants.



Unexploited biodiversity



Panama contains more species than all of North America.

Why is biodiversity important?

Genetic diversity in agriculture enables crops and animals to adapt to different environments and growing conditions. The ability of a particular variety to withstand drought or inundation, grow in poor or rich soil, resist one of the many insect pests or diseases, give higher protein yields or produce a better-tasting food-these are traits passed on naturally by its genes. This genetic material constitutes the raw material that plant and animal breeders and biotechnologists use to produce new varieties and breeds. Without this diversity, we would lose the ability to adapt to ever-changing needs and conditions. Sustainable agriculture could not then be achieved in many of the world's different production environments.

Diversity among individual plants and animals, species and ecosystems provides the raw material that enables human communities to adapt to change-now and in the future. Deprived of biodiversity, the ability of humankind to meet the challenges resulting, for example, from global warming and ozone depletion would be severely limited. The diversity found within the small number of plant and animal species which form the basis of world agriculture and food production remains a small but vital part of the earth's biodiversity. Through modern

biotechnologies, wild diversity can also be incorporated into crops and contribute to world agricultural development.

Indigenous knowledge and biodiversity

For centuries, rural peoples have encouraged and relied upon biodiversity for their livelihoods. Farmers have managed genetic resources for as long as they have cultivated crops. For some 12,000 years, they have selected varieties of crops and livestock breeds to meet environmental conditions and diverse nutritional and social needs. The immense genetic diversity of traditional farming systems is the product of human innovation and experimentation-both historic and ongoing.

Traditional medicines

An estimated three-quarters of prescription drugs derived from plants were discovered because they were first used in indigenous medicine. Forest-dwelling indigenous people throughout the world employ at least 1,300 plant species for medicines and related purposes. Over 60 species of plants are used to treat skin infections in the Amazon region alone.

Traditional food plants

For generations, subsistence farmers have been producing or gathering plants in the wild or semi-wild that have long been accepted as desirable sources of food. At least 1,000 million people worldwide are estimated to use such traditional plants as food.

Traditional medicines

Biodiversity for sustainable development

A 13.7 km^2 area of La Selva forest in Costa Rica contains almost 1,500 plant species-more than all those found in the United Kingdom's 243,500 km^2.

The biological resources of every country are important, but not all are equally endowed. In general, a small number of countries lying within the tropics and subtropics account for a very high percentage of the world's biodiversity. Tropical forests, for example, cover only 7% of the earth's land surface, but they are estimated to contain at least 50% of all species.

The most important food crops, however, appear to have originated in areas that have pronounced seasons, not in the tropical forests. Their areas of origin tend to coincide with arid and semiarid zones, which include famine-prone countries such as Ethiopia. It makes sense, therefore, to look for sources of certain food crop diversity in such areas. A single Ethiopian barley plant, for example, has yielded a gene that now protects California's annual barley crop from yellow dwarf virus.

The fact that the riches nations are home to the smallest pockets of biodiversity, while the poorest are stewards of the richest reservoirs underscores the interdependency of all nations and the urgency of crafting common strategies for sustaining biodiversity that share both responsibility and benefits. On the eve of the 21st century, the challenge for the global community is not to save its biodiversity for its own sake, but to ensure that biodiversity is used sustainably and equitably for human development.

Biodiversity as a resource

In the developing world, biodiversity provides the assurance of food, countless raw materials such as fibre for clothing, materials for shelter, fertilizer, fuel and medicines, as well as a source of work energy in the form of animal traction. The rural poor depend on biological resources for an estimated 90% of their needs. In the industrialized world, access to diverse biological resources is necessary to support a vast array of industrial products. In the continuing drive to develop efficient and sustainable agriculture for many different conditions, these resources provide raw material for plant and animal breeding as well as the new biotechnologies. In addition, biodiversity maintains the ecological balance necessary for planetary and human survival.

Adapted from: Hope Shand, 1993. Harvesting nature's diversity. Food and Agriculture Organization of the United Nations

1.4 User survey

Please tell us what you think of this information kit. This will help us improve the next version of this kit, and will help make future information and educational materials better.

Please return this form to one of the following addresses:

• Education Officer World Wide Fund for Nature-India, 172-B Max Mueller Marg Lodhi Estate New Delhi 110 003 India or.

• Communication Division International Institute of Rural Reconstruction Silang Cavite 4118 Philippines.

Both the World Wildlife Fund and IIRR publish a range of other materials on nature conservation and sustainable development. Please write to the addresses above for more information.

Thank you for taking the time to answer these questions.

1. Do you have a copy of the information kit?

Ž Yes

Ž No

2. If yes, how did you obtain it?

Ž Purchase

Ž Free

Ž Borrowed

Ž Other (please describe)

3. Where did you obtain the kit?

Ž From WWF

Ž From IIRR

Ž NGO or nature club

Ž Bookshop

Ž Other (please describe)

4. Have you used the information kit?

Ž A great deal

Ž Quite a lot

Ž A little

Ž Not at all

5. In what ways have you used it? (please check all that apply,

Ž Classroom teaching and training

Ž Field work

Ž Reference

Ž Field teaching and training

Ž As a resource to prepare other materials

Ž Other (please describe)

6. With whom have you used the kit? (please check all that apply)

Ž School-age children

Ž Students

Ž Nature clubs

Ž NGO staff

Ž Others (please describe)

7. What topics do you find most useful? (please describe)

8. What topics do you find least useful? (please describe)

9. What additional topics do you think should be included in the kit?

10. Which topics need to be revised or corrected? Please make concrete suggestions for revision.

11. What format would be best for a revised kit? (please check one)

Ž As is, in a card folder

Ž As is, but in a ring binder

Ž Series of pocket-sized booklets

Ž Other (please describe)

12. Have you adapted or translated any of the materials in the kit? If so, please explain.

13. Did you find the illustrations helpful?

Ž Yes

Ž Partly

Ž No

14. Would you like more or fewer illustrations?

Ž More

Ž OK as is

Ž Fewer

15. Do you have suggestions for further improving the illustrations? If so please specify.

16. Have you shared the kit with others? If yes. with whom' What feedback did you receive from them?

17. Please list any additional comments.

Please give us the following brief information about yourself.

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1.5 Biodiversity: A synthesis

This information kit brings together over 70 topics related to the biodiversity of the Western Ghats region of India. Each sheet stands alone as a source of information on a particular subject. The whole Set provides an extensive-though not exhaustive-review of the pressing biodiversity issues in the region.

Levels of biodiversity

The sheets in this kit cover the three levels of biodiversity: ecosystem, species and genetic. The topics themselves can be read as a typical transect from west to east: marine ecosystems Of the Arabian Sea (sheets 3-1, 3-9), mangrove-lined estuaries (4-3), reclaimed khazan lands (5-8), other agroecosystems (5-2), cashew plantations on the midlands (5-3), and a range of forests and grasslands (9-6, 9-7, 9-8, 9-11). The species diversity of these ecosystems includes animals such as the King Cobra (8-1), Malabar Pied Hornbill (8-3), and the Lion-tailed Macaque (8-4). At the genetic level, the region houses numerous varieties Of domesticated crops such as rice (5-1) and mango (5-3).

Genetic diversity

A number of sheets in the kit focus on biodiversity at the genetic level. These include the sheets on silkworms (7-3), bees, vermicomposting (7-6), rice (5-1), arboriculture (5-4), mango and cashew (5-3). These sheets illustrate the dual nature Of domestication on biodiversity. In one sense, numerous individual farmers practising pure line selection of cultivated crops have led to an increase in genetic diversity. On the other hand, increasing commercialization often leads to monoculture production. Whether germplasm storage can address this issue-in the long run-has yet to be seen. Protecting varieties.

With lower current value but potential future value will be increasingly important.

Species diversity

A number Of topics focus on broad types of plants and animals such as birds (8-3), fungi (6-5), shellfish (3-7), spiders (7-4) and mangroves (4-2). This coverage is not intended to be comprehensive; rather, it seeks to highlight particular groups Of plants and animals for their educational value. For example, rodents are no less important than snakes, yet snakes are, to the lay person, more interesting and attractive than their lowly prey. The sheet on snakes (8-1) helps introduce points Which often apply more broadly. Such charismatic species also include large carnivores found high in the food chain. Protecting these animals requires protecting large areas of land, Which also helps protect many other forms of biodiversity.

Species diversity

Ecosystem/habitat diversity

The many ecosystems in the region can be divided into two types: natural and anthropogenic (i.e., man-made). Marine ecosystems (31, 3-9) and sacred groves (9-6) are examples of ecosystems that are still largely natural. Mining areas (9-7, 9-8) and cities (2-3) are largely anthropogenic. We may think that human interference in natural ecosystems always reduces biodiversity; the kit gives many examples of this. The sheet on khazan lands (58), however, shows that some sustainable agroecosystems which do not completely replace nature can actually increase local biodiversity. These agroecosystems should be held Up as models for future sustainable agricultural development.

Cultural diversity

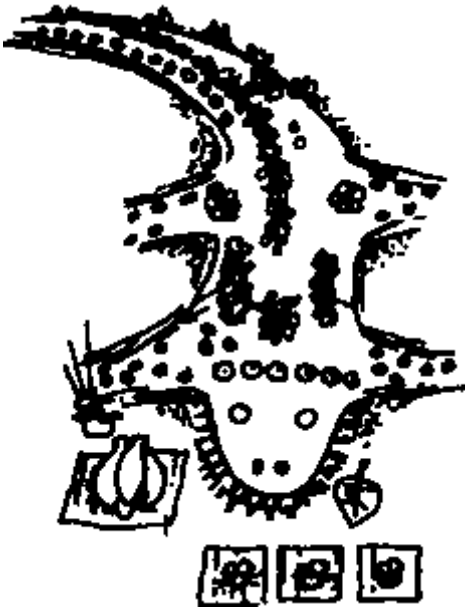
The diversity of culture is also important. Cultures, like species, can also become extinct. People, too, develop unique adaptations to their environment. Although the kit does not include any specific sheets on cultural diversity, it is implicit in maintaining anthropogenic ecosystem and protecting genetic and species diversity. Two good examples of this can be seen in the practice Of crocodile worship (8-2) and the social organization that maintains the khazan lands (5-8). Yet these are only a few examples of how cultural diversity relates to biodiversity. In addition, cultural diversity has its own intrinsic value.

Value of biodiversity

The impact of the loss of particular forms Of biodiversity can, for the most part, be determined by looking. at the loss of its various forms of value. For example, the loss of mangroves will result in greater coastal erosion, loss of habitat for associated biota, loss of consumptive and productive uses and, possibly, the loss of potential medicines.

Species diversity

The value of biodiversity is viewed and measured differently according to one's perspective. Three general perspectives are economic, ecological, and ethical. All share one thing: uncertainty. That is, a great deal still has to be learned about plants and animals, theirs role in local and global ecology, and their potential uses for humankind.



Species diversity

Economic

The most developed valuation of biodiversity comes from economics. Two types of values are es are generally considered: use values and non-use values. The latter refers to the existence value of biodiversity and corresponds loosely to the ethical category discussed below.

Use values refer to the current or future utilitarian value to humans. They are further divided into option values. indirect. and direct.

Option values refer to the potential of biodiversity for future use. This may be in the form of medicines, crop/livestock improvement or industrial use.

Indirect use values refer to ecological services such as watershed protection (see the section on ecological values below).

Direct values are the most commonly measured and can be non consumptive. consumptive or productive.

Species diversity

Non-consumptive

Tourism is an example of the non-consumptive value of biodiversity because no product is used or consumed during the process. A number of sheets stress the role of protected areas for conservation. Ecotourism is a potential source of income which can help sustain effective management of protected areas. Ecotourism also plays an important educational role a a form of experiential learning. A number of sheets [birds (8-3), butterflies (7-1), mammals (8-4), wetlands (4-4), nature trails (9-5), and sacred groves (6-9)] give tips on how to better appreciate nature while in the field.

Consumptive

Fruits and building materials used for subsistence are "consumptive" because they are not traded. Many such biological resources are considered common property and play a valuable (albeit often underestimated) role in local economies. The sheets on edible mushrooms (6-7), medicinal plants (6-3), and mangroves (4-2) all relate to the consumptive values of biodiversity.

Productive

Productive uses include products derived from biodiversity mainly for aquaculture, agriculture, medicine, and industry. These can also be consumptive if they are used on a subsistence level. The majority of sheets in the kit provide examples of the productive value of that particular form of biodiversity. Productive uses often exceed biological limits of regeneration. The need to manage these resources at sustainable levels of use is a clear message of the kit.

Ecological

Ecological values of biodiversity include the environmental services they provide for humans and other species. Ecological services for humans include soil formation, watershed protection, climate regulation, cycling of nutrients, and assimilation of pollutants. The sheets on mangroves (4-2), sand dune vegetation (3-10), estuaries (41), plant associations (6-1) and wetlands (4-4, 4-5) emphasize the ecological values of biodiversity. The importance of the ecological value of biodiversity is often masked by two factors: they are rarely given an economic value; and, among those known to science, most are rarely understood by policymakers. The former is now being addressed in the discipline of ecological economics. The latter is one of the objectives of this kit.

Ethical

The existence of a particular species or ecosystem often has cultural, moral, religious, or ethical significance which gives it intrinsic value. Examples of this intrinsic value can be seen for plants, animals and even entire areas. The sheets on edible mushrooms (6-7), mango and cashew (5-3), crocodiles (8-2) and sacred groves (9-6) provide insights on values which transcend direct or indirect use to humans. Various cultures designate non-utilitarian value to biodiversity often through extensive ritual and ceremony. These indigenous forms of conservation may hold important lessons for environmental educators and can help broaden an increasingly economic benefit-oriented world.

Only about 1.4 million living species out of a total of approximately 30 million have actually been described.

Species diversity

Causes of biodiversity loss

Human activities can lead to the loss of biodiversity in many ways. Five. Of the most common processes are habitat conversion, habitat degradation, overexploitation, introduction of exotics, and creation of monocultures. These processes often occur in combination. These are the immediate causes of the loss of biodiversity, but there are also driving forces or underlying causes behind them. These include greed, population pressure, market failure, inappropriate government policies, and excessive consumption as a result of rising affluence. All of these causes are evident in the Western Ghats region and discussed in many of the sheets in the kit.

Estimates of the current extinction rate are at 1000 species a year (Wilson, 1988). By the 1990s, the figure is expected to rise to ten thousand species a year (one species an hour).

Species diversity

Destruction of tropical forest proceeds at the rate of more than 20 hectares a minute, despite the fact that nearly half the area cleared so far has been abandoned as wastelands within a period of less than 10 years (UNEP, 1992).

Direct causes

Ecosystem conversion

The conversion of ecosystems to conditions completely different from their natural state is called habitat or ecosystem conversion. New uses include agriculture, settlements, industry, and infrastructure. Coastal areas and wetlands are two ecosystems most affected. Coastal areas are often densely populated, and sand dune areas (3-10) are commonly used for tourism and industry. Wetlands such as swamps and marshes (4-4, 4-5) and estuaries (4-1) are often seen as wastelands to he reclaimed for agriculture or aquaculture. The sheets on tobacco (2-9), mangroves (4-2). estuaries (4-1) and others deal with this issue. That on watershed management (9-3) takes a prescriptive approach: it explores how planning can protect ecosystems.

A growing concern is the fragmentation of wildlands. Thousands of years of conversion and rising populations have created a patchwork of ecosystems, more and more of which are human-modified. The remaining wildlands are shrinking and fragmented. This is important because certain species require a minimum area for their long-term survival. The sheet on national parks and sanctuaries (10-1) identifies the main protected areas in the region.

Habitat degradation

Habitat or ecosystem degradation results from the disturbance but not complete conversion of an area. The main type of disturbance is pollution-of the air (2-6) or water (2-5), or as solid waste 2-7. Pesticides (57) affect not only their target species but also a wide range of other organisms. Sedimentation (9-9) is also a major cause of habitat degradation and results from activities such as mining, agriculture and infrastructure projects.

Habitat degradation occurs on a global scale as well. Ozone layer depletion and increasing concentrations of greenhouse gases are two examples (2-6). These, may have serious- impacts on terrestrial and aquatic ecosystems and species.

Overexploitation

Species can be lost as a result of overexploitation from hunting, fishing, and collecting. Some species-usually those high on the food chain or with a specialized niche-are particularly susceptible to overexploitation. Unfortunately, these are the very same animals which are prized for the wildlife trade - both legal and illegal. The sheets on wildlife trade (2-8), overexploitation of marine resources (3-3), and mangroves (4-2) include information on the role of overexploitation on the loss of biodiversity.

Species diversity

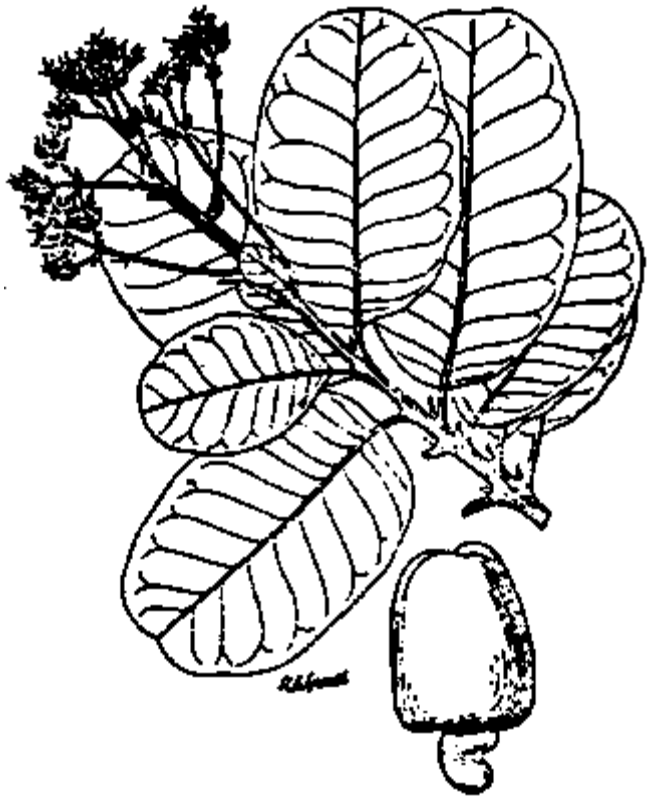
Competition from exotics

Introduced species can often negatively affect native species. Often -they are selected specifically for their adaptability, which is the reason why they frequently outcompete native species for resources. The result is the expansion of the introduced species and decline of native species. Two sheets deal with introduced species from two divergent perspectives. Sheet 5-6 looks at the negative aspects of introduced species in terms of their impact on native flora.

Sheet 5-5 shows the benefits of introduced species and the subsequent genetic diversity arising from the new plants. These two sheets reinforce the need to limit introduced species and understand potential ecological interactions if introductions are necessary.

Monoculture due to commercialization

The commercial production of many domesticated plants and animals has commonly led to the decline in local varieties. This has been dramatically shown in rice and also in some livestock. Six sheets deal with commercially cultivated crps and animals: silk- worms (7-3), bees (7-2), vermicomposting (7-6), floriculture and arboriculture (54), mango and cashew (5-3) and rice (5-1). The productive value of all of these activities is obviously high; sustaining this productivity will require a diverse genetic base for future improvements.



Genetic diversity

Underlying or root causes

The underlying or root causes of biodiversity loss include national and international policies (environmental protection, resource exploitation, and trade issues), rapid population growth, and the inequitable distribution of land. These create conditions leading to the direct causes of biodiversity loss. Although the kit does not directly deal with this, a number of sheets (e.g., 2-2) provide examples.

Conservation approaches

Ex situ conservation

Botanic gardens, game farms, captive breeding programs, zoos, and gene banks are all forms of conservation that maintain biodiversity outside their natural habitat. Under certain conditions, these approaches are useful or necessary:

• When populations are so low that the species may become extinct.

• When the educational value is high.

• When they reduce exploitation pressure on wild populations.

• When species or genes can be efficiently propagated for commercial or other purposes.

Domestic animals

Various sheets (e.g., 5-1, 5- 3, 6-6) propose ex situ conservation as an important strategy. In most cases, these are situations with potential economic benefits.

In situ conservation

Maintaining biodiversity in a natural habitat-in protected areas-allows evolutionary processes to continue.

Compounds of microbial plant or animal origin account for 80% of prescriptions in the developing countries and 40% of medications in the industrialized world. These compounds currently have a value of $20 billion annually to the pharmaceutical industry (UNEP, 1992).

At least 10 percent of India's recorded wild flora, and possibly more of its wild fauna, are on the list of threatened species, many on the verge of extinction

In this way, living things evolve according to the constant change in environmental conditions-both natural and anthropogenic. In addition, in situ conservation protects entire assemblages of

living communities as opposed to individual components. The sheets on sacred groves (9-6) and national parks (10-1) deal directly with in situ conservation. In addition, the majority of the other topics identify in situ conservation approaches as important components of any conservation strategy.

Summary

A subject as abstract and extensive as biodiversity can be overwhelming. In addition, the size of the region involved, the Western Ghats, is larger than many small countries. In order to systematize the process of understanding biodiversity, the sheets in the kit use an approach which looks at the value. cause of loss, impact of loss, and conservation approaches for various forms of biodiversity. This approach is by no means definitive; however, it can be easily applied to other topics not included in the kit. We hope this will allow users of the kit to apply it to biodiversity issues particularly relevant to their own area.

Domestic plants

Prepared by Greg Ira

Information kit produced by

WWF-India, Goa division and the

International Institute of Rural

Reconstruction.

2. Threats

2.1 Biodiversity of the Western Ghats

The biological diversity of the Indian subcontinent is one of the richest in the world owing to its vast geographical area, varied topography and climate, and the juxtaposition of several biogeographical regions.

The greatest concentration of biological diversity is found in the Himalayas, the Andaman and Nicobar islands and the Western Ghats regions.

The Western Ghats is a mountain chain running from the north to the south and is isolated by the Arabian Sea to the west, the arid Deccan Plateau to the east, and the Vindhya-Satpura ranges to the north. They have different vegetation types: scrub jungles, grasslands at low altitudes, dry and moist deciduous forests, montane grasslands and sholas, and the precious tropical evergreen and semi-evergreen forests. Complex topography, high rainfall and relative inaccessibility have helped the region retain its diversity.

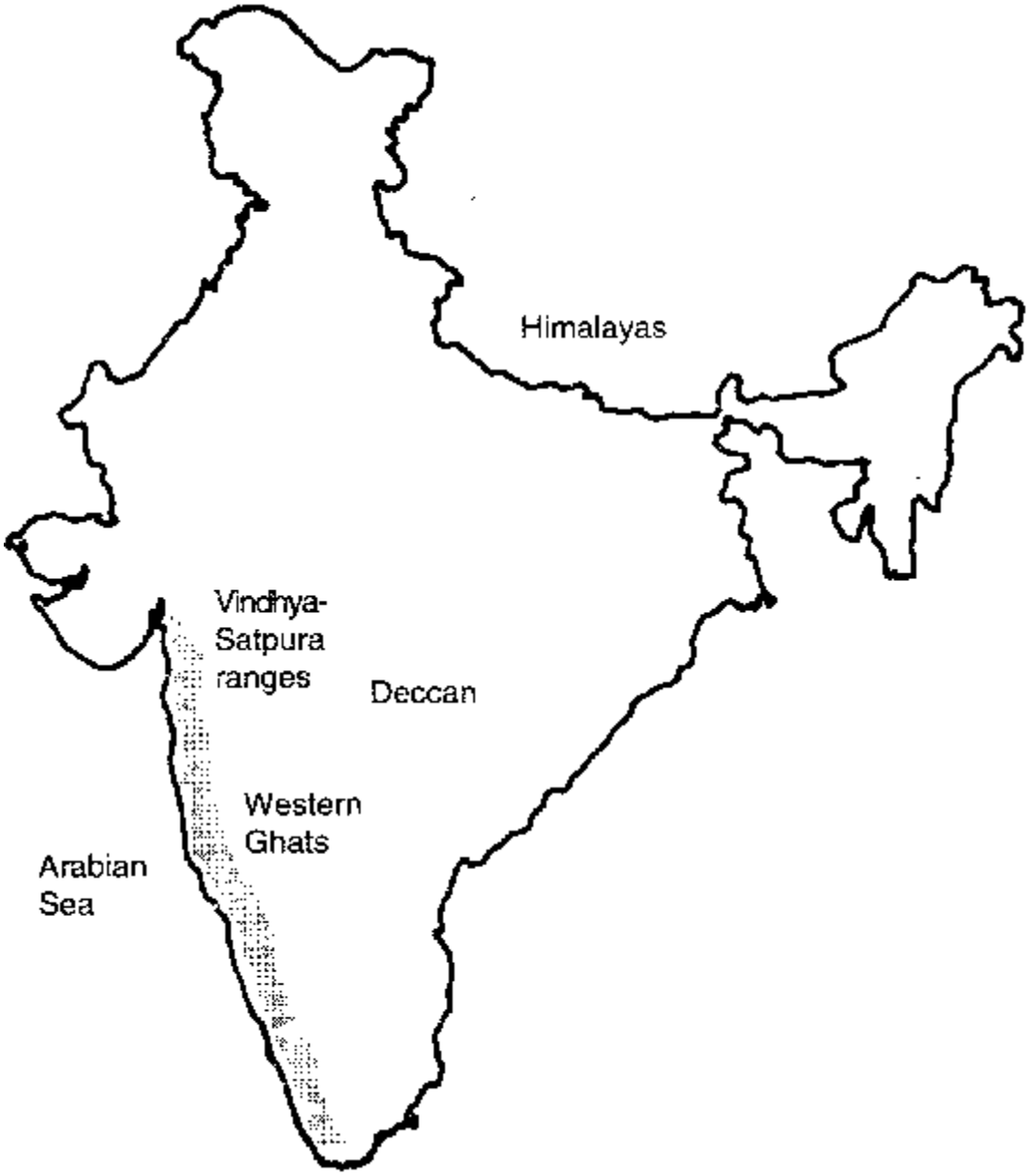
Floral and faunal wealth

Of the 15,000 flowering plant species in India, over 4500 occur in the Western Ghats region. The grasses, legumes, the plant families Acanthaceae, Orchidaceae, Asteraceae, Euphorbiaceae, Rubiaceae, Asclepiadaceae,

Geraniaceae and Lamiaceae are the ten dominant families in the region. Ferns and other lower forms of plant life are also well represented. There is also a great diversity of traditional crop plants.

There is an equal diversity of animal life. A large number of amphibian, freshwater fishes and invertebrate groups occur in the Western Ghats. All of

India's indigenous species of honey bees, and several species of stingless bees are found here.



Floral and faunal wealth

Endemic species

The Western Ghats are home to many endemic, rare and endangered species, as well as scores of economically important species and wild relatives of cultivated plants. The southern areas, in particular, have the richest gene pool of the region. Of the 4500 species in the Western Ghats, 1720 are endemic. Nearly a third are rare or threatened, and several are believed to be extinct (e.g., Dalbergia travancorica and Vanda wightii).

Fifty-eight genera of flowering plants are endemic to the region. Of these, 42 genera are "monotypic": they have only one species. An example is Blepharistemma membranifolia.

Endemics include the Strobilanthes group, such as Carvia callosa, Supushipa scrobiculata and Phlebophyllum kunthianum. These plants flower once in their life span of 4 to 16 years. They play an important role in the local ecology. Their reproduction and proliferation depend on local insects, such as honeybees that pollinate them while collecting nectar. Species like Carvia callosa help bind soil and provide shelter for bird nests. Local tribals use the sticks for thatching and other purposes.

Eighty endemic Species of trees and shrubs are confined only to evergreen forests. They are not found in other types of forests.

Several woody genera found here have a large number of endemic species. Examples are Syzygium (18 endemic species) and Litsea (14 endemic species).

Eighty-four species and two varieties of orchids are endemic to the Western Ghats. This is the only region where the south Indian species of the Lady's Slipper Orchid occurs.

Animals endemic to the Western Ghats include the Rusty Spotted Cat, two species of civet and two types of mongoose, the Nilgiri Marten, the Grizzled Giant Squirrel, the Nilgiri Tahr, the Lion-tailed Macaque, and the Nilgiri Langur.

Some plant groups with a large number of endemic species in the Western Ghats

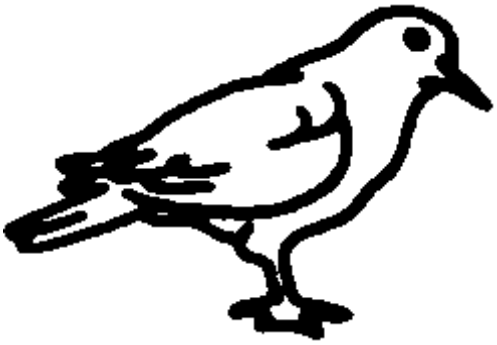
Grasses	10 genera, 150 species
Orchids	2 genera, 100 species
Palms	11 species
Impatiens	71 species
Peppers	9 species
Sissoo (Dalbergia)	7 species
Ochlandra	7 species

What are endemic species?

Endemic species are species that are found only in a certain area. They have evolved to adapt to the special conditions in that area. If their habitat is destroyed, for instance by deforestation, they can easily become extinct.

Endemic to the Western Ghats

Mammals 48 genera



Birds 275 genera

Reptiles 60 genera

Fishes

Invertebrates

Amphibians

Flowering plants 58 genera

Plant resources

The forests of the Western Ghats are a veritable storehouse of economically important species. Trees that yield timber and fuelwood include Dalbergia spp., Dipterocarpus spp. and Hopea spp. Non-wood forest species provide:

• Fibre (e.g., bamboo, rattan)

• Food

-Edible fruits (e.g., Artocarpus hirsutus, Garcinia indica)

-Edible nuts (e.g., Sterculia guttata, Terminalia bellerica)

-Spices and condiments (e.g., Garcinia gummi-gutta, Piper nigrum)

• Extractive products

-Gums, resins and oleoresins (e.g., Canarium stictum, Vateria indica)

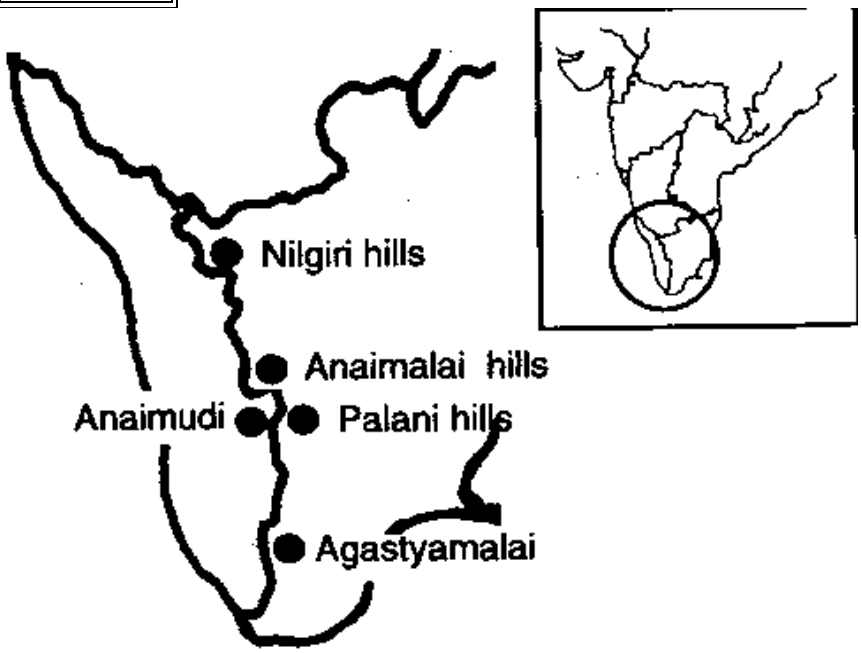
-Tans and dyes (e.g. Garcinia morella, Terminalia spp.)

-Essential oils (e.g., Cymbopogon spp., Mesua ferrea)

• Medicines (e.g., Dioscorea spp., Rauwolfia serpentina)

Areas in the Western Ghats rich in endemic species

Nilgiri hills	93 species
Anaimalai hills	13 species
Palani hills	18 species
Anaimudi	30 species
Agastyamalai	150 species



Areas in the Western Ghats rich in endemic species

These species are found only in these areas

Wild relatives of these crops are found in the Western Ghats

• Rice

• Finger millet

• Pearl millet

• Sugarcane

• Pepper

• Turmeric

• Ginger

• Nutmeg

Wild relatives of cultivated plants

The Western Ghats region is a rich gene pool of cultivated plants. It contains wild relatives of many different crops.

These wild relatives play a vital role as gene sources in plant breeding programmes. We need a reservoir of wild species to prevent the "genetic erosion" in our cultivated plants. This erosion can occur as farmers plant a very few high-yielding varieties of crops like rice and millet. The wild species Saccharum spontaneum has been extensively used in breeding superior varieties of sugarcane (Saccharum officinarum).

Ethnobotany

As human societies develop, they distance themselves more and more from nature. It is easy to lose sight of the importance of a diverse, stable ecosystem to human life. Since humans first evolved, we have depended on natural vegetation for food, fuel, clothing, shelter and medicine. The multi-faceted relationship between human societies and plant forms since ancient times is the subject of the field of ethnobotany.

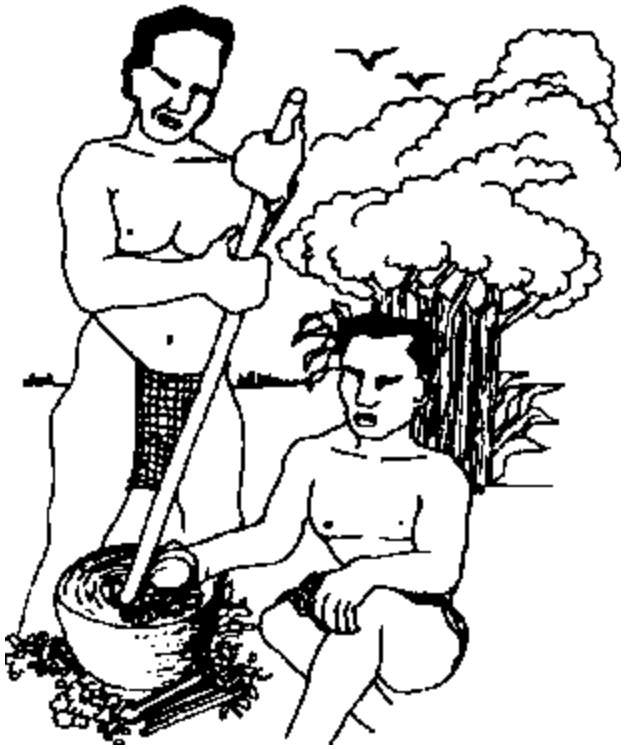
Research in India has revealed the vast store of knowledge of plant properties and uses still present in tribal cultures. Tribal groups are known to use about 5000 wild plant species for many different uses: food, clothing, fibre, antidotes for insect or snake bites, hunting, fishing, and farm implements. The traditions, beliefs, needs and cultures of tribal people are linked to the diversity of plant life around them.

Ethnobotanical studies can help us understand the plant diversity and ecology in a region and design ways to protect its important species.

Some endemic species believed extinct or on the verge of extinction

Scientific name	**Family**
Trees	
Hopea jacobii	Dipterocarpaceae
Nothopegia aureo-fulva	Anacardiaceae
Cynometra beddomei	Leguminosae

Syzygium palghatense	Myrtaceae
Actinodaphne bourneae	Lauraceae
Herbaceous species	
Haplothismia exannulata	Burmanniaceae
Hubbardia heptaneuron	Gramineae
Impatiens anaimudica	Balsaminaceae
Arisaema articulate	Araceae
Anoectochilus rotundifolius	Orchidaceae



Ethnobotany

Information kit produced by

WWF-India, Goa Division and the

International Institute of Rural Reconstruction.

2.2 Threats to biodiversity

During the past 40-50 years the plant and animal life in the Western Ghats has been degraded. The environment as a whole has suffered, mainly due to urbanization and so called "development". Many plants and animals have become extinct or are in danger of becoming extinct.

Causes of extinction

• Destruction of habitats, especially in tropical forests.

• Disturbance of small areas that are home to endemic species.

• Pollution because of industry, mining and other human activities.

• Continuous cultivation of single crops such as sugarcane, leading to elimination of "weeds" and pre-existing vegetation.

• Unsustainable shifting cultivation in forests.

• Use of fertilizers, changing the soil chemistry and microfauna.

• Accidental introduction of exotic species. Congress grass (Parthenium hysterophorus) and eupatorium (Eupatorium odoratum) are weeds that were introduced from outside. They are replacing local plant species.

• Preventing fires in forests leads to luxuriant growth of some species and suppresses or eliminates less competitive species. Some plants need a certain amount of disturbance to grow, reproduce and survive.

Growth in the human population is a root cause of many of these problems: the higher the population density, the greater the pressure on the natural environment.

Ecosystems of the Western Ghats and their location Tropical wet evergreen forest Amboli, Radhanagari Montane evergreen forest Mahabaleshwar, Bhimashankar Moist deciduous forest with bamboo breaks Mulshi Scrub forest with drought-resistant plants Mundunthurai

Consequences of biodiversity loss

• Extinction is forever. A species that is lost cannot be regained by means of modern technology. This biodiversity might have proven of great significance for human welfare in the future.

• In a stable ecosystem, all species-animals, plants and microbes-are in a dynamic equilibrium. Any disturbance in one gives rise to imbalance in others. A vanishing plant species can take with it 10-30 dependent species such as insects, fungi, higher animals and even plants.

• The loss of one or even a few species may not affect an ecosystem. But the cumulative effect of many such losses may lead to serious destabilization of natural ecosystems. The time is too short for new species to evolve that are more suited to the new environmental conditions.

• Plant species of medicinal, horticultural, agricultural and biological importance will be lost.

Some of the endangered plants

Queen of Flowers

Roxburgh's Kydia

Indian Laburnum

Large-flowered Dellenia

Blue Acacia

Rangoon Gupor

***In situ* conservation**

Ex situ conservation

A practical conservation alternative is ex-situ: in zoos, seed banks, arboreta and botanical gardens. Conservation in these sites may be necessary for plants and animals that have been lost from their natural range. They can then be reintroduced into the wild.

Conserving crops and livestock

The conservation of biodiversity is not limited to wild species. Over thousands of years, farmers have selected crops and livestock, developing and maintaining many varieties and breeds. These varieties are being replaced by modern, high-yielding strains. They are valuable sources of genes for plant and livestock breeders, and must be conserved before they disappear. These plants and animals can be maintained in two ways: in situ and ex situ. Farmers can help preserve them in situ by continuing their traditional farming practices. Many universities and research institutes maintain ex situ collections of seeds and live plants and animals to help maintain these valuable genetic resources.

Conservation of genes, species and ecosystems is normally done in one of two ways. In situ conservation is based on protection of biodiversity in existing natural areas. Ex situ conservation, on the other hand, involves the establishment of man-made areas where biodiversity is conserved outside of its natural habitat.

In situ conservation is preferred because it allows living organisms to continually adapt or evolve, according to changing environmental conditions. This can be done by establishing biosphere reserves, national parks, wildlife sanctuaries, and gene reserves.

There is only one biosphere reserve in the Western Ghats, the Nilgiri Biosphere Reserve. This reserve helps conserve many endemic and endangered species, economically important species and their wild relatives. It is also hoped to preserve traditional landraces of cultivated plants under traditional agricultural practices around the reserve.

• New biosphere reserves. There is a need for more biosphere reserves and other sanctuaries in the Western Ghats region. The sacred groves and evergreen rainforests in Agastyamalai, Koyna, Mulshi, Amboli, Bhimashankar and Radhanagari areas would be ideal sites for such conservation. Canepalm grows now only in restricted areas in Koyna and Mulshi forests. The Department of Forests in Maharashtra has identified certain forests as important for plant diversity.

• Floristic and ethnobotanical studies are needed to identify valuable genetic variations and species diversity.

• Exclusive habitats should be developed for different plant and animal associations. Rare species of Podostemaceae, for example, grow only on certain rock surfaces with flowing water near waterfalls. Freria indica, a beautiful asclepiad, grows only on rocky slopes. Tree ferns grow only in tropical, wet evergreen forests with thick shade and high relative humidity.

• Protect valuable areas Areas that contain specific habitats should be identified and protected from human and other interference. Measures should be taken to propagate rare and threatened plant species within these areas.

• Sustainable resource management systems are needed that integrate conservation and development.

• Education is needed to increase knowledge and awareness of the importance of the ecosystem and how to preserve it.

Susala gene-bank project

The Four Eyes Foundation, Pune, runs a biodiversity conservation project in Susala island in the Mulshi lake, about 50 km from Pune. The Susala gene bank is an example of what can be done for biodiversity conservation in the Western Ghats.

Objectives

• Conserve botanical wealth through soil and water conservation measures and protection from human and biotic interference.

• Study plans diversify.

• Introduce and propagate plant species endemic to Western Ghats but not present locally.

• Study genetic diversity of plant species with nutritional, fodder, timber and medicinal value.

Species found

• 530 plant species from 110 families (excluding grasses and sedges).

• 75 medicinal species (e.g., Helicteres isora, Fagara budrunga, Lobelia nicotianaefolia and Gymnema sylvestres).

• 30 rare and endangered species.

• 50 wild edible plants.

About 150 new species have been introduced.

For more information, contact: Four Eyes Foundation, 798, Bhandarkar Road, Pune, 411004, India, Fax 91-212-337302

Prepared by B. V. Shetty, V. D. Vartak,

M. C. Suryanarayana and Dr. S. Yadav

2.3 Urbanization and biodiversity

Urbanization in Goa

1961	**1991**
11 towns	31 towns
15% of population urban	43% urban

Effects of urbanization on biodiversity

• Loss of natural vegetation

• Water and air pollution

• Increased water runoff

• Changes in temperature (thermal pollution)

• Introduced species of plants and animals

• Overexploitation of resources (e.g., surrounding forests, fisheries)

Conservation approaches

• Land use zoning: Prevent undesirable land uses in certain areas.

• Restrictions on development: e.g., no new building within 200 m of coast or river.

• Environmental impact assessment: to predict effects of development on the environment

• Greenbelts: Areas of green land around cities.

• Pollution control

Set limits on the amount of waste a factory may emit.

Require factories to treat waste before disposal.

Human settlements in the Western Ghats are concentrated mainly near the coast. These settlements include hamlets, villages, small towns, cities, and megacities like Bombay.

Over the last 30 years, the Western Ghats region has become rapidly urbanized. Settlements have become more complex. Small fishing villages have grown into towns with many types of industry. It is becoming more difficult to classify a settlement as being mainly a fishing settlement, a port, or an industrial town. In many areas, it is difficult to distinguish between urban and rural settlements.

Towns and cities can function efficiently only if enough infrastructure is provided. Infrastructure includes roads, railways and public transport, water and electricity supplies, drainage and sewerage, parks, telephones, and so on. Rapid urbanization makes providing these services very difficult.

The problems of megacities like Bombay illustrate these difficulties. Road space is insufficient. Transportation systems cannot cope with the number of people who need to travel Open spaces are far below the standard requirements. Water supplies cannot meet the needs. Urban areas and the provision of infrastructure must be planned to avoid such problems.

Urban areas

• Dense population

• Main economic activity is secondary or tertiary (industry and services) rather than agriculture

• Densely built-up area

• Many resources consumed

• Much energy used

• High pollution levels

Urban areas

Coastal Goa

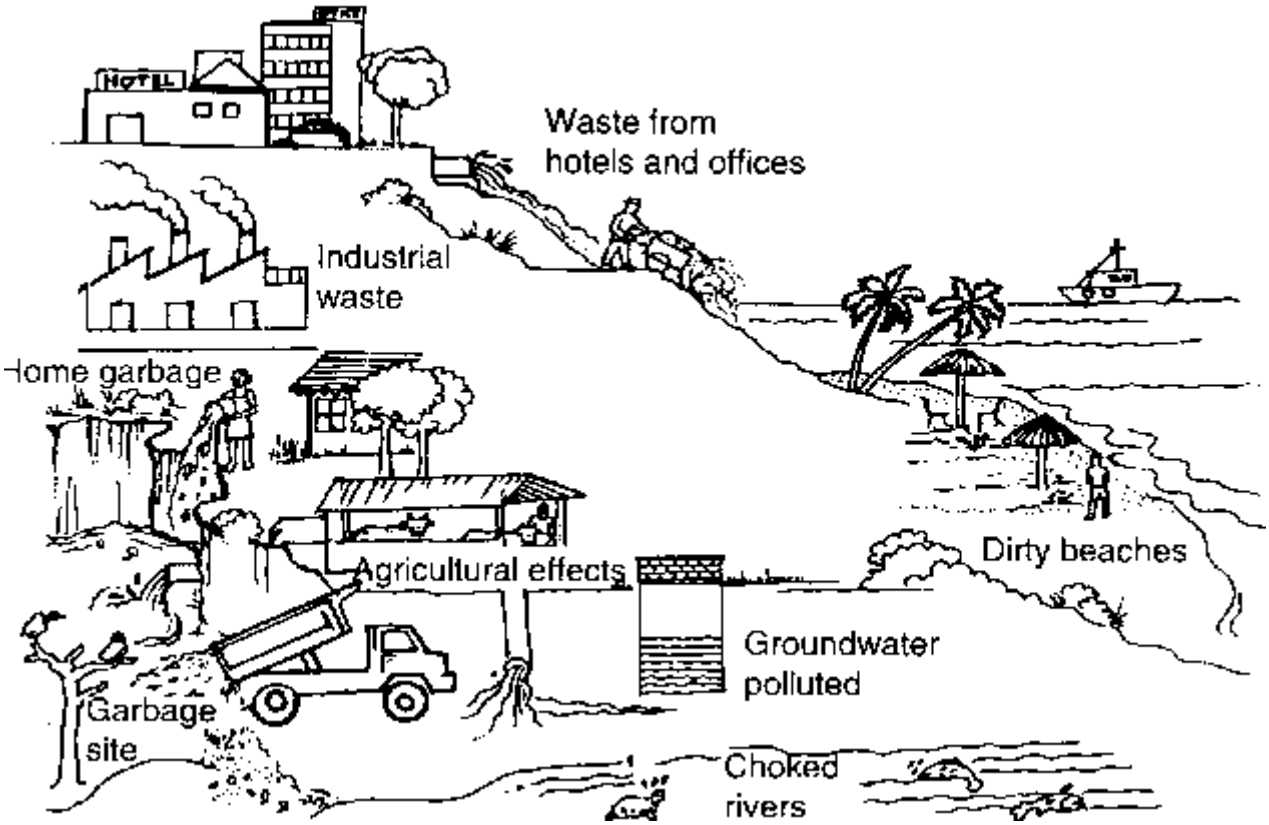
The coastal area of Goa has undergone rapid changes because of tourism. Untouched beaches have been opened up for intensive commercial development. All along the coast, especially in Salcete and Bardez districts, a variety of settlements have sprung up with residences, hotels, commercial buildings (some converted from other uses), and vastly increased amounts of traffic.

Planners try to focus urban development in areas where it is desired. In Goa, plans call for restricted development in the coastal zone. Instead, urban centres in the hilly midland zone are to be stimulated.

Coastal Goa

Effects of urbanization on groundwater

Development in the coastal zone can be so intense that it can affect groundwater



Effects of urbanization on groundwater

2.4 Population and biodiversity in the Western Ghats

Biodiversity in the Western Ghats is linked to the human habitation in the region. The number of people in the region has increased because of natural growth and migration from other parts of India.

People depend on living resources for their survival. In general, an increase in population puts extra pressure on these resources.

Besides population, biodiversity is also affected by other factors, including the level of affluence and the type of technology used.

Relationship between population and environment

I=PxAxT

Impact on = Population x Affluence x Technology environment

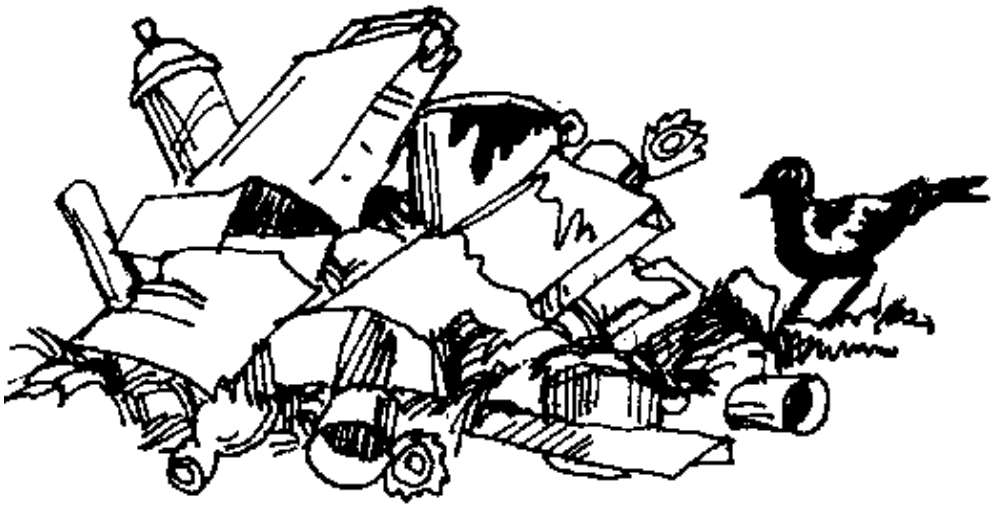
This equation shows the relationship between population and the environment. Higher populations affect the environment more. So too do increased affluence and the use of technology to exploit living resources.

This equation is, of course, a simplification. Many other factors can also affect the environment, and the relationships among the factors are in reality very complex.

Consumption of resources

• In a developed country, one person consumes 340 kg of paper per year.

• In a developing country (India), one person consumes 0.4 kg of paper per year.



Consumption of resources

Uttara Kannada District, Karnataka

In 1951, the forest cover of the district was 82%.

In 1981, the forest cover was only 20%.

Does the increase in population in developing countries destroy biodiversity?

-Yes and No!

Rising populations reduce the amount of resources available per person in a region. For instance, there is less land per person. But in the reality it is not that simple. People in developed countries have affluent lifestyles. Although they are a minority of the world's population, people in developed countries consume far more of the earth's resources than the majority in the developing world. Through trade, developed countries exploit the living resources of the developing world-for instance, cutting forests to satisfy their demand for wood and paper.

So affluence in the developed world is more destructive to biodiversity than are the people in developing nations. Similarly, the rich in developing countries consume more than the poor.

Population increase in the Western Ghats

Increasing human and livestock population pressure in the Western Ghats region is an important factor in determining the use of genetic resources. This pressure affects forests, pastures and cultivated land.

Forests

The tropical forests of the Western Ghats contain a large number of species which yield timber and non-timber resources such as herbs and medicine. Rising population is putting extra pressure on these natural resources. People in cities need timber and fuelwood. Rural people encroach on forest land to grow food and cash crops. Mines destroy forests to reach the ores buried beneath them, and reservoirs behind dams drown the trees. Forest-based industries convert natural forests into monoculture plantations. Mangrove forests are being converted for commercial and agricultural use. All these are changing the forests from a renewable to a non-renewable resource.

Pastures

The area of pastureland is limited and is not enough to meet the fodder needs of an ever-increasing number of livestock. Grazing and fodder production is unorganized, so most cattle are weak and undernourished and produce little milk. In many areas, cattle are kept for their manure. There is a need for livestock policies that do not put extra pressure on available pastures.

Cultivated land

The Western Ghats region is hilly, and much is covered with forest. Rising numbers of people in search of land clear the forest to cultivate rice and other annual crops. But conventional methods of growing these crops damage soil fertility. Heavy rainfall leaches our soil nutrients and leaves infertile soil. This change in the land use is also detrimental to biodiversity.

Horticultural and tree crops may be more suited to these hilly areas. Fruit trees provide an ecologically sound alternative to annual crops. They help conserve biodiversity because many other plant and animal species can live in association with them.

Conservation strategies

We can do something to help conserve our environment. Governments can design more appropriate policies that support rather than damage the environment. Non-government organizations can work with people and government on conservation activities. And each one of us can change the way we live.

Government

• Change land use policy The government should prohibit expansion of agriculture in the hills. Land use policy should support the intensified cultivation of existing cultivated land using new technologies. It should not permit forest land to be used for non-forestry purposes or for projects like hydroelectric dams.

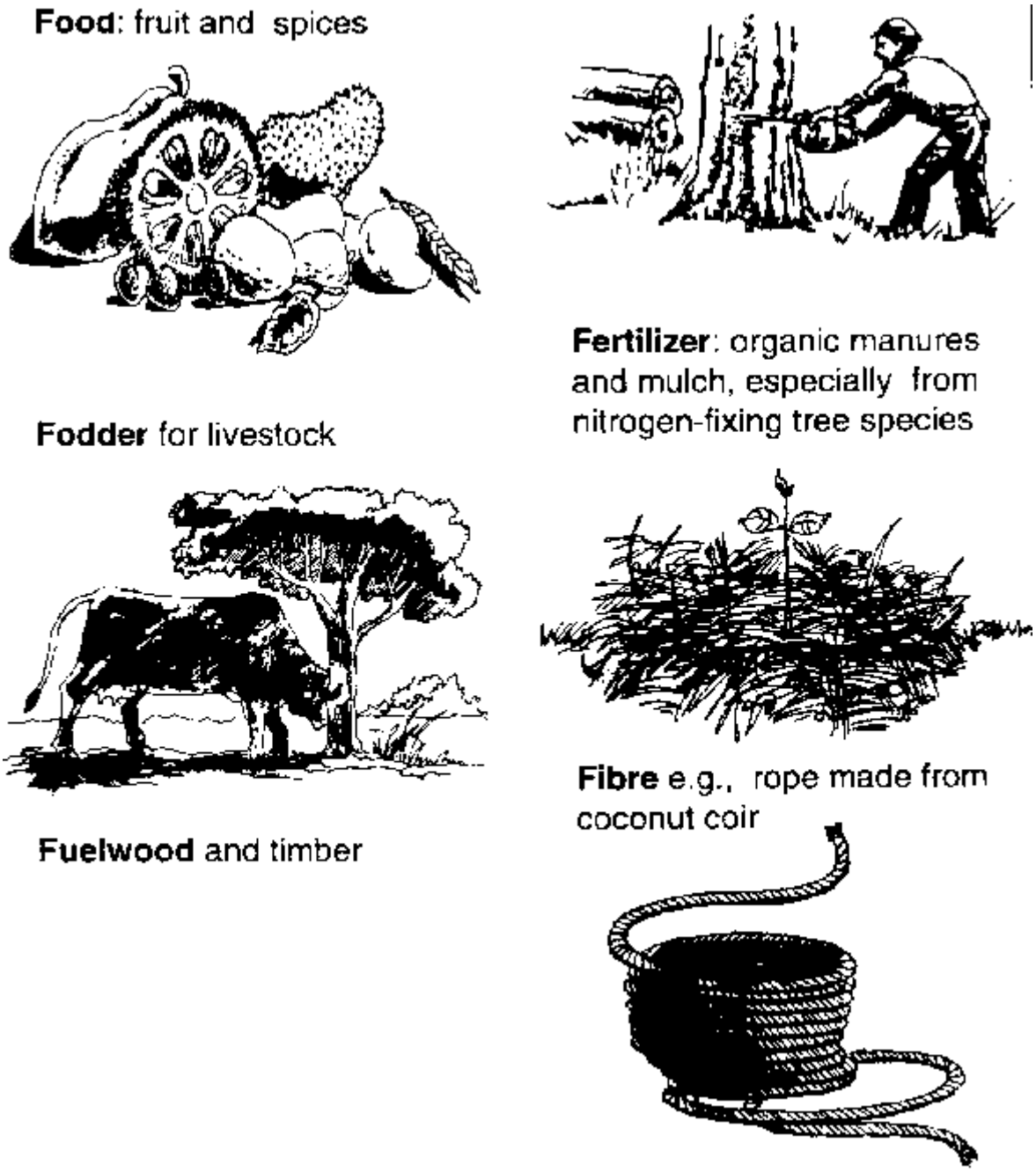
• Conserve forests It is necessary to identify undisturbed. natural forests and pass laws to conserve them.

• Plant trees Afforestation programmes should use indigenous species of trees that meet the needs of local people. These needs include the "Five Fs": food, fodder, fuelwood, fertilizer and fibre (see box).

• Promote alternative energy sources Government can promote innovative energy sources such as solar or wind energy. This will reduce the need to cut trees for fuelwood.

• Develop livestock policy The government should evolve policies that control livestock, promote appropriate technologies and meet the fodder and nutrient requirements of cattle and the needs of people.

• Promote family planning Government should support a progressive family welfare policy which motivates couples to limit their family size.



Human uses of trees: the 5 Fs

Non-government organizations

Non-government organizations such as nature clubs and pressure groups can work with schools and communities to promote education and awareness about nature and the importance of conservation. They can pressure the government to change policies and halt or revise harmful projects. They can promote small-scale development projects in villages as models for larger-scale efforts by government later.

Individuals

• Use resources more rationally. For instance, we can install biogas plants and use fuel-efficient stoves to reduce the pressure on forests.

• Stall feeding Stall feeding livestock can use fodder more efficiently and prevent the uncontrolled browsing of forests. Fodder can be grown on land that is not used, such as roadsides and field borders.

• Conserve plants, for instance by growing herbs and medicinal plants and rare indigenous varieties of crops in homegardens or fields.

Prepared by Pandurang Hegde

Information kit produced by

WWF-India, Goa Division and the

International Institute of Rural

Reconstruction.

2.5 Pollution in Goa's rivers and estuaries

The Mandovi and Zuari are the two main rivers of the state of Goal Together, they drain 69% of the state's area, and their basins-are home to 50% of its population and most of its industries.

Sources of pollution

Mining

Mining covers 500 km²: 14% of Goa's area. There are 581 mining concessions in force, with 350 km² within forest areas.

Mining

Goa's iron-ore mines generate between 1000 and 6000 tonnes of rejects every day. Removing the soil reduces infiltration rates and the level of groundwater. The. material removed may be carried into rivers and reservoirs, reducing their depth and water-holding capacity.

Mining

High concentrations of iron (0.65 to 180 mg/l) have been detected in the estuarine waters of Goal In 1972-73, about 700,000 tonnes of particulate iron were carried by the Zuari river to the sea each year; 10% settled in the estuarine zone and 20% in the near-shore region. It is likely that the Mandovi river also carries a similar load. Various aquatic organisms accumulate heavy metals, including iron, nickel, zinc and mercury.

Mining activities also release arsenic into Goan rivers. The concentration of this element in coastal waters was 3 to 20 times higher than those normally found in sea water.

Sedimentation due to mining rejects has reduced the river depth required for navigation, requiring extensive dredging.

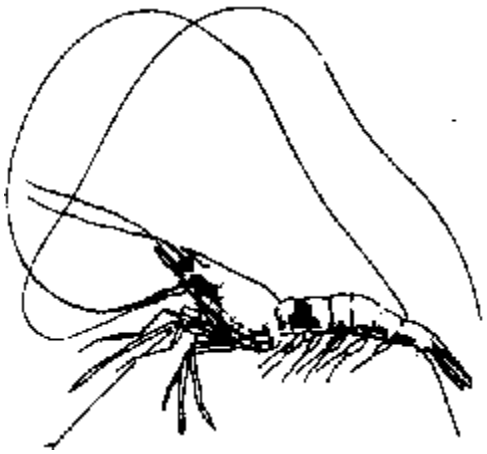
Use of explosives

High concentrations of nitrates in the surface water of the estuaries are often associated with the use of ammonium nitrate in explosives. It is reported that 10 tonnes of ammonium nitrate is used per month in the mining belt Nitrates are known to cause eutrophication of water bodies.

Use of explosives

Prawn breeding grounds destroyed

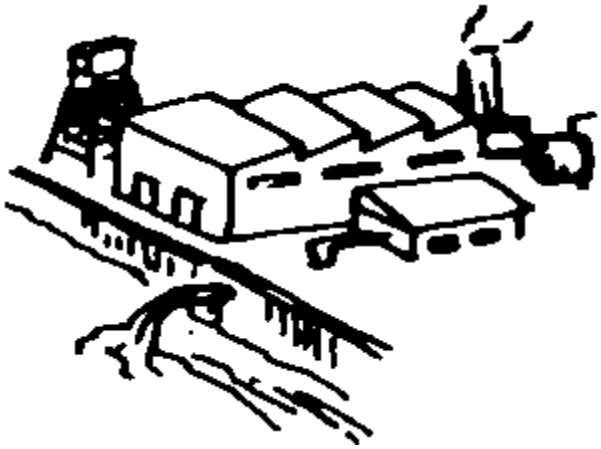
Prawns lay their eggs in sediment in inshore waters. The larvae and juveniles move into the estuaries for food, shelter, and protection from predators. The adult shrimps moves out to sea to repeat this cycle. High sediment loads, with high turbidity caused by mining rejects, reduce the productivity of the estuaries.



Prawn breeding grounds destroyed

Industries

Industries are major polluters of the rivers and the sea. They discharge heavy metals, arsenic, ammonia, urea, phosphates, oils and greases into the water. In the past, fertilizer factories released effluents containing arsenic. Urea discharged from fertilizer factories is known to kill two local fish species, Ambassis gymnocephalus and Puntius bimaculatus. Discharge of effluents rich in ammonia and phosphates results in phytoplankton bloom. Effluents also destroy beach ecosystems.



Industries

The alcohol industry in Goa generates over 7360 kilolitres of spent wash each year. This waste has a very high biological oxygen demand. This means that micro-organisms in the waste water use large amounts of oxygen, reducing the amount that fish and other animals can use.

Tar balls

About 40 tonnes of tar balls, the heavy fraction of oil, are deposited on Goa's beaches every year. Apart from the ecological damage they cause, they also deter tourists, thereby harming the local economy.

Tar balls

Agriculture

High use of synthetic agrochemicals like fertilizers, herbicides and insecticides affect terrestrial and aquatic ecosystems and potable water supplies. These toxic agrochemical pollutants cannot be removed from water supplies by conventional treatment techniques. Wells in rural areas could be polluted by farming that uses these chemicals. Insecticides and fertilizers also affect earthworms, frogs and snails.

Agriculture

Shellfish

Between 1973 and 1983, there was a 70% reduction in the population of clams in beds in Goa's main estuaries. National Institute of Oceanography studies have indicated that the window-pane oysters (Placuna placenta), which adorn traditional Goan windows, have been seriously damaged by mining rejects. The shell-boring organisms Cyanobacteria plectonema terebans and Phormidium sp. concentrate iron 700 to 1000-fold in the oyster shells from the ambient concentration, turning them black.

Tourism

Tourism has caused serious water pollution problems in coastal areas. Many hotels discharge untreated sewage into nearby water bodies. High concentrations of pathogenic organisms have been detected around such sites.

Tourism

Accumulated metals in fish

Scientific name	Common name	Accumulated metals
Rastrelliger kanagurta	Mackerel	16.5 ppm Fe
Clupea ilisha	Indian herring	22.17 ppm Fe 22.66 ppm Zn 5.6 ppm Ni
Thrissocles Malabaricus	Shad	17.66 ppm Fe 0.21 ppm Hg
Heminhamphus marginatus	Half beak	16.6 ppm Fe
Thrissocles purava	Ribbon fish	0.4 ppm Hg
Cynoglossus semifasciatus	Matabar sole	3.28 ppm Ni

Domestic waste

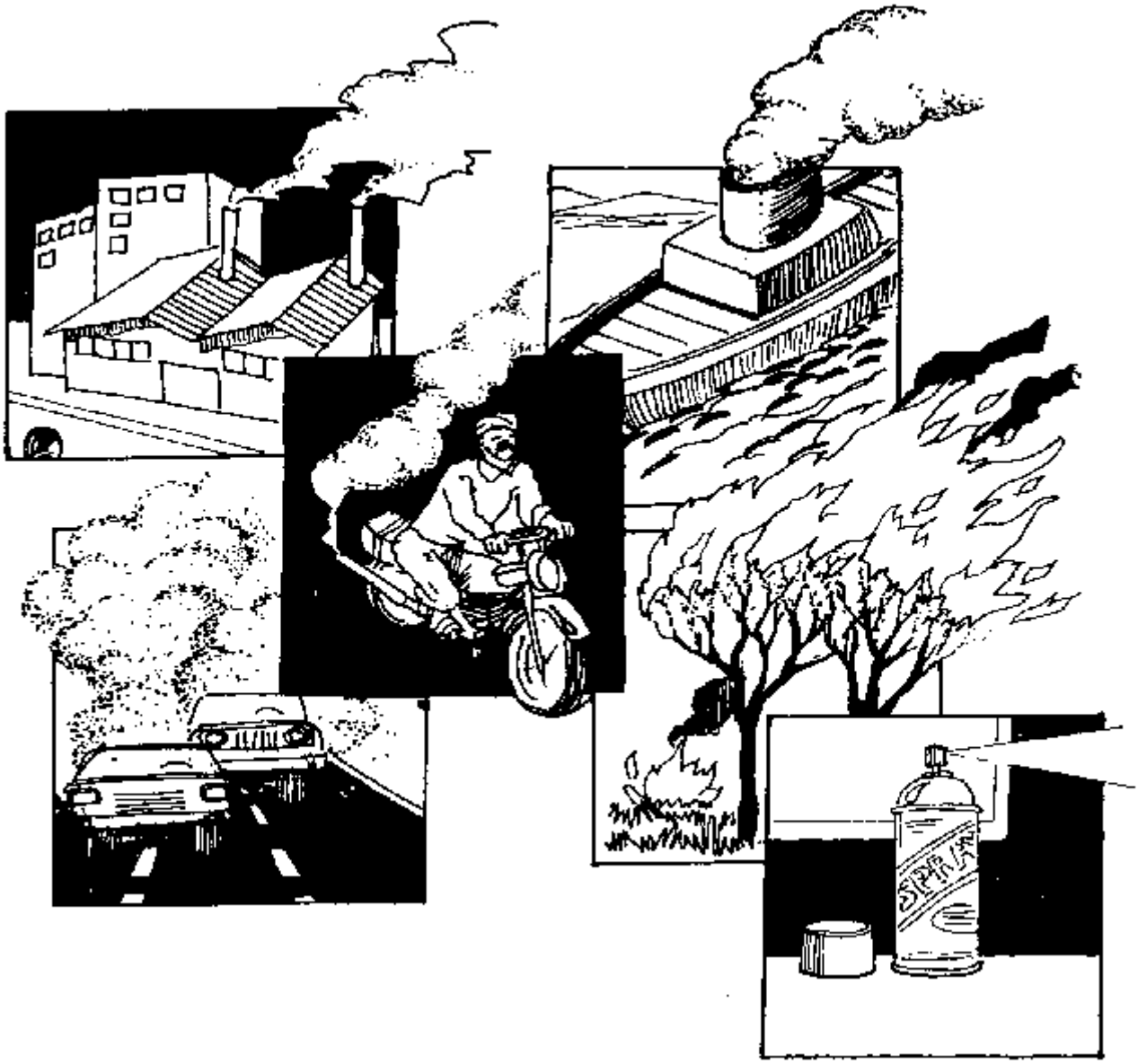
Most of the waste generated by nearby towns is discharged directly into the estuarine ecosystem without treatment. In the Mandovi-Zuari estuary, over 30 million liters per day are discharged. This has reduced biodiversity and changed the balance of organisms in the estuary.

Prepared by Bonifacio Menezes

2.6 Atmospheric pollution and biodiversity

During the past two decades, air pollution has got worse in the developing world and somewhat better in the developed. Air pollution comes in many forms, but six types are particularly important

Pollutant	**Source**
Sulphur oxides	Power stations, industry
Nitrogen oxides -	Power stations, industry, vehicles
Carbon monoxide	Vehicles
Carbon dioxide	Burning fuel
Particulates	Burning fuel, vehicles
Chloroflurocarbons	Aerosols. refrigeration units



Atmospheric pollution

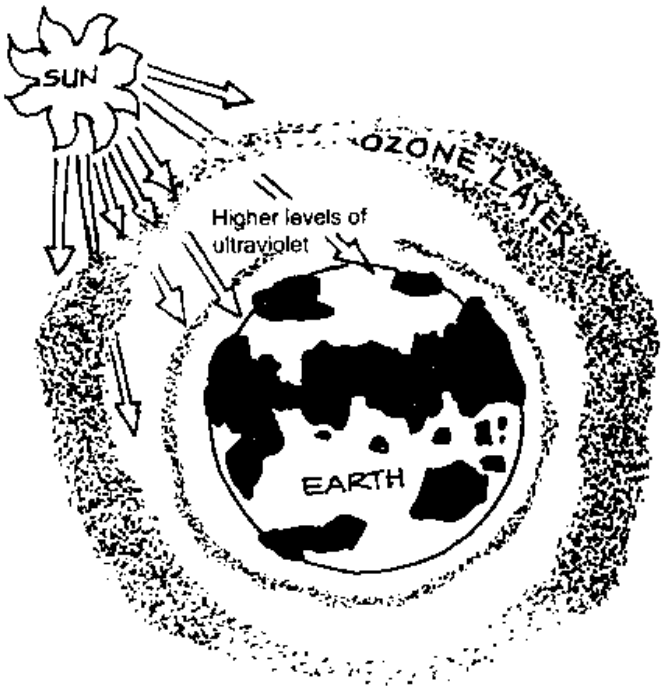
Effects of air pollution

Air pollution can disturb the delicate balance of the atmosphere around our planet.

• It can fall as acid deposition, damaging lakes, forests and infrastructure.

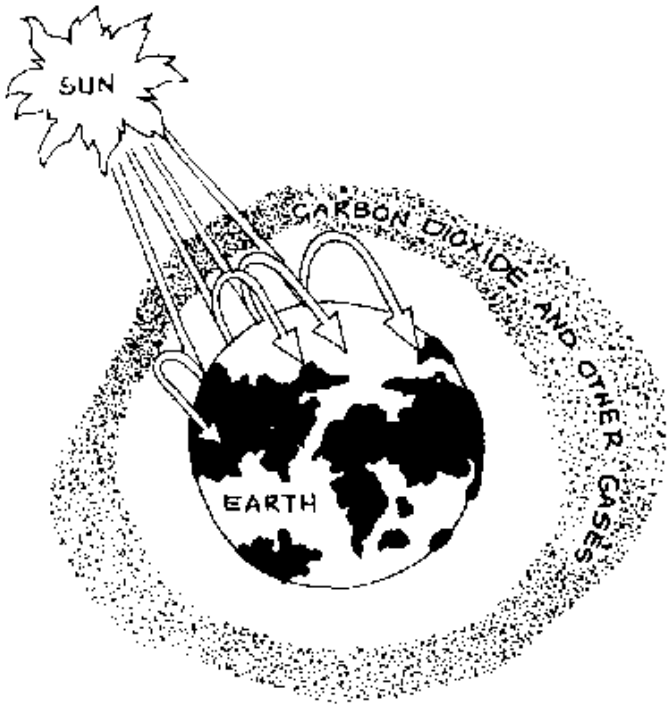
• It can destroy the ozone layer, which protects life from the sun's ultra-violet rays.

• It can change climate due to the greenhouse effect.



Ozone depletion

These are global environmental problems, requiring both a local and international response. The processes involved are complex, interconnected, and not fully understood.



Greenhouse effect

Greenhouse effect

The atmosphere plays a critical role in maintaining an adequate temperature on the earth's surface. It acts like the glass in a greenhouse, trapping some of the long wave radiation emitted by the earth and radiating this energy back to the earth.

Several gases trap more of the earth's radiation and return more of it back to the earth. Instead of escaping harmlessly into space, this energy increases the earth's surface temperature.

"Greenhouse gases" that have this effect include carbon dioxide, nitrous oxide, methane, ozone and chloroflurocarbons.

The earth's surface temperature has increased by 0.5°C over the past 120 years. Current predictions are for the temperature to rise between 1.5°C and 4.5°C by the year 2030. Even these apparently low figures will have a major effect on climate.

Ozone depletion

Ozone is a gas made up of three oxygen atoms. Where it is found near the earth's surface, ozone is a pollutant: it adds to urban haze and causes respiratory health problems.

High in the atmosphere, up to 60 km above the surface, ozone is beneficial. A layer of ozone here traps ultraviolet radiation from the sun, protecting living things from harmful radiation.

Several chemicals in or produced by industry break down the ozone layer. These chemicals include chloroflurocarbons, used as propellants in aerosols, in refrigeration, and as solvents in electronics. These molecules can last up to 100 years in the stratosphere, breaking down the ozone. Changes of a few percent in ozone levels let substantially more ultraviolet radiation reach the earth's surface.

Ultraviolet radiation causes sunburn, snow blindness, eye damage, skin cancer and wrinkling of skin. It also slows down photo-synthesis, harming plant growth.

Possible effects on biodiversity

• Areas suitable for growing crops change.

• Grasslands and deserts expand.

• Ecosystems/biomes shift towards the poles.

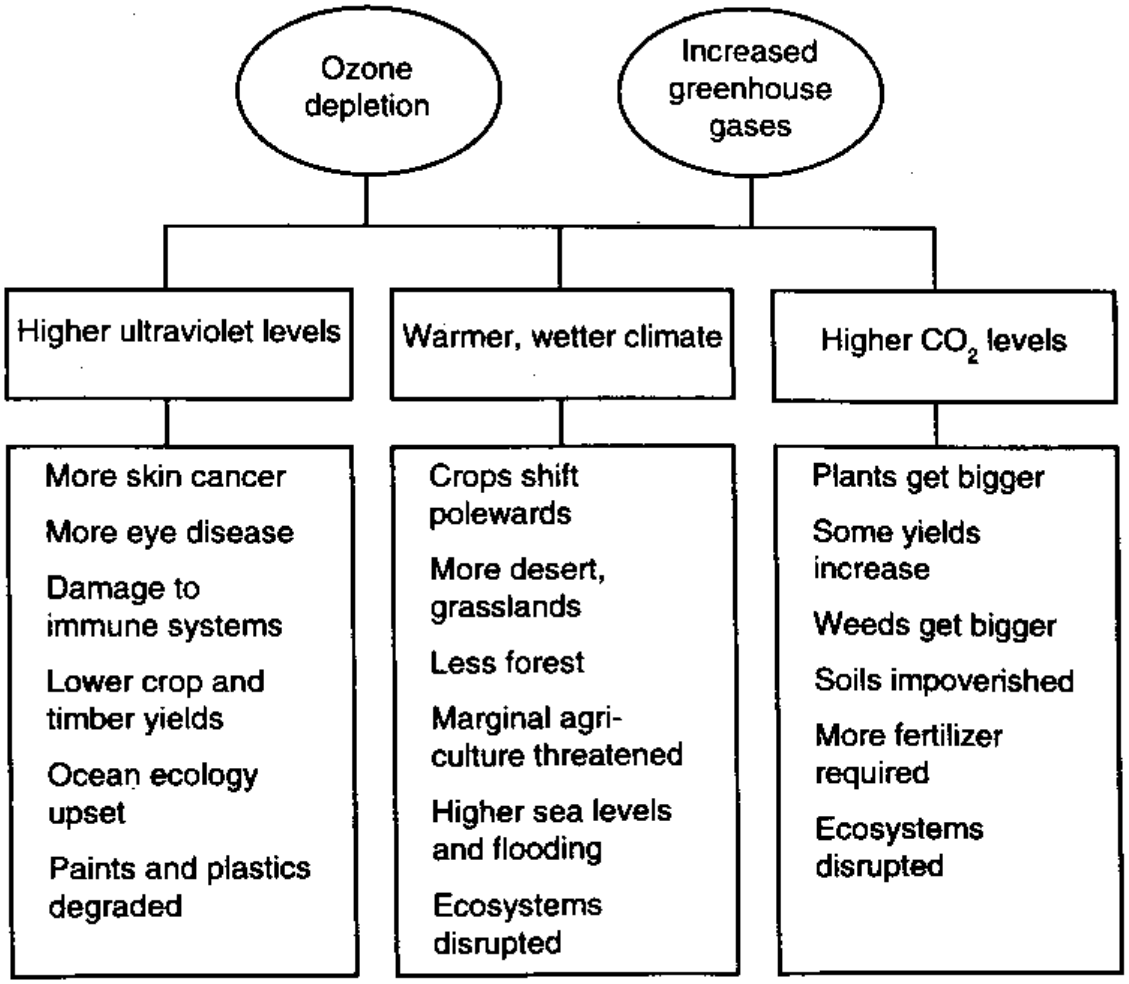
• Wetter climates in some places, drier in others.

• The polar icecaps melt and warmer oceans expand, raising the sea level and flooding low-lying areas.

• Some plants (including weeds) grow faster and larger because of more carbon dioxide.

• Ultraviolet radiation may harm reproduction and growth of some plants and animals, including phyto and zooplankton in the oceans.

• More frequent occurrence of extreme climatic conditions.



Potential social and environmental effects of atmospheric pollution

Reducing the problem

• Reduce burning of fossil fuels and emission of other greenhouse gases.

• Restrict production and use of chlorofluorocarbons.

• Reduce deforestation and step up afforestation.

Prepared by Dr. N. D. S. Varde

2.7 Managing solid waste

Consumer lifestyles

Many of the problems we face are a result of our modern consumer lifestyles. Here are some environmentally friendly ways to deal with solid waste:

Reduce

Do not buy products with excessive amounts of packaging. Use leaves of popular plants such as teak, kumyo (Careya arboea) or flame of the forest (Butea monosperma) as packaging material.

Buy fresh food rather than canned goods.

Reduce energy and water use: turn off lights and taps.

Reuse

Reuse scrap paper.

Reuse old tin cans, e.g., for storage or decorative purposes.

Reuse household articles, e.g., old clothes as dusters.

Recycle

Segregate garbage into biodegradable and non-biodegradable materials.

Non-biodegradable materials (plastics, metal, glass and ceramics): recycle at recycling plants.

Biodegradable wastes (food, leaves): compost and use as fertilizer.

Dispose

Dispose of garbage properly using different types of litter bins provided.

Take litter home. Clean up litter, especially in beaches, parks and nature reserves.

Garbage

Garbage is a misplaced resource. It is a major source of pollution, with direct effects on the ecosystem and biodiversity.

Garbage comes from the things we use in our daily lives: food, paper, plastic, rubber, and so on. Modern lifestyles produce much more garbage than do traditional ones. We cut down trees to

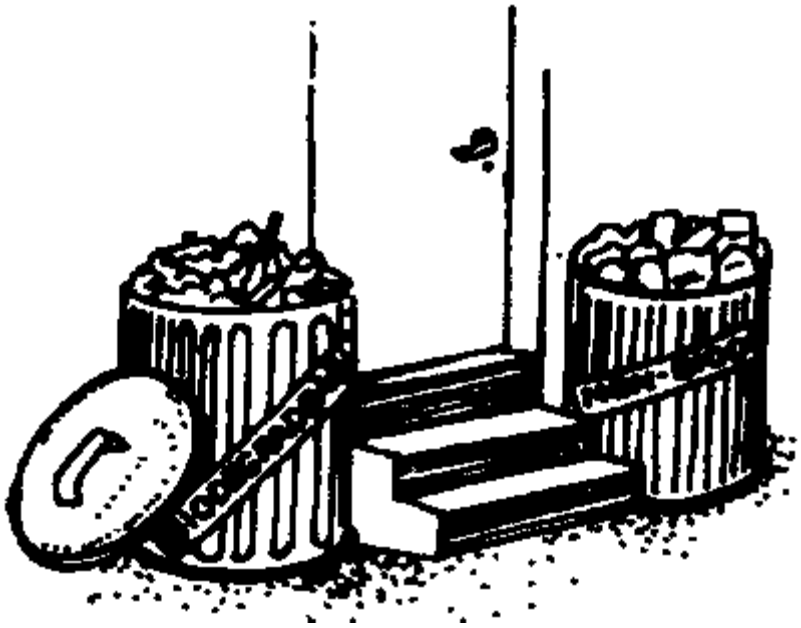
make paper. We drill for oil and turn it into plastics. We mine ore to make tin cans. All this puts a stress on our natural resources: trees, animals, minerals, and water.

When we have finished using something, we throw it away. The more we use, the more garbage we produce.

Much of this garbage is not disposed of properly. It ends up in streams and lakes, by roadsides and in the sea. Many components of garbage, especially plastics, cannot be broken down by natural processes. Even paper decomposes very slowly.

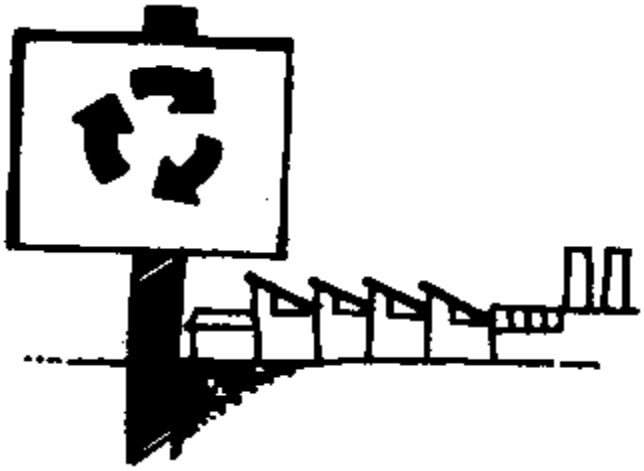
Garbage is ugly, dangerous, attracts vermin like rats and cockroaches, which carry diseases.

Even if the garbage is taken to a dumpsite, it still causes problems. Animals, insects and birds can carry the garbage away from the dump. They can carry diseases with them into nearby villages. People that scavenge on the dumpsites to recycle paper and metal are also threatened by diseases.



Garbage

Rain falling on the dump leaches out heavy metals and other dangerous compounds. It carries these into the groundwater and rivers. Plants can absorb these chemicals. Animals feed on these plants and store the toxic compounds in their bodies. Predators (such as eagles) that feed on smaller animals can accumulate large amounts of toxins. This can damage their health and ability to reproduce. For instance, chemicals accumulated in some birds can cause defects such as thin eggshells, reducing the survival of the young.



Recycling

Aquatic life is especially affected. Many types of fish and invertebrates cannot live in polluted water. Polluted waters also give rise to various fish diseases. The biodiversity of streams and lakes can be severely affected. In extreme cases, rivers can be so polluted that they are biologically dead.

Recycling

Polluted groundwater can carry disease-causing micro-organisms into wells and rivers. They cause outbreaks of enteric diseases like typhoid, cholera and dysentery and skin diseases like eczema, fungal infections and dermatitis.

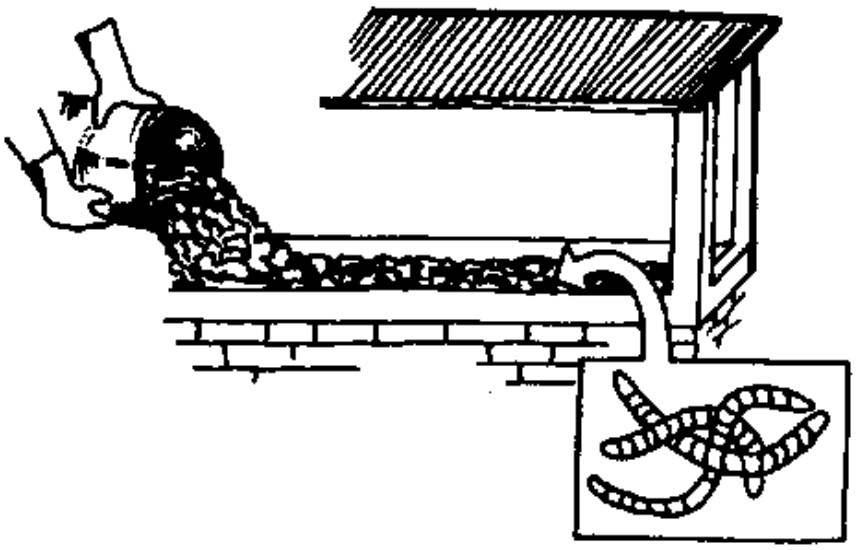
Garbage chokes drains and rivers, cutting off the oxygen supply for fish and plankton. This disrupts the aquatic food chain and reduces the number and type of organisms that can survive.

Recycling

Plastics and other non-biodegradable materials in fields can interfere with the micro- and macro-fauna in the soil. This can affect the roots of plants, reducing yields and diversity.

Garbage is a pollutant. Strewn on beaches, it disrupts the beach fauna and adversely affects tourism.

Microorganisms and microbial enzymes are important in the mineralization process, recycling of nutrients and coomposting. The proper use of microorganisms can help transform garbage into nutrients. This will promote plant growth, and plant and animal diversity in the ecosystem.



Vermicomposting: Using worms to help make compost

2.8 Traffic in wildlife products

Illegal trading in wildlife and its products has become big business. With an annual turnover of US$ 1.5 billion, it has beaten back the illegal trade in gold, jewels, arms, and is now second only to the trade in drugs and narcotics, at the international level.

Wildlife traffic refers to the sale, purchase, and transit of wild animals, plants, their products and derivatives. While a large part of this 5 billion dollar trade each year is within national and international laws, about a third is illegal.

What's TRAFFIC got to do with wildlife?

TRAFFIC (short for Trade Records Analysis of Flora and Fauna in Commerce) is an international network of organizations engaged in the monitoring and investigation of wildlife trade. In India, TRAFFIC nuns as a unit of WWF-India. TRAFFIC personnel analyze the trade figures and study the effects of such trade on the survival of species, particularly those already in danger of being wiped out. A number of wild species are particularly threatened by illegal trade, and Traffic makes special attempts to gather intelligence about their trade. TRAFFIC offices alert the local enforcement agencies, and help conduct raids. Major seizures have resulted from this cooperation. Another important task is the training of enforcement staff of the concerned agencies (Customs, Excise, Coast Guards, Police, Forest and Wildlife Departments), and preparation of identification manuals of relevance to India.

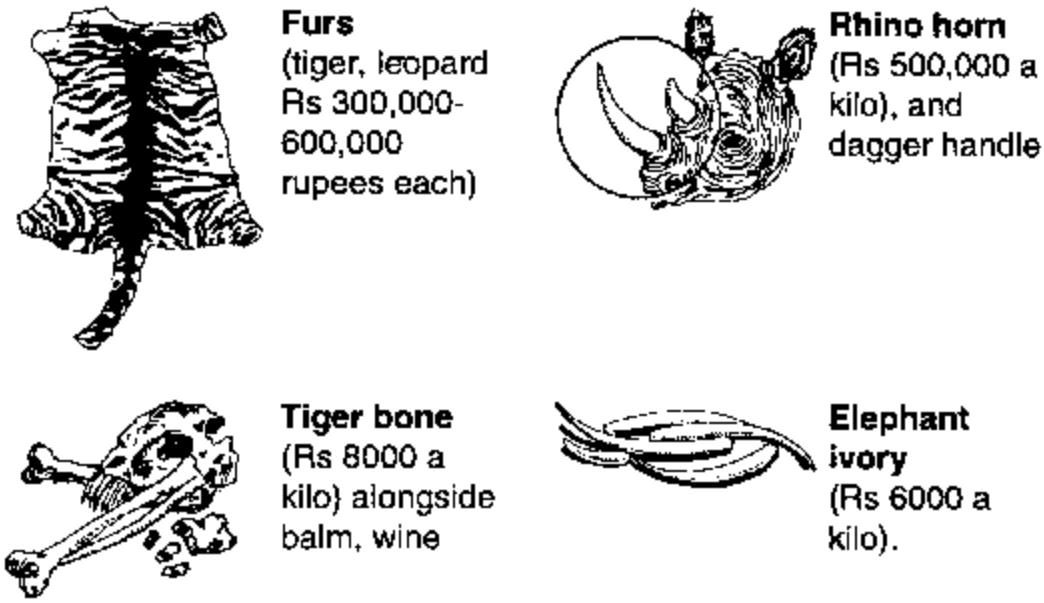
The need for regulation

Trade in wildlife resources is permitted on the assumption that it will not deplete the principal stock of the species concerned. But the returns have become so lucrative in the past few years that the operators don't mind running the risks involved in breaking the laws and transgressing limits, for instance, poaching and trading in banned items, endangered species, hunting or trading in the closed season, and so on.

There are national and international laws governing trade and traffic, but the quantum of the unregulated trade has assumed alarming proportions. There is undeniable evidence of the large-scale destruction of wildlife caused by it, and of the resultant threats to the survival of several species.

The Western Ghats states have a critical place in this scenario. A sizable fraction of the poaching and illegal procurement each year is taking place in this I region, and in the case of a few species such as elephant, slender lords, some orchids and sandalwood, almost the entire stock is being poached off these states. But even more dangerous is the fear that several places in this region are being used as transit points in the trade circuit. The states concerned have extensive shorelines, and some of the less policed beaches are frequently used for loading or landing of contraband by smugglers.

Furs



Products and their current prices

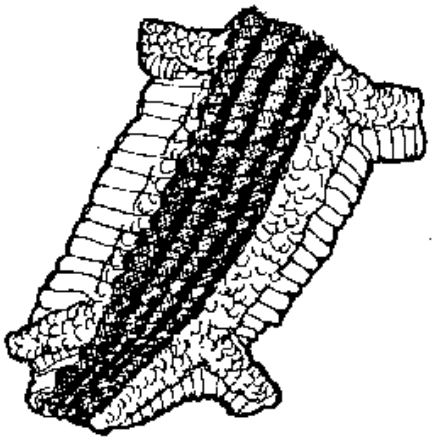
What can you do?

Wildlife trade couldn't survive if the demand did not exist for the products. Therefore, our actions as individuals and groups can go a long way. The following are just a few suggestions.

• Refrain from using wildlife products. Dissuade friends and relatives from using them, too.

• Promote conservation awareness, and dispel the myths and superstitions associated with some of the products (e.g., aphrodisiacal, medicinal, or magical properties). Such beliefs are responsible for much of the demand, and the resultant destruction of the species concerned.

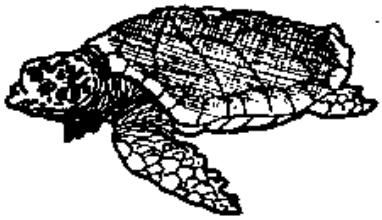
• Alert the authorities if you notice any illegal or suspicious activities involving capturing, poaching, trading, or transport of wildlife or its products.



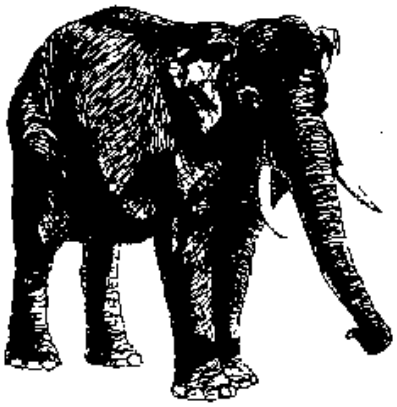
Species providing furs and skins

Aquarium fishes

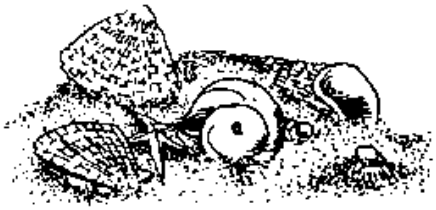
Orchids



Turtles (especially green turtle)



Elephant (ivory)



Marine shells

Some Western Ghats species threatened by trade:

Prepared by Sharad Gaur

2.9 Effect of tobacco growing on biodiversity

Tobacco: Poisonous to humans; dangerous to ecology

Tobacco use causes about 800,000 deaths every year in India by causing various cancers, heart attacks, vascular diseases and chronic lung diseases.

Besides its clear dangers to human health, tobacco also causes many ecological problems. Large quantities of wood are burned to cure the leaves. More is needed to produce packing materials. Tobacco growing depletes the soil, encourages erosion, and takes up valuable farmland that could be used for other crops.

Deadly equation

How many trees does it take to produce India's cigarettes?

• 77% of all Virginia or cigarette tobacco is cured by burning wood (the remainder uses coal).

• 5.6 tonnes of air-dried wood are needed to produce one tonne of cured leaf.

• In 1986, more than half a million tonnes (528,690 t) of air-dried wood were needed, mainly to cure tobacco.

Cigarette tobacco production in India

1982-83	130 million kg
1991-92	153 million kg
1996-97	175 million kg

Wood needed for cigarette manufacture and exports of unmanufactured tobacco

1986	50,140 t/year
1991-92 (estimate)	56,899 t/year
1996-97 (estimate)	80,966 t/year

Wood used by the tobacco industry

More than 500,000 t of air-dried wood are used by the Indian tobacco industry each year. Most goes to cure tobacco for cigarettes. The figures below are in air-dried tonnes for 1986.

	Source of wood			
Use	**Plantation& fruit trees**	**Indigenous wood**	**Bamboo**	**Total**
Fuelwood	78,890	359,400	-	438,290
Poles & sticks	6,830	-	6,570	13,400
Packaging	11,000	39,600	24,400	77,000
Total	96,720	399,000	32,970	528,690

• 118 trees must be felled to produce every air-dried tonne of wood.

• That means 118 x 528,690 t = 62.3 million trees must be felled every year. Only some of these come from plantations; most comes from indigenous forests contributing to deforestation and biodiversity loss.

How many trees does it take to cause one death from smoking?

• About 20% of the 800,000 (= 160,000) deaths each year due to tobacco consumption can be attributed to smoking cigarettes. Smoking Bidi or non-Virginia tobacco (natu, cheroot, hookah, chewing and snuff) caused the remaining 80% of deaths.

• If smoking cigarettes causes 160,000 deaths in India each year, then 62.3 million trees/160,000 deaths = 389 trees must be felled to cause each death.

Impact on agriculture

A tobacco plantation is a "clean" crop: i.e., weeds do not grow in the plantation. That makes this soil more prone to erosion and water loss

Much of India's tobacco crop is planted on valuable, irrigated farmland. The rest is grown in "dryland" areas-land with good rainfall that does not require irrigation and that could also be used for many other crops.

Tobacco removes more nutrients from the soil than nearly all other major crops (see table below).

Nutrients removed from soil by crops (kg/ha)

Crop	**Yield**	**N**	**P_2O_5**	**K_2O**
Rice	2240	34	22	67
Wheat	1568	56	24	67
Jowar	1792	56	15	146
Baira	1120	36	22	66
Maize	2016	36	20	39
Cotton	448	30	17	45
Tea	896	45	13	28
Coffee	896	34	11	34
Tobacco	1456	94	57	91

Tobacco exports

India produced 87.6 billion cigarettes in 1991-92. Only about 3 billion (3.5%) were exported. The remainder was consumed within the country. The majority of growth in the tobacco industry is likely to occur through increased domestic consumption- harming the health of people in India. Boosting either exports or domestic consumption will cause more deforestation and soil erosion.

Irrigated area used for tobacco

1953 10% of total tobacco crop

1992 40% of total tobacco crop

Tribals and tobacco

Tribals have much higher prevalence of tobacco consumption (67%, compared to the national average of 55%) Their life span is shortened by higher disease incidence, less availability of medical care, and the loss of their forests.

Prepared by Dr. S. G. Vaidya

2.10 For those vanishing species

"Of the 1.5 million species known to inhabit the Earth (humans are just one of them), an estimated one fourth to one third is likely to become extinct within the next few decades."

Global agreement

At the Earth Summit in June 1992, the majority of the world's nations signed a Convention on Biological Diversity. This commitment to conserve whatever remains of the earth's astounding plant and animal diversity came in the wake of some intense negotiations, marked as much by their serious concern for the fate of this diversity, as by vocalizing the longstanding disputes between the countries of the industrialized North and the industrializing South. Indeed, the Convention reflects many concerns, regional and international conservation measures, in situ (on site) and ex situ (off site) protection, role of local communities, transfer of technologies and funds, and aspects of biotechnology and intellectual property rights.

This global agreement comes against a backdrop of awesome destruction. Of the 1.5 million species known to inhabit the Earth (humans are just one of them), an estimated one fourth to one third is likely to become extinct within the next few decades. A species a day, perhaps as high as high as a species an hour, is the current toll-the result of the extensive habitat changes wrought by mankind.

Rainforest destruction

Rainforests, home to half of the world's life forms, continue to be destroyed at the rate of over 100,000 km^2 every year. This is A tragedy of unprecedented dimensions, for what right does the human species have to ride roughshod over the rest of creation? But equally important, this loss of biodiversity has immediate and long term effects on human survival itself. The majority of the world's population still depends on wild plants and animals for their daily food, medicine, housing and household material, agriculture, fodder, fuelwood, spiritual sustenance, and intellectual stimulation. For these billions the loss of biodiversity is a direct and irreversible attack on their livelihood and social security.

Domestic biodiversity

The loss is even more direct in the case of domesticated biodiversity. Traditional farmers of the world have developed an incredible variety of crops and livestock. This too has been eroded over the last few decades, with literally lakhs of traditional crop strains and hundreds of domesticated livestock breeds being replaced by a handful of laboratory-generated hybrids or by dominant cash crops.

Cheetah

The traditional diversity was bred to meet diverse human needs of nutrition, taste, colour, ritual smell, and to resist drought, flood and pests. It provided several kinds of insurance against crop failure to the farmer. Modern hybrids, on the other hand, while substantially increasing the grain yield and monetary profits, have forced the farmers to look elsewhere for their other daily needs (especially fodder), and left them dependent on the vagaries of markets, governments, and private corporations.

Rich heritage

India's biological diversity is one of the most significant in the world. As many as 45,000 species of wild plants and over 77,000 species of wild animals have so far been recorded, together comprising about 6.5% of the world's known wildlife. Given the fact that a number of biologically rich ares in India, such as the Northeast, are not yet fully explored and studied, many more species may still be discovered.

Equally impressive is the range of domesticated biodiversity. At least 166 species of crops and 320 species of wild relatives of crops are known to have originated here. Within each of these species, the variety is astounding.

For instance, there were an estimated 50,000 to 60,000 varieties of rice grown in India till not so long back. Similarly significant is the indigenous livestock diversity, with 27 breeds of cattle, 40 of sheep, and 22 of goats.

Disappearing species

Yet, at least 10% of India's recorded wild flora, and possible more of its wild fauna. are on the list of the threatened species, many on the verge of extinction. For in the last few decades India has lost al least half is forests, polluted over 70% of its waterbodies, built on or cultivated much of is grasslands, and degraded most of its coasts. In fact, none can say for sure how many species we have already lost. The cheetah (Acinonyx jubatus) and the pink-headed duck (Rhodonessa

caryophyllacea) are amongst the few conspicuous ones everyone talks about. But there must be hundreds, perhaps thousands, of species which have gone forever, unsung and unrecorded either because they were not "glamorous" enough, or because we simply did not know them.

In a parallel process, possibly thousands of crop strains have disappeared from the field, and not all of these remain even in the gene banks. Since the advent of "miracle" dwarf varieties of wheat under the Green Revolution, a handful of seeds generated in the laboratory have replaced the countless indigenous varieties.

Conservation efforts

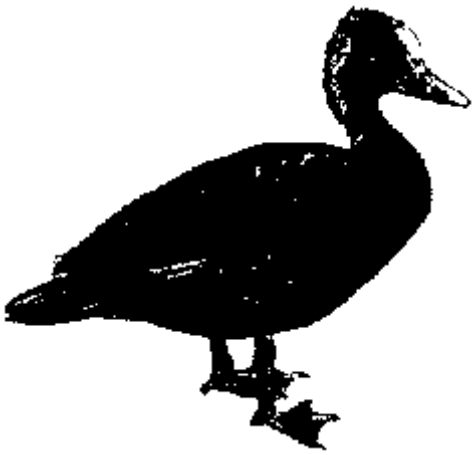
India's efforts at countering the rapid erosion of biodiversity have been significant and varied, ranging from one of the world's largest network of protected areas (almost 500 national parks and sanctuaries) providing in situ conservation, to an ambitious project to document and preserve germplasm of domesticated plants, livestock, and fish in ex situ conditions. Yet, the slide continues: does the Biodiversity Convention offer hope of reversing it?

Roots of destruction

The roots of biodiversity destruction lie not so much in population increase, as in the relations between the communities within each nation, and between the nations themselves. This is responsible for cornering the vast biological resources for the benefit of a small minority within the poor nations, and for the wasteful consumption patterns of the North. Eighteen million ha of Amazonian forest has been cleared in Brazil to met the European and American coffee demand. Germany causes the degradation of 200,000 ha of rainforest a year for timber. Adverse terms of trade, protectionist policies of the North, dumping of environmentally destructive technologies and materials in the South, and a host of other factors continue to cause severe and widespread biodiversity destruction.

"The poor are forced to overstrain the meagre resources that are left in their control, and are then portrayed as ecological culprits.)"

The same goes, of course, for the exploitative polices followed by elites within the southern countries. Vast natural habitats have been plundered to meet the Pink-headed Duck ever growing needs of this minority, aided by laws which legitimize urban-industrial control over resources. The poor are forced to overstrain the meagre resources that are left in their control, and are then portrayed as ecological culprits. In countries like India, the development policies and projects have rarely been sensitive to the need for biodiversity conservation, and that of the local communities. The government's failure to remove poverty and curb middle class consumerism has led to conditions in which sensible natural resource management assumes low priority.



Pink headed duck

Priorities

The first task is to review India's development policies. Article 6 of the Convention commits countries to "integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies". Article 14 requires that they "introduce appropriate procedures requiring Environmental Impact Assessment of is proposed projects that are likely to have significant adverse effects on biological diversity with a view to avoiding or minimising such effects"..

These and other clauses would, in principle, commit the Indian Government to overhaul drastically its current destructive developmental model. The agricultural policy, for instance, should be revised to incorporate conservation and upgradation of indigenous crop and livestock varieties perhaps by redirecting subsidies and incentives towards them. But given the entrenched interests and midst of our decision makers, it will require a long, uphill struggle to get the Government to change.

Adapted from "For those

vanishing species" by Ashish

Kothari, Indian Institute of Public

Administration.

3. Marine

3.1 Biodiversity of the Arabian Sea

The Arabian Sea, the western waterfront of the Indian subcontinent, has an exclusive economic zone of 850,000 km² and a shelf area (i.e., up to 200 m depth) of 280,000 km². With its high evaporation and limited precipitation and freshwater influx, the Arabian sea is a biological paradise.

Some 624 species of plants and 12,000 species of marine fauna are found in these waters. Despite a substantial amount of published information on these species, the biodiversity of the Arabian Sea is still not well known.

The Arabian Sea has diverse ecosystems and biota. We find estuaries, backwaters, mudflats, mangroves, sandy shores, rocky foreshores, corals, submerged banks, islands, an extensive continental shelf and the abyssal deep.

Industrial development and rising human populations have an increasing variety and severity of impacts on the ecosystems and biota of the Arabian Sea. Marine ecosystems have evolved the ability to assimilate and minimize environmental stresses. However, in recent times the scale and magnitude of human influences on the marine environment has increased so much that self-cleansing and assimilative capacity is being suppressed. It has also created "hot spots" (areas where the environment is under severe stress) in coastal areas near large cities.

Development should be based on environmentally sound management and should avoid destroying the resource base on which biodiversity and sustainable development depends. Development can be monitored by identifying:

• Present and future demands on resources and space.

• Ecologically sensitive areas that should be conserved.

• Pollution sources and causative agents and ways to treat and dispose of these safely.

Biodiversity of the Arabian Sea

Marine fisheries

Indian marine fisheries support 1,500 fishing villages with 1.8 million fisherfolk, 30,000 mechanized boats and 115,000 boats without engines. The industry's annual turnover is Rs 63,000 million, and in the year 1 991 -92 exports of marine products were Rs 13,400 million.

The Arabian Sea accounts for almost 60% of the annual yield of 2.2 million tonnes from the seas around India. In 1985-1990, the marine fishery yield grew by 3.1% a year, as against a worldwide rate of 1.5%. Internal consumption accounts for more than one million tonnes. Around 92,000 tonnes of marine food products are exported annually, with shrimps accounting for 80%. The foreign exchange earnings in 1992-93 were Rs 23,000 million.

Besides edible varieties, nearly 30,000 tonnes of other species (seaweeds, shells, ornamental fish, bait fish and trash fish, etc.) are harvested from the Arabian Sea each year. In the last ten years,

coastal aquaculture production, especially of shrimps, has been on the rise. The annual yield is about 50,000 tonnes.

The present level of economic harvesting from the Arabian Sea is only 50% of the potential, although in certain areas, harvesting of certain aquatic resources exceed this.

Marine expanse of India (km^2)

	Shelf (< 200 m depth)	**EEZ (< 200 m or 380 km from shore)**
West coast (Arabian Sea and Lakshadweep archipelago)	282,120	859,992
East coast (Bay of Bengal)	132,375	561,388
Andaman Sea (Andaman and Nicobar Islands)	35,000	566,554
Total	449,495	2,057,934

Pollutants in the coastal zone

Pollutant	**Quantity (per year)**	**Effects**
Land runoff	1600 million t	Increase in sediment load and turbidity; reduced penetration of sunlight; siltation
Sewage(mostly untreated)	410 million m^3	Organic enrichment; oxygen depletion; sulphide formation; mortality of biota
Industrial effluents	50 million m^3	Deterioration of biota and ecology; sub-lethal and fatal.
Domestic waste	34 million m^3	Water quality; physical blanketing and choking of marine life

Fertilizer residue	5 million t	Eutrophication; red tides; mass mortality
Synthetic detergent residue	125,000 t	Eutrophication; food chain disturbances
Pesticides and	65,000 t	Non-biodegradable input;
insecticides	65,000 t	toxicity and mortality
Petroleum, hydrocarbon residue	3,500 t	Tainting; physical blanketing; esthetic degradation
Mining rejects; dredging, sand extraction	2 million t	Turbidity, loss of habitat

Prepared by Arun Parulekar

3.2 Seaweeds

Algae are the most common marine vegetation. Commonly called "seaweeds", these plants are very diverse, ranging from single-celled flagellates to large, branched plants. They include blue-green (Cyanophyta), green (Chlorophyta), brown (Phaeophyta) and red (Rhodophyta).

People use seaweeds as food, fodder, fertilizer, medicines, jelling agents, and for energy production. They also play a very. important role in marine food chains. It is suggested that seaweeds could become a major food and energy resource in the 21st century.

Distribution and biodiversity

The 780 km of coastline of Maharashtra, Goa and Karnataka has a rich marine flora. Mangrove swamps, intertidal and subtidal zones, including submerged banks, are habitats for algae. Altogether 130 species belonging to 72 genera have been recorded in this area. The country as a whole has 630 marine algae species.

Mangrove swamps

Mangroves swamps support many economically important algae, including Monostroma (edible), Enteromorpha (antiviral), and Gracilaria verrucosa (source of agar).

Intertidal region

The intertidal region is regularly covered and unconvered by the tides). The Maharashtra coast has 85 species of algae in the intertidal zone, followed by Goa (75 species) and Karnataka (68).

Zonation Different plants adapt to varying conditions of light, temperature and exposure etc. This forms more-or-less distinct zonations of plants. Altogether the tidal range on the west coast is small, three basic zones and associated species can be distinguished:

• Supra littoral zone: Porphyra, Ulva, Enteromorpha, Bangia

• Mid littoral zone: Centroceras, Ceramium, Gracilaria, Grateloupia

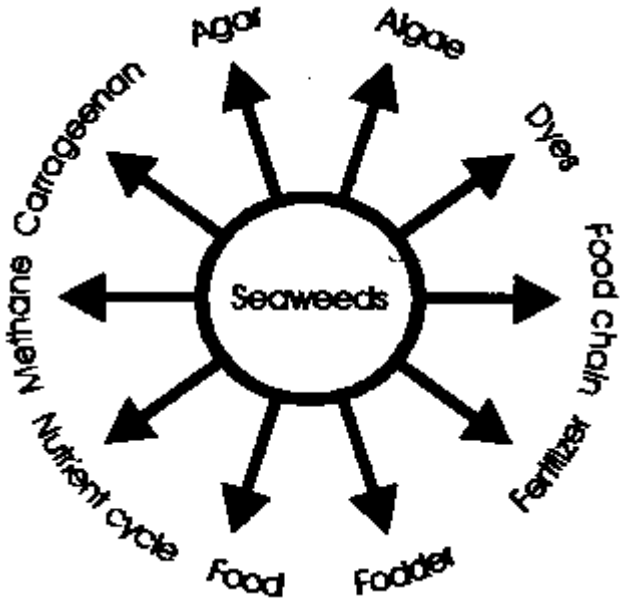
• Lower mid littoral: Chaetomorpha, Sphacelaria, Cheilosporum and Sargassum.

Seasonal variation Seaweeds grow luxuriantly from October to February. They are negligible during late summer.

Algae in the central west coast of India

	Genera	**Species**
Chlorophyta	20	38

(green)		
Phaeophyta (brown).	14	24
Rhodophyta (red)	32	65
Cyanophyta (blue-green)	6	13



Seaweeds

Utilization Seaweeds are not utilized directly, except for manure at some coastal places. Numerous algae of economic importance grow along the coast which can be the source of agar-agar, carrageenin, food and bioactive compounds. Simple uses of marine vegetation can evolve into industrial production and marine agricultural practices.

Deep water flora

A submerged "bank" is a unique habitat as it is free from disturbance by waves or artificial changes. The floristic composition of submerged banks located off the central west coast is varied and rich. It includes 72 species representing 53 genera of 27 families and is unique in composition.

Management

Increasing demand by various industries means that seaweeds are in short supply. In view of this, it is necessary to enhance the raw material supply by cultivation. Different techniques of cultivation are available.

Conservation

With increasing development pressures such as reclamation, pollution and overcollection, many economically important seaweeds are on the verge of disappearance. To preserve this germplasm, some areas with luxuriant seaweed growth such as Malwan (Maharashtra) and Baga (Goa) can be considered for protection.

Seaweed recipes

Ulva jam

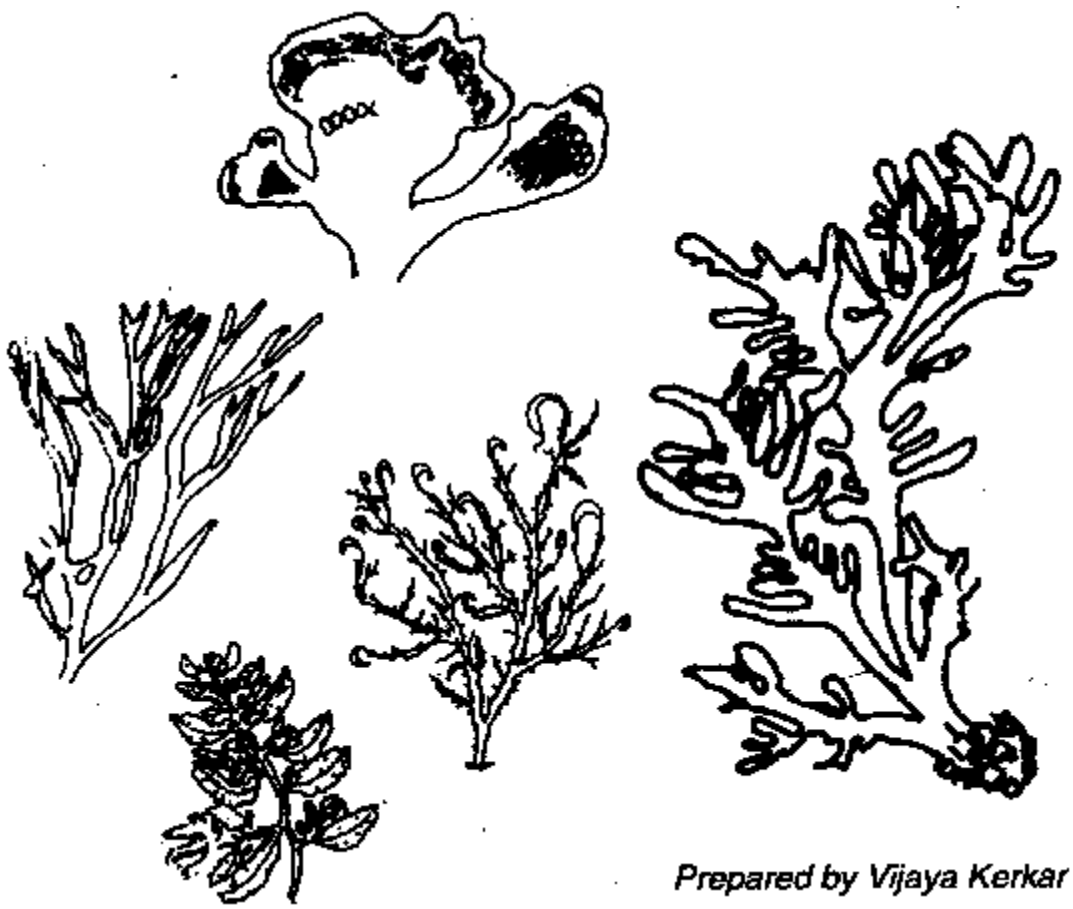
Ingredients: Ulva, sugar, citric acid and potassium metabisulphate

Procedure: Cook Ulva for 5 minutes, grind and add double quantity of sugar to the pulp. Cook together till it hardens and add 1/2 spoon of citric acid and potassium metabisulphate. Cook for 23 minutes. Cool and store in clean, dry bottle.'

Dry Porphyra chutney

Ingredients: Porphyra (dry), garlic, copra, salt, chillies (red), sesamum.

Procedure: Thoroughly wash and shade-dry Porphyra. Grind without water with other ingredients. Garnish with roasted sesamum



Algae

Porphyral Ulva Soup

Ingredients: Porphyral Ulva. corn-flour, salt, sugar, pepper, coriander leaves.

Procedure: Put washed, chopped Porphyra/Ulva in boiling water. Add cornflour paste and other ingredients. Serve hot with breadcrumbs and butter.

Prepared by Vijaya Kerkar

3.3 O verexploitation of of marine living resources

Marine living resources include fish, whales, shrimps, crabs and other species. They vary from place to place and over time, and are affected by human activities.

Fisheries around the world face various problems:

• Catches vary from year to year.

• Large amounts oof money have been invested to exploit a limited resource.

• The average size of fish caught is declining.

• Conflicts between management and traditional fisherfolk are increasing.

Fishery management is complex: it involves social, political, legal and economic as well as biological and environmental factors. The scarcity of fish in one area is linked to many factors, including overexploitation in other areas.

Overfishing

Overfishing means simply "fishing harder than is desirable". It reduces fish populations to a level where the numbers of young cannot replace the fish caught. This reduces the total fish stock. Several major fisheries (e.g., the Antarctic blue whale) have collapsed completely as a result of overexploitation.

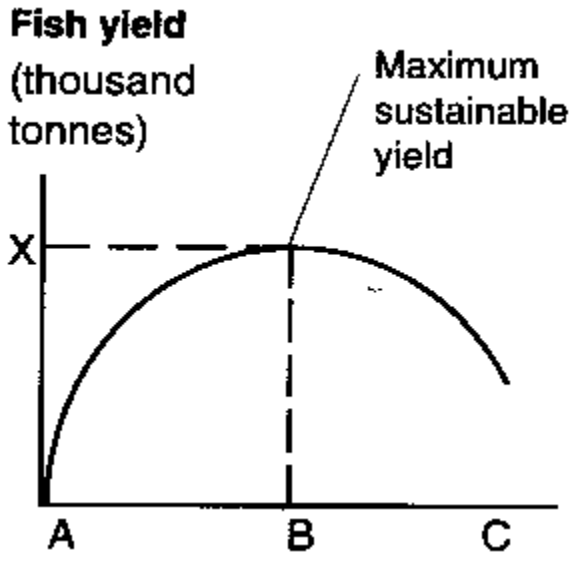
Misuse of fish resources

Overcatches

Sometimes fisherfolk catch more than the actual requirement. For want of buyers, the excess catch is thrown back into the sea or left at landing places to decay. This not only affects the resources; it also creates environmental problems in coastal areas.

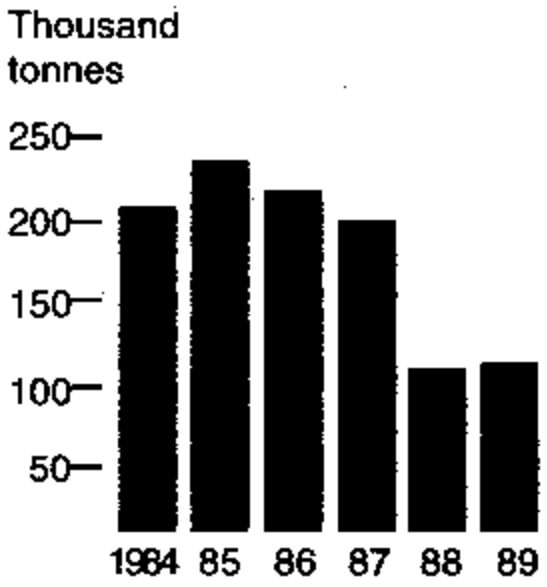
By-catch

When specific kinds of fish are targeted, other species also get caught. These other species are called the "by-catch". In shrimp trawling, the by-catch can be much greater and more varied than the targeted species. While some of the larger, commercially valuable species are sold along with the shrimp, the remaining by-catch is thrown overboard at sea. It is "trash fish". In the central west coast of India, the "trash fish" from trawling is mainly Squilla, Ribbon fishes, Carangids, Tongil soles, Silver biddies and Croakers. The by-catch also contains many immature fish; this is of great concern for resource management.



Fishing effort (e.g., number of boats)

Obviously, if a village (or a country) puts no effort into fishing, it ill catch no fish (point A on the graph). If it puts in some effort in the form of labour, boats and nets, the catch will rise (point B). If it puts in too much effort, for instance by increasing the number of boats still more, the stock will be overexploited and catches will fall (point C). The maximum sustainable yield, X thousand tonnes, will be caught at a level of effort corresponding to point B.



Fish catches decline if the stock is overexploited.

Maximum sustainable yield :

The maximum sustainable yield is the greatest yield of a resource (such as a fish species) that can be removed each year without impairing the capacity of the resource to renew itself.

Three types of overfishing

Growth overfishing takes place when the fish are caught before they have time to grow.

Recruitment overfishing reduces the number of young fish entering the fishing ground.

Ecosystem overfishing occurs when fishing alters the balance of the system, allowing some species to multiply but failing to replace the depleted ones.

Demersal fish

Fish living on or near the sea bed.

Pelagic fish

Free-swimming fish inhabiting the open sea, independently of the sea bed.

Banned fishing practices

Out of ignorance or necessity, fisherfolk may put short-term gain before future benefit and try to catch as much fish as possible- young, juveniles and mature adults. Faced with declining catches, they destroy the resource in an effort to obtain a livelihood. They may:

• Use gear and net mesh sizes not sanctioned by government.

• Use gear that destroys the resource base.

• Use techniques such as dynamite or-sodium cyanide that endanger the fisherfolk themselves as well as the environment.

Management techniques

Frequently recommended techniques for conserving the fishery resource are:

• Restrict fishing efforts

• Establish a quota system

• Regulate net mesh sizes

• Limit the number of fisherfolk or vessels

• Institute a closed fishing season

• Close an area for fishing temporarily.

These methods are suited mainly for the single-species fisheries of temperate regions. But most tropical fisheries (particularly demersal) are multispecies, so these methods are inappropriate.

Diagnosis of overfishing is easy, but integrated management is needed to remedy it. Mesh size regulations and temporary area closure seem useful and can be implemented successfully in India and other parts of the tropics. There is an urgent need to monitor systematically changes in catch size, rate and relative proportation of various fish species caught in the shrimp trawl.

Pelagic fisheries are more likely to be monospecies; mesh size regulations can be enforced to maintain their optimum economic yield.

Prepared by Z A. Ansari and B. S. Ingole

3.4 Small-sector coastal fisheries along the Kerala coast

More than 150,000 non-mechanized, traditional fishing boats operate in the narrow coastal belt around India. Together, they land nearly two-thirds of the country's marine fish production.

Despite the importance of such fisheries in many developing countries, policies have been slanted against the interests of the small-scale fisherfolk. These people have not been provided adequate protection from mechanized operators and big business interests.

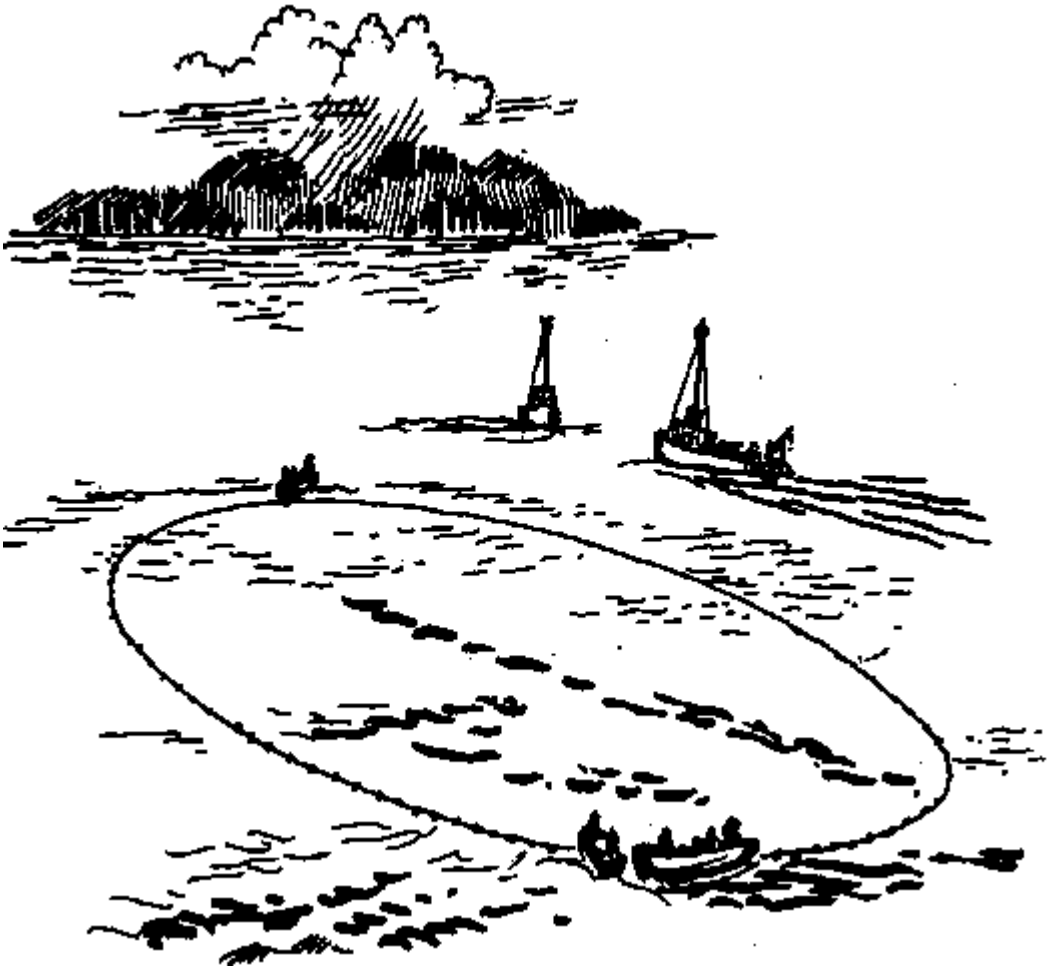
Unfortunately, trends point to a grim future: it may be difficult to sustain even the existing fish catch, the livelihood of poorer fisherfolk is steadily threatened, and fishing techniques used often harm biodiversity and coastal habitats.

Coastal Kerala is home to fishing communities who have handed down their occupation from generation to generation. The waters they depend on are one of the world's richest prawn grounds. Spurred on by high international demand for prawns, powerful capitalists appeared on the export scene. These entrepreneurs use efficient catching techniques and improved processing methods. These-changes have spread beyond Kerala and have had a major impact on marine fisheries in India.

Bottom trawling for prawns, highly destructive of all marine life, has been carried out in the inshore zone, with scant regard to the livelihood of traditional fisherfolk. This trawling sometimes does not even stop during the monsoon months, the breeding period for several types of fish.

Purse-seining for oil sardines and mackerel can also severely deplete populations of these species. The result is that several inshore areas are showing signs of being overfished. The overall catch is declining, fish of smaller size are being caught, and some varieties of fish have become locally extinct or are in danger of this.

"Artisanal fisheries are the largest single supplier of animal protein for several hundred million people in developing countries. In the majority of tropical Asian countries, for example, artisanal fisheries contribute more than 50 % of the annual protein intake."-World Resources Institute.



Small-sector coastal fisheries along the Kerala coast

"It is particularly important to protect and enhance small-scale fisheries... These are characterized by high labour involvement, low capital investment, low levels of mechanization and often the use of passive fishing methods. "-Food and Agriculture Organization of the United Nations

While fish exports have reached high levels, the per capita availability of fish in coastal villages, where it is the staple protein for the masses, is declining.

Smaller fish fetch low prices and provide protein for the masses. But spiralling world market prices for fish meal mean that these small fish, which deep sea boats catch in large quantities, will be diverted to supply the fish meal demand. When the choice is between fish meal to earn foreign exchange and protein for the masses, the choice for the entrepreneur is obvious.

Increases in the number of coastal fisherfolk, moderate rises in their economic needs and increased equipment to enable them to meet those needs, will mean that fishing pressure in coastal areas will grow. There is a need to monitor coastal areas carefully and take action in case

of threatened overfishing. This may ensure that even at the risk of some short-term losses, the longer term sustainable yield will not suffer.

We have to learn from the mistakes of the past. We must bring fisheries back to the objectives of sustainable development, emphasizing the livelihood and nutrition of the poorer groups in our society.

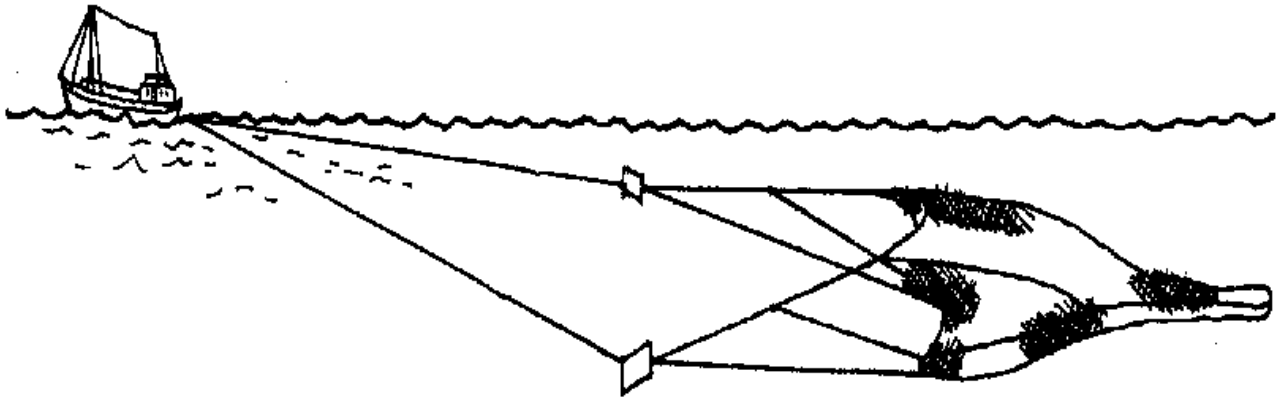
New fishing methods

During the last two decades almost all fisherfolk have shifted from cotton to nylon fishing nets. The number of nets and other tackle has increased significantly.

Notwithstanding the threat of overfishing by existing fisherfolk, a large number of new operators have been encouraged to fish in the coastal waters. These new operators were allowed to use highly mechanized, destructive fishing methods such as trawling (scraping the sea bottom with a bell-shaped net to catch demersal fish) and purse-seining (quickly encircling whole shoals of pelagic fish).

In Kerala, each fisher had an average of 16 hectares of coastal commons to fish in 1961. By 1985, this decreased to 9 hectares (calculations by John Kurien and T. R. Thankappen Achari).

Adapted and compiled from Crisis in India's fisheries by Bharat Dogra, Navdanya (1993)



Fisherie

3.5 Coral reefs

Coral reefs are among the most diverse, species-rich ecosystems in the world. They are living systems with complex interactions among biological and physical factors.

Although corals are the major organisms that form the basic reef structure, many other organisms are associated with or inhabit reefs. For example at Malvan, 49 species of algae (green, brown and red), 193 species of invertebrates (from sponges to sea cucumbers) and many species of fishes inhabit the region along with stony corals.

Coral reefs are so diverse because of the great variety of habitats they provide (sand, holes, crevices, algae, etc.). In addition to the variety in habitats, coral reef biota can take advantage of the relatively stable ecosystem to create their own niche. Minor adaptations such as periods of activity (day or night); type of shelter (crevice, sand, etc.); or symbiotic relationships (as above) have helped create the species richness of the coral reefs.

Reefs are the most productive ecosystems of the world. They occupy 0.1% of the planet's surface and yet account for 10% of world fish landings.

Coral reefs are characterized by the symbiotic relationship between coral polyps and zooxanthellae that enables trapping, utilizing and cycling of nutrients in very efficient ways.

Coral reefs are oases in the nutrient-poor deserts of the tropical seas. Gross primary production estimates of 1500-5000 grams of carbon per square metre per year are reported in contrast to only 18-50 g $C/m^2/y$ in open tropical oceans. Corals produce mucus which serves as food and forms an important input in the detrital food web. The food web in coral reefs is very complex.

Symbiosis

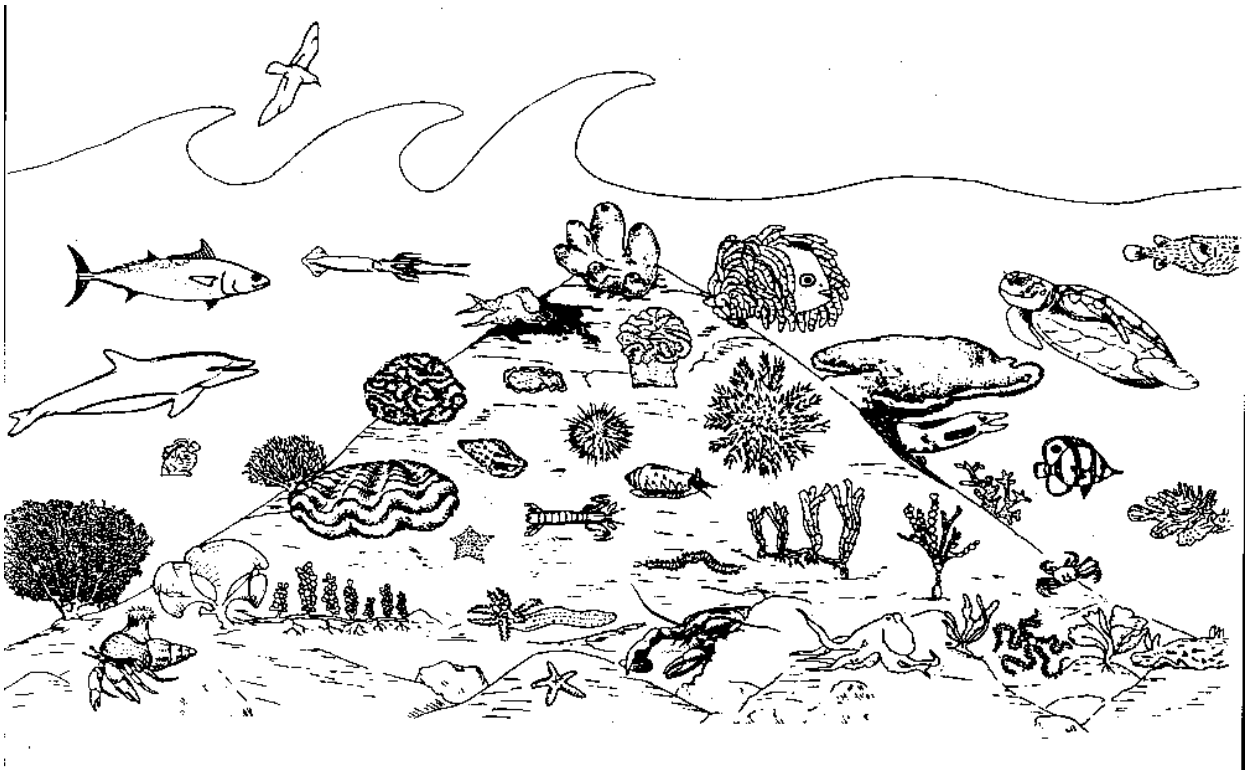
Coral reef species depend on one another. Long-lasting, direct interactions between different species are called symbiosis.

Types of symbiosis

Mutualism: Mutually beneficial

Commensalism: Beneficial to one organism and neutral for the other

Parasitism: Beneficial to one organism and detrimental to the other



Coral reefs

Food web of coral reef ecosystem

Food webs in coral reefs are very complex. Various types of plants: algae, seagrasses, zooxanthellae and phytoplankton convert sunlight into biomass, which then becomes food for a huge variety of animal life. At the top of the food chain are turtles (herbivores) and birds, dolphins, tuna and octopuses (carnivores).

Zooxanthellae are symbiotic algae living in coral tissue (a relationship shown by the dotted line in the diagram).

Economic importance

Coral reefs are exploited for:

• Food (fish, lobsters, clams, snails, squids, octopuses, sea urchins, sea cucumbers, seaweeds).

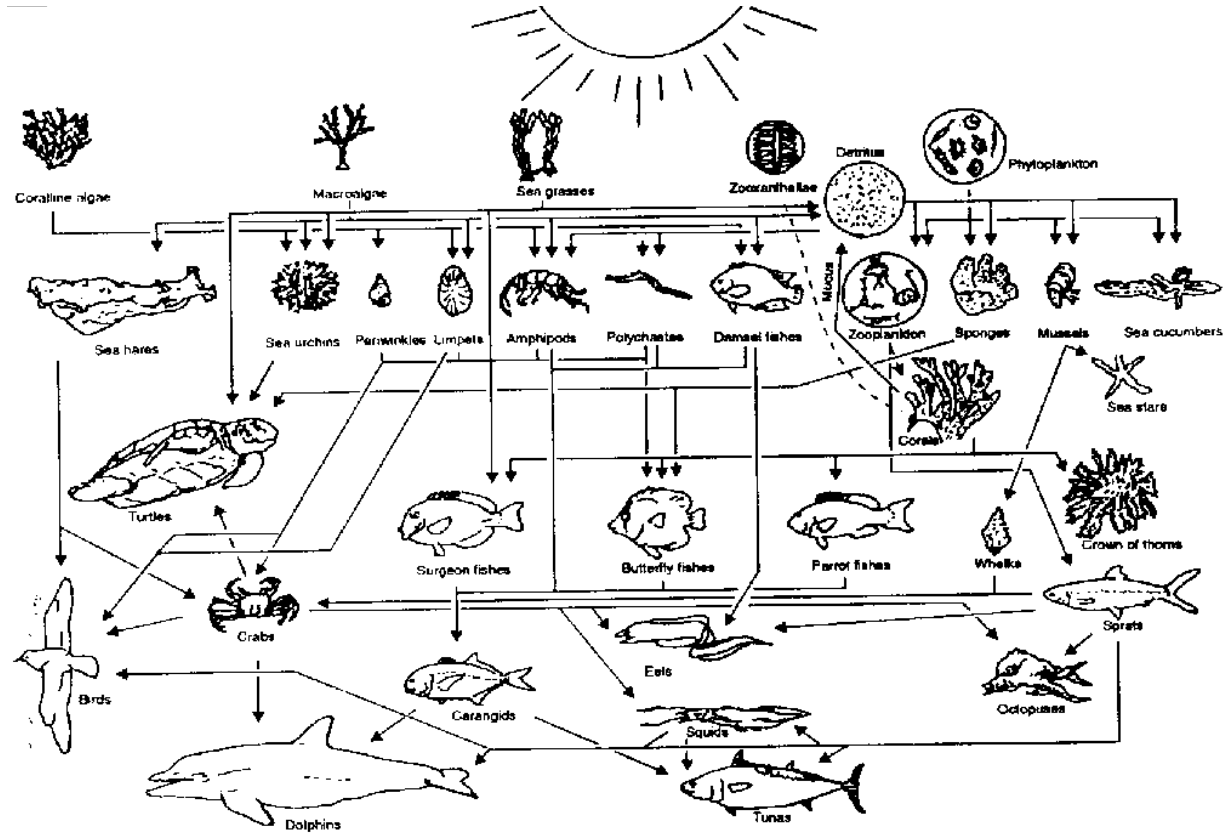
• Ornaments (corals, shells, ornamental fish, sea-snake leather).

• Materials for fishing/hunting (baits, toxins).

• Building materials for houses and roads (corals).

• Lime for agriculture, cement manufacture-and whitewashing.

• Bioactive substances (drugs with antimicrobial, antileukemic, anticoagulant, cardioactive properties; insecticides, etc.) extracted from reef organisms.



Food web of coral reef ecosystem

Coral reefs act as fish nurseries and breeding grounds for turtles. They serve as places for recreation and tourism. They are also important for education and research.

Human impact and conservation

The usual history of human impact on living resources is: discovery, exploitation, over-harvest, decline, and recognition of the need for sustainable management.

Humans affect coral reefs by:

• Overfishing and overcollecting which destroy both the ecology and economy of the region.

• Introduction of chemicals or changes to the waters around reefs, which may affect the physiology of organisms. Examples are:

- Detergents, herbicides, pesticides, heavy metals, antifouling paints, radioactive wastes

- Sewage, petroleum products' excessive nutrients, fertilizers

- Thermal or hypersaline wastes

- Sediments, turbidity

- Dredging.

• Commercial and recreational activities may have unintentional commutative detrimental effects on reefs. Examples are: boulder moving, reef walking, diver damage, small boat damage, anchor damage and the construction of infrastructural facilities.

The need to maintain coral reef productivity is recognized by the International Union of Conservation of Nature and Natural Resources (IUCN) as global priority in the World Conservation Strategy.

Reefs must be protected because of:

• Ecological reasons (productivity, species interaction, species richness and habitat diversity)

• Economic reasons (exploitable resources)

• Potential bioactive substances

• Aesthetics.

Coral reefs can be protected through education, conservation management with public involvement, and legislation.

What are coral reefs?

Coral reefs are massive deposits of calcium carbonate produced primarily by hermatypic corals with minor additions from calcareous algae, gorgonians (e.g., sea fans) and molluscs (e.g., giant clams). These stony corals have in their tissues symbiotic dinoflagellates (plant cells) called zooxanthellae and occur only in tropical regions. The other group of stony corals (ahermatypic corals) do not form reefs, have no zooxanthellae and are distributed worldwide. Corals reproduce both asexually (by budding) and sexually (by gametes). The rate at which colonies grow differs with species, form, age of colony and location on the reef. Their growth rate ranges from 0.2 to 8 mm per year.

Conservation management approaches

Zoning

• Demarcating areas for different types of uses.

• Establishing marine parks and reserves.

Periodic closure during the breeding season of important or endangered species or to permit recovery. Regulating harvesting by fixing the level of exploitation for fishes and other organisms, fixing size limits and discouraging large-scale collection of organisms for research, bioactive substance extraction, etc. Options:

• Encourage culture of exploitable resources (fish, sea cucumbers, ornamental fishes, etc.).

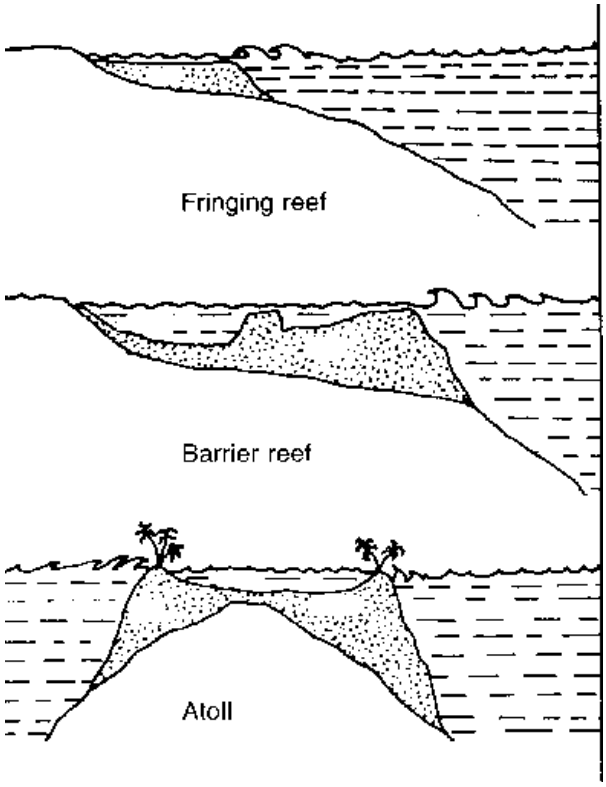
• Use of biotechnological techniques to mass-produce bioactive substances.

Monitoring pollution, dredging, commercial and recreational activities.

Prohibiting collection of endangered or protected species such as turtles; collection of corals and shells by tourists or for commercial and construction purposes; fishing with explosives, poisons unacceptable gear; and dumping of dredged material in the vicinity of reefs.

If we wish to conserve biodiversity, we must start with coral reefs, one of the world's most diverse and species-rich ecosystems.

Acknowledgements: Thanks to Ms. S. Caeiro, Mr. E. Gracias, Mr. S. Raikar and Ms. A. Balamani for assistance.



Types of reefs and their distribution

Prepared by C. L. Rodrigues

3.6 Crabs

Though they are an important source of food, little is known about crabs on the west coast of India. Information on the diversity of these fascinating creatures is confined to crabs collected from sandy beaches, rocky foreshores, mud flats, marshes and mangrove swamps.

Altogether 83 species of the crabs have been reported along the west coast of India. Of these, 37 species are marine, 40 estuarine, and six live in freshwater.

Commercial value

Crabs are an inexpensive source of protein. They fetch a good price during the monsoon or off-season. Crab fishing provides livelihood for a large number of people in coastal villages.

Due to limited yield and great local demand, there is no export potential for crabs. Large annual fluctuations occur in the numbers caught. Soylla serrata is the most common edible crab of India. Portunus pelagious, Charybdis cruciata and Portunus sanguinoleutus are other commercially important crabs; they are caught throughout the year and support a minor but regular fishery along the Goa coast.

The gear and methods for catching crabs are not highly specialized. Most are caught during the daytime using various types of conventional nets, traps, lines, bait and hand picking during low tide. The crabs are kept in baskets with wet weeds to reduce mortality, and are marketed live.

Ecological role

Crabs play an important role in recycling nutrients in mangrove ecosystems. They are a prime source of food for various fish, (including stingrays), frogs, crocodiles, swimming and wading birds, jackals and other carnivores. They are important scavengers of the seashore, making up in numbers what they lack in size.

Despite their ecological importance, crabs are often treated as a nuisance. They burrow actively, causing considerable damage to canal and river banks and pond bunds. This can cause heavy losses to commercial aquaculture.

Habitat of estuarine and freshwater crabs

Habitat	**No. of species**
Rocky shores	20
Mangrove swamps	2

Sandy beaches	13
Mud flats	6
Inside mollusc shells	2
Rocks	3

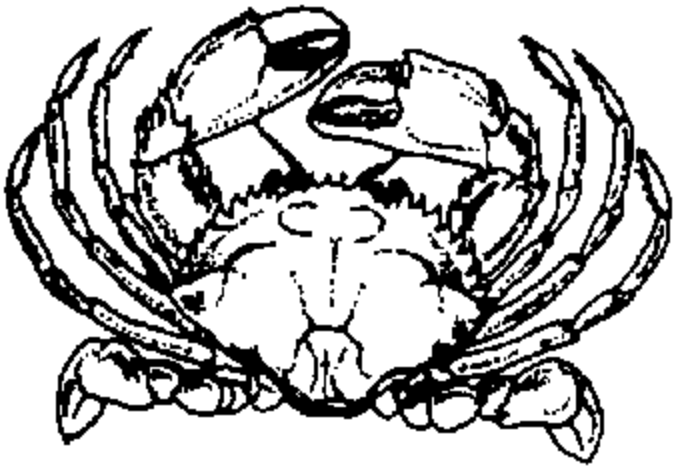
Crabs and the moon

The lunar cycle is thought to influence the occurrence and body composition of crabs. The highest numbers of crabs are found during the full moon, while the weight of the crabs is highest during a new moon.

People believe that during a new or full moon, the texture and taste of crab meat changes considerably. This is due to moulting of the shell and seasonal variations in the chemical composition of the meat.

Crab culture

There is no regular culture in India specifically for crabs. Though Scylla serrata and Portunus spp. are suitable for culture due to their high growth rate, adaptability to brackish water, voracious feeding and early attainment of sexual maturity, no attempt has been made to raise them commercially. The coastal and brackish water farms of Goa could be used to culture these species.



Crabs and the moon

Conservation

The best way to conserve crabs is to protect their habitat. Some commercially important species inhabit mudflats and sandy beaches. These and related habitats such as mangroves can be protected by minimizing erosion, planting Casuarina trees and protecting sand dunes.

Crab species along the west coast

Marine species

Dromia dromia

Matuata planipes

Leucosia pubescens

Leuosia sima

Arcania septemspinosa

Droppe astute

Cryptopodia aneulata

Scylla serrate

Neptunus sanguinolentus

Neptunus belagicus

Thalamita crenata

Thalamita prymna

Platypodia cristata

Xantho scaberrimus

Medaeus granulosus

Estisus laevimanus

Galene bispinosa

Actaea savignivi

Pilmunus vespertilio

Heteropanope levis

Eurycarcinus orientalis

Eriphia laevimana

Eucrate dentate

Litocheria setosa

Macrophthalmus latreille

Macrophthalmus pacificus

Macrophthalmus depressus

Macrophthalmus crinitus

Grapsus strigosus

Metopograpsus messor

Metopograpsus maculatus

Varuna litterata

Metaplax indica

Metaplax distincta

Plagusla tuberculata

Portunus pelagicus

Potrunus sanguinolentus

Estuarine species

Pseudodromia integrirong

Calappa lunaris

Philvra globosa

Philyra corallicola

Elamena cristatipes

Menaethius monoceros

Hyastenus planasius

Declea gracilipes

Paramithrax aculetus

Schizophrys aspera

Lambrus pensor

Atergatis integerrimus

Atergatis floridus

Atergatis roseus

Leptodius exaratus

Myomenippe hardwickii

Ozius regulosus

Epixanthus frontalis

Pilmunus longicornis

Litocheria angustifrons

Pinnotheres placunae

Pinnotheres cicafii

Ocypoda ceratophthalma

Ocyoda cordimana

Ocyoda rotundata

Gelasimus annulipes

Gelasimus marionis

Gelasimus nitidus

Glasimus dussumieri

Dotila myctiroides

Macrophthalmus pectinipes

Macrophthalmus sulcatus

Pseudograpsus intermedius

Sesarama quadrata

Sesarma oceanica

Sesarma taeniolata

Sesarma minute

Paratelphusa spp.

Freshwater species

Charybdis cruciata

Charybdis jucifera

Charybdis annulata

Charybdis callianassa

Charybdis orientalis

Charybdis hoplites

Prepared by Anil Chatterji

3.7 Estuarine shellfish

An estuary is a semi-enclosed coastal body of water which has a connection to the open sea one side and a river with fresh water on another side. Due to the presence of freshwater and seawater together, a, wide spectrum of flora and fauna can be found in estuaries. Land runoff, coastal nutrients and contributions by rooted vegetation like seagrasses and mangroves support high biological productivity. The resulting wide range of fish and shellfish supports a productive fishing industry.

Western Ghat estuaries

All the west-flowing rivers of Maharashtra, Goa and Karnataka rise in the Western Ghats hills. None is longer than 150 km. Where they meet the Arabian Sea, they form extensive estuaries.

The high rainfall in the Western Ghats means that large amounts of freshwater flow into the estuaries. Water temperatures are generally low during the monsoon and high during the summer. Most of the estuaries are shallow and predominantly sandy. The meteorology, physico-chemical conditions of the estuary and the substratum are ideal for shellfish to grow and propagate.

Shellfish

Shellfish include all species with either shells or exoskeletons. These are mainly molluscs and crustaceans. Molluscs such as clams, mussels and oysters are important in the Western Ghat states.

Molluscs

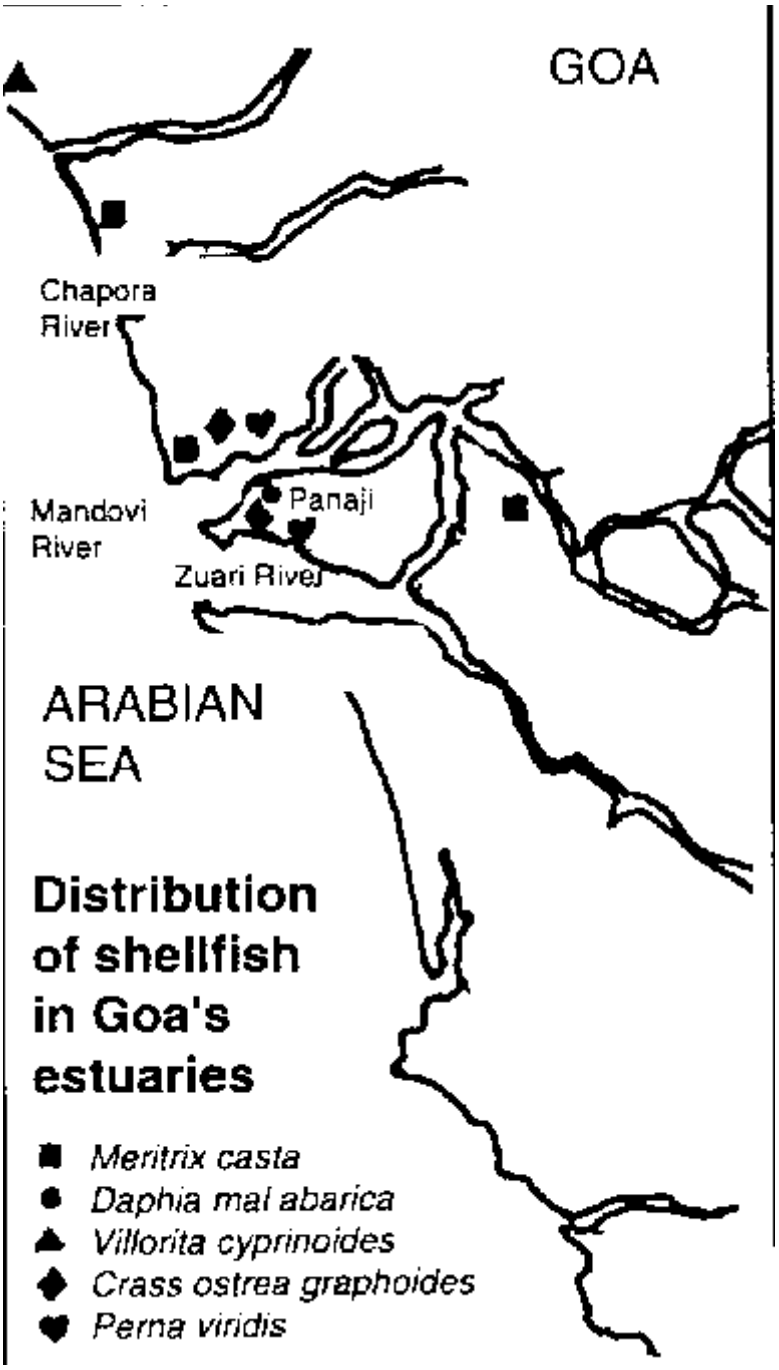
Molluscs have a soft unsegmented body which is usually covered by a shell. The shell is formed by an outer body wall (mantle) which secretes the calcareous substances.

Microhabitat of shellfish

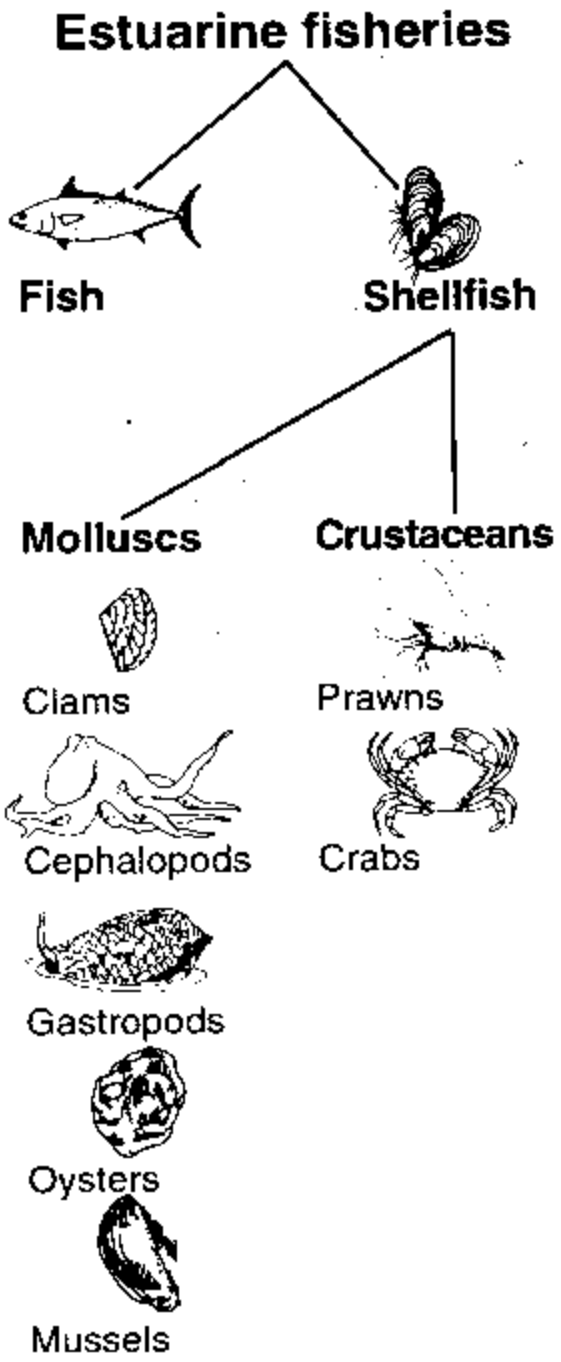
The estuaries in the Western Ghat region support a variety of fauna. The distribution of clams illustrates how microhabitats vary.

Clams show a definite settlement pattern and breeding cycles based on changes in the environment such as salinity. The substratum plays a prominent role in the formation of clam beds.

The clams occupy characteristic zones within the estuary from the bar mouth to the interior.



Distribution of shellfish in Goa's estuaries



Estuarine fisheries

Five species of clams occur on the west coast of India: Meritrix meritrix, Meritrix casta, Katelysia opima, Paphia malabarica and Villorita cyprinoids. They have an annual yield of 12,000 tonnes a year.

Red tide

Red tide is an algal bloom that can poison shellfish and the people eating them. The growth period of shellfish is January-March. Meritrix casta (Khube) affected in Karnataka and Tamil Nadu has been responsible for deaths of people. However, such incidents are rare.

Uses of shellfish

A total of 15,000 tonnes of shellfish are consumed in the Western Ghat states each year. An average of 10% wet weight of the meat is protein. Shellfish also contain substantial amounts of vitamins and minerals.

Overexploitation of fish in the coastal waters has increased pressure on shellfish resources. Besides being used as food, mollusc shells are also used in paper, rayon, leather, carbide, cement, lime and fertilizer industries as well as for shell grit for poultry and aquaculture.

Conservation and culture

A constant watch on the population structure and growth of shellfish in the intertidal region is the best way to monitor the biodiversity of shellfish in the estuarine region. The shellfish can be easily transplanted and grown on rafts, ropes, cages and on rocks during the lean season. These approaches may help increase the availability of shellfish products and protect shellfish biodiversity.

Threats from people and industry

• Dredging

• Increased turbidity

• Reclamation, changing bed profiles

• Organic wastes, using up dissolved oxygen

• Hot water

• Discharge of chemicals such as phenols

• Organochloride compounds, e.g., DDT, PCB (polychlorinated biphenols)

• Heavy metals, e.g., mercury, lead, zinc and cadmium

• Sewage

• Hydrocarbon pollution

• Runoff from iron ore mining

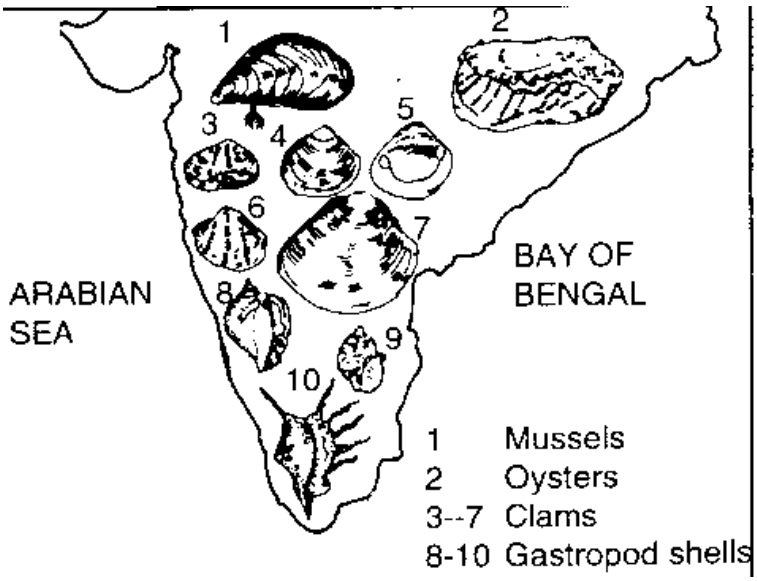
• Sand

• Chemical fertilizers

Influences on shellfish habitat

Physical	**Chemical**	**Biological**
Tides and waves Current Salinity Temperature Substratum Turbidity and light	Oxygen Carbon dioxide Hydrogen sulphide Nutrients Phosphate Nitrate Silicate Ammonia	Flora Phytoplankton Bacteria Macro algae Seagrass Mangroves Fauna Benthos

Prepared by S.G.P. Matondkar, Nakul Mhamal and D. P. Kavlekar



Conservation and culture

3.8 Fish

Among the 20,000 species of fishes known, more than 2000 are found in India. The country's great river systems and extensive network of irrigation canals, reservoirs, lakes, tanks and ponds are some of the many freshwater ecosystems for fish.

Estuaries, lagoons, backwaters, impoundments, mangroves and swamps harbor a wide variety of estuarine fish. These estuarine ecosystems represent a few of the brackish water ecosystems found on the west coast of India.

The estuaries of west-flowing rivers such as the Zuari and Mandovi (Goa), Netravathi Gurupur (South Canara) and Kalinadi, Aghanashini and Sharavati (North Canara) provide excellent habitats for fish.

All the rivers of the west coast of peninsular India arise in the Western Ghats hills and flow for a short distance into the Arabian Sea. Though many are perennial, others are torrential streams only during the southwest monsoon. The major fishes of these rivers include carps, catfishes, mahaseers, mullets, perches, and pearl spots.

Fish like the Indian shad, Hilsa ilisha, which migrate into rivers from the sea for spawning are called anadromous fish. Local fish that migrate between ecosystems in search of breeding grounds include the mahseers, the Indian major carps and large and medium-sized catfish.

Types of fisheries

Two types of fisheries are found on the west coast of India:

• Capture fisheries-In the sea, rivers, estuaries, large reservoirs, and lakes. Here, people reap without having to sow. Fish stocks are replenished naturally.

• Culture fisheries-Otherwise known as pisciculture, culture fisheries are done in small water bodies which people can manipulate. The fish fry have to be sown, tended, nursed, reared and finally harvested when grown to table size.

Important fishing gear used in West Coast includes shore seines, gill nets, cast nets, hook-and line nets and mini-otter trawls.

What are fish?

Fish:

• Are cold-blooded

• Have a backbone

• Live in water

• Breath with gills

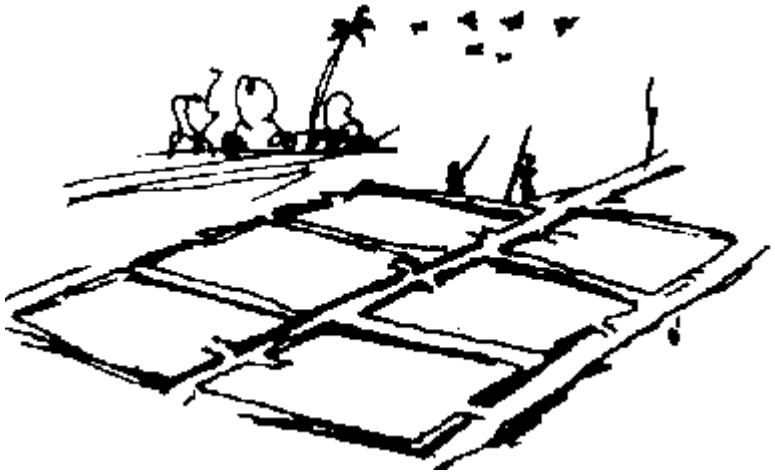
• Use fins to balance and move

• Most have scales.

Fish are classified into two major groups:

• Bony fish (e.g., carp, mullets)-skeleton is of hard bones.

• Cartilaginous fish (e.g., sharks, rays)-skeleton is of soft and flexible cartilages only.



Types of fisheries

Endemic and exotic species

Endemic fishes

The following fish are endemic to Western Ghats river systems.

• Mahseers (for spp)-One of the most important game fishes of India. (Tata Electric Company has developed ways to restore and rehabilitate them in Lonawala and Koyna water reservoirs)

• Tor khudree (Khudree Mahseer)-Attains a length of 1.5 m, found in Walwhan and Shirawta reservoirs of Lonawala, streams of South Canara and down to north Kerala.

• Barilius bendelisis-An important game fish found in Nilgiri waters.

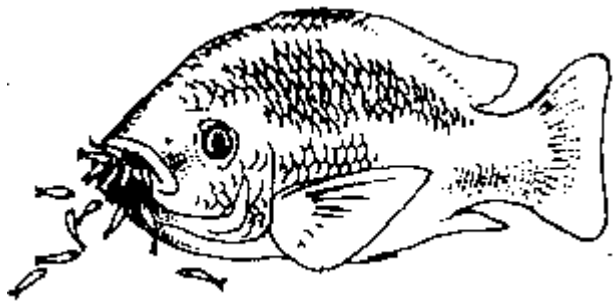
• B. gatensis-Attains a length of 150 mm. Found in the streams of the Western Ghats.

Endemic fishes

Exotic species

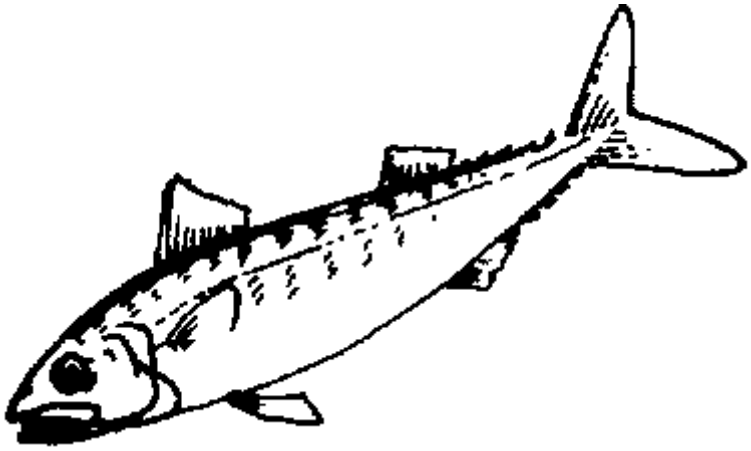
These cultivable fishes are extensively used in intensive freshwater aquaculture.

• Grass carp (Ctenopharyngodon idella)-Introduced from Japan in 1959 for experimental culture and weed control.



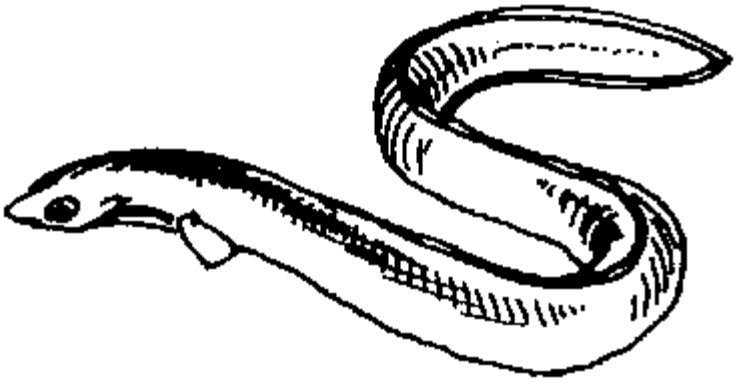
Grass carp

• Silver carp (Hypophthalmichthys molitrix)-introduced to India from Hong Kong in 1959 for experimental culture.



Silver carp

• Tilapia (Tilapia mossambica)-introduced from Bangkok in 1952 for experimental culture. Original inhabitant of rivers of East Africa.



Tilapia

Burden of fatherhood

Some male fishes "deliver" their young. Male tilapia (Tilapia mossambica) pick up fertilized eggs, incubate them in their mouths, and deliver the young ones. This is known as buccal incubation and is a kind of parental care. This behaviour ensures greater survival of young ones.

Some catfishes also take care of their young in this way.

The paternal brood pouch of a male sea horse (Hippo campus) enables its young to pass their embryonic days inside their father. Later, he "delivers" the young ones.

Uses of fish

Food-High nutritive value, contains protein (about 20%). Fish oil has higher proportion of unsaturated fatty acids. Fish is a good source of trace elements like Cu. P. Fe and I, and of vitamins A and D.

Economy-Sustainable fishing generates economic prosperity. Fish bones are used to make combs. Shark skin is used to make high-quality leather purses, belts and shoes.

Organic manure-Non-consumable fish is used in agriculture as organic fertilizer as it is rich in nitrogen and phosphates.

Medicine-Unsaturated fatty acids in fish oil are good for the heart. They also prevent cellular aging and are used to make gelatin. Fish oil (such as shark liver oil) is used as therapeutic agents for vitamin A and D deficiencies.

Animal and poultry feed-Fish meal is used to feed ruminants and poultry. It increases milk supply and weight gain.

Pest control-Gambusia sp. (common guppy) is used to control mosquito larvae. Grass carp is used to control aquatic weeds.

Education, research and recreation-Fish have many uses for teaching and research, and for aesthetic reasons (e.g., aquarium fishes).

Some economically important fishes of the West Coast

Sillago sihama

Thrissocles mystax

Anadostoma chacunda llisha indica

Mugil sp. (mullet)

Therapon jarbua

Cyanoglossus sp. (sole fish)

Mystus gulio

Tachysurus sp. (marine catfish)

Pseudosciaena sp.

Gobius sp.

Plectorhynchus sp.

Pseudorhombus triocellatus (flounder)

Ambassis gymnocephalus

Kowala coval (sardine)

Pltycephalus scaber

Sphyraena sp. (barracuda)

Pristipoma argyreus

Tenthis oramin

Belone cancila

Rastrelliger kanagurta (Indian mackerel)

Etroplus suretensis (pearl spot)

Indian major carps

• Catla (Catla catla)

• Mrigal (Cirrhinus mrigala)

• Rohu (Labeo rohita)

• Calabasu (Labeo calabasu)

• Common carp (Cyprinus carpio)

Conservation

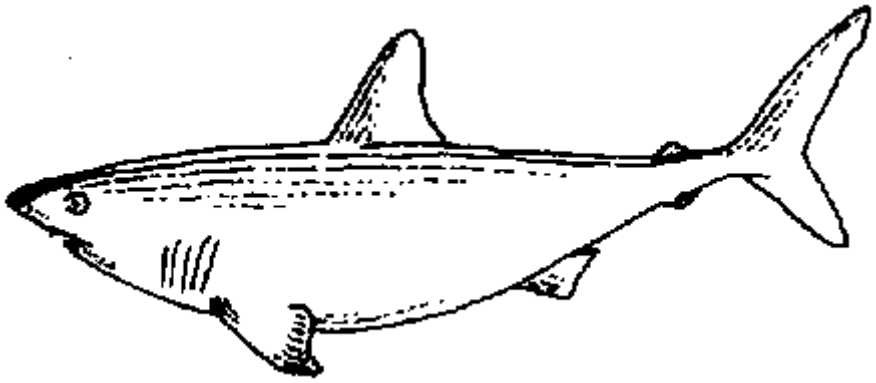
• Implement existing mesh size limits (the minimum mesh size for nets is 30mm)

• Implement size limits to allow juveniles to reach maturity.

• Enforce a closed season ban on fishing during June-July to September, so that fishes can spawn and breed.

• Prevent pollution: Prevent domestic sewage and industrial effluents from entering the breeding zones of fishes in rivers, estuaries and seas.

• Declare sanctuaries: Major breeding zones should be declared as sanctuaries.



Gambusia sp.

Air breathing fishes

Some fishes are provided with accessory respiratory organs which enable them to live out of water for a long time. They include:

Mystus seenghala (freshwater catfish)

Clarius batrachus (catfish)

Boleophthalmus sp. (mud-skippers)

Periophthalmus sp. (mud-skippers)

Anabas testudineus (climbing perch)

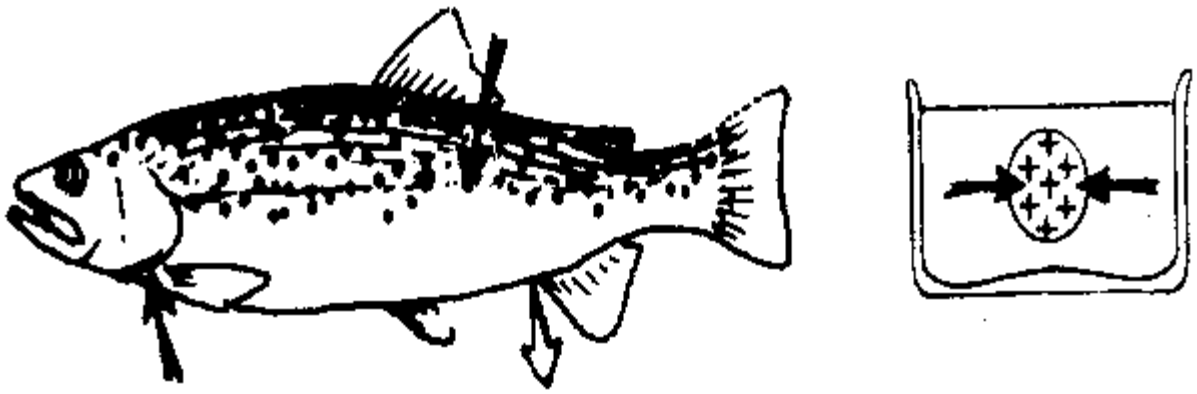
Channa punctatus (snakehead)

Heteropneustes fossilis (stinging catfish)

Rasbora daniconius (danio)

Glossogobius giuris (goby)

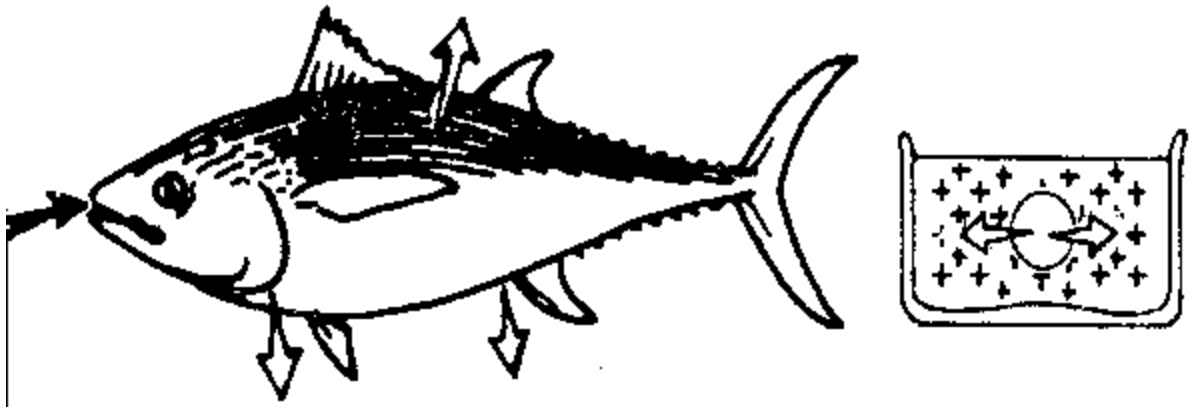
Water balance (osmoregulation) in fishes



Freshwater fish

Since the liquids in a freshwater fish's body are saltier than the surrounding water, it is in constant danger of soaking up water and swelling, just as a bladder of salt water in a laboratory beaker of fresh water. As a result, it doesn't drink, and what water comes in through the skin and gills is carried to the kidneys and used to carry away waste products in large quantities of urine.

A saltwater fish has exactly the opposite problem. Its liquids are less salty than the surrounding water, and it is in constant danger of dehydration, like a shrinking bladder of fresh water in a laboratory beaker of salt water. Thus the fish must drink large quantities of water to make up for what it loses through its gills and skin. Some of the salt goes through the digestive tract and is excreted. Some is forced through special gill cells back into the ocean. A saltwater fish seldom urinates.



Saltwater fish

Prepared by Dr. A. Thomson Mathai

3.9 Coastal ecosystems

Coastal ecosystems occupy the foreshore waters and the zone out to a depth of about 200 m. They consist of the beach, the intertidal area (which may be rocky or sandy), the benthic bottom habitat (sandy or muddy) and overlying green productive waters (as opposed to the open ocean blue waters which are less productive).

Characteristics

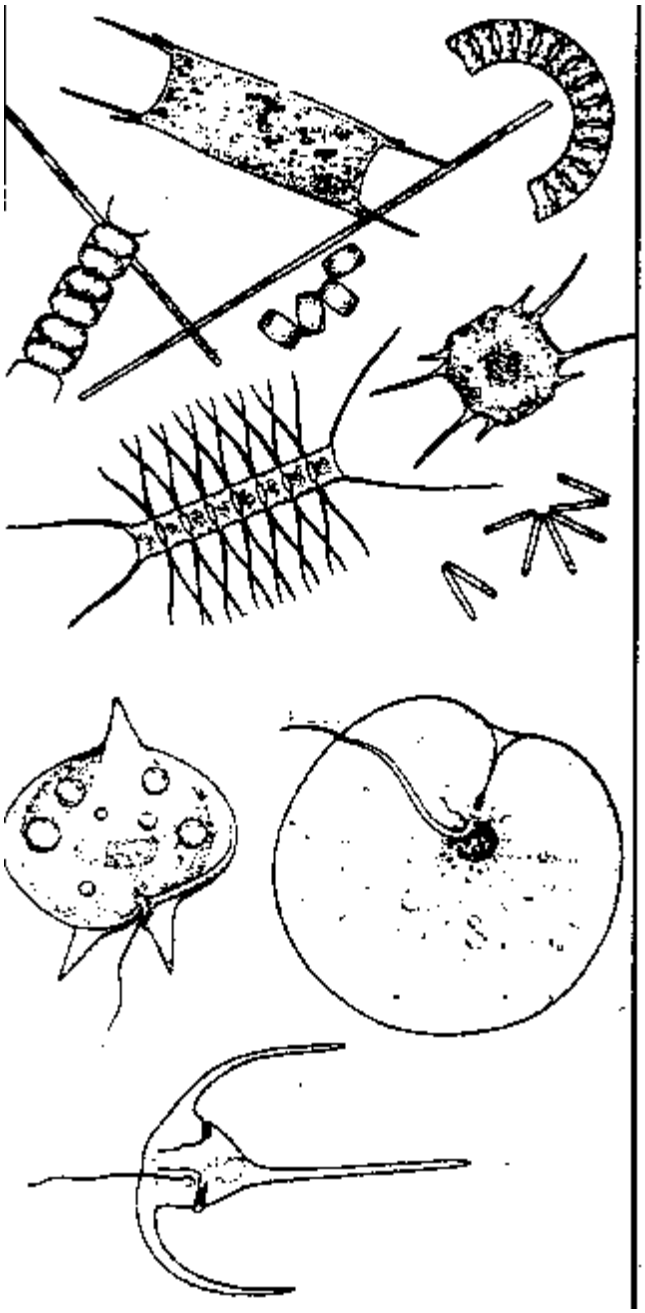
As on land, life in the ocean is supported by plants. The counterpart of the land plants in the ocean are microscopic plant cells called phytoplankton. These fix carbon with the aid of sunlight.

Phytoplankton need nutrients to do this. Coastal ecosystems receive large amounts of nutrients and hence are highly productive and sustain most of the major fisheries around the globe. The nutrients in these waters come mainly from river runoff and upwelling. Upwelling is a process through which nutrient-rich deeper waters are brought to the surface layers where the phytoplankton can utilize them in presence of sunlight. Along the west coast of India, upwelling occurs with the reversal of the wind field during the southwest monsoon and the associated reversal of currents. Plant and subsequently animal biomass rises during this period.

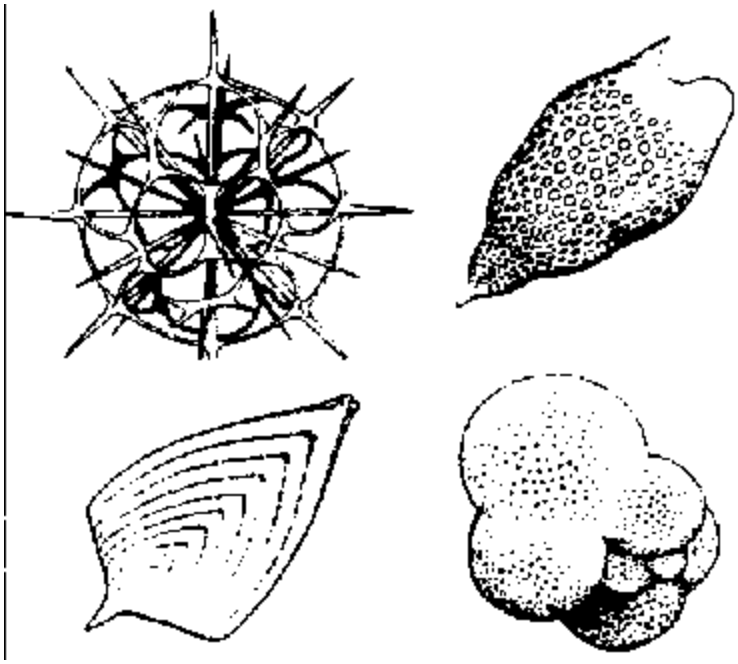
At higher latitudes, where light is often a limiting factor for biological production, spring blooms occur. Blooms of phytoplankton, known as red tide, produce toxic substances may lead to mass mortality of fish and other life.

Apart from phytoplankton, the water column is inhabited by zooplankton (which feed mainly on phytoplankton), bacteria and fish. Some of the larger zooplankton such as jellyfish are carnivores. Fishes feed mainly on phyto- and zooplankton.

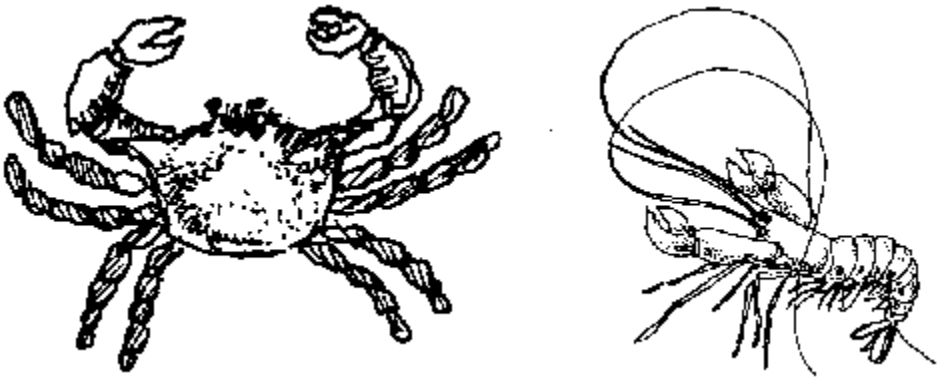
The bottom habitat is home to a variety of benthic animals. These include both invertebrates and vertebrates such as worms, molluscs, starfish, crabs, shrimps, and demersal fishes.



Phytoplankton



Zooplankton



Coastal ecosystems

Marine Biota

Type	**Habitat**
Neusion	Surface film
Phytoplankton	Surface to sunlit depths
Zooplankton	Surface to deep scattering layers

Pelagic	Near surface to 100 m water column
Nekton	
Bathy-pelagic	100-300 m water column
Demersal	Near sea floor
Benthos	Within or in the vicinity of sea floor-Intertidal to deepest depth

Functions and utility

Although they cover only 5% of the oceans, coastal waters sustain about 75% of the world's fisheries. This includes both pelagic (open water) and demersal (near sea floor) fisheries, plus others such as shellfish catches.

Coastal areas are the breeding and nursery grounds for a variety of organisms. Beaches and inshore waters are used in recreation and sports and for tourism. They absorb large quantities of domestic and industrial waste. These areas are often rich in seaweed which is used as food and in industry (e.g., as agar). Large areas of coastal waters and the adjoining land are used for aquaculture, for instance to grow shrimps, mussels, oysters and fish.

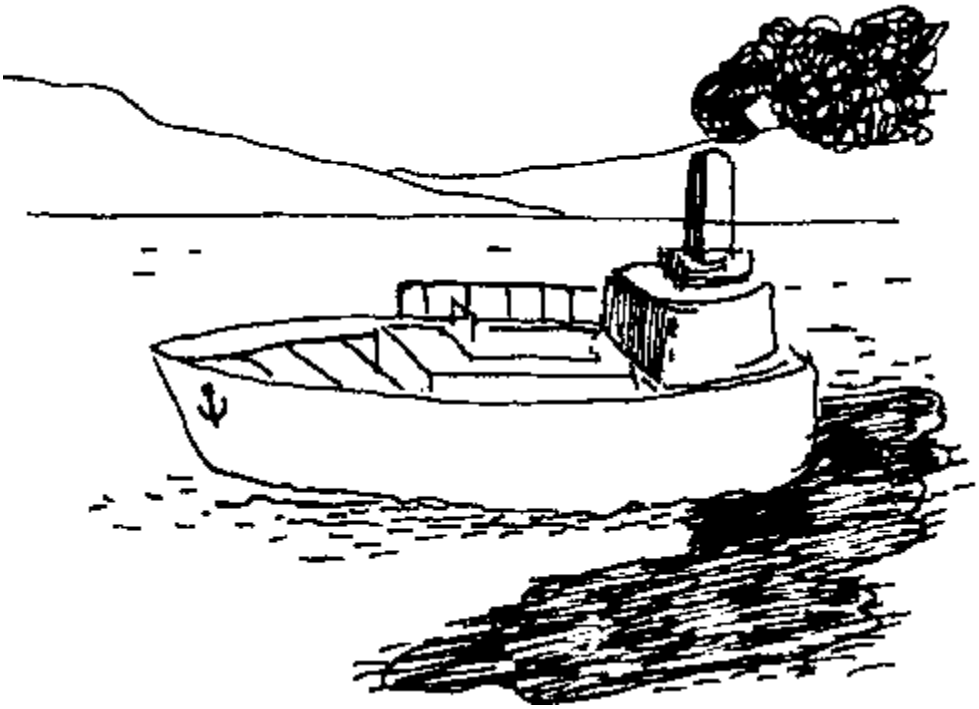
Conservation

Beaches and coastal waters are often subjected to large-scale pollution by the dumping of domestic and industrial wastes and by oil spills. Although these are somewhat resilient ecosystems, control measures to ensure safe limits must be enforced.

Beach erosion is a cause of concern. Sea walls do not solve this problem. They are unaesthetic, and when erosion happens somewhere, accretion occurs elsewhere. Indiscriminate construction and removal of sand alters currents, leading to erosion and effects on fauna and flora.

Exclusive economic zone

The Indian coastline is about 7000 km long. The Exclusive Economic Zone (EEZ) has an area of 2.02 million km^2. This sustains the major pelagic and demersal fisheries, which produce sardines, mackerel, anchovies, shrimps and other species. Resource mapping of the EEZ and understanding the productivity of the region has been more or less completed by the National Institute of Oceanography and other maritime agencies. Studies to estimate the level and effects of pollution in coastal waters are under way.



Exclusive economic zone

Prepared by M. Madhupra

3.10 Coastal sand dune vegetation

Currents, tides and waves move sand of various particle sizes towards the shore. The wind moves the sand back from the beach and forms dunes.

The shifting sands, saline conditions, lack of humus, high temperatures and deep groundwater make it difficult for vegetation to grow. Nevertheless, special types of flowering plants are well adapted to such adverse conditions. These plants include creepers, herbs, shrubs and trees, collectively known as "sand dune vegetation" or "psammophytes".

These species show certain ecological, physiological and reproductive adaptations, such as thorns, thick waxy cuticles and sunken stomata, succulent leaves, deep tap roots and fibrous rhizhoidal growth to bind the sand.

Sand dune vegetation is found along the east and west coasts of India and on several islands. So far, about 148 species, representing 115 genera and 49 families have been recorded from Indian coasts.

Dune self-maintenance

The strip of land just inland of the mean high tide mark is subject to regular or seasonal disturbances: storm surges and tidal waves. These occasionally inundate the area with water and sand. The regular, albeit infrequent occurence of this disturbance, maintains the pioneer vegetation.

Vegetation zones

The sandy shore vegetation is divided into several zones.

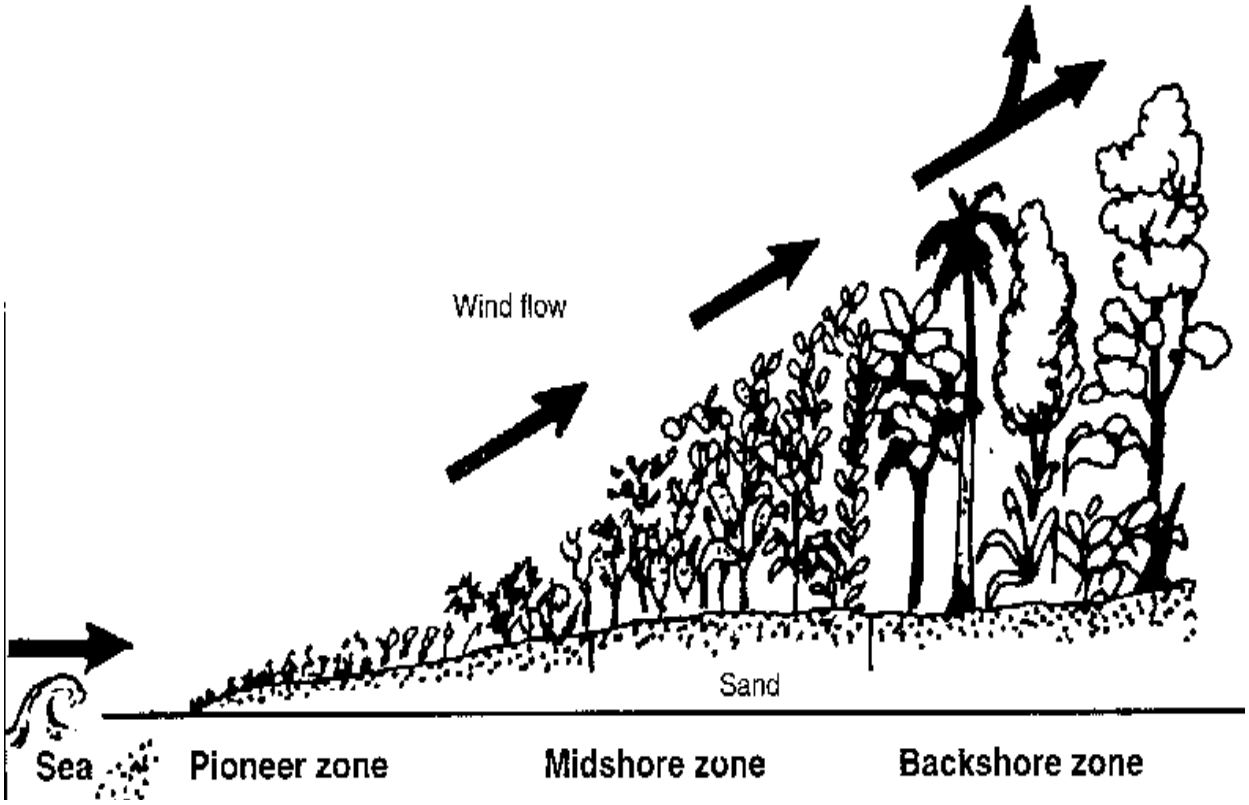
Backshore zone: Farthest from the sea, this is mostly covered by trees. The plants here are the tallest. Examples are Casuarina sp., mango and coconut.

Backshore zone

Middle zone: Behind the pioneer zone, shrubby plants are common. The plants are taller than in the pioneer zone. Examples are Vitex nigandu and Pandanus sp.

Pioneer zone: Closest to the sea. Herbaceous crawling species with long, wiry branches are common. They send out "rhizoids" (runners) that extend the plant's reach and bind the sand. An example is Ipomoea pes-caprae.

These three zones form a gradual triangle or "vegetation slope" which diverts the wind flow and helps check the movement of sand.



Typical sand dune vegetation

Pioneer zone	**Midshore zone**	**Backshore zone**
Herbs: shallow rooted	Shrubs: medium rooted	Trees: deep-rooted
No humans; seawater influence	Little humus; mixed water influence	Maximum humus; maximum freshwater influence
Ipomoea pes-caprae	Vitex nigandu	Casuarina equisettifolia
Spinifix littoreus	Opuntia sp.	Calophyllum ioniphyllum
Cyprus sp.		Tamarindus indicus

Simplified sand dune reclamation

Functions of sand dune vegetation

Sand dune plants (especially the herbs and shrubs) are not commonly used for economic gain. However, their ecological value is very high. They:

• Bind sand particles.

• Develop and stabilize different types of dunes..

• Check sand movement.

• Produce humus.

• Increase soil water-holding capacity.

Conservation

In desert areas, sand movement causes acute problems, so local people are very aware of the importance of dune vegetation. However, along the coast, the level of awareness is low.

Sustainable management of sand dune vegetation is essential. Pressures from development activities such as hotels and the extraction of beach sand are increasing. These areas can be protected, maintained and managed by suitable plantation programmes.

Prepared by A. G. Untwale

3.11 Fish breeding and habitat

India's national marine fisheries are supported by over 500 species of fish, crustaceans and molluscs. These are a protein-rich food resource. These fisheries employ large numbers of people and provide substantial foreign exchange earnings through exports of marine products. States on the west coast contribute over 65% of the national marine landings.

Fish resources are affected by a number of natural forces and human interferences. The ultimate size of any population is governed by nasality, mortality (death due to fishing and ageing) and dispersion (migrations for feeding, breeding, resting or overwintering). Different species occupy different habitats for breeding and feeding. Some, such as salmons and eels, migrate thousands of kilometers to breed.

We must study fish reproductive biology if we are to understand how fish stocks regenerate. Information on size at first maturity, sex ratios, spawning habitats, spawning frequency and fecundity helps predict fish stocks and formulating management strategies.

Knowledge of the marine ecosystems that are homes to fish during their life cycles can help in conserving both the fish and their habitat. A species must be able to breed successfully in their natural habitat if it is to survive. Any damage to its usual breeding habitat threatens not only the fish but also the people who depend on it for their livelihood and food.

Mangrove deforestation

Young barracuda larvae, 23 cm long feed and hide in the mangroves. Almost all Indian marine prawns spend their juvenile stages in the estuaries, mangroves and nearshore sheltered habitats. Destroying of these natural habitats may also destroy or dislocate the breeding grounds of commercial fish species.

Marine fish catches in Kerala

	Average annual production (tons)	Rate of growth
1950-59	181	—
1960-69	301	5.3%
1970-79	380	2.4%
1980-89	378	- 0.1%

The number of mechanized fishing vessels is increasing substantially and without regulation. This growth puts tremendous pressure on fish resources and has caused stagnation in the fish catch.

Marine fish landings

State.	**Coast-line (km)**	**Continental shelf (1000 km²)**	**Percent of marine catch (%)**
Kerala	590	40	29
Karnataka	300	25	10
Goa	90	10	2
Maharashtra	720	112	25
Gujarat	1600	164	9

Breeding patterns

Most fish species seem to have rather long spawning seasons but tend to reproduce intensively during strong monsoon winds of June to October. Many commercially important fish produce large numbers of small, pelagic eggs. These eggs have oil glob ules which help them float. They are released in the water to drift with currents. The eggs hatch in the warm water in a few days. The numbers of a fish species caught can change dramatically from year to year, probably because of variations in the numbers of young that survive to adulthood. Only a small percentage of the many eggs survive.

Many oceanic species (such as seer fishes, tuna, barracudas and sharks) seek coastal waters for nursery grounds.

Major fish breeding habitats in the west coast of India

Estuarine	**Shallow coastal (<30m)**	**Deep coastal (30-200m)**	**Oceanic**
Indian whiting	Oil sardine	Indian mackerel	Tuna

Mullets	Other sardines	Eels	Bill fish
	Bombay duck	Larger sciaenids	Seer fish
	Polynemids	Carangids	Barracudas
	Lizard fish	Ribbon fish	Some sharks
	Unicorn cod	Flat fish	
	Small sciaenids	Moon fish	
	Pomfret	Queen fish	
	Pony fish	Darts, King fish	

Coral reefs as breeding habitats

In the marine environment the highest species diversity of both animals and plants is found in coral reefs. Virtually every open-water species living in close vicinity chooses the reef as its breeding habitat. Tunas, acanthurids and barracudas are among the many fishes breeding in coral reefs.

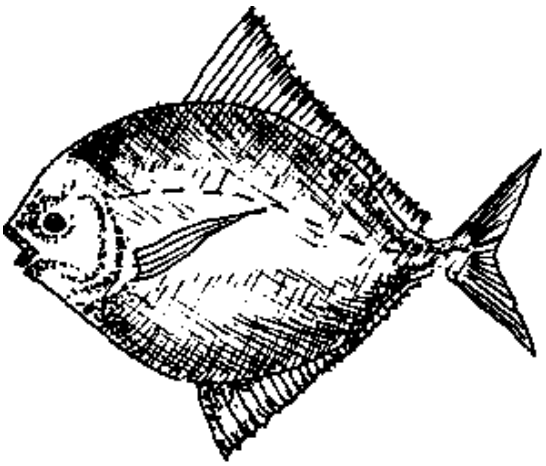
Stay-at-home eels

Unlike most eels, Indian marine eels do not migrate for breeding.

European, American and Japanese eels (all in the genera Anguilla) migrate from freshwater to seawater habitats to breed. But none of the marine eels around India is known to migrate for breeding. This is substantiated by the large numbers of elvers (larval eels) found near the shore or in estuaries.

Like fruits left to rot?

Fish such as pomfrets and silverbellies are currently under-utilized. We could harvest substantially greater numbers of these fish. without affecting the population or its sustainability. Not harvesting them is wasting a valuable resource like fruits left to rot on a tree.



Like fruits left to rot?

The maximum sustainable yield is the highest possible catch that can be taken without disturbing the equilibrium of the stock.

Conservation and resource management

Some fish species are over-exploited; others are currently under-used. A rational management strategy should restrain the fishing of the overexploited species-such as oil sardines and mackerels. It should increase production of species such as pomfrets and silverbellies that are currently under-utilized.

Mangroves, seagrass beds, coral reefs and other sheltered areas should be preserved. They are nursery grounds for most cosatal species and oceanic fish such as barracudas and tunas.

Pollution particularly affects young fish. Next year's stock of fish depends on the healthy growth of the young in a complex, hazardous environment. Pollution lessens the chances of the young surviving as healthy adults.

Limits to the number of fish caught can also help conserve fish resources. Possible ways of controlling the catch are:

• Limits on fishing boat numbers in an area.

• Closed seasons or areas.

• Minimum legal size of fish that can be caught (e.g., for prawns, mackerels, Bombay duck and oil sardines) to allow these species to breed

• Limits to the catch size.

Prepared by M Ramaiah

4. Fresh- and brackishwater

4.1 Estuarine ecosystems

Estuaries are where rivers discharge into the sea. They are semi-enclosed bodies of water, connected to the open sea, but where the sea water is diluted by fresh water from the land.

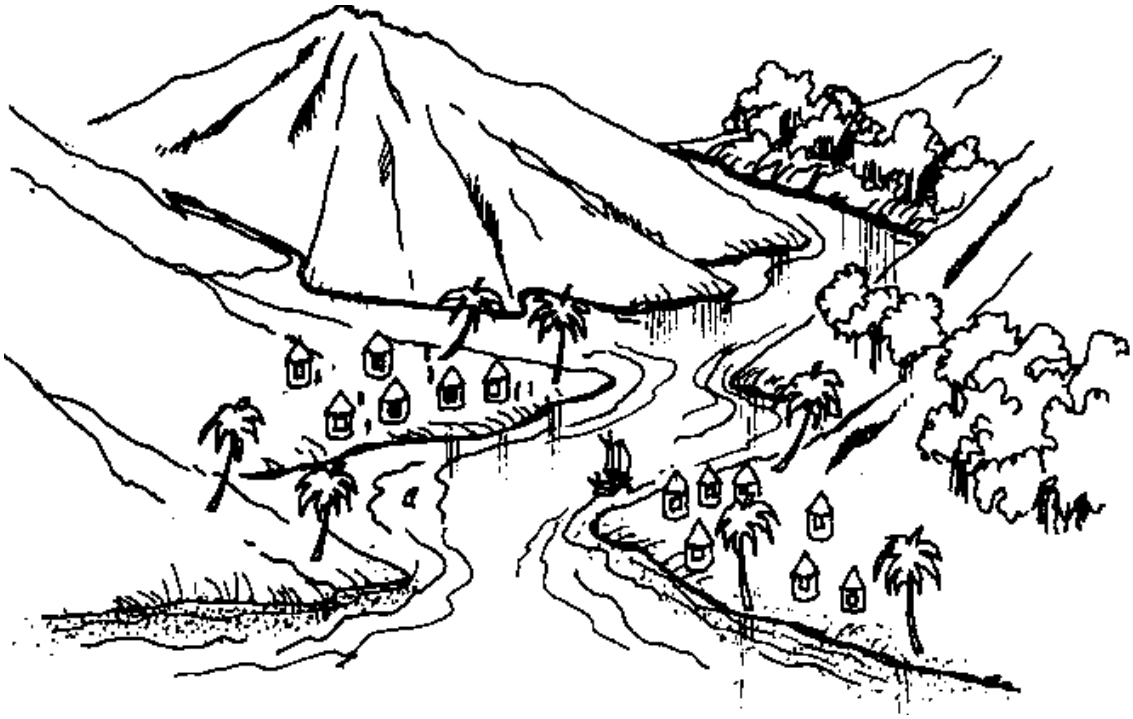
Both land and sea affect estuaries, and their influence varies throughout the day and from season to season. These factors pose serious challenges for living organisms, and estuaries have developed unique ecosystems in response.

Salinity

Inflow of fresh water from one side and the open sea at the other gives rise to a gradient of increasing salinity from the interior to the estuary mouth. The salinity also changes with the tides and the season. The Mandovi-Zuari estuary in Goa and Cochin backwaters in Kerala are typical estuaries in which surface salinity ranges from 0.65% at the peak of the monsoon in August to 33.64% in the hot pre-monsoon period in April.

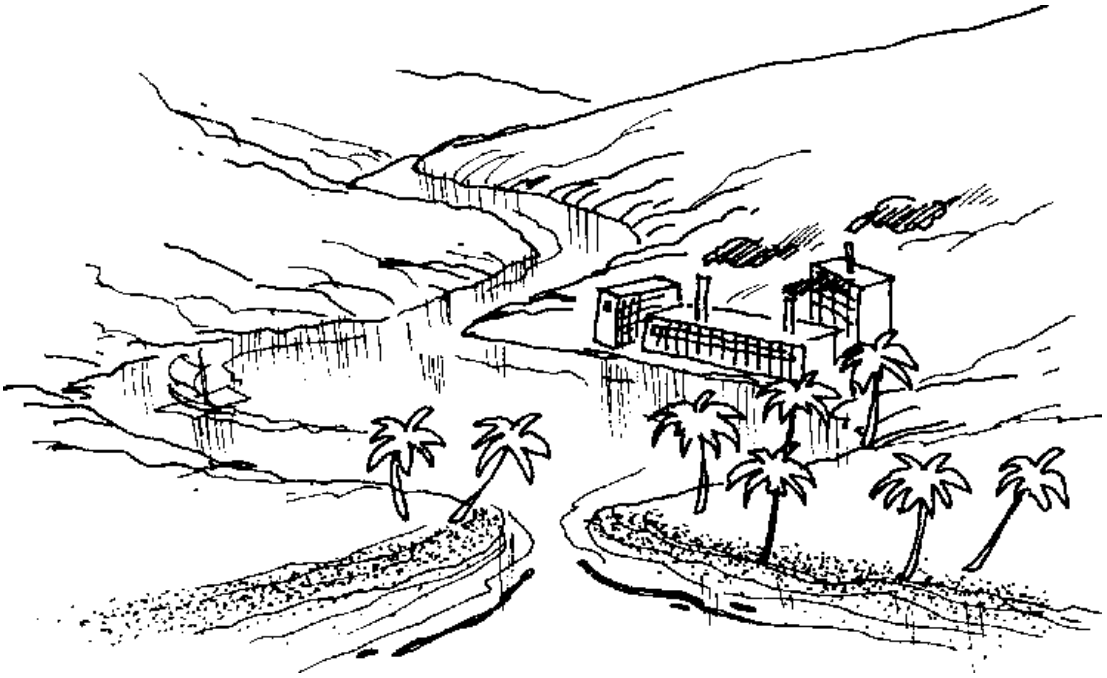
Brackish waters are poorer in species diversity than either the sea or fresh water. Seasonal fluctuations in salinity influence the distribution of organisms in the estuary. Continuous rains during the monsson harms marine fauna. When salinity returns to normal after few months, the marine animals re-establish themselves. Estuarine animals either adapt to avoid unfavourable salinities or tolerate a range in salinity by using physiological mechanisms. For instance, to avoid unfavourable salinity, barnacles shut their valves, mussels close their shells, eupogebia burrow into the substrate, and other creatures migrate up and down the estuary.

Many estuaries in India were formed when the sea level rose, submerging parts of the coast and drowning river valleys. The Mandovi and Zuari estuaries in Goa were formed in this way.



Estuarine ecosystems

Estuaries can also be formed when shingle and sand bars form parallel to the coast, enclosing a shallow area and partly blocking a river's exit to the sea. One example of this is the Vellar Estuary in Tamil Nadu.



Vellar Estuary in Tamil Nadu

Most estuarine animals have effective osmoregulatory adaptations (methods of controlling the amount of salt in their bodies). Some regulate their salt content higher than the surroundings when the surrounding water has low salinity (this is called hyperosmotic regulation). The shore crab Carcinus, amphipod Gammarus, the crab Sarsama erythrodactyla certain prawns and the bivalve Mercenaria mercenaria all show hypertonicity in blood in diluted sea water.

Mytilus edulis and Arenicola marina have no osmoregulatory mechanism. They adjust as their tissues are able to function under low salt content. However they are unable to survive in salinity below their threshold concentration.

Temperature

Temperatures vary widely in estuaries owing to the mixing of water of different temperatures and shallowness of the water. In shallow estuaries, the water is much cooler in winter and warmer in summer. These temperature fluctuations affect the species composition and eliminate most animals that cannot withstand wide changes.

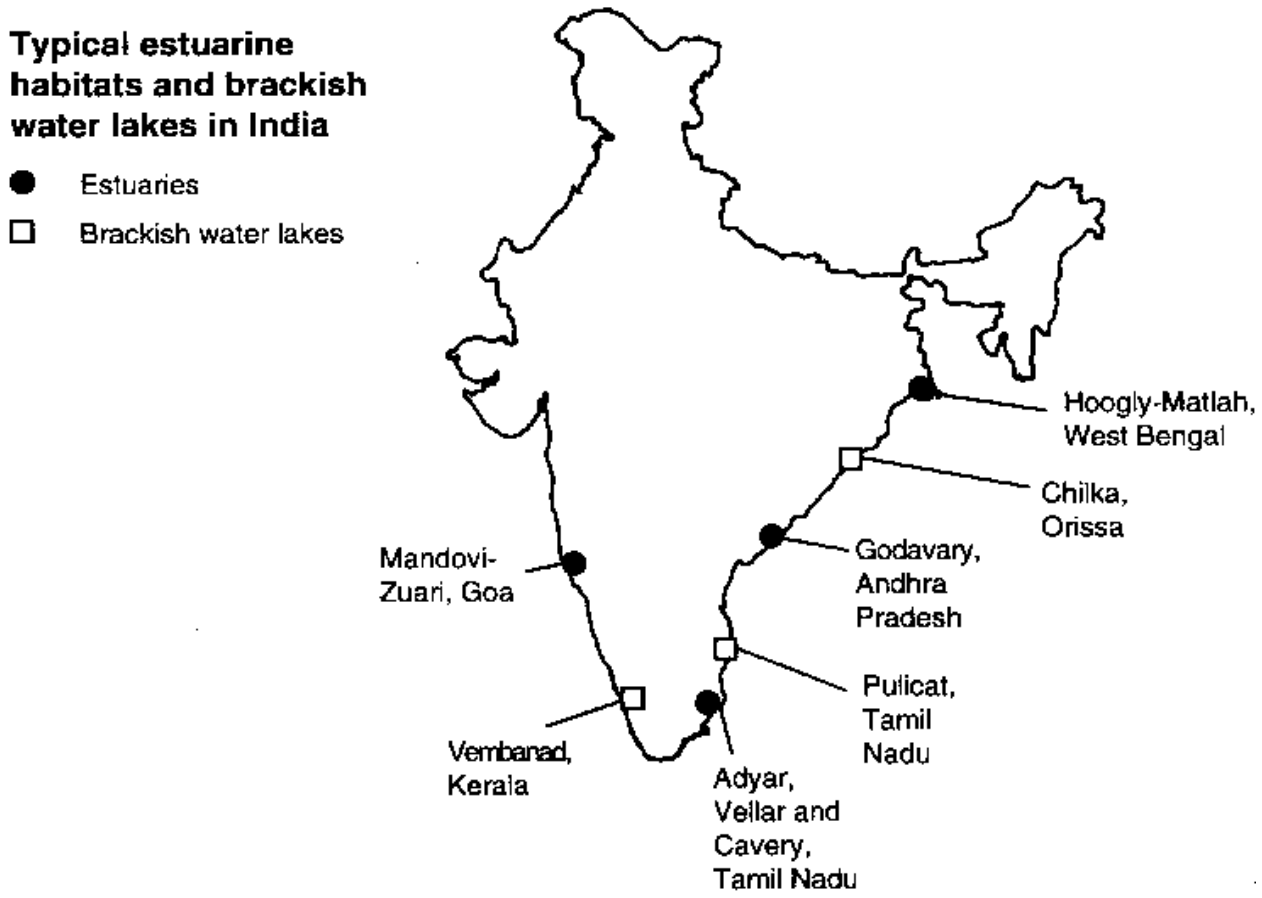
Sediments

The sediment type influences the organisms living in the estuary, especially plants and benthic animals. Mudflats are common. The substrate here is composed of soft, loose mud or a mixture of mud and sand. Characteristic vegetation such as eel grass in temperate areas and mangroves in the tropics develops on mudflats, making estuarine ecosystems very productive and at the same time providing special habitat for animals. Mangroves are found in most estuaries along the Indian coast.

Mangroves

Turbidity

Silt suspended in the water in estuaries causes the water to be turbid. The degree of turbidity varies widely throughout the year; it is at a maximum during the rainy season. It also varies from place to place within the estuary. Turbid water prevents light from penetrating even one metre below the water surface. This reduces the level of photosynthesis by phytoplankton in the deeper layers. Shore plants which are not covered by turbid waters are therefoore the most important photosynthesisers of organic matter. Salt-marsh plants such as spartina and zoostera and mangrove forest assume great importance as primary producers.



Typical estuarine habitats and brackish water lakes in India

Nutrient flows

The fertility of the estuary depends on the flow of nutrients from the river and on tidal currents. The Mandovi-Zuari rivers are rich in nutrients, especially nitrates and phosphates. Drainage from the land is the major source of nutrient inputs into the estuary. In addition, industrial effluents and city waters also find their way into the estuary. Some estuaries in Gujarat are subject to heavy industrial pollution, making it difficult for fish to survive.

The overall productivity of most Indian estuaries is low because of their high turbidity. In Cochin backwaters, the gross primary productivity measure of ranges from 270 to 298 g $C/m^2/yr$, while net production is 124 g $C/m^2/yr$. In Cochin backwaters, only 25% of the total phytoplankton production is estimated to be used by the herbivore population. The unconsumed food sinks to the bottom as detritus.

Even though the estuarine phytoplankton production is low, it is well compensated by the productivity of plants such as marsh grass, reeds and mangroves. More than 50% of production is available to estuaries in the form of detritus. Land drainage also supplies abundant detritus.

The abundant detritus means that it is the basis for most of the estuarine food chain. Several animals, or zooplankton, feed on the detritus and thus are primary consumers.

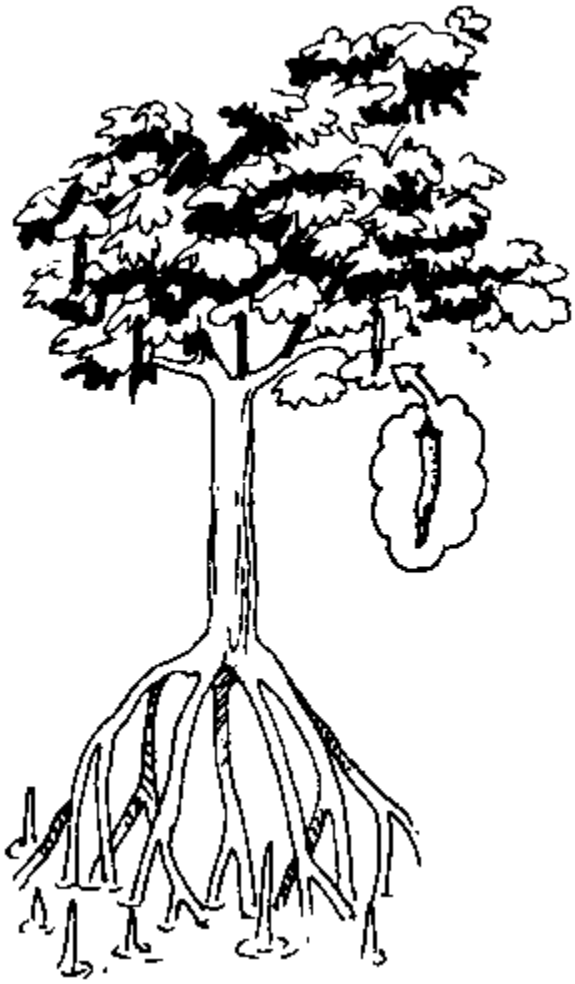
Gross primary productivity: the rate at which energy from light is absorbed and used with carbon dioxide to produce organic matter through photoosynthesis. It is measured in grammes of carbon per square metre per year (9 $C/m^2/yr$).

Net productivity: The amount of organic matter formed in excess of that use in respiration.

Prepared by Dr. X. N. Verlencar

4.2 Mangroves

Mangroves are flowering plants which can tolerate salinity and show peculiar ecological adaptations. They are able to tolerate mean temperatures only above 20°C, so are mostly confined to the tropics. Various species have different salinity tolerances and are founnd in different zones in estuaries. They prefer soft clay, silty, waterlogged substrata in the intertidal region (the area experiencing the daily influence of high and low tides).

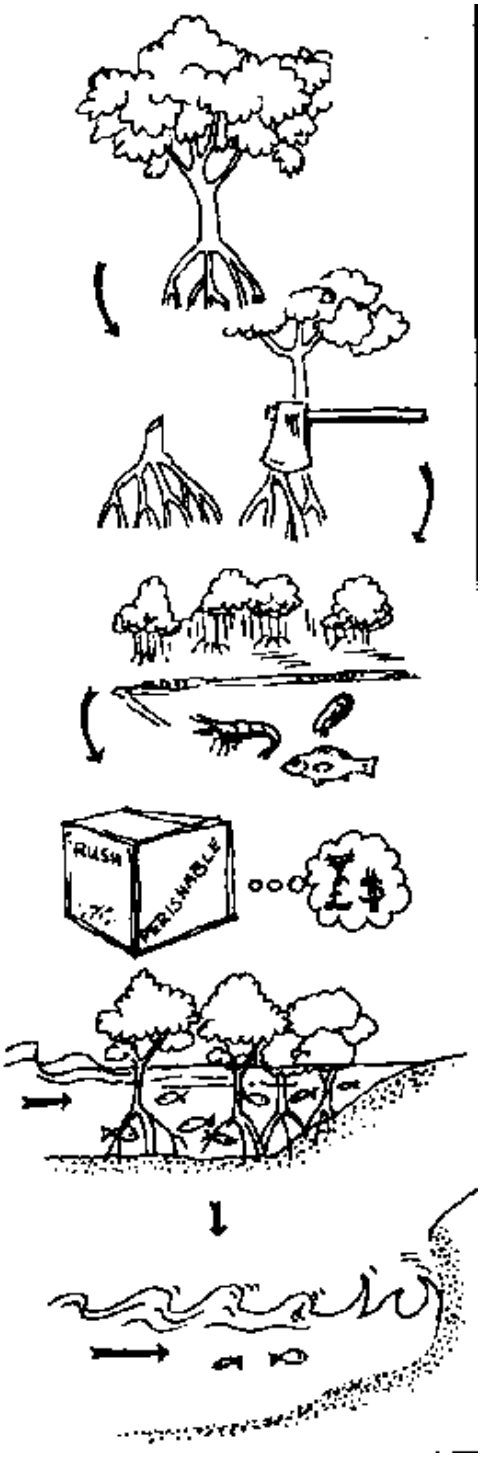


Mangroves

Mangroves have developed various ways of surviving in this challenging environment. They have an unusual root system of prop and knee roots and aerial breathing roots. The seeds germinate while still attached to the mother plant. The leaf surface has glands that exude excess salt.

Ecological and economic value

Mangroves act as a shelter belt to minimize the impact of cyclone winds and waves. The dense roots mean the sedimentation rate in mangrove swamps is very high, helping build up new land, reducing coastal erosion and protecting human habitations.



Ecological and economic value

The food chain of the mangrove ecosystem is mainly detritus-based. Protein-rich detritus is broken down by micro-organisms and provides food for various organisms-fishes, crabs and molluscs.

The abundance of food and suitable habitat in mangrove swamps attract many nearshore and estuarine organisms. The biodiversity of plants and animals is very rich. Mangrove areas are invaluable feeding, breeding and nursery grounds for many economic species of fish and shellfish.

Mangroves have many uses for humans. The trees are widely used for fuel, fibre, tannin, timber, alcohol, paper, charcoal and such byproducts as honey and fodder. Some species have medicinal properties such as anti-fertility and anti-cancer drugs and to treat arthritis. Research on these properties is continuing.

Despite their economic value and provision of environmental services, there is a growing trend to reclaim mangrove areas for fishponds or agriculture.

Causes of degradation

Various abiotic and biotic factors are responsible for the degradation of mangroves. Direct or indirect interference by humans has affected mangroves all along the west coast of India. Deforestation, reclamation and pollution are three major problems.

Deforestation. Firewood collection in mangrove areas is an age=old practice. This causes acute deforestation around metropolitan cities like Bombay. Urban expansion has also cleared large areas.

Reclamation. Mangroves are being reclaimed for agriculture, aquaculture and industrial development.

Pollution. Pollution by toxic and non-toxic effluents from various sources has created a range of complex problems. Raw sewage discharge in these swamps increases the eutrophication rate. This is most severe near big cities.

Mangrove ecosystems are overexploited and misused. Often the short term economic gains from conversion or exploitation result in long term ecological problems.

Environmental impact of degradation

Continuous overexploitation of mangroves along the west coast of India has had several serious negative impacts.

• It has resulted in the degradation or loss of biodiversity in the region.

• Removal of the mangroves and their root systems has increased coastal erosion.

• Fish yields have suffered because of the loss of a vital food source and breeding and nursery grounds.

Conservation

It is necessary to identify the available mangrove areas with good forest cover for conservation. Possible approaches include:

• Identify luxuriant mangrove areas and protect them from exploitation.

• Plant mangroves on currently barren intertidal mudflats.

• Allow degraded mangroves to regenerate.

• Prepare land use plans for coastal and estuarine areas and pass the necessary legislation to conserve mangroves.

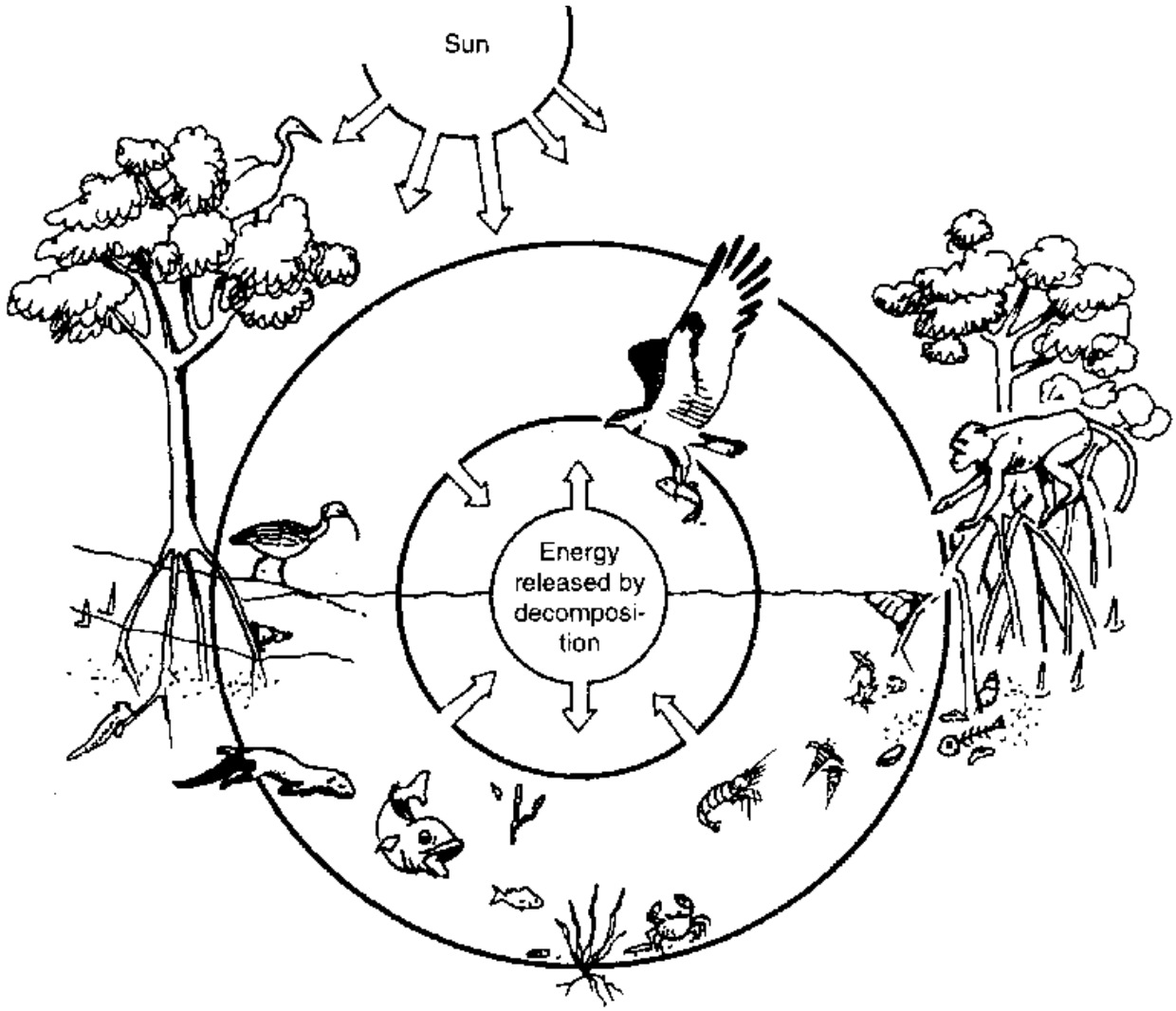
• Create awareness through the media at all levels.

Prepared by Dr. A. G. Untawale

4.3 Mangrove communities

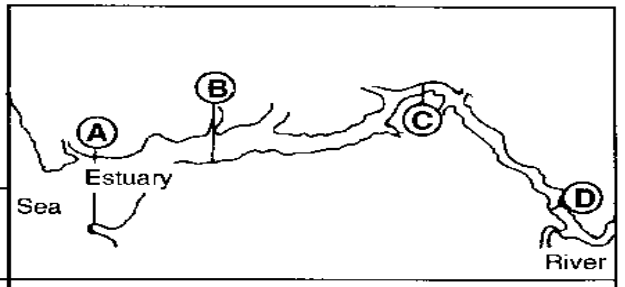
Mangrove ecosystems are forests uniquely adapted to salty water. They produce large quantities of vegetative matter which, in turn, provides food for other organisms. They are located along the shores of estuaries where fresh water meets the sea. Mangrove forests provide food, fuel, timber and medicines either directly or indirectly. However, these renewable, ecologically and economically important habitats have been largely degraded, severely damaging the coastal environment.

India has approximately 315,000 ha of mangrove cover, of which about 65,000 ha occurs along the west coast. Gujarat and Kerala coasts have the most degraded mangroves, while Maharashtra, Goa and Karnataka have occasional luxuriant pockets. Various biotic communities associated with mangroves form a complex food web in these areas.

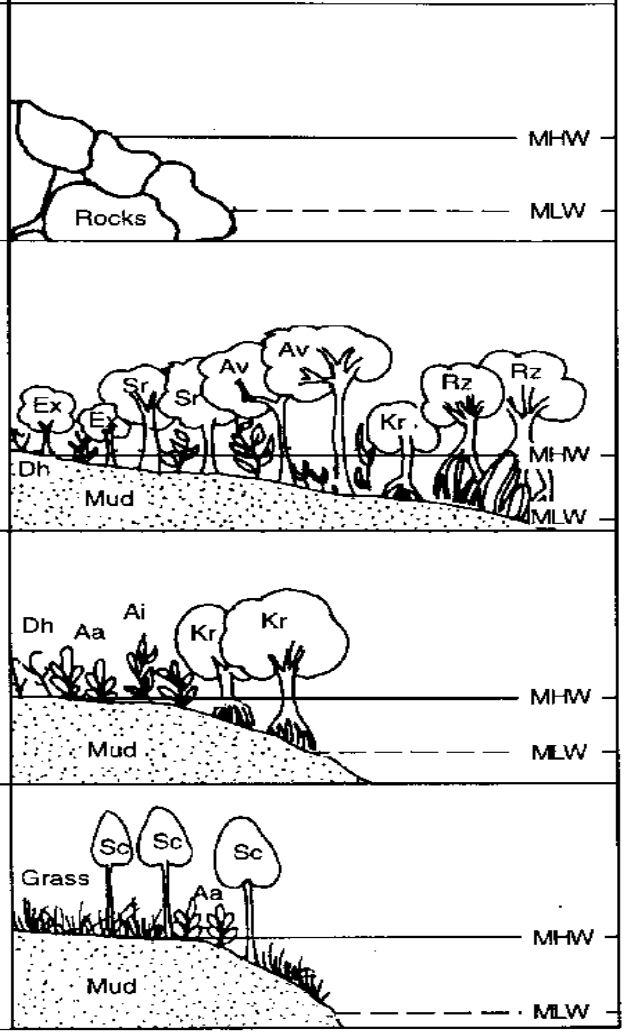


Mangrove communities

Distribution of mangrove species in West Coast estuaries



Salinity (parts per 1000)	Common species	Ecological status
Euhaline (>30) (A)	Mostly no mangroves	
Polyhaline (30-18) (B)	*Rhizophora mucronata* *Kandelia rheedii* *Avicennia* spp. *Sonneratia alba* *Acanthus ilicifolius* *Excoecaria agallocha* *Derris heterophylla* Common grasses: *Potersia coarctata* *Auleropus* sp.	Common Common Dominant Dominant Common Common Common Common Rare
Mesohaline 18-5 (C)	*Avicennia officinalis* *Kandelia rheedii* *Sonneratia alba* *Acanthus ilicifolius* *Excoecaria agallocha* *Derris heterophylla* Common grasses: *Potersia coarctata* *Auleropus* sp.	Dominant Common Common Common Common Common Common Common
Oligohaline 5-0.05 (D)	*Kandelia rheedii* *Sonneratia caseolaris* *Acrostichum aureum* Grass: *Myriostichya waghitana*	Dominant Dominant Common Dominant



Rz	*Rhizophora mucronata*	Kr	*Kandelia sheedii*	Av	*Avicennia* spp.
Sr	*Sonneratia alba*	Sc	*Sonneratia caseolaris*	Ex	*Excoecaria agallocha*
Aa	*Acrostichum aureum*	Dh	*Derris heterophylla*	Ai	*Acanthus ilicifolius*
MHW	Mean high water	MLW	Mean low water		

Distribution of mangrove species in West Coast estuaries

Extent and composition

The distribution and extent of mangroves are influenced by topography, tidal height, substratum and salinity. The west coast of India has a narrow intertidal belt which supports fringing

mangroves. Large areas with many mangrove species occur in the polyhaline and mesohaline zones (salinity 5-30 percent). The oligohaline (salinity 0.05 to 5 percent) zone supports limited species such as Kandelia candal, Sonneratia caseolaris and Acrostichum aureum.

Mangrove flora of west coast is comprised of 22 species belonging to 15 genera. Maharashtra has the most species (19), whereas only 9 species occur along the Gujarat coast. Avicennia alba, A. marina, A. officinalis, Rhizophora mucronata, Sonneratia alba and S. apetala, are dominant. Scrubby vegetation, mainly of A. marina, Salicornia brachiata and Sueda sp. occurs just above the high tide level. The largest area is in Gujarat, with 37,000 ha, but better formations with greater species diversity occur in Goa and Maharashtra.

Biodiversity of Indian mangroves

Taxonomic group	**Number of species**
Flora	
Bacteria	20
Terrestrial	184
fungi	
Manglicolous	
fungi	71
Bryophytes/	35
ferns	
Lichens	2
Algae	48
Seagrasses	2
Mangroves	50
Associated	
mangroves	37
Fauna	

Crustaceans	229
Molluscs	212
Wood borers	25
Fishes	1 85
Reptiles	39
Birds	117
Mammals	36

Associate flora and fauna

Associate flora and fauna are important components of the mangrove ecosystem as they enhance the productivity and recycling in the system.

Floral components

Clerodendron inermae, Hibiscus tiliaceus, Thespesia populnea, Sessuvium portulacastrum, Porteresia coarctata and Myriostichya waghitiana are commonly found in the mangroves. Another 29 species dominated by Aeluropus lagopoides, Cressa cratica, Fimbristylis cymosa and Heliotropium curassavicum are found just inland of the mangroves, elevated above the spring tide mark.

Seagrasses

Seagrasses are often associated with mangroves. Halophila beccarii and H. ovalis, H. ovata and Halodule uninervis occur in the mangrove-influenced regions. Halophila ovalis occurs in sheltered parts (salinity > 30%) of estuaries. H. ovata and Halodule uninervis; have been seen in the vicinity of mangroves in the Gulf of Kutch, Gujarat.

Seaweeds

Marine algae in the mangrove environment are either floating or attached to the sea floor. Very little is known of the marine algae associated with mangrove regions of India. The seasonal occurrence of 48 species of marine algae from the mangrove ecosystems of the central west coast of India has been reported.

Caloglossa lepriurii, Catnella impudica and Enteromorpha clathrata form the characteristic flora and commonly occur throughout the year. Economically important algae such as Monostroma spp and Gracilaria verrucosa grow in mangrove areas with high salinity.

The poor distribution and low diversity of marine algae in mangrove environments could be due to unstable soils and wide fluctuations in salinity, temperature, turbidity and nutrients. The maximum number of marine algae occurs during October to April, when the salinity gradually increases. Microscopic blue-green algae (Cyanophyceae) dominate the mangrove environments during the monsoon (June-September).

Manglicolous fungi

Higher marine fungi play significant role in the formation of mangrove detritus. Seventy-six species of higher fungi have been reported from the mangroves of the west coast.

Microbes

Microbial flora (yeast, bacteria and fungi) play a significant role in the degradation of mangrove litter. Mangrove environments harbour 50 bacterial strains, mostly grampositive. Micrococus, Brevibacterium and Kurthia have been reported as predominant. Other species of bacterial genera such as Lactobacillus, Corynebacterium, Listeria, Bacillus and Clostridium have also been found.

Phytoplankton

Mangrove environments, though fairly high in primary production, have very few phytoplankton species. These include Pleurosigma, Navicula and Nitzchia, followed by Bacillaria, Coscinoidiscus and Cymbella. Other forms like Biddulphia, Diploneis, Mastogloia and Thalassiothrix occur only rarely.

Manglicolous fungi

Ascomycetes

Didymosphaeria enalia Lophiostoma sp. Swampomyces aremeniacus Hypoxylon oceanicus Dactyospora haliotrapa Massarina thalassia Aquialus grandis Acrocordiopsis patilie Lulworthia grandispora Helicascus sp.

Basidiomycetes

Trichocladium archarasporum

Cirennalia pygmea

Deuteromycetes

Periconica prolitica

Floral components of mangrove environs in the west coast

	Characteristics	**No. of species**
Mangroves	65,000 ha	22
Associate	-	37
angiosperms		
Subaerial	-	29
Seagrasses	Small patches seasonal	4
Seaweeds	Seasonal; less diversity	48
Phytoplankton	0-30 mg/m³	
Terrestial fungi	Seasonal	184
Manglicolous	Seasonal	76
fungi		
Microbes	-	50
Lichens	-	2

General status: moderately known

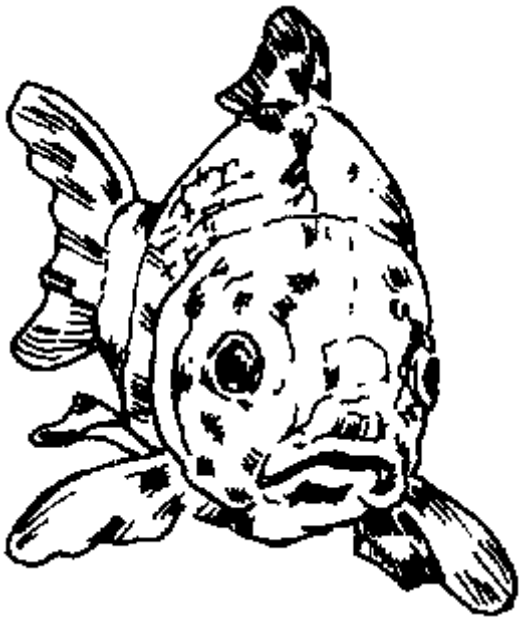
Fauna

Zooplankton

Zooplankton biomass in mangrove waters has been reported in the range of 6-1 13 mg/m³ per day. Crustaceans and copepod species dominate. The annual mean count of copepods ranges from 570 to 1270/m³, and their diversity is low compared- to estuarine and open ocean waters in the west coast.

Benthic macrofauna

111 species of macrofauna have been reported from the mangrove regions of Goal Segmented worms (Polychaetes) and bivalves contribute over 70% of the macrofaunal component by number and weight. Dominant species are Modiolus metcalfel, Mytilus viridis, Diapatra neapolitanea, Meretrix casta, Paphia malabarica, Cerithidea fluviatilis, Diogenes custus and Golycera alba.



Benthic macrofauna

Benthic meiofauna

Meiofaunal density in the mangrove environments have been reported to range from 3538-111.000/m². It is higher during the premonsoon and postmonsoon periods. Nematodes, especially Chromadoidae and Desmodoridae, account for 80% of the density, followed by copepods with 7%. Almost 60% of the meiofauna occur in the top 2 cm layer of sediment.

Wood borers in mangroves

Dictyathiefer manni

Lyrodus pedicellatus

L. masse

Bankia rochi

B. campanellata

B. carinata

Nausitord hedleyi

N. dunlopei

Bactronophorus thoraciles

Martesic striate

M. nairi

Lignopholas chengi

Sphaeroma terebrans

S. annandalci

S. annandalci var

travancorensis

Faunal components of mangrove environs in the west coast

	Characteristics	**No. of species**
Zooplankton	6-113 mg/m³/day	--
Copepods	570-1270/m³	--
Macrobenthos	54.17/m²(wet weight)	111
Meiobenthos	3538-11100/m²	
Wood borers	--	2 6
Fishes	--	105
Shellfishes	--	20
Crustaceans	--	229
Reptiles	--	3
Mammals	--	2
Birds	--	119

General status: poorly known

Wood borers

Biodeterioration of mangrove wood is quite severe along the Indian coast. The destruction is caused by 14 species and one variety of borers belonging to the molluscan and crustacean family.

Fishes, shellfishes and crustaceans

105 species of fish, 20 species of shellfish and 229 species of crustaceans have been reported in mangroves of the west coast. Commercially important species include Meretrix sp., Crassostrea sp., Peneaus sp., Scylla serrata and Mugil cephalic. The commonly cultivated species are Penaeus monodon, P. indicus, Metapenaeus monoceros, Mugil cephalus, M persica, Chanos chanos, Etroplus suratensis, and Lates calarifer.

Wildlife

Crocodylus palustris, Varanus sp., different kinds of monkeys, otters, deers, fishing cats snakes and wild pigs are very commonly found in the mangroves. Common birds are flamingos, herons, storks, sea eagles, kites, kingfishers, sandpipers, fits, bulbuls and whistlers. About 119 species of birds have been recorded from the mangrove regions of the Gulf of Kutch.

Crocodylus palustris

Threats

Rising population, urbanization and industrialization put continuous, intensive pressure on coastal regions. As a result, the mangrove habitats have suffered a reduction in the biota or total loss of some species. The degradation of coastal ecosystems is resulting in severe ecological

imbalance in the coastal environments. The conservation and management of mangrove resources is needed immediately to mitigate the further deterioration of coastal environments.

Though mangrove ecosystems are poor in biodiversity, they have a characteristic biota of significant ecological and socioeconomic importance. During the last three decades, almost 40% of the mangrove area along the west coast has been "reclaimed", mainly for agriculture and urbanization. Thoughtful conservation and management of the mangrove environment for sustainable development could prevent further deterioration.

Prepared by T. G. Jagtap

The physical environment

The tidal amplitude along the west coast of India ranges from 0 to 11.5 m. The air temperature ranges from 11° to 39.6°C. Rainfall varies from 600 too 3000 mm a year, falling mainly in May to August. Humidity varies from 71 to 89%. In general, the climate remains relatively dry along the Gujarat coast, but is warm and humid along the other coastal states to the south. The west coast is characterized by steep slopes, rises, and drowned estuaries. The Gulf of Kutch to some extent represents a deltaic environment to a little extent. The west coast plain is very narrow and has alluvial soils.

4.4 Wetlands

Wetlands are unique transient ecosystems, falling between true aquatic systems on one hand and terrestrial systems on the other. The water table is usually at or near surface, or the land is covered by shallow water. About 6% of the total surface area of the world is covered by wetlands.

With almost twice the productivity of tropical rain forests, wetlands are among the earth's most productive ecosystems.

Value

Wetlands have immense value from ecological, economic, biological and aesthetic viewpoints.

• They support extensive freshwater and marine fisheries.

• They are natural sewage treatment plants. An 8-ha marsh or pond can clean 4.54 million litres of raw sewage every day.

• Wetland plants like water hyacinth act as pollution filters for some heavy metals.

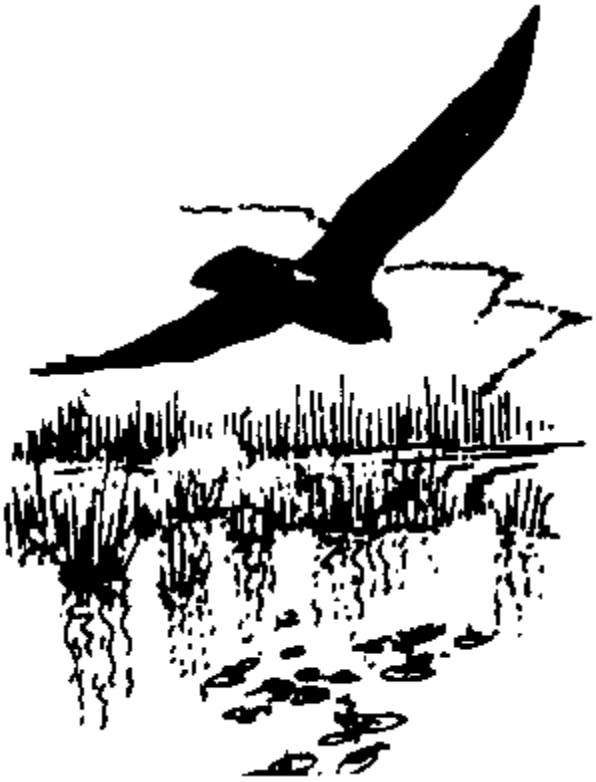
• Wetlands serve as the breeding and feeding sites for resident and migrating water birds.

• Wetlands act as an efficient buffer against natural calamities in floodor cyclone-prone areas. In estuaries, mangrove forests shield the coast against storms.

• Wetlands help maintain the water table by recharging ground water.

Wetlands and birds

Many species of birds use wetlands for breeding, feeding and roosting. In India, 26.5 percent of the total 1200 species are found in wetlands (this figure includes migratory winter visitors). Because many birds occupy higher trophic levels in the food chain, they can be considered as biological indicators of a healthy wetland.



Wetlands and birds

Threats

Cattle grazing

Though large-scale grazing has detrimental effects on wetlands, natural grazing by stray cattle is not a threat. Stray cattle are an integral part of the ecosystem; as they graze, they loosen the soil, allow vegetation to be recycled, add to fertility through their dung, and open passages for free-swimming water fowl.

Wetland types

Wetlands are basically of two types-natural and man-made. Natural wetlands can be formed in many ways: a landslide blocks a mountain valley, dissolved limestone rock forms depressions, shifting sand in arid areas forms a hollow, or a meandering river leaves behind an oxbow lake. People also make wetlands, for instance irrigation canals, reservoirs and irrigated fields.

Siltation

The silt brought in by surface runoff during torrential tropical rains is a natural phenomenon. Siltation helps transform wetlands into land, and forms shallow wetlands from deeper water. But excessive siltation due to excessive soil erosion, opencast mining and other activities is of serious concern.

Fishing and aquaculture

Many wetlands are rich fisheries. But large-scale, indiscriminate fishing will affect wildlife, especially fish-eaters such as kingfishers, cormorants and oyster catchers. Aquaculture may be commercially profitable but can upset the chemical balance in the wetland, natural gene pools and biodiversity.

Large irrigation and hydroelectricity projects

Large dams across rivers form deep reservoirs and destroy shallow wetlands.

Pollution

Indiscriminate use of pesticides and chemical fertilizers pollutes wetlands. Industrial and domestic effluents add to the load. Though wetlands are natural purifiers, they cannot withstand excessive pollution. Pollutants may also get into the food web. Petroleum products interfere with the reproductive process of water fowl, reducing the eggshell thickness and hatchability.

Reclamation

Rising demand for land for housing, industries and agriculture is having its toll on wetlands-especially near urban areas. In addition, wetlands are often used as municipal garbage dumps.

Remedial measures

• Phase out the indiscriminate use of pesticides and chemical fertilizers.

• Ban release of raw sewage.

• Implement afforestation programmes that are effective rather than cosmetic. Successful afforestation would minimize siltation.

• Control the reclamation of wetlands.

Waterfowl

Defining waterfowl is as difficult as defining the wetland itself. Like other birds, wetland birds can be:

• Residents

• Local migrants, or

• Long distance migrants

Waterfowl

These birds are also classified as:

• Completely dependent on wetlands

• Less dependent, or

• Opportunistic users.

Asian mid-winter waterfowl census

An annual census of waterfowl is conducted under the auspices of the Asian Wetland Research Bureau and the International Waterfowl and Wetland Research Bureau. The census aims to:

• Collect data on waterfowl at individual sites and flyways to facilitate conservation of waterfowls and wetlands.

• Monitor threats to waterfowl populations so solutions can be foound before the species and their habitats are irreversibly affected.

• Enhance awareness on the utility of waterfowl and wetlands to promote their conservation.

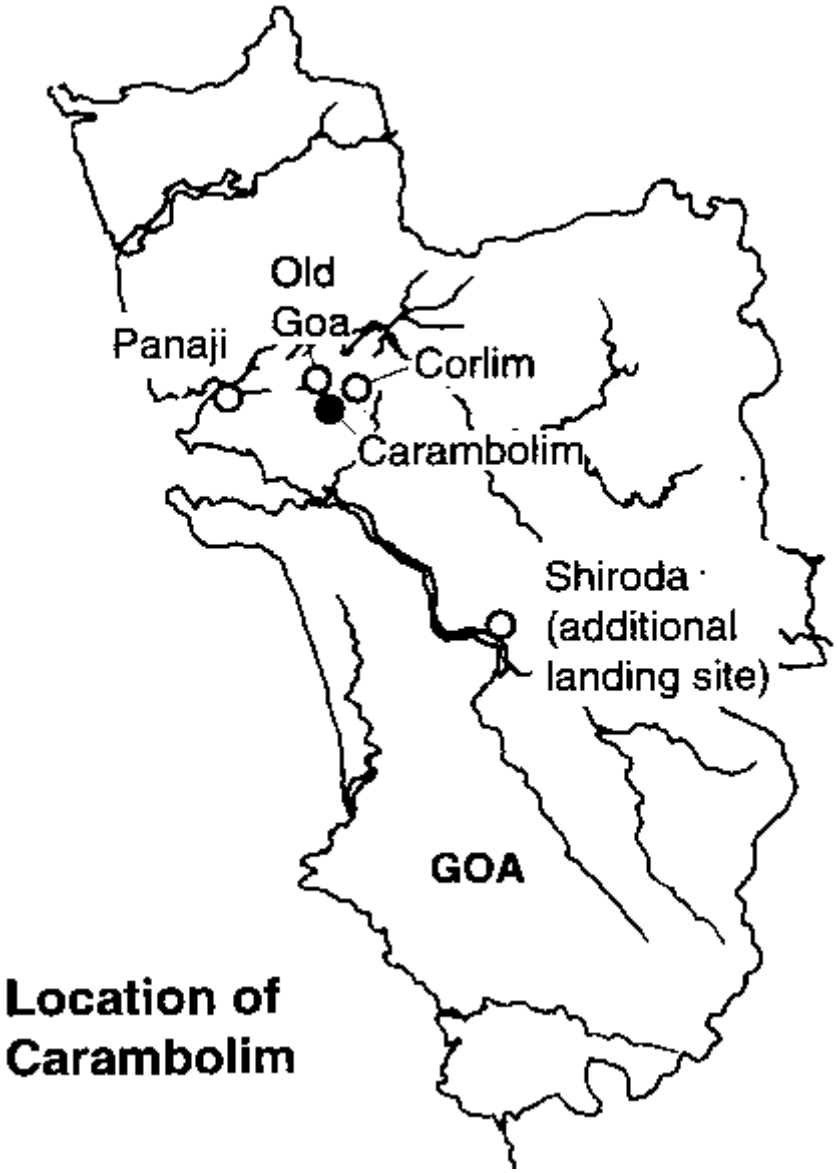
Prepared by Dr. A. B. Shanbhag and Ajay Gramopadhye

4.5 Freshwater wetlands: Carambolim Lake

Carambolim Lake is a man-made wetland covering about 70 hectares in the coastal area of central Goal

The wetland is flooded for about five months from October to March. The water level is raised to about 2m by closing a sluice-gate, enabling farmers to grow rabi (dry season) rice on the low-lying land around the wetland. In January, the water reaches its maximum depth. In April, the sluice is opened and the water drains out to the rice fields and eventually to the sea.

Surrounding land use changes are affecting the lake, especially its depth.



Location of Carambolim

Birds

Between November and March, around 15,000 birds can be seen in Carambolim. The best time to see them is in the early morning or early evening.

The birds feed on algae, grasses, insects, crustaceans, molluscs, and fish. It is this rich food source that attracts both local and migratory species. Egrets are commonly seen foraging for insects in the neighbouring fields while the rice is being transplanted.

About 120 species of birds are known to use the wetland during the year. Half of these are migratory, including around 30 winter visitors from as far away as NE Siberia and the Caspian Sea. Mallard and wigeon, normally found only in Northern India, have been sighted in Carambolim.

The rich bird life also attracts an increasing number of human visitors. Bird watchers and nature lovers, including foreign tourists, visit the wetland.

Other uses of Carambolim

Tourism: must be carefully controlled so that it does not harm the ecosystem.

Education: field visits by students.

Research: Research is needed on why there are no mosquitoes in the wetland, and on the role of Carambolim as a habitat for beneficial insects for the surrounding rice fields.

World travellers

Studies by the Bombay Natural History Society show that some migratory birds travel great distances between their breeding grounds and wintering sites

Distances (in a straight line) travelled by some migratory birds seen in Carambolim:

	km
Shoveller	5500
Spotted sandpiper	5200
Pintail	5000
Glossy ibis	4600
White wagtail	4200

Garganey	3500
Gadwall	3400
Common teal	3300
Marsh sandpiper	3200
Mallard	2500

Some ideas for conserving birds

• Enforce existing measures against hunting.

• Conduct awareness programmes for local people on the importance of the wetland ecosystem.

• Publish a booklet on the wetland.

• Arrange field trips for nature clubs, bird watchers, journalists, students and tourists.

• Erect signs telling the public not to harm the birds.

• Start nature clubs in schools around the wetland.

• Require trains to reduce speed near the wetland.

• Culture fish at appropriate times of the year to attract birds.

• Control erosion of the railway embankment.

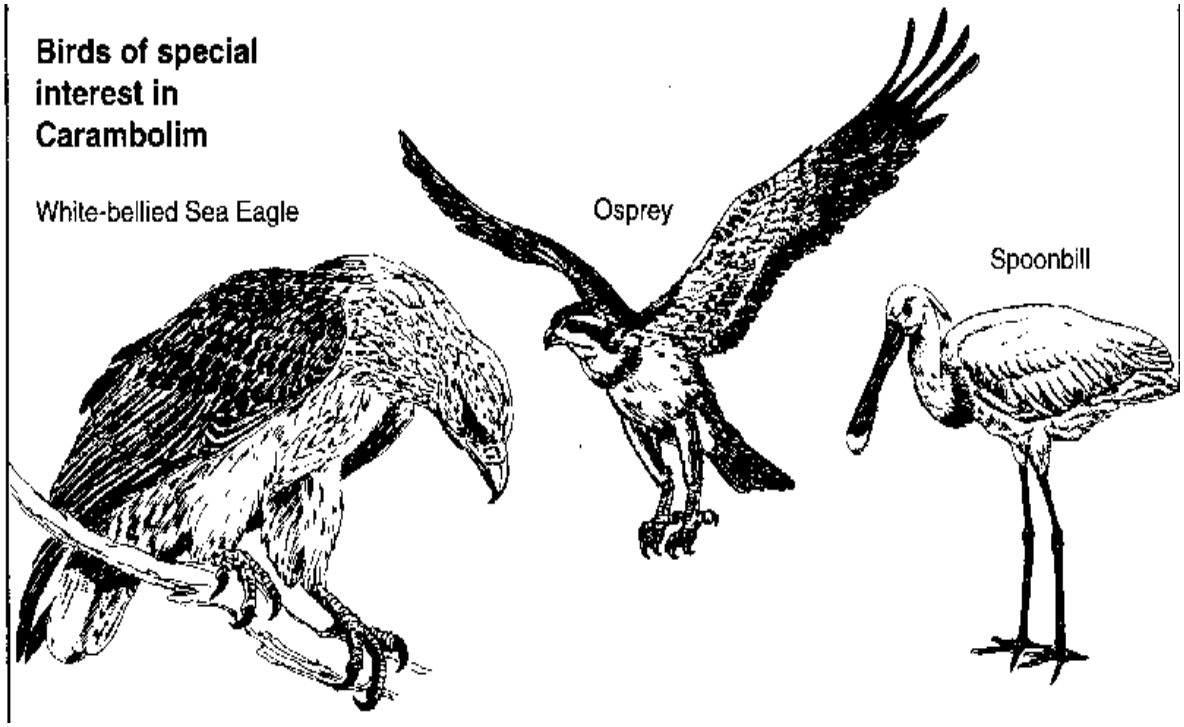
• Plant trees of different heights along the track to absorb train noise.

• Erect a few barren trees around the wetland edges as roosts for cormorants, storks and eagles. The one-third reduction in the wetland area due to the railway can be partly compensated for by increasing the roosting sites.

• Ring migrating ducks to determine the role Carambolim plays on migration routes.

• Track the feeding, roosting and nesting grounds of birds outside Carambolim.

Some ideas for conserving birds



Birds of special interest in Carambolim

Birds seen in Carambolim

Lesser Adjutant

Avocet

Crimsonthroated Barbet

Large Green Barbet

Small Green Barbet

Baya

Bluetailed Bee-eater

Small Green Bee-eater

Bittern

Redwhiskered Bulbul

Redvented Bulbul

Whitebrowed Bulbul

Crested Honey Buzzard

Coot

Little Cormorant

House Crow

Jungle Crow

Crow-Pheasant

Curlew

Large Darter or Snake Bird

Indian Spotted Dove

Black Drongo

Comb Duck

Spotbill Duck

Greater Spotted Eagle

Steppe Eagle

Tawny Eagle

Whitebellied Sea Eagle

Cattle Egret

Large Egret

Little Egret

Median or Small Egret

Gadwall

Garganey

Little Grebe or Dabchick

Blackheaded Gull

Marsh Harrier

Montagis Harrier

Grey Heron

Night Heron

Pond Heron

Purple Heron

Reef Heron

Hoopoe

Glossy Ibis

White Ibis

Bronzewinged JaÃ§ana

Pheasant-tailed JaÃ§ana

Blackcapped Kingfisher.

Lesser Pied Kingfisher

Small Blue Kingfisher

Storkbilled Kingfisher

Whitebreasted Kingfisher

Blackwinged Kite

Brahminy Kite

Pariah Kite

Indian Koel

Redwattled Lapwing

Indian Lorikeet

Mallard

Scarlet Minivet

Small Minivet

Indian Moorhen

Purple Moorhen

Blackheaded Munia

Whitebacked Munia

Common Myna

Jungle Myna

Golden Oriole

Osprey

Blossomheaded Parakeet

Roseringed Parakeet

Blue Rock Pigeon

Pintail

Tawny Pipit

Golden Plover

Kentish Plover

Little Ring Plover

Magpie-Robin

Indian Robin

Indian Roller

Common Sandpiper

Marsh Sandpiper

Spotted Sandpiper

Ruddy Shelduck

Shoveller

Indian Baybacked Shrike

Rufousbacked Shrike

Indian Skimmer or Scissorbill

Common or Fantail

Snipe

Jack Snipe

House Sparrow

Yellowthroated Sparrow

Spoonbill

Blackwinged Stilt

Little Stilt

Openbilled Stork

Painted Stork

Whitenecked Stork

Loten's Sunbird

Purple Sunbird

Wiretailed Swallow

Swift

Common Teal

Cotton Teal

Lesser Whistling Teal

Gullbilled Tern

Indian River Tern

Whiskered Tern

Grey Wagtail

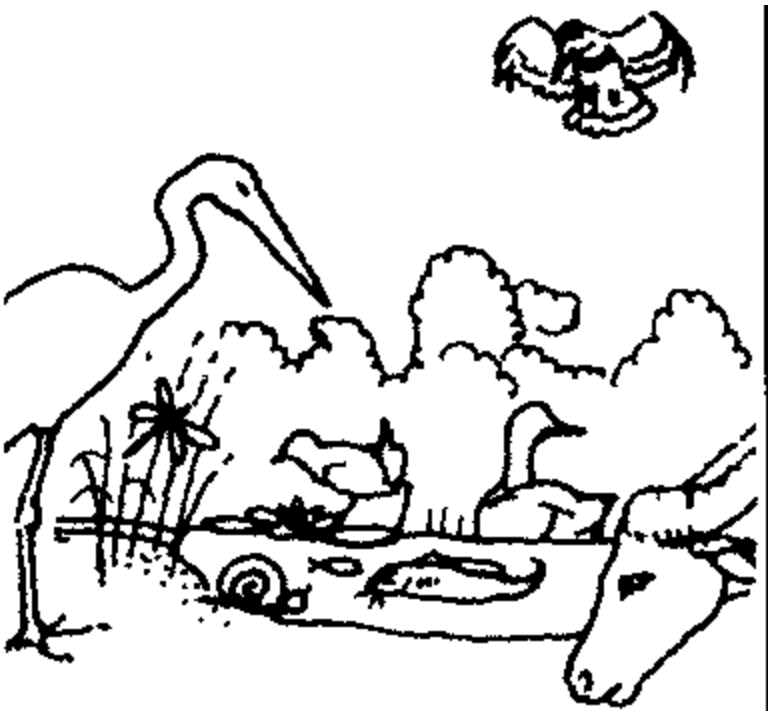
White Wagtail

Large Pied Wagtail

Blyth's Reed Warbler

Watercock

Wigeon



Birds seen in Carambolim

Fish and crustaceans

Carambolim has six species of freshwater fish and various species of crabs and shrimps.

In April, an auction is held and the fish are harvested and sold. The auction coincides with the departure of the birds. People thus harvest only what the birds leave behind-the human population has adapted to the needs of the birds.

The number of fish caught is declining apparently because Carambolim is attracting more and more birds-perhaps because other overwintering sites are being degraded.

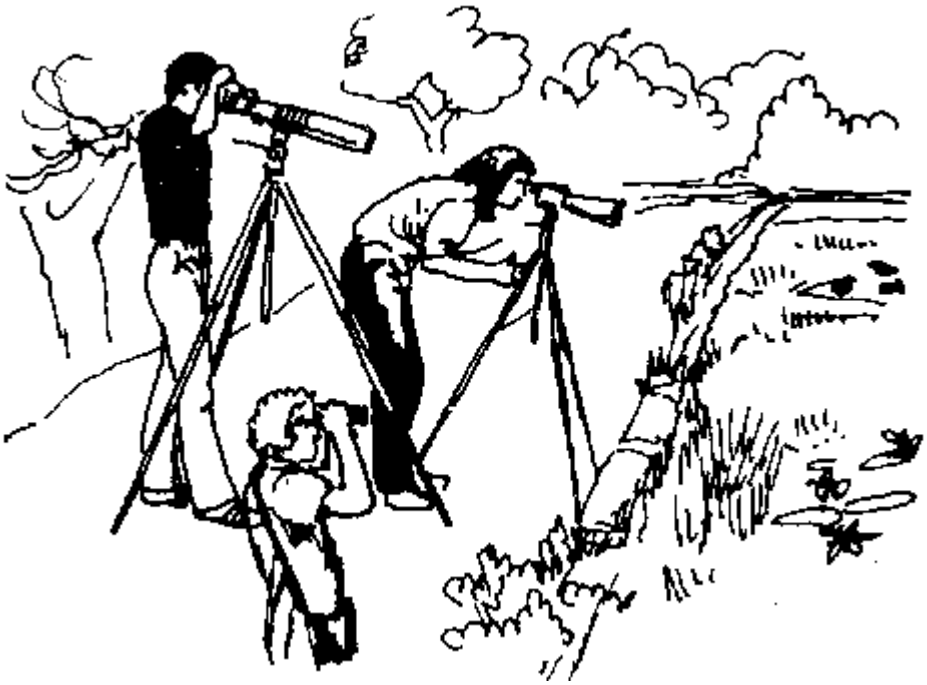
Reptiles

In the past, Carambolim was home to crocodiles. The Cumbarjua Canal and Banastari, where muggers (marsh crocodiles) still live, are within 5 km of the wetland. A mugger was seen in the wetland in 1991. Snakes such as the Checkered Keelback, Ratsnake and Dog-faced Snake have also been spotted in and around the wetland.

Insects

Carambolim abounds in insects, including ladybirds, butterflies and moths, cicadas, flies, beetles, dragonflies and many other insect species and spiders. Many parasites live on these insects, such as parasitic Trichogramma wasps. Coccinellids hibernate around the wetland, ready to move to nearby rice fields to prey on insect pests in the rabi season.

Researchers have found no mosquito eggs or larvae in the wetland-maybe because Chara algae thrive in the water.



Researchers observation

The wetland and its immediate surroundings are a very stable ecosystem, where the predator and prey populations are held in a balance during the winter months.

Flora

Wild varieties of rice grow in and around the wetland; 25 varieties have so far been identified. They are a valuable potential resource for plant breeders.

Many of the algae and other plants help break down pesticides.

The wetland is a permanent source of water for a large area of rabi rice. This is one of the best rice-producing areas in Goal

The Konkan railway

The Konkan railway was originally designed to pass through the middle of the wetland. But pressure from environmentalists groups succeeded in changing the route to along one side of the wetland. The Konkan P airway Corporation has undertaken to monitor how the railway activities affect the wetland's ecosystem.

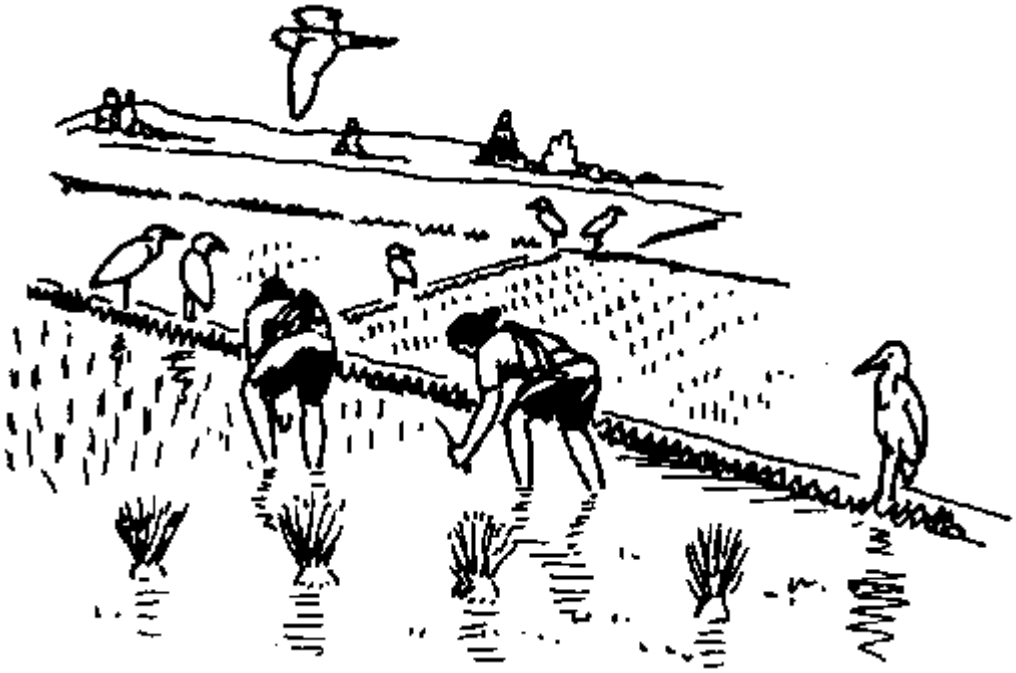
Impact of degradation on birds

• Some migratory and residential species may be disturbed.

• The total population of birds will decline.

• The tracks pass through the western part of the wetland where Storks feed. These birds may have to adapt to some other feeding ground.

• Erosion from the railway embankment into the wetland will disturb the food chain and lead to further shallowing of the lake.



A stable ecosystem

Threats to wetlands

Like other wetlands, Carambolim is threatened by several factors.

Encroachment

Rising numbers of people living in and around wetlands encroach on these areas. Vast areas have been drained for agriculture and buildings.

Poaching

People in villages around Carambolim are aware of the need to conserve the wetland wildlife, although hunting of wild ducks still takes place.

Siltation

Deforestation causes erosion, washing soil down rivers and into wetlands. The silt overwhelms the fragile ecosystem, making the wetland shallower and smaller.

Weeds

Weeds can choke wetlands, covering the open water surface and making the area less attractive for birds.

Pollution

Sewage, solid waste, industrial effluents, fertilizers and excessive use of pesticides increase the total level of nutrients in the water, leading to algal blooms. When the algae die, they decompose. This decomposition process uses up oxygen in the water, killing fish.

Aquaculture

Many wetlands have been converted into aquaculture ponds for prawns and fish.

Symptoms of strain on wetlands

• Lower biological diversity, particularly endangering endemic and endangered species.

• Poorer water quality.

• Sedimentation and shrinkage in size.

• Fewer migratory birds; fewer fish and other animals.

• Prolific growth of obnoxious aquatic weeds.

For more information, see Dilip K. Biswas and C.

L. Trisal. Initiatives for conservation of wetlands of

in India. Ministry of Environment and Forests:

Prepared by V. Gowthaman and Dr J. B. Sardessa.

4.6 Freshwater algae

Like all plants, algae contain chlorophyll. Unlike plants, however, they have no roots, stems or leaves. They range in size from 0.5 microns to huge seaweeds. Algae can be found in many conditions worldwide. As many as 450 species have been recorded.

Algae as food

Algae are efficient photosynthetic "machines" which convert solar energy into biomass. In fact, it has been suggested that some algae be used as a new weapon to fight worldwide protein shortages. Algae can produce 55-110 tonnes of dry matter/hectare/year, of which up to 50% is protein. The blue-green algae Spirulina has received much attention from nutrition researchers. Chlorotea, a green algae, has been proposed as an organism that could absorb CO_2 and regenerate oxygen in space stations.

Treating sewage

Algae are important in treating sewage. They help in oxygenating waste water and reduce the number of fecal coliform bacteria in the water by 99%. The algal biomass produced from treating sewage contains toxic substances but can be used to make biogas.

Blue-green algae

Blue-green algae, or cyanophyceae, are highly adaptive and can colonize even polluted water. This means they can be used as an "indicator species": large numbers of blue-green algae show that water is polluted. Some rivers in Goa contain large quantities of iron because of mining. This encourages the growth of blue-green algae.

Monitoring water quality

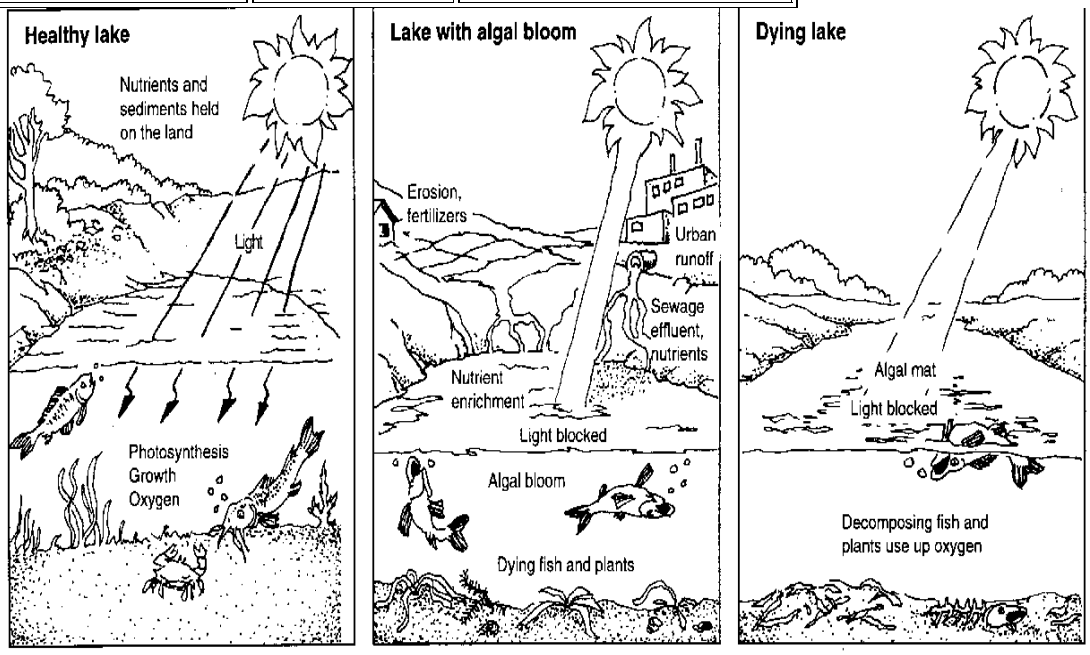
Nature clubs, schools and non-government organizations can help monitor rivers and lakes for dangerous levels of pollution. They can do this by regularly measuring the water pH, CO_2 content, oxygen content and hardness. They should also watch for algal blooms. Any unusual changes should be reported to the local pollution control board. These groups can also mobilize public support ro prevent pollution.

Toxic algae

Many algae are toxic to animals and humans.

Algae	**Species affected**	**Disease/symptoms**

Anabaena, Microcystis, Aphanizomenon, Coelosphaerium, Rivularia	Sheep, cattle, dogs, gulls	Weakness, jaundice, diarrhoea, convulsion
Oscillatoria intestini	Humans	Dyspepsia
Anabaena	Humans	Gastro-intestinal disorders
Microcystis	Humans	Crampy stomach pains, nausea, vomiting
Aphanizomenon	Humans	Abdominal pain, nausea, vomiting, diarrhoea



Nutrients and sediments held on the land. Low level of nutrients in the water, limiting the growth of algae. → Nutrient enrichment due to erosion, sewage effluents and fertilizers stimulates the growth of algae (algal bloom). This shades out the submerged aquatic vegetation, depriving fish and shellfish of habitat, food and dissolved oxygen. → Algae die and decompose, using up all dissolved oxygen in water. Fish and shellfish die from lack of oxygen. → Removal of algal mass. Re-introduction of fish and plants. → Normalcy restored. → Nutrients and sediments held on the land.

Prepared by K.G. Hiremath

Monitoring water quality

5. Agriculture

5.1 Rice diversity and conservation in the Konkan

The spread of high-yielding varieties means that in 15 years just 10 varieties may cover as much as 75% of the total rice area. The country's rich genetic diversity in rice is being destroyed.

Some 50,000 rice varieties are grown in India. This is a very rich source of genetic variety, of great value for plant breeding.

But government officials and industry have promoted only a very few "modern" rice varieties. The spread of high-yielding varieties means that in 15 years just 10 varieties may cover as much as 75% of the total rice area. The country's rich genetic diversity in rice is being destroyed.

This diversity is a result of centuries of selection by farmers, adaptation to various environments, breeding with wild relatives and local varieties, and the evolutionary process over centuries.

In the Konkan region of Maharashtra, hundreds of indigenous cultivars were cultivated. The sophistication and stability of rice farming can be judged from the fact that even the smallest tribal farmer, with a land holding of less than a hectare, had six to eight varieties of traditional seeds suited to local microclimates and soils.

But farmers are replacing these hundreds of cultivars with just six or seven high-yielding varieties. This is reducing the genetic background of rice varieties over wide areas in the Konkan. This genetic erosion poses a danger to the long term food security of the region.

Conservation

Now efforts are on to conserve these valuable rice varieties. ADS, the Academy of Development Sciences in Karjat is painstakingly collecting samples of rice varieties which have been grown in this country over generations.

While many of the old varieties have disappeared, many still survive. Some "orthodox" and "stubborn" farmers still stick to planting traditional varieties of paddy, Around 300-400 traditional varieties of rice are currently grown in the Konkan, according to an ADS study.

ADS has a three-acre field gene bank and seeks to encourage the use of traditional seeds by farmers. ADS workers meet farmers and seek their help to identify farmers who still have traditional rice-varieties in their fields. They ask for a few panicles of the rice, which are then taken back and replicated at ADS. They can then be once again promoted among farmers for cultivation.

A rice field

Amazing diversity

Rice has amazing diversity. In colour alone, the grain varies from white to red, brown and black. This diversity is a result of selection by farmers. adaptation to various environments, breeding with wild relatives and local varieties, and the evolutionary process over centuries. Rice of different types can be differentiated one from another on the basis of various characters.

For instance, there is the yield and duration of the crop. Rice varieties also vary in terms of their ability to withstand excess or shortage of water, their ability to grow in acid, alkaline or saline conditions, and their resistance to pests and diseases.

Rice varieties also differ from one another in terms of habitat; plant height; leaf shape, size and colour; ligule and auricle; grain shape, size and colour; features of the panicle; sterile/ fertile lemma; and the awn.

Dangers of uniformity

Going in for genetic uniformity is fraught with dangers, warns ADS.

Industrial monocultural agriculture and its high-yielding varieties favour genetic uniformity. Vast areas are planted to a single variety, requiring expensive inputs such as irrigation, chemical fertilizers and pesticides to maximize production. In the process, not only traditional crop varieties, but long-established farming ecosystems are obliterated.

Genetic uniformity invites disaster because it makes a crop vulnerable to attack. A pest or disease that strikes one plant can spread quickly throughout the crop. In some regions, the risk is considerable: Some 62% of the rice varieties in Bangladesh, 74% in Indonesia and 75% in Sri Lanka are derived from one maternal plant.

Farming the Konkan

Agriculture in the Konkan-the narrow strip of land along the Bombay-Goa belt-is mainly rainfed. Lands in the Maharashtra part of this region are divided into Garva lands (with good water), Neem-Garva lands (with medium water holdings), and Halva lands (with poor soil).

Indigenous vs modern rices

Modern rice varieties have high yields, but they lose to indigenous varieties when it comes to other characteristics.

	Indigenous varieties	**Modern varieties**
Ability to withstand water stress	+ +	-
Ability to withstand adverse soil conditions	+ +	-
Resistance to pests and disease	+ +	+/-
Conservation of gene banks	+ +	-
Cost of inputs	+	+ + +

Genetic uniformity invites disaster because it makes a crop vulnerable to attack.

5.2 Conservation of traditional vegetables in the backyard

You can make a big contribution to conserving the biodiversity of vegetables in the Western Ghats region in Goal

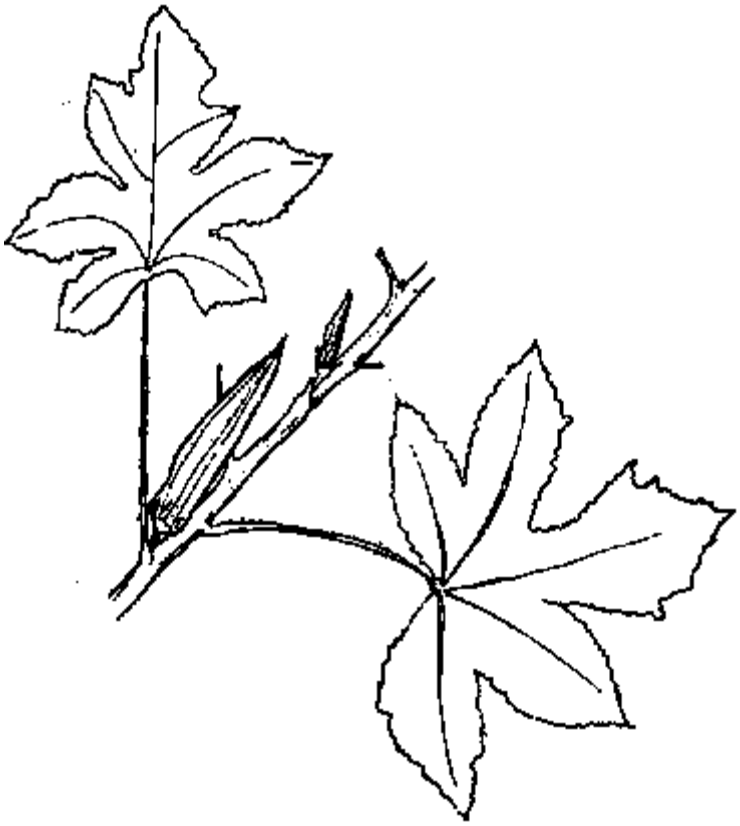
• Grow traditional vegetables in your backyard in your spare time.

• Conserve these plants to assure their survival for generations to come.

• Grow them using organic techniques so as not to alter the original characteristics of the variety.

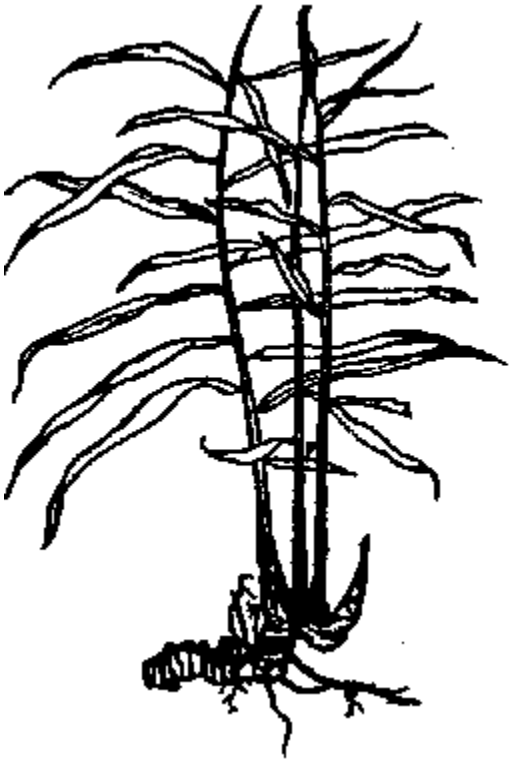
This list is not exhaustive.

Start conserving biodiversity. Your backyard is your first environment!

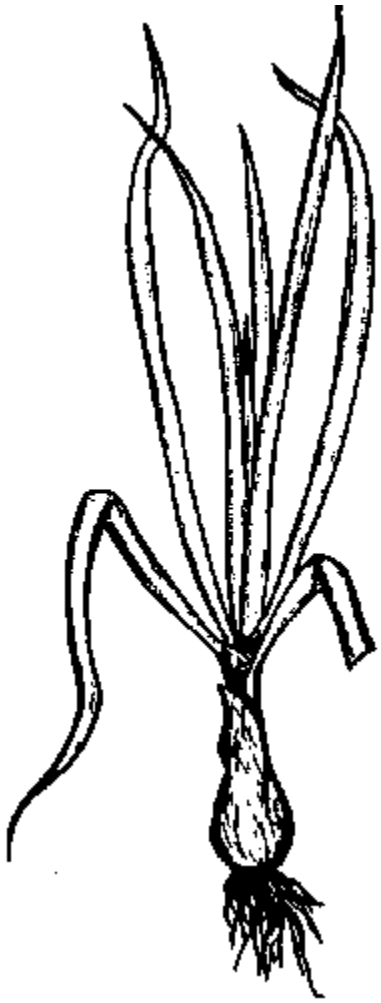


Okra, Ladies' finger (Hibiscus esculentus)

Sweet potato (Ipomeea batatas)



Ginger (Zingiber officinalis)



Onion (Allium cepa)

Traditional vegetables in Goa

Local/Common name	**Scientific name**	**Part used as vegetables**	**Additional uses and features**	**Ecological Status**
Tambdi bhaji	Amaranthus gangeticus	Entire plant	Rich in iron, cellulose, fibre	Declining
Shepu, Dill	Anethum sowa	Entire plant	Treats stomach ailments	Declining
Konkan dhudi,	Lagenaria	Fruit	Large size and soft	Common

Bottle gourd	vulgaris		texture medicinal value	
Vaingan, Brinjal, Eggplant	Solanum melongena	Fruit	Round purple (annual)	Common
			Long green (perennial)	Very rare
			Long greenish purple (perennial)	Common
Padwal, Snake gourd, Podollim	Tricosanthes anguina	Fruit	Agshi variety (1m long, 8cm across)	Getting rare
			Common variety(75cm long, 4-5cm across)	Common
Gonsallim, Ridge gourd, Angled loofah	Luffa acutangula	Fuit	Large and long	Very common
Mullo, Radish	Raphanus sativus	Entire plant	Taleigao variety of medicinal value	Seed not available, variety conserved by certain growers
Moshing, Drumstick, Horse-	Moringa oleifera, radish tree	Fruit, leaves flowers	Rich in iron	Common
Cucumber	Cucumis sativus	Fruit	Long variety (usually eatern when mature)	Declining
			Smaller variety(eaternwhen tender)	Common
Tendli, Gerkin	Coccinia indica	Fruit	Small variety	Not very common

			Large variety	Grown for market
Red sorrel, Roselle	Hibiscus sabdariffa			
Okra, Bhendi, Lady's finger	Hibiscus esculentus	Fruit	Satpani (large) early fruiting	Seed not easily available
			Small	Common
Chilli, Mirsang	Capsicum annuum	Fruit	Canacona variety(kholchi)	More common in south Goa
			Aidona variety(sweetish)	Endangered
Portugali mirsang, Chilli	Capsicum frutescens	Fruit	Very tiny, used for papads and pickles(very pungent)	Declining
Red pumpkin	Cucurbita maxima	Fruit, leaves, flower	Large and long (oval shaped) Round (of medicinal value)	Endangered Common
Ash gourd, Wax gourd, Kunvallo	Benincasa hispida	Fruit	Used for sweets	Endangered
Karela, Bitter gourd	Momordica charantia	Fruit	Large (Ponda variety)	Seed not available to others, conserved by grower
			Small	Common
Golchi bhaji, Parslane	Portulaca oleracea	Entire plant	Medicine for diabetes	Endangered
Valchi bhaji/Climbing spinach	Basella alba	Leaves, tender shoots	Rich in iron, vitamin A	Very common

Tirphal	Zanthoxylum shetsa	Fruit	Used as a spice	Endangered
Bilimbi	Averrhoa bilimbi	Fruit	As a souring agent	Common
Matti Gonsallim, sponge gourd	Luffa cylindrica	Fruit	Fibre used as sponge/scrubber	Rare
Suran, elephant yam	Amorphophallus campanulatus	Tuber	Not to be mistaken in edible variety	Rare
Zad conong		Tuber, bulbil	Smooth skin, small size	Rare
Tero, Arum	Colocasia esculenta	Leaves	Green variety	Declining
Kokum/Bindam	Garcinia indica	Fruit	Of medicinal value, Used as a souring agent	Endangered
Haldi/Turmeric	Curcuma longa	Rhizome, leaves	Used as a spice, of medicinal value, leaves used for their flavour	Very common
Alem/Ginger	Zingiber officinale	Rhizome	Of medicinal value, used as a spice	Common
Onion/Piao	Allium cepa	Bulb	As a seasoning agent, of medicinal value	Local variety endangered
Pepper/Miriam	Piper nigrum	Berry	Used as spice, of medicinal value	Local variety high yielding endangered
Vir-vir	Vigna cylindrica	Pod, seed	Of medicinal value	Very common
Alsando, Lentil	Lens esculenta	Pod, seed, leave	Nutritive	Declining

Chovili	Vigna unguiculata	Seed	White+ brown	Endangered
Moog, Mung, Green gram	Phaseolus aureus	Seed	Nutritive value	Local variety extinct
Anvre, Hyacinth bean	Dolichos lablab	Seed	Large variety	Common
			Small	Declining
Merulle	Phaseolus sp.	Seed	Resembles white pepper	Endangered
Bamboo, Kill	Bambusa bambos	tender shoots	Maroon shoots	Endangered
Nachni, Finger millet	Eleusine coracana	cereal	Rich in iron, of medicinal value	Endangered
Kudukki Bhaji	Amaranthus spinosa	Leaves	Rich in iron	Endangered
Madi	Alocasia	Rhizome, leaves	Rich in protein	Endangered
Kata konong,	Dioscora esculenta	Tuber	Nutritive value	Endangered
Potato yam				
Karando	Dioscora esculenta	Tuber	Nutritive value	Endangered
Sweet potato	Ipomoea batatas	Tuber	Food value	Common
Nir ponos, Bread fruit	Artocarpus incisa	Fruit	Nutritive value	Common
Taikulo, Foetid Cassia	Cassia tore	Entire tender plant or leaves	Rich in iron	Common, hardly used
Tidki/Cluster beans, Gawar	Cyamopsis tetragonoloba	Pod	High fibre content	Common

Chinni		Tuber, bulbil	Nutritive value (pinkish white variety)	Endangered
Kiraitem, Chirata	Swertia chirata	Entire plant	As a dewormer, for treating diabetes, malaria	Common
Carambola	Caramida	Fruit	As a souring agent	Rare
Sword bean, coto vad	Canavalia ensiformis	Pod	Long and broad	Rare

Prepared by Francis Borges

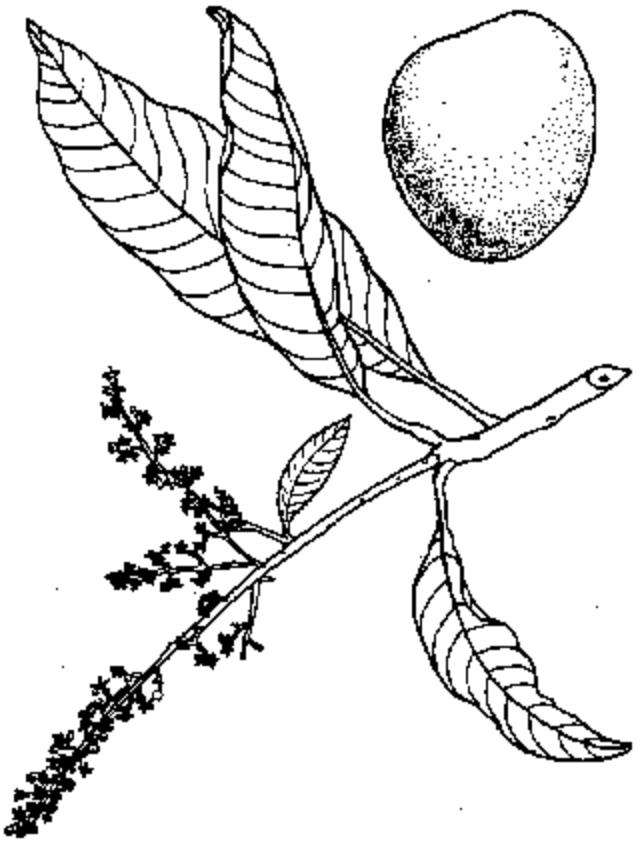
5.3 Genetic diversity in mango and cashew

Though they look very different, mango and cashew are relatives. Both belong to the botanical family Anacardiaceae.

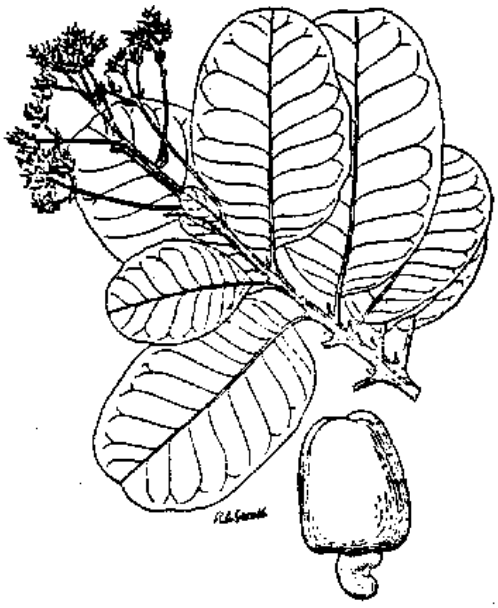
Both are economically very important in all the Western Ghat states from Gujarat to Kerala.

Though they are related, mango and cashew come from opposite ends of the globe. Mango is native to Assam in the Indo-Malayan realm, which stretches from Pakistan to western Indonesia. Cashew originates from Brazil in the western hemisphere.

But both have become naturalized in the Western Ghats, and most people in the region think of them as natives. The two tree species and their produce form part of the religion and culture as well as the diet of local people.



Mango



Cashew

Cashew (Anacardium occidentale)

Cashew seeds were brought to India by the Portuguese in the 16th century to prevent soil erosion and mud-slides during the heavy monsoon rains. It was only in 1926 that local people discovered that the kernel was edible.

The cashew has been naturalized in the Western Ghats to such an extent that scientists refer to centuries-old varieties as "indigenous". These varieties have adapted to local soil, climatic and biotic conditions. Natural selection has ensured that the best adapted varieties could survive and multiply.

Cashew kernels are rich in protein (21%) and fat (47%). They contain 22% carbohydrate. They are high in iron (5 mg/100 g), vitamin B_1 (630 mg/100 g) and B_2 (190 mg/100 g), but low in vitamin A (100 I.U./100 g).

Cashew kernels, or "nuts", are a much sought-after and healthy snack food. The germinating nuts, called godavlim, can also be eaten.

In the northern Western Ghats, cashew juice is drunk fresh or is fermented into fenny, wines and vinegar.

Cashew nut shell liquid is used to treat wood against termites, and is used to make paints, varnishes, and other chemicals.

A major problem in cashew cultivation is fungal pink disease. The most serious pest is the tea mosquito bug, which can cause complete crop loss. The stem boring beetle, though less important economically, can kill the trees.

Conservation

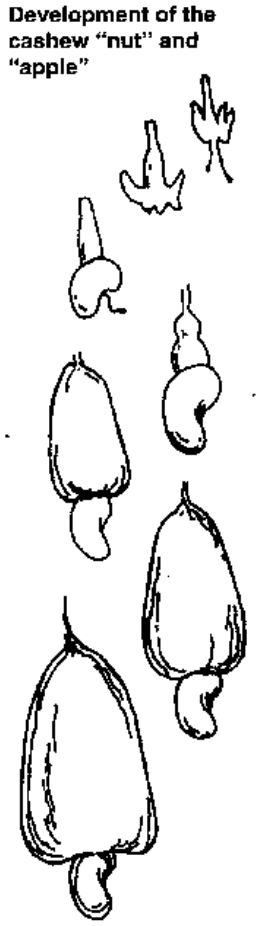
Attempts to boost cashew production have meant that a few high-yielding varieties are now multiplied by the million. They are sold to farmers with government subsidies. These varieties have low tolerance to the tea mosquito bug. Planting a single variety exposes entire plantations to being wiped out by this or other pests.

The National Research Centre for Cashew, at Puttur in the central Western Ghats, has collected more than 300 varieties of cashew. Universities and research stations maintain plants in Vengurla (Maharashtra, 161 varieties), Chintamani (Karnataka, 172 varieties), and Madakkathara (Kerala, 115 varieties). Research stations at Ullal and Vittal (Karnataka) also have cashew collections.

Not a nut

Cashew "nuts" are not really nuts: botanically they are fruit because they contain a kernel and pericarp (an outer hard coating).

The cashew "apple" is not a fruit: it is a swollen fruit stalk.



Development of the cashew "nut" and "apple"

Mango (Mangifera indica)

India has more than 1000 named varieties of mango. Forty species of Mangifera are known, but only three are found wild in India: the cultivated Mangifera indica, and two others. In Goa, 77 varieties of mango have been reported.

Mango has five genomes (sets of chromosomes). This is unusual because most plants have an even number of genomes: two, four, six or eight. This complicates the breeding of new mango varieties.

Because seedlings are genetically different from the parent plants, true varieties can be maintained only through grafting.

Some varieties common in northern parts of the Western Ghats, such as Alphonso and Malcurada, have delicious fruits but bear fruit only every other year. Varieties further south produce fruit every year, but the fruit is of poorer quality. Plant breeders have crossed varieties from the north and south to get trees that produce good quality fruits every year. Some of these hybrids are Anmol, Ratna and Sindhu.

Popular mango varieties

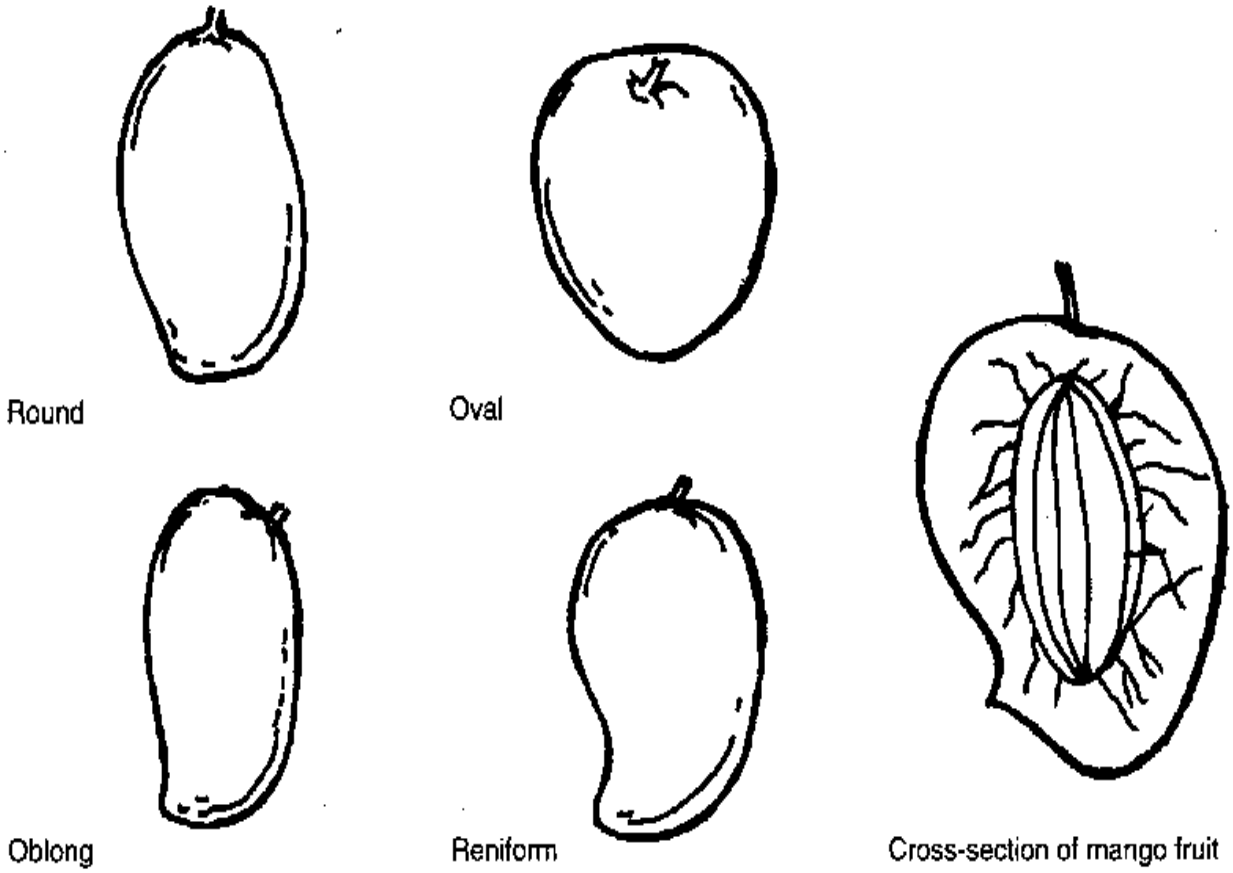
- Early season Malcurada, Malgueso, Bemcurada, Pairi

- Mid-season Xavier, Colaco, Alphonso, Chimud, Udgo, Bispo, Secretina

- Late season Fernandina, Hilario, Monserata

Endangered or extinct varieties

Brindao, Mogri, Mirio, Don Filipe, Don Bernado



Mango fruit shapes

Mango fruit

Different mango varieties produce fruit of various sizes, taste and colour. They bear fruit at different times of the year, meaning that the mango season is getting longer. Some varieties are resistant to powdery mildew disease and pests such as mango hopper and fruit fly.

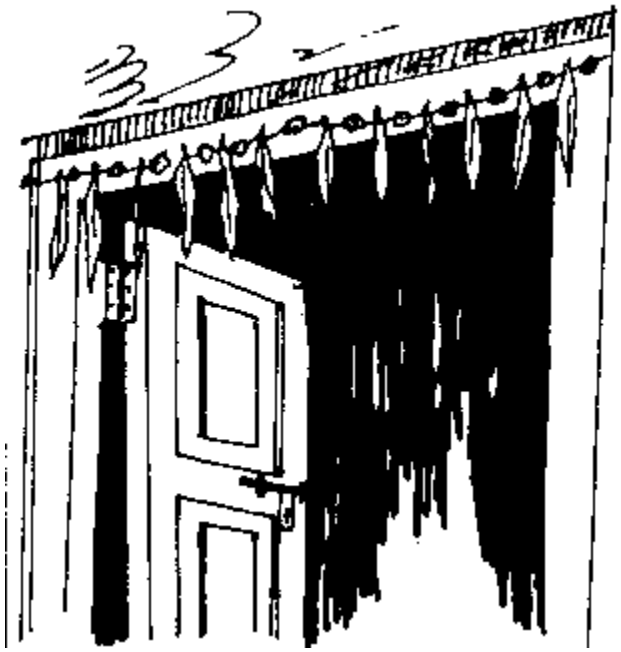
Mangoes are sweet because they contain a lot of sugar: between 10 and 18% of their weight. They are also high in vitamin C (25 to 175 mg/100 g) and vitamin A (0.8 to 13 mg/100 g).

Summer, from March to June, is mango season in the Western Ghats. Although it is a seasonal fruit, Indians eat a large number of mangoes: an average of 4 kg a year. They consume only 9 kg of bananas a year, even though bananas are available all year round.

The fruit can be eaten in many forms: fresh, canned, as juice or jam, sun-dried, or pickled in brine or spices.

Conservation

A new technique of grafting the very young shoots of newly germinated seedlings has made it easier to propagate and conserve rare varieties. Universities and research institutes are establishing germplasm banks to conserve important varieties.



Conservation

Mango trees symbolize goodness, and mango leaves are strung across doors on auspicious occasions.

Prepared by Miguel Braganza

Information kit produced by

WWF-India, Goa division and the

International Institute of Rural

Reconstruction.

5.4 Floriculture and arboriculture

The warm, humid climate of the Western Ghats is conducive to plant growth all year round. A vast collection of grasses, herbs, shrubs and trees grow in the varied ecosystems of the region. Some have been commercially used-even over-exploited. Others have their commercial or ornamental value yet to be discovered.

When a plant species is domesticated and used, its economic value ensures that it is multiplied and preserved. On the other hand, this can lead to a narrowing of the genetic resource as only those varieties or species of economic value are conserved.

Floriculture

The Western Ghats are home to 250 orchid species, of which 100 are endemic. There are 71 species of Impatiens, some species of palms, 150 species of grasses and other plants of ornamental value. A host of introduced plant species, including Hibiscus, Lantana and Capsicum have naturalized in this region.

The government focuses attention on commercial floriculture by identifying centers where particular plants can thrive (such as orchids in Kerala), and promotes the industry through generous subsidies. It discourages the offering of bouquets and garlands by encouraging event organizers to offer a potted plant to guests. Alternatively, the guest can plant a tree at the event site.

Worth 1000 words...

Flowering plants beautify our houses and add colour and fragrance to our cities. They hide ugly spots and protect homes from dust and noise. They absorb carbon dioxide and release oxygen.

Flowers adorn women's hair and decorate pictures of gods, saints, national leaders and deceased loved ones. Garlands are exchanged by the bride and groom in traditional Indian marriages, especially among Hindus. Flower scents are extracted for use when the flowers themselves are not available.

Flowers of a certain species or colour are associated with Hindu dieties. For instance, white flowers are offered to Shiva. At Mangueshi temple, only Zuyee flowers are offered at a special pools during the full-moon at the end of the rains.

Irrespective of religion, we offer bouquets on joyous occassions and wreaths at funerals. The age-old tradition of putting a token trowel of soil on the grave has been replaced by the placing of a flower.

Arboriculture

Trees are original inhabitants of the Western Ghats. Native tree species are still abundant, though their numbers have decreased.

Coconut and cashew plantations are not a threat to native species. Acacia auriculiformis and A. mangium, introduced from Australia for planting on mining dumps, may become a threat to native species if they are not controlled.

Large-scale felling of teak and other timber species is not desirable in the Western Ghats. The region's steep slopes and heavy rainfall makes the soil prone to erosion. The traditional practice of selective felling of mature trees is a more suitable alternative.

Flowers in the economy

The jasmine group of Mogrem, Zuyee (J. sambac, J. officinale and J. auriculatum) combine beauty with fragrance. Jasmines are used to make aromatic jasmine oil used in cosmetics and soaps.

Jasmine

Cut flower growing is a booming business in India. Orchids, anthuriums, roses and chrysanthemums are grown for export of cut flowers.

Periwinkles are grown extensively for extraction of cancer-curing alkaloids.

Glorylily pods and roots are used in medicine.

Timber plantations

A number of companies are promoting monoculture teak and rosewood plantations in the Western Ghats. They promise high profits, but current levels of technology does not make such planting feasible or desirable. Block felling at a later date will result in soil erosion.

Timber plantations

Indigenous and exotic tree species in the Western Ghats

Name	**Species**	**Uses**
Runeala plum, jagam, jangma	Flacourtia jagomas	Fruits relished by children. Eaten after softening between the palms of the hands.
Adam's fruit, adao, manilphal	Mimusops kauki	Fruits are eaten. Seedlings used as rootstocks for sapota grafts. Wood is used for furniture.
Elengi, bakul, vonvlam	Mimusops elengi	Creamy-brown scented flowers are used as hair adornment and to mask body odour. Fruits are edible.

Java plum, jamun, jambool	Syzyzium cumin	Fruit is edible and used in control of diabetes. Excellent for wines, liquor. Wood is good timber.
Guava, pew, amrud	Psidium guajava	Fruit is the tropical apple, rich in vitamin C and pectin. Made into jellies. Wood for walking sticks.
Cashew, kaju	Anacardium occidentale	Kernel is excellent snack, Shell liquid used for termite control, "apples" used for alcoholic drink.
Mango, ambo, am*	Mangifera indica	Excellent table fruit, trunk is used to make dug- out boats. Leaves used in religious ceremonies.
Hog plum, ambado	Spondias mangifera	Immature fruit cooked at Divali, made into pickle in brine or spices. Ripe fruit relished.
Bengal almod, badam*	Terminalia catappa	Fruit pulp and kernel edible. Leaves become red in cold weather, beautiful tree for large garden.
Marat, marti*	Terminalia creneleta	High class timber, adopted as the State Tree of Goa.
Kindol*	Terminalia	High class timber

	paniculata	obtained from its trunk.
Benteak, nano, nanan*	Laigestroemia lanceolata	Wood used in furniture and ship-building. Bark is used for tanning leather.
Indian teak, sailo, jati*	Tectona grandis	Most commonly used wood for furniture, rafters, railway sleepers.
Jack, pangs, borkoi*	Artocarpus integrifolia	Multiple fruit relished, rich in vitamins A and C, Wood used for furniture. used as cattle feed.
White teak, shewan*	Gmelina arborea	Wood used in mine-shafts and or handles. Fruit is eaten by some birds and animals.

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* indigenous to India

Flowering trees, shrubs and creepers

Common name	Scientific name	Local name	Parts used	Uses
Shrubs/herbs				
Crossandra(Indigenous)	Crossandra udulifolia	Abolim, priyadarsha	Flowers	Festivals, weddings, Lent season processions, traditional folk dances(Dekni, Fugdi

				and Mando)
Jasmines (Indigenous)	Jasminum sp.	Mogrim, zuye, zayee	Flowers, scent	Zayeechi Poornima (full moon) festival
Periwinkle(Exotic)	Catharanthus roseus	Perpet, sadaphuli	Flowers, leaves	Leukemia treatment. Normally grown in cemeteries as it requires little maintenance. Commercially cultivated.
Ixora (Exotic)	Ixora coccinea	Pitkol, pidkol	Flowers, stem	Wreaths, walking sticks.
Lantana	Lantana camera	Ghanerem	Flowers	Flower beds. Used as mosquito replellant. Easily becomes a weed if seeds are allowed to germinate.
Paper chase(Exotic)	Mussaendra		White bracts	Ornamental
Shoeflower(Exotic)	Hibiscus rosasinensis	Doshin, dushwanti	Flowers	Ornamental, shoe/heir blackener. As salad dressing, along with onions. White flowers used in Shiva temples.
Sickle senna(Indigenous)	Cassia tore	Thaikulo, taikulo	Leaves, seeds	Vegetable, ringworm cure, mordant, coffee substitute during economic crisis
Rose	Rosa sp.	Gulab	Flowers	Bouquets, rose water. "Gulkand" (a paste of rose petals and sugar) eaten with betel leaves and areca nut ("pan supari') on festive occassions.

Impatiens	Impatiens	Chido	Flowers	Potted plant which flowers almost all year
(Patient Lucy)	tomentosa			
Trees				
Indian labernum(Exotic)	Cassia fistula	Bayo	Flowers, leaves, pods	Ornamental, liver ailments, purgative(crushed pipe-Eke pod)
Champac	Michelia champaca	Champa, chamfo	Flowers	Hair adornment, fragrant flowers, normally wrapped in banana leaf, often sold at bus stands.
Coral tree(Indigenous)	Erythrina indica	Pongara	Flowers, leaves, whole tree	Ornamental, fodder (leaves), shade in coffee plantaions, support for pepper vines
Cycus	Cycus bedami	Cycus	Whole tree, leaves	Ornamental palm
Fishtail palm	Caryota urens	Billo mead	Whole tree, leaves	Ornamental, caryota leaves and fruit bunches used as decoration at feasts and weddings.
Seasonals				
Tuberose	(Exotic) Polianthes sp.	Rajniganda, tuberose	Flowers	Bouquets, garlands, scents. Flowers add fragrance to reception halls.
Marigold (Exotic)	Tagetes erecta	Rosam	Flowers	Garlands, anthelminthic, stomach upset(flower decorations),

				garlands at Desshera festivals and weddings
Glory lily(Indigenous)	Gloriosa superba	Wagnak	Flowers, fruits, roots	Ornamental, leprosy treatment
Ice-cream creeper (Exotic)	Antigonum leptopus	Santamaria	Flowers	Ornamental
Rangoon creeper (Indigenous)	Quisqualis indica	Kolvont	Flowers	Ornamental, flowers worn in hair

Prepared by Michael Braganza

5.5 Enriched biodiversity by plant introductions

Five hundred years ago, India had no potatoes, groundnuts, tomatoes or chilliest These important crops are relative newcomers to Indian fields and cuisine.

Ports on the west coast of India-Surat, Bombay, Dabhol, Goa, Honavar, Mangalore and Cochin-have played an important role in the import and dispersal of useful exotic plants. Before medieval times, Goa traded with the African coast, Egypt, the Persian Gulf and S.E. Asia.

Despite this, the agricultural resource base of India, especially of cash crops, was very limited before Vasco da Gama's discovery of the sea route to India in 1498. The subsequent arrival of the Portuguese, British, French and Dutch intensified battles to control the seaborne trade. The Moghul empire (1526-1857) granted liberal trade concessions to foreign powers. Intense trans-oceanic and maritime trade brought exotic species to Indian shores and diversified regional plant gene-pools.

The growing demand for novel crops (such as tobacco and pineapple) led to the establishment of experimental nurseries and plantations, mostly by missionaries. The novelty and utility of many exotic plant species brought a change in the agricultural economy, food habits and cultural practices of the Western Ghats and India as a whole. By the early 18th century, the cultivation of tobacco, chillies, chickoos, guavas, sitaphals, pineapples, oranges, cashews, papayas and breadfruit was established in South India.

India became one of the world's largest producers of some of the imported crops.

Biodiversity revolution

The natural dispersal of isolated plant species is not a major factor in the spread of cultivated plants from their native countries. Human action is thus the only significant way regional plant diversity is enriched. The intercontinental exchange in plant species in the last 500 years was thus a major event in world history.

Over history, isolated wild plant gene pools have been used for strategic reasons, to bring about a calculated shift in agricultural economies of colonized areas. For instance, the Portuguese took Indian and Southeast Asian spices to Brazil for cultivation; the British and Dutch brought rubber from Brazil to Malaya and Indonesia. Other plants brought as gifts for local elites later became popular, resulting in their widespread local cultivation. These crops are now very important in their new areas, often overshadowing their role in their original homes.

Major producer of exotic crops

In 1992, India produced:

• 480 million kg of tobacco

• 8 million tonnes of groundnuts

• 5 million tonnes of tapioca

• 0.5 million tonnes of chillies

• 15 million tonnes of white potatoes

• 1.3 million tonnes of sweet potatoes

• 1 million tonnes of pineapple

• 0.3 million tonnes of cashew nut

• 1 million tonnes of tomatoes, chickoos, pumpkins, etc.

Before 1498, none of these was found in India. Today, India is among the world's major producers of many of these crops.

Conservation of introduced, economically useful plants

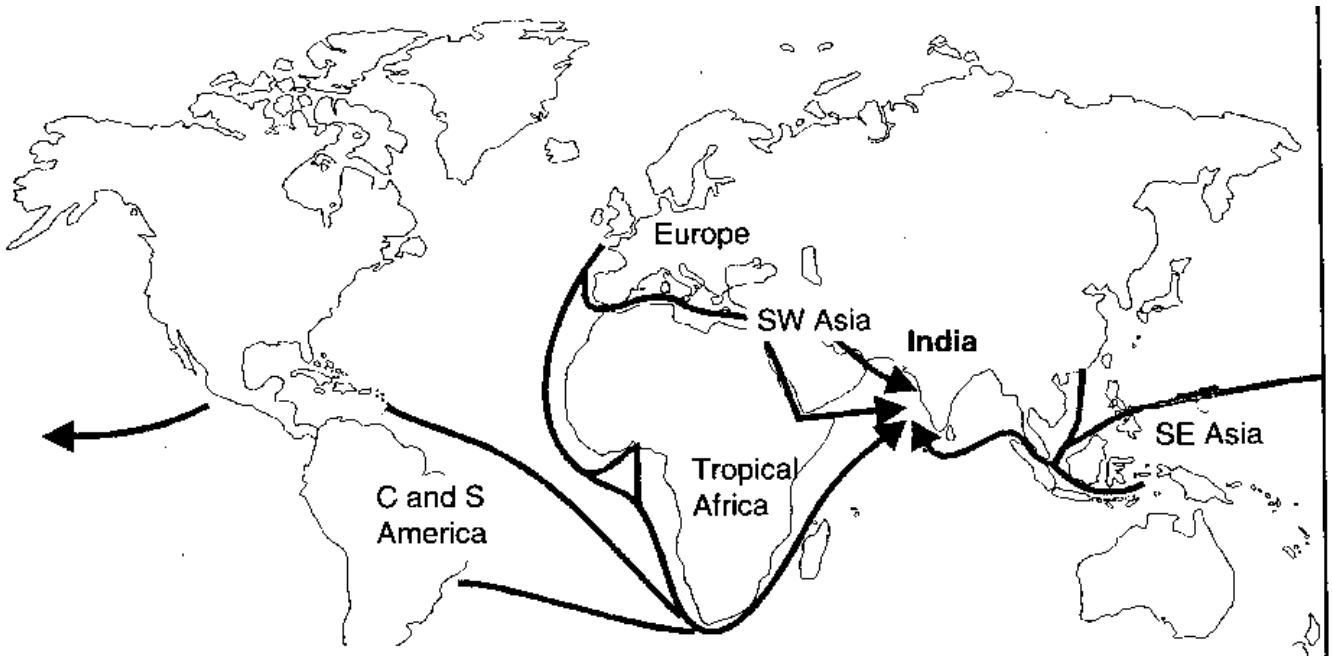
• Survey, document and identify introduced species and their cultivars.

• Exchange information with authorities in regions with high diversity.

• Monitor the status of endangered species in their native places and share such data.

• Freely export healthy wild germplasms to their native places for reintroduction.

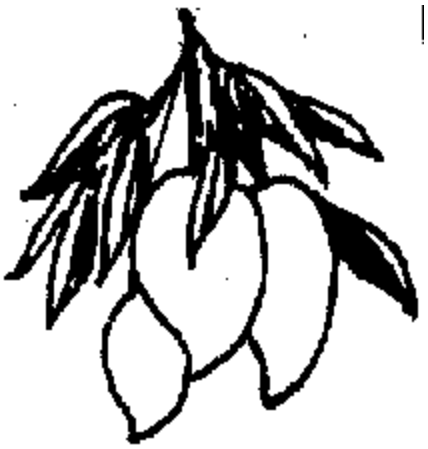
• Follow up reintroduced plants until the species is established and multiplies in its original habitat.



Intercontinental maritime trade routes linking India, SE Asia, Africa and S America were also routes for the exchange of plant germplasm. This enriched regional biodiversity and revolutionized cropping pattern and the agricultural economy of many parts of the world.

Exotic species in Goa

The Portuguese rulers of Goa catalyzed intercontinental plant genetic resource exchanges. Techniques of mango grafting were improved substantially by Portuguese missionaries in Goa, helping diversify mango cultivars. Over 20% of Goa's plants appear to have been introduced by the Portuguese between 1510 and 1961.



Exotic species in Goa

Pre-Vasco da Gama (before 1498)

Major crops were limited to rice, lentils, cotton, sugar cane, wheat, jowar and bajra.

The Indian menu had no chillies, potatoes, tomatoes, peanuts, pineapples, guavas, papayas, maize, custard apples or pumpkins.

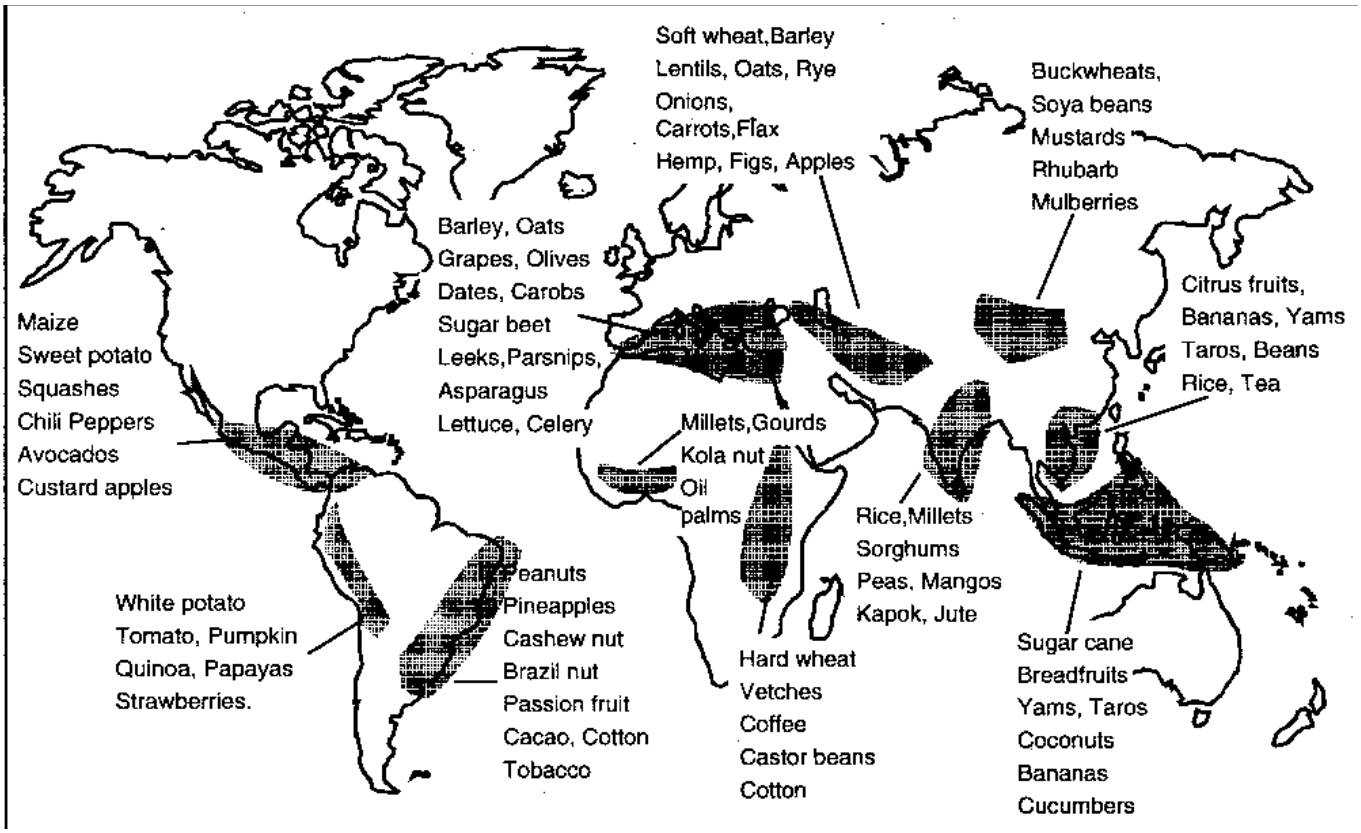
None of these plants were family or tribal totems or mentioned in literature or used in rituals.

Post-Vasco da Gama (1498 onwards)

Tobacco and pineapples were favoured by Deccan sultans and Moghul emperors.

In the 16th century, chillies, cashew, peanuts, potatoes, pineapples, papayas and other crops were introduced.

Exotic species gradually enter the Indian menu and markets.



"Vavilov centres": areas of origin of most cultivated plants

Some economically useful plants species and their original home

Species	**Common name**	**Native of**
Tagetes erecta	African marigold	Mexico (intro via Africa)
Ananas cosmosus	Ananas	Brazil
Acacia auriculiformis	Australian acacia, Bengali babool	Australia
Casuarina equisitifolia	Beefwood, shuru	Australia
Artocarpus indica	Breadfruit	Polynesia
Brassica oleracea	Cabbage, kobi	Mediterranean Europe
Anacardium occidentale	Cashew	Brazil
Manikara achras	Chickoo	Brazil

Lagerstroemia indica	Chinai mendi	China
Portulaca grandiflora	Chini gulab	South America
Theobroma cacao	Cocoa	Mexico
Coffea arabica	Coffee, cafe	Ethiopia
Coriandrum sativum	Coriander, kothmiri	Mediterranean Europe
Punica granatum	Dalimb	Iran
Terminalia catappa	Deshi badam	Molluccas
Hibiscus rosa-sinensis	Dassun	China
Ricinus communis	Erand	Tropical Africa
Eucalyptus tereticornis	Eucalyptus, nilgiri	Australia
Quisqualis indica	Firangi chameli, rangoon creeper	Molluccas
Tagetes patula	French marigold	Mexico (intro via Africa)
Cercus pentagonus	Firangi, nivalkati	Brazil
Kallanchoe pinnate	Ghaipat	Tropical Africa
Adansonia	Gorakhchinch,	Tropical
digitata	baobab	Africa
Delonix regia	Gulmohar.	Madagascar, Mauritius
Flacourtia inermis	Jagam	Moluccas
Myristica fragrans	Jaiphal, nutmeg	Indonesia
Gardenia jasminoides	Jasmine	China
Ipomoea batatas	Kangi, sweet potato	Tropical America
Averrhoa carambola	Karmal	Moluccas
Gossypium barbadense	Kidney cotton	Peru, Brazil

Syzygium aromaticum	Lavang	Molluccas
Lens esculenta	Lentil, alsando	Mediterranean Europe
Litchi chinensis	Litchi	South China
Hibiscus mutabilis	Madyani	China
Syzygium malaccensis	Mallaca jamb	Moluccas
Annona muricata	Mamphal	West Indies
Acacia mangium	Mangium acacia	Australia
Capsicum spp.	Mirchi, mirsang	Haiti, Tropical America
Citrus sinensis	Mozambique orange, musambi	China
Opuntia elatior	Nivdung	Brazil
Eupatorium triplinerve		Tropical America
Alliumcepa	Onion, kanda, Iruli	Persia
Carica papaya	Papai,	West Indies &
	papaya, pawpaw	Gulf of Mexico
Canavalia gladiata	Pandhri abai	West Indies
Psidium guajava	Per, Peru, guava	Mexico
Citrus reticulate	Portugal/mandarin orange	China & Indochina
Arachis hypogaea	Peanut	Brazil
Cucurbita maxima	Pumpkin, dudhi, keddu	America
Annona reticulate	Ramphal	West Indies
Elaeis	Red oil palm,	Tropical
guinensis	tel-maad	West Africa

Cupressus lusitanica	Saro, Mexican cypress	Mexico (intro via Africa)
Bixa orellana	Sendri rangmala	Brazil
Chrysanthenum coronarium	Shevanti	China & Japan
Annona squamosa	Sitaphal, Ateria	Mexico (intro via Philippines)
Phaseolus caracalla	Snail plant	Brazil
Phaseolus lunatus	Snail plant	South America
Phaseolus vulgaris	Snail plant	South America
Helianthus annus	Suryaphool, sunflower	Western U.S.A.
Borassus flabellifer	Tadmad	Tropical Africa
Hibiscus subdariffa	Tambdi ambadi	Tropical America
Manihot esculenta	Tapioca, cassava	Tropical Africa
Camelia sinensis	Tea, chai	China
Nicotiana tabacum	Tobacco, Tambakhu	Brazil
Citrus maxima	Toranj	Moluccas

Prepared by Mr. Nandkumar Kamat

5.6 Impact of introduced plants

Plants from all over the world have been brought to the Western Ghats and grown there. Some have vanished, while others have become naturalized and multiplied, either with or without active human intervention. Some have been beneficial, while others have become weeds or have had other serious consequences.

Vegetables

Chillies have substituted black pepper in trade, cultivation, research and culinary use. The colonial powers of the 16th century had sought exactly this when they discovered this easy-to-grow spice in South America.

Onions from Persia were used to keep slave labour healty while building the pyramids of Egypt. They have displaced vegetables during the winter cropping.

Beverages

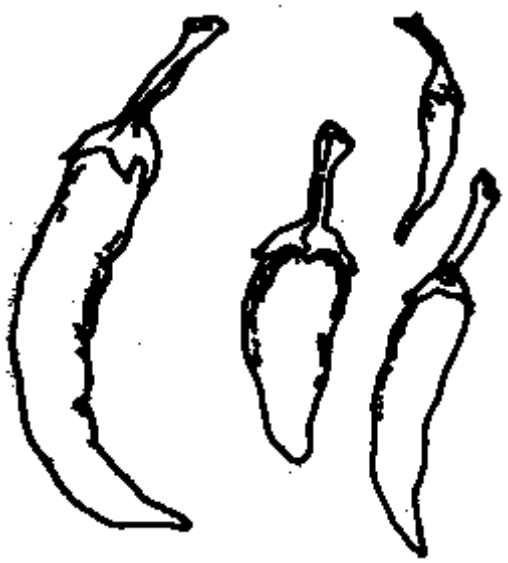
Coffee and tea are the products of plants introduced from Africa and China respectively. Large areas of virgin rainforests have been thinned down in Coorg and Wynad to grow these crops.

Revegetation programmes

Revegetation programmes have brought about the introduction of some many-seeded, quick-growing plant species suitable for adverse soil conditions and poor management practices. Two species of Acacia, many species and hybrids of eucalyptus and Casuarina equisitifolia have been brought from Australia for these projects. The high demand for wood pulp for the paper and rayon industries and for poles as construction props led to an exponential growth of areas under these species with little thought on their impact.

The Australian acacia's name has been indigenized within a decade of its introduction in social forestry programmes. It is called the "Bengal acacia" or "Bengali babool" so is confused with the native acacias called locally "babool" and "subabool".

Plants of the above three genera have been extensively grown along roadsides. They cause severe chest and bronchial sickness in many people, especially during pollen-shedding seasons.



Vegetables

Some introduced plants in the Western Ghats

- Spices

Chillies, onion, cloves, nutmeg, allspice, coriander

- Beverages

Tea, coffee, cocoa

- Fruits

Custard apple, pine apple, papaya, guava, chikoo, mango, iamun.

These three plant types shade the ground and their leaf-fall mats the ground below. Little or no undergrowth is present. In the high rainfall conditions of the Western Ghats, this results in soil erosion, poor rainwater percolation and low water table in the post-monsoon season. The high water-uptake efficiency of these xerophytic plants aggravates the water problem during summer.

The "leaf" of Australian acacia is a modified petiole (phyllode) while that of the casuarina is a modified branch (cladode). These and the true leaves of the eucalyptus do not decompose easily, suppressing insect and microbial activity and changing the soil characteristics. Casuarina has destroyed both the beauty and the sands of beaches which it was planted to protect against erosion.

Accidental introductions

Not all introductions are intentional. Eupatorium, Parthenium and Mexican Weed came along with American wheat. The blame for these weeds goes to PL480 aid and poor quarantine in the USA and India in the 1960s. These weeds first established near railway and shipyards handling the wheat and then spread to other areas. Eupatorium is a serious problem even in Goa's Cotigao Wildlife Sanctuary. It can cause immense damage to the plant, mushroom and animal diversity in this sanctuary. Lantana, Milkbush Euphorbias and some other plants have also become weeds in some areas.

Water Hyacinth

The Water Hyacinth has beautiful flowers. Fragments of the plant can regenerate and it sets many seeds. Once established in a lake, canal or marsh, it is almost impossible to eradicate. Salvinia is no different. These plants choke out all other life forms before drying up the lakes. They are a scourge to fisheries, agriculture and water transport.

Effects of - weeds

• Invade land and water area.

• Compete with native plants and crops for space, water, nutrients, light.

• Cause irritations and allergies.

• Poison animals and birds.

• Dry up water sources.

• Interfere with agriculture, aquaculture and waterborne transport.

• Require high expenditures for removal or eradication.

• Reduce native biodiversity of plants, fungi, insects.

• Suppress seedlings, causing poor regeneration of forests.

Quarantine

Any plant material must be certified by the exporting country as free of insect pests and diseases prior to export. Quarantine facilities must be established at the import points (airports and harbours) to monitor the performance of the plants. Genetic defects and effects are monitored in case of new plants species or varieties. The apex body in India for these services is the Central Plant Protection and Quarantine Centre in Faridabad, Haryana.

Suggested reference: George Usher, A dictionary of plants used by man. CBS Publishers and Distributors, Shahadara, Delhi.

Prepared by Miguel Braganza

5.7 Effects of pesticides on biodiversity

The continuing intensive chemicalization of the world's agriculture introduces large amounts of pesticides into the planet's biosphere-the habitat of all living beings, including humans.

As environmental contaminants, pesticides are different from other types of chemicals:

• It is nearly impossible to prevent their circulation in the biosphere.

• They are biologically active. This creates potential dangers to nature and people.

• A large proportion of the human population comes into contact with pesticides.

• Many pesticides persist in natural conditions and are transferred along the food chain.

• Many pesticides can be accumulated in the bodies of organisms that come into contact with even low concentrations.

Pesticides can have both lethal and sub-lethal effects on organisms they come into contact with.

• The average crop loss resulting from insects, diseases and weeds has been calculated as high as 35% of the potential production of crops.

• Pesticide consumption in India for agriculture and public health has risen from 2000 tonnes a year in the fifties to over 80,000 tonnes.

• Annually in the world, there are about 750,000 reported pesticides poisonings with about 13,800 deaths. India accounts for 1/3 of pesticide poisoning cases in the world.

• In nine weeks, earthworms can accumulate 18 ppm of DDT from soil containing only 1 ppm of DDT. This demonstrates the serious big-accumulation effects of pesticides in the environment.

• Per average of 76 mg/kg of pesticide residues have been found in samples of cow's milk obtained from local vendors in Bombay. This level is more than 500 times higher than the maximum intake level of 0.15 mg/kg recommended by WHO.

• The "Handigodu Syndrome" in the population of many rural areas in Kamataka was traced to the victim's diet of crabs found in ponds and rice fields which were contaminated with pesticides (endrin and parathion). Victims were crippled; their limbs, lips and shoulders became deformed.

• The major source of dietary intake of pesticide residues is human milk and milk products, followed by oils and fats.

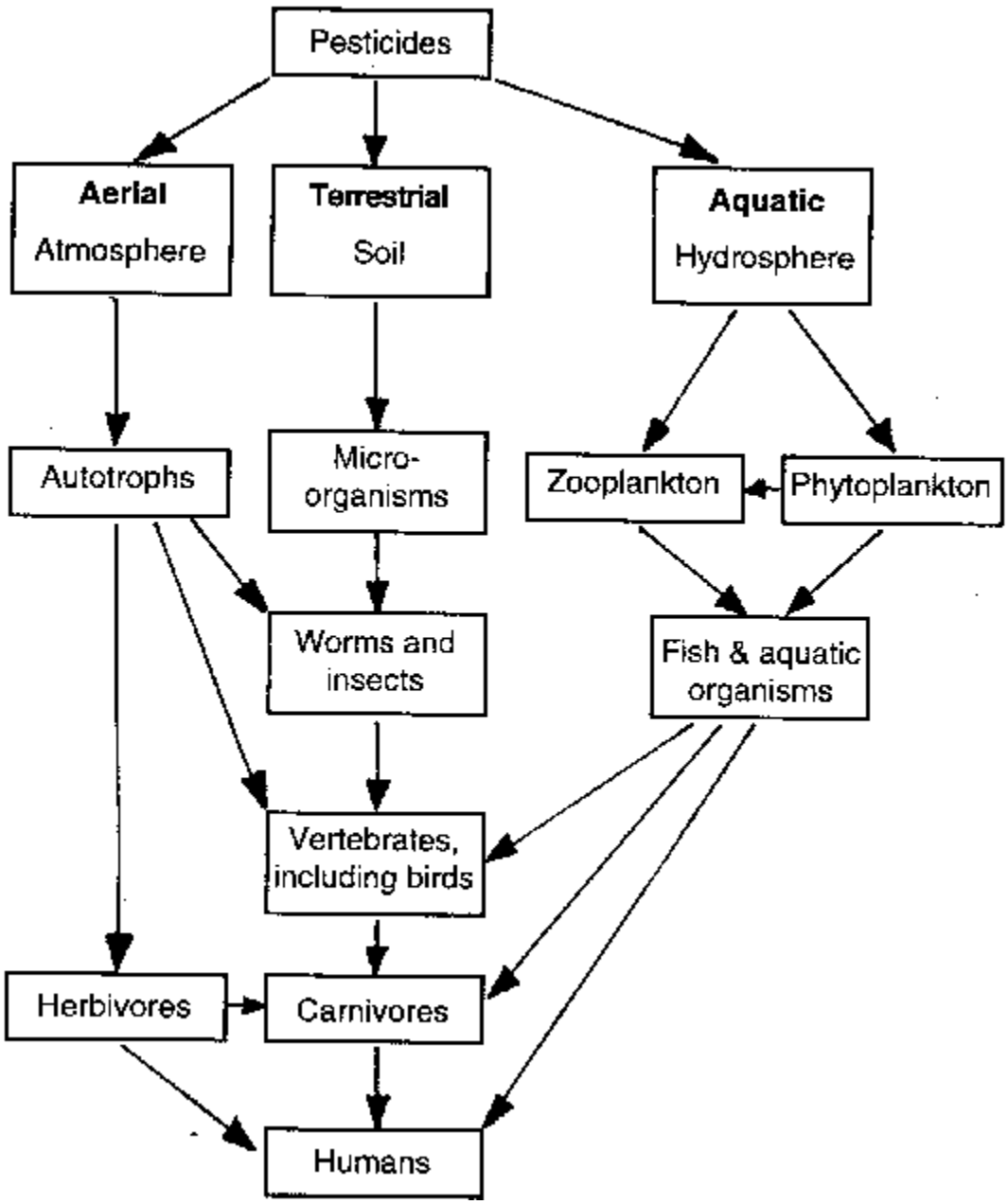
Effects of pesticides on the environment

Element	**Potential effects**

Abiotic	Presence of residual amounts in soil, water and air.
Plants	Presence of residual amounts. Damage due to phytotoxicity. Changes in vegetative development.
Animals	Presence of residual amounts in domestic and wild animals. Physiological actions (non-vitality of birds eggs). Extermination of some wild species. Development of second-generation pests.
Man	Presence of residual amounts in tissues and organs. Occupational diseases.
Food	Presence of residual amounts.
Organism being controlled	Development of resistance.

Biological transfer of pesticides

Pesticides enter a biological system by three main routes: aerial, terrestrial and aquatic.



Biological transfer of pesticides

Biomagnification of pesticides

The accumulation of pesticides in various biological systems is called "biomagnification". Some persistent pesticides accumulate in various biological system at levels much higher than those in their surroundings. For example, 1 kg of soil may contain only 1/1000 of a milligram of organochlorine pesticides-but a kilogram of carrots grown in the same soil may contain as much as 6 mg of pesticides.

Pesticides in the air

Pesticides enter the atmosphere mainly through the treatment of agricultural crops, seeds, forests, and water basins. They get into the air together with soil dust' via wind erosion, during soi! cultivation and crop harvesting. They are also evaporated from moist surfaces such as soil, water and plants. From the atmosphere, the pesticides and their metabolites get into water and soil and continue to circulate in the environment.

Aquatic environments

Pollutants, including pesticides, accumulate in sediments which serve as a habitat for various organisms in the aquatic food chain, which ultimately involves fish. Even in insignificant concentrations, some pesticides may change the taste and odour of water, have a negative effect on the process of oxygen formation by phytoplankton, and affect the vital activities of the inhabitants of the water ecosystems.

Pesticides are dispersed in water and are picked up by living creatures. The chemicals enter the food chain and accumulate faster in living organisms through the aquatic route than through the other routes.

Pesticides can have both lethal and non-lethal effects on fish. Non-lethal effects include disturbed population dynamics and changed food habits and reproductive behaviour. Pesticides such as DDT reduce the ability of fish to adapt to changing temperatures. They also result in vertebral fractures and can deform fish backbones and fertilized eggs. Fish can be used to indicate the level of pesticide contamination in water.

Birds

Sub-lethal dosages of pesticides can reduce the thickness of eggshells, making them fragile and reducing the number of eggs that hatch. Pesticides also cause hormonal changes in birds, influencing their courtship and nesting behaviours.

Pesticide degradation

When pesticide residues get into the hydrosphere, some are volatilized and lost to the atmosphere, some are degraded, some are incorporated in the biota, and some move into the sediment.

Animals, plants and micro-organisms are responsible for degradation and detoxification of pesticidal residues. Pesticides are modified or completely decomposed in the soil as a result of physicochemical processes, microbiological

decomposition and absorption by higher plants and the soil fauna. The soils are rich in micro-organisms, which mostly include actinomycetes, fungi and bacteria. These micro-organisms play an important role in the degradation of pesticide residues from the soil. Many pesticides become detoxified by their adsorption by humus and other colloids or the formation of stable complexes in the soil. Poisonous chemicals are removed from the soil as a result of volatilization, evaporation with water vapour, migration beyond the root-habitat layer, washing out by rain water, melted snow, irrigation, ground and soil water.

Biomagnification in the food chain

When a pesticide enters the food chain, it can be deposited in the bodies of organisms. Predators that prey on large numbers of these organisms can accumulate large quantities of the pesticide. For this reason, the maximum accumulations of the toxicant are found at the top of the food chain.

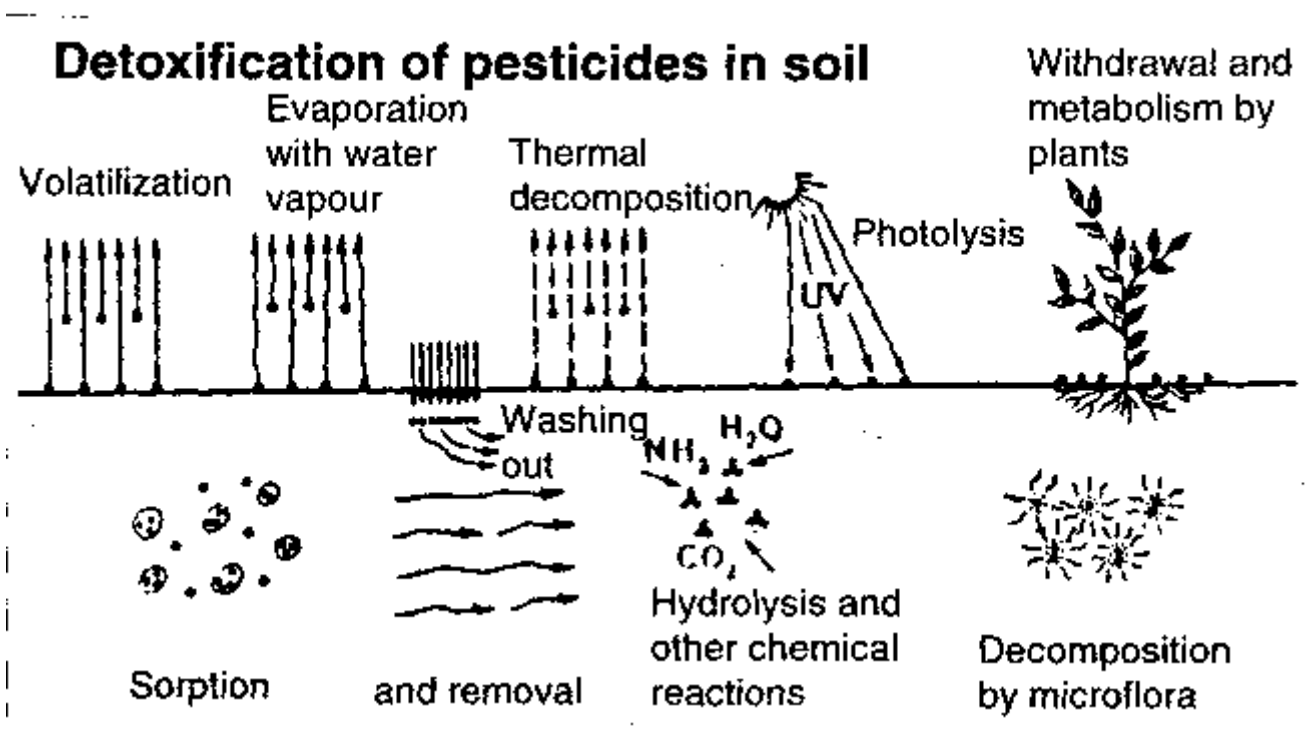
The species affected depend on the predator-prey relationships in the food chain. For instance, a pesticide in the soil that is picked up by earthworms may end up in snakes:

Earthworm-bird- salamander-snake

A pesticide picked up by soil insects may enter a different food chain that also ends with snakes:

Soil insects-predacious insects-toad-snake

Some types of pesticides persist in the environment because they are not broken down easily into harmless substances. The use of persistent organochlorine pesticides like DDT and HCH for agricultural and nonagricultural purposes should be discouraged. They should be replaced with easily degradable "soft" pesticides of organophosphates, carbamates and synthetic pyrethroid group. Better still, integrated pest management approaches that avoid pesticide uses should be used to control pests.



Detoxification of pesticides in soil

Sources of pesticides

Pesticides can reach rivers, lakes, ponds and oceans from various sources:

• Industrial wastes and factory effluents

• Accidental spillage

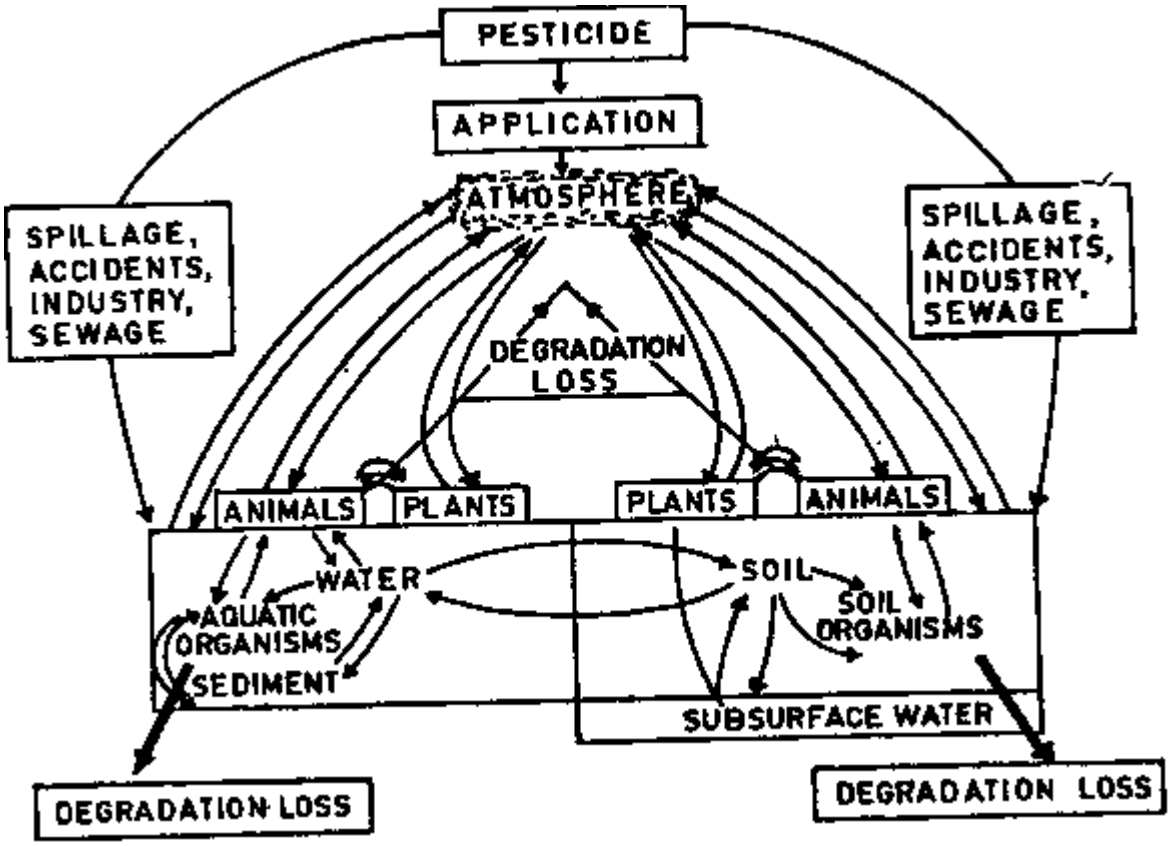
• Spray drift at the time of field application

• Direct application to the soil for control of crop pests

• Atmospheric transport

• Agricultural wastes

• Sewage effluents.



Pesticide cycle in the environment

Alternatives to chemical pesticides

The dangerous side-effects of a number of conventional pesticides on wildlife, their human health hazards and their pollution of the environment have forced the discontinuation of their use or manufacture. In addition, many harmful insects have become resistant to synthetic insecticides. It has become imperative to find other ways of controlling pests.

Various approaches are used to control pests. Those using natural predators, parasites and pathogens (biological control), sexual sterilization, sex pheromones and insect growth regulators (third generation pesticides) appear to offer the greatest opportunity for success- particularly if used in integrated pest management programs.

Micro-organisms that affect insects, or "entomo-pathogens", induce diseases that often suppress and, in some cases, completely eliminate natural populations of insect pests. Over 1000 such pathogens have been isolated from insects. Many are associated with major pests and could be developed into microbial insecticides.

Plants are the richest source of renewable bioactive organic chemicals. Plant-based pesticides are the oldest pesticides used by man. Recently there has been renewed interest in botanical pesticides.

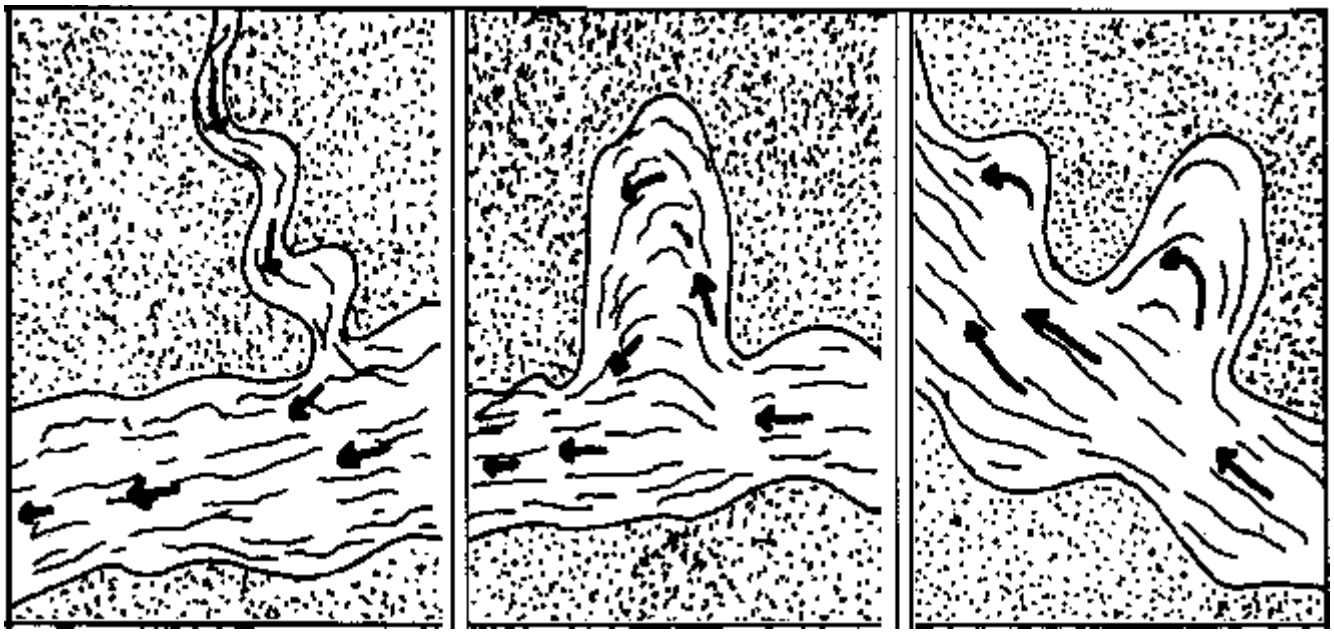
Prepared by Dr. Vijayendra P. Kamat

5.8 Khazan (saline) lands

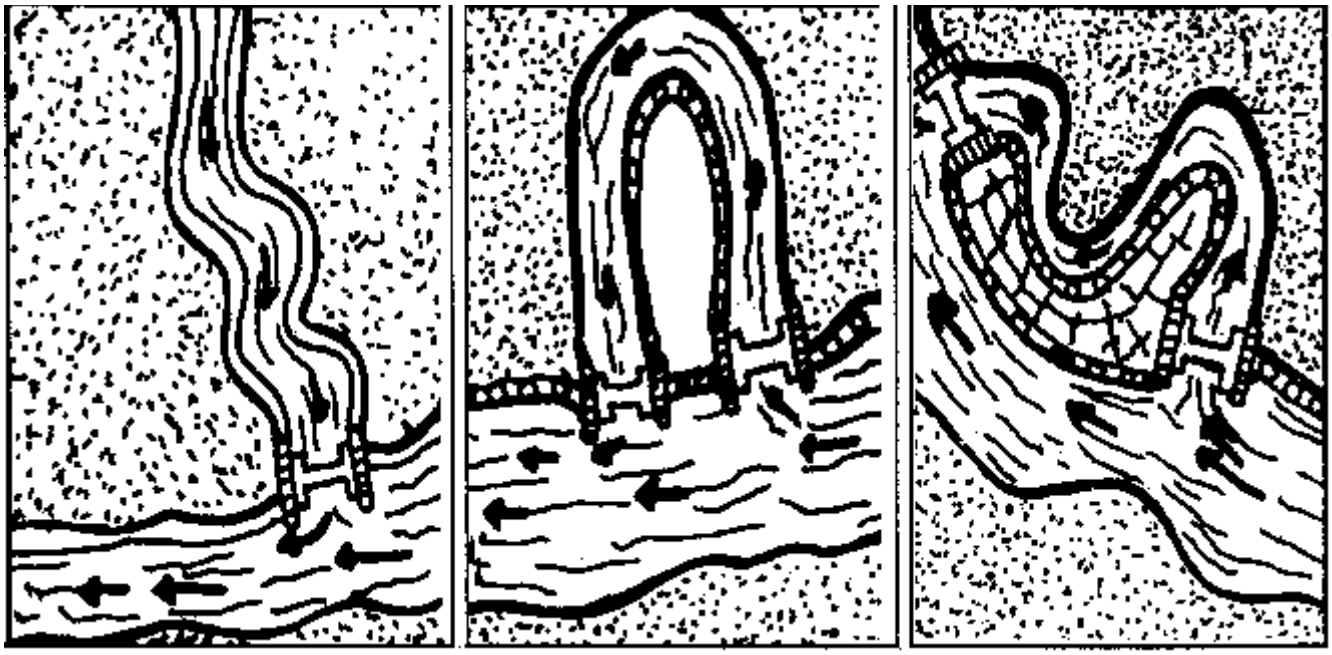
The tidal estuaries of Goa stretch some 30 km inland. Either side of the estuaries lie "khazans": saline floodplains that lie below sea level at high tide. Over centuries, Goans have reclaimed these lands with an intricate system of dykes (bunds) and sluice gates. These barriers prevent salt water from entering the fields.

Eight of the 11 talukas (subdistricts) in Goa have a total of 17,500 ha under khazans. At least 2000 ha (12% of the total) are under dense mangrove vegetation. The mangroves help protect the outer side of the mud and laterite bunds that enclose the khazan. The total length of these bunds is about 2000 km.

Cultivation of the khazan lands dates back at least 3000 years. After 400 A.D., royal charters granted them to high-caste Hindu (Brahmin) settlers. Age-old co-operative, self-governing institutions known as gaunkaris or communidades reclaimed the khazan lands, engineered the intricate system of bunds and sluices, and maintained the khazan infrastructure. In 1975, this complex task was transferred to government-supervised "tenants associations". These are comprised of farmers who benefit from a particular protective bund. There are 138 such associations in Goa with a total of 20,000 farmer members.



Before reclamation



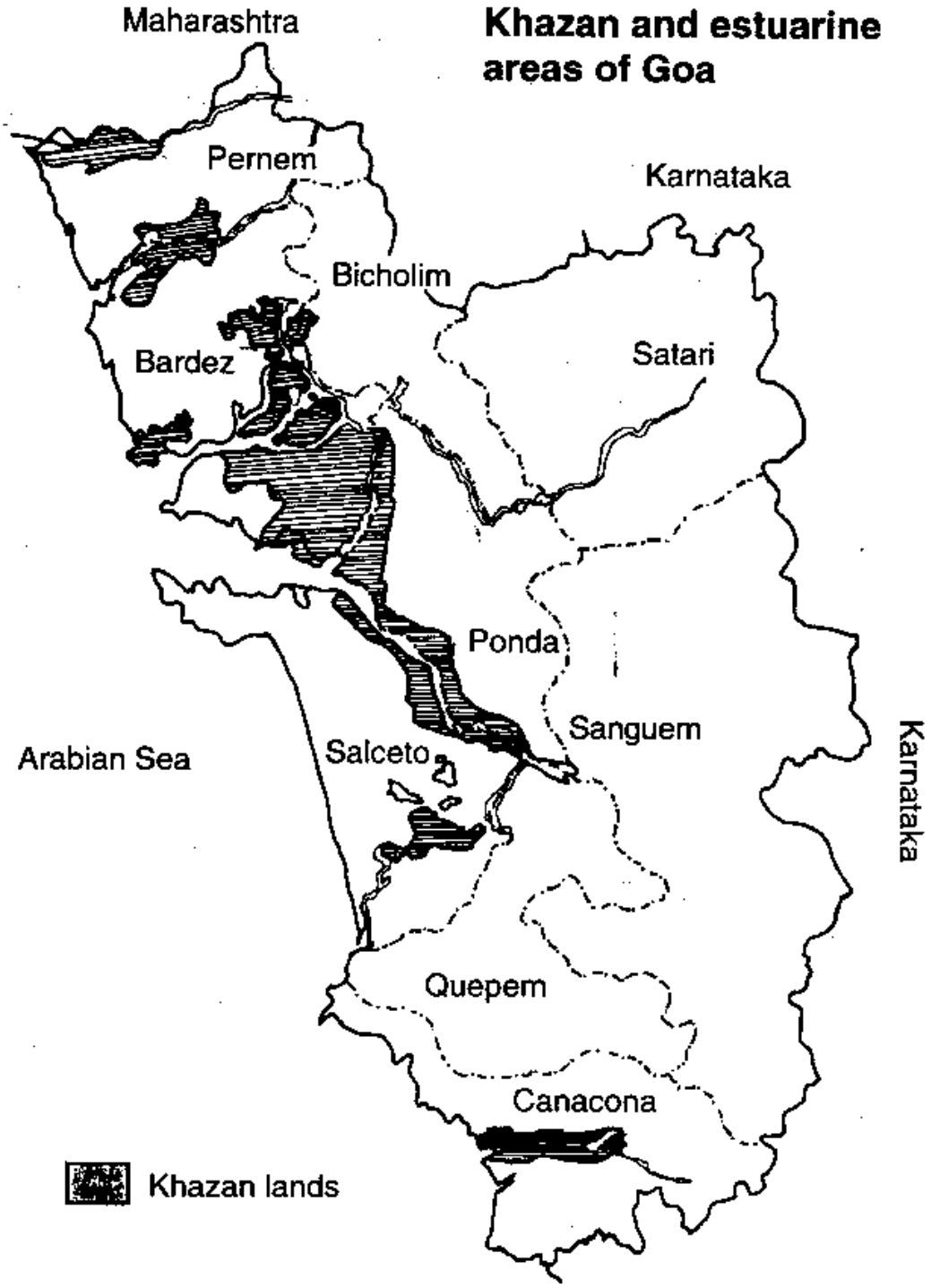
After reclamation

Biodiversity

As a result of careful management of the khazans, the estuarine biodiversity has been largely retained and enriched despite population pressure in these areas. The khazans

have a wide range of indigenous and introduced plant species, many tolerant to salinity.

Mussels, clams, oysters, crabs and prawns arc harvested seasonally and appear in village markets. The fish and shellfish sustain a large population of indigenous and migratory birds and the "mugger", or marsh crocodile.



Khazan and estuarine areas of Goa

Biodiversity of khazan and estuarine lands

Plants: Endemic and introduced

Mangroves: 15 species

Rice: 17 salt-tolerant varieties are cultivated

Grasses and weeds: 20 species

Fish and shellfish: 10 varieties of edible bivalves, 6 of mussels, and clams, oysters, crabs and prawns

Birds: Many resident and migratory birds

Crocodiles, other reptiles

Mammals

Insects and other invertebrates not fully studied

Microflora: Salt-tolerant species of bacteria, fungi, algae and other microorganisms. 150 species of fungi so far known. Many potentially useful microorganisms have been found. Some can degrade oil, other petroleum products and pesticides. Others accumulate heavy metals such as iron and manganese.

Rice

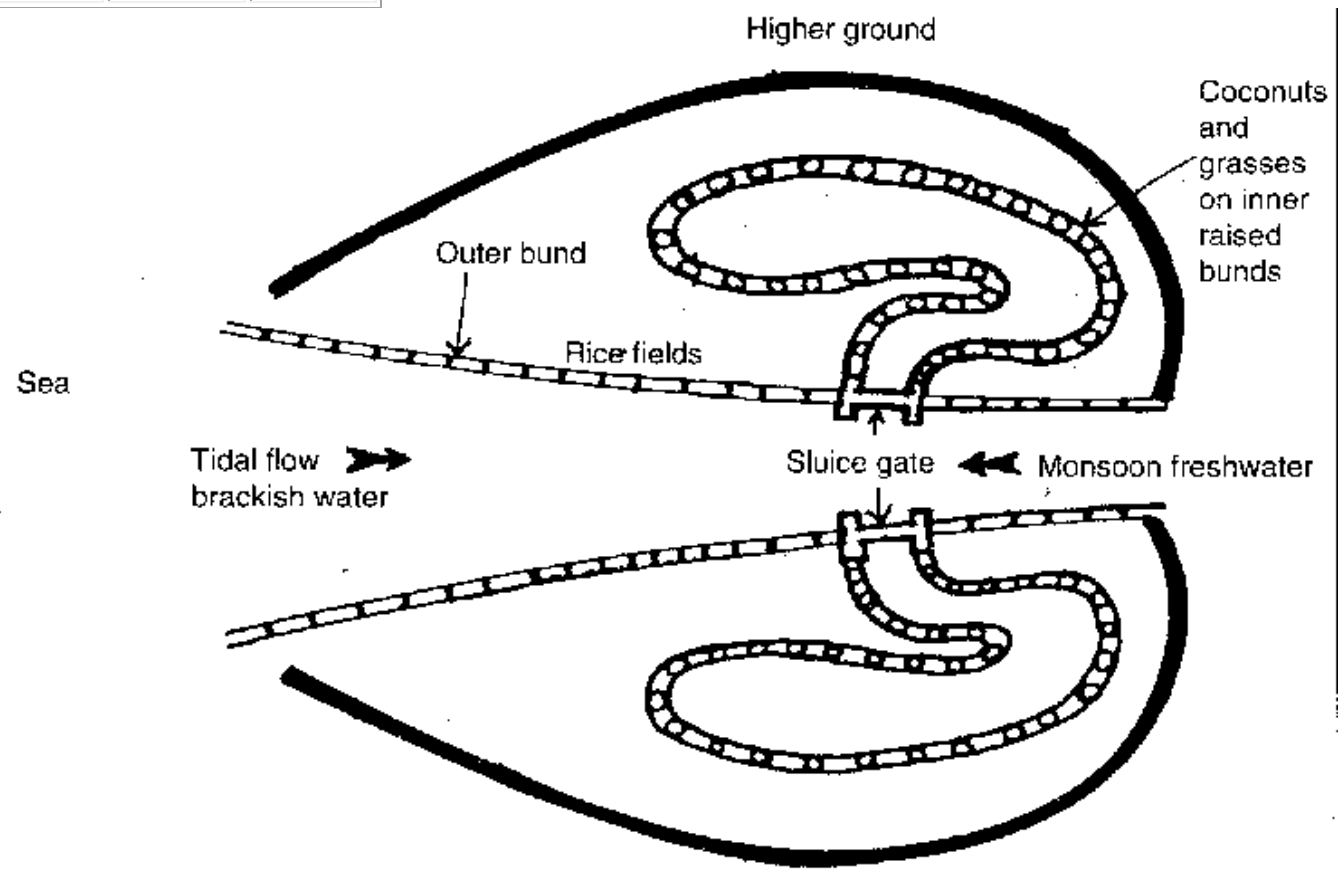
Conditions in the khazan pose special problems for agriculture. The khazan soils are poorly drained and acidic (pH 4.8-5.3), relatively high in organic carbon and iron, and low in calcium.

Numerous types of wild rice have evolved to suit the saline conditions of the khazan. Over centuries, farmers have cultivated rice, selecting and replanting the best strains. In this way, new salt-tolerant varieties have developed, containing genes of enormous value to plant breeders. But these traditional varieties are gradually being replaced by modern, high-yielding varieties. The older varieties and their germplasm are disappearing.

Salt-tolerant rice varieties used

in khazan farming

Asgo	Babri	Belo
Chagar	Corguto	Damgo
Dodig	Giresal	Kendal
Kochri	Kusalgo	Patni
Rungo	Shirdi	Sotti
Valai	Xitto	



Khazan land agro-ecosystem

Cost of a sluice-gate

There are about 600 sluice-gates in khazan areas of Goal Every year the wooden structure needs replacement. This structure is made from beams of local matti timber.

Planks of mango or ghoting are used for shutters and horizontal beams. Each structure needs 100 cubic feet of wood and costs Rs 35,000.

Economic value of the khazan

Besides agriculture, the khazan ecosystem supports 200 ha of traditional salt manufacture, 2000 ha of coconuts and intensive fisheries.

It employs 40,000 farmers, 15,000 horticulturists and toddy-tappers (known locally as renderos), 10,000 fisherfolk and 10,000 others. These activities generate about Rs 150 to 250 million a year. It is estimated that more intensive sustainable use of the khazan land ecosystem could directly and indirectly generate a total of 115,000 jobs.

Impact of "development"

Development activities have had significant impacts on the ecology and economy of the khazan and estuarine areas.

Unfortunately the pace of degradation of the khazan ecology has increased in recent years. This is due to short-sighted planning, public apathy, industrialization and urbanization. The economic lives of the poor will continue to be affected, unless something is done to conserve or restore this complex and valuable ecosystem and its biological resources.

Employment types

1. Estuarine and tidal areas

• Fishing

• Shellfish collection

• Shell extraction for lime-making

• Boat transport

2. Embankments

• Building, supervision, repair, maintainance

3. Farming

• Cultivation of salt-tolerant rice during monsoon

• Pisciculture on co-operative scale after monsoon

• Intentional flooding every 3 years to kill weeds and pests

4. Plantation crops

• Mainly coconut. Also cashew, banana, mango, papayas, onions, chillies

• Seasonal crops

• Vegetables, tubers

• Salt production

The declining salt industry of Goa

From 1891 to 1991, the number of salt-producing villages in khazan areas of Goa dwindled from 36 to 13. The number of working salt pans fell from 268 to 119, and crude salt production declined from 40,000 t to just 18,000 t per year.

Activity	**Ecological impact**	**Economic impact**
Deforestation in river catchment	Increased sediment load, lower biodiversity	Shellfish industry declines
Uncontrolled urban growth	Overload on life-supporting systems	Housing, transport, sewage disposal problems
Pollution (effluents, solid waste, sewage)	Bioaccumulation of toxic residues, eutrophication, loss of aesthetic value	Rivers choked, aquatic life dies, lower fish catches, salt industry harmed
Barge traffic	Erosion of protective embankments	Rice and coconut crops decline; added maintenance cost
Mining	Increased heavy metal load	Agriculture, shellfish and salt industries harmed
Reclamation of low-lying land	Land-water equilibrium disturbed, other areas flooded	Flood damage, loss of pre-existing employment
Road and railway	Drainage pattern affected,	Agriculture affected

construction	erosion	
Uncontrolled pisciculture	Increased soil salinity	Damage to rice, coconut and salt production; groundwater contaminated
Sand, shell and mud extraction	Erosion on bunds, destruction of subsoil fauna	Food chain damaged; soil conservation agents stressed
Slums and scrapyards on bunds	Vegetation cleared, land and water polluted	Local administration stressed

Unique agro-ecosystem

The khazan lands are a unique agro-ecosystem that has proven its sustainability through centuries of use. Although they are the result of conversion of natural estuarine ecosystems, they do not seriously alter either its physical or living components. Instead, the khazans work with existing natural features. Unlike many modern forms of agriculture, the range of agricultural species and varieties adds to the diversity of the estuaries.

Prepared by Nandkumar Kamat

Information kit produced by

WWF-India, Goa division and the

International Institute of Rural Reconstruction

6. Plants, fungi and bacteria

6.1 Plant associations of the central Western Ghats

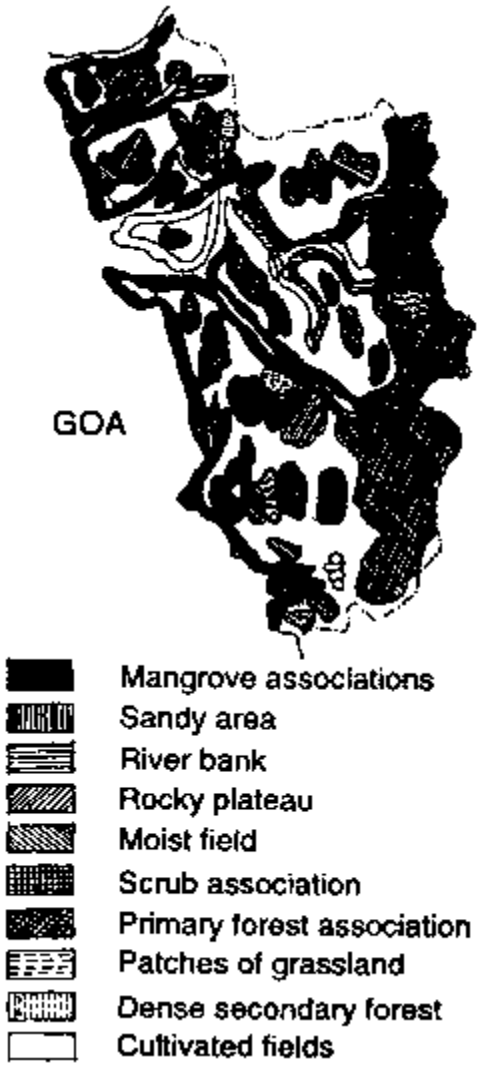
Plant associations

The concept of "plant association" is used in ecology in two ways:

• As a measure of similarity of occurrence of two species.

• As an assemblage of species comparable to a community. This is the meaning used in this sheet.

Plant associations can act as indicators of site quality. For example, the occurrence of Calmus pseudotenuis, Murraya paniculata and Ardisia solanea in primary forest indicates a very good soil. On the other hand, Calotropis gigantea, Trema orientalis and Lantana camara indicate poor soil.



Plant associations

Threats

Studies show that Goa, in the central Western Ghats, has lost 2% of its forest cover annually in the last thirty years. Of the original forest, 55% has disappeared through

conversion to arable land, mining, human settlement or illicit clearing for fuel and timber.

Of an area of 3701 km², 55% of Goa is now non-forested; 42% constitutes dense primary forest, and 3% is secondary forest. Forest degradation is thought to be accelerating at the alarming rate of 2.4% per year.

Conservation approaches

Setbacks Mangrove, riverbank and sandy area associations should be protected by setbacks which limit land use for a certain distance from the mean high water mark.

Protected areas Representative samples of these ecosystems should be preserved in protected areas.

Land use zoning Land use activities which could have negative impacts on various plant associations should be sited accordingly.

Use of indigenous species Land use development should use indigenous spicies adapted to specific sites rather than introduced species. For example, sandy associations could use Ipornoea rather than Casuarina.

Human modifications of plant associations

• Development of hotels and other allied activities has led to the destruction of the sandy area association.

• Firewood collection in the rocky plateau association is resulting in laterization.

• Deliberate burning of grass results in the selection of fire-resistant varieties, which are often unpalatable and of low protein content.

• Humans have created various new associations, for instance in monocropped fields.

Association and role	Species diversity	Representative species
Mangrove The hatching, breeding and spawning ground for several fishes, crustaceans and reptiles; stilt roots of *Rhizophora* and pneumatophores in *Avicennia* aid soil formation by trapping debris.	35	*Rhizophora mucronata, R. conjugata, Kandelia candel, Avicennia officinale, Acanthus ilicifolius, Bruguiersa gymnorrhiza, Cyperus laevigatus, Cyperus arenarus*
Sandy area Effective sand binders; *Spinifex littoreus* and creepers like *Ipomoea pes-caprae* trap sand carried by strong winds.	302	*Sonneratia apetala, Pandanus tectorius, Vitex negundo, Thespesia populnea, Pogostemon paniculatus, Spinifex littoreus* (co-dominant), *Ipomoea biloba, Launea fallax, Urginea indica, Cassytha fileformis, Plumbago zylanica, Lantana camara, Phyllanthus reticulatus, Calophyllum inophyllum, Polycarpaea corymbosa, Ipomoea pes-caprae.*
Riverbank freshwater Reduces soil erosion and harbours many endangered plant species.	300	*Barringtonia acutangula, Ficus glomerata, Lagerstroemia parviflora, Pandanus tectorius* (occasionally), *Pongamia pennata, Syzyguim leucoxylon.* Includes hydrophytes, especially those in marshy areas and slow moving water. E.g., *Flagellaria indica, Acrostichum aureum, Cyperus, Nymphaea, Utricularia* and *Drosera* spp.
Rocky plateau Predominantly deep-rooted lithophytes which avoid competition with shallow-rooted plants. It also contains threatened plant species.	520	*Alstonia scholaris, Hydnocarpus laurifolia, Sterculia urens, Careya arboreg, Bombax ceiba, Holarrhena antidysenterica* (co-dominant) *Lepidagathis cristata, Lepidagathis prostrata.*
Moist field Contains many evergreen plants for food and timber; also a number of leguminous plant species which modulate and improve soil fertility.	462	*Syzyguim sumini, Mangifera indica, Holigarna arnottiana, Artocarpus gomezianus, Buchanania lanzan.*
Scrub Indicates the extent to which degradation has taken place.	456	*Ziziphus glaberrima, Z. oenoplia, Aburs precatorius, Terminalia paniculata, Calyopteris floribunda, Memevylon wightii.*
Dense primary forest Represents the climax vegetation of the region and is the starting point of all the rivers.	804	*Bridelia retusa, Dillenia pentaphylla, Vitex altissima, Xylia xylocarpa, Viteria indica, Dalbergia latifolia, Rauwolfia densiflora.*
Patches of grassland Important for livestock forage	130	*Iseilema laxum, Ischaemum conjugatum, Heteropogon contortus, Digitaria longiflora.*
Dense secondary forest Many economic plants. Sunlight penetrating the mid-ventral portion of the canopy results in great diversity of orchids.	628	*Garcinia indica, Mimuscops eleuge, Strychnos nux-vomica, Terminalia belleriac.*
Cultivated areas Man-made associations; harbour genetic diversity of domesticated plants.		

Prepared by Henry N. Nyabuto, Jovita V. D'Costa and Dr. S.G. Tome

Major plant associations of Goa

6.2 Rare and endangered flowering plants

Today we are losing at least one flowering plant species per day from tropical forests alone. If the present trend continues, about - 25% of the world's 250,000 flowering plant species will be lost in the next few decades. Another 25% may be lost by the end of the 21st century.

Because plants and animals depend on each other, as many as 30 dependent species may be lost when one plant becomes extinct. It is estimated that the loss of species attributable to the loss of rain forest is somewhere between 0.2 and 0.3% per year. If the world contains one million species, this amounts 2,000 to 3,000 species lost per year. If the world has 10 million species, we could be losing as many as 30,000 species per year-or almost 100 per day.

India is one of the world's main centres of biodiversity. As many as 15-20% of India's flowering plant species are threatened.

Importance of flowering species

• Each species plays a role in its ecosystem. The loss of one species can reverberate through the ecosystem, reducing its total diversity and possibly its stability and long-term sustainability.

• Flowering plants provide most of our food and have many other uses. A species may have uses we have not yet even dreamed of.

• Some 80,000 species of edible plants are known. But we presently use only 30% of these for food. The vast majority of our staple food needs are met by just three species: wheat, rice and maize. The remaining species are underexploited.

• Many endangered plants could have medicinal uses.

• Some species could provide fuelwood, timber or fibre.

• A number of endangered species can be used in horticulture or as ornamentals.

Endangered species: In danger of extinction if present trends continue.

Vulnerable: Likely to become endangered if trends continue.

Rare: Not currently endangered, but at risk of becoming so.

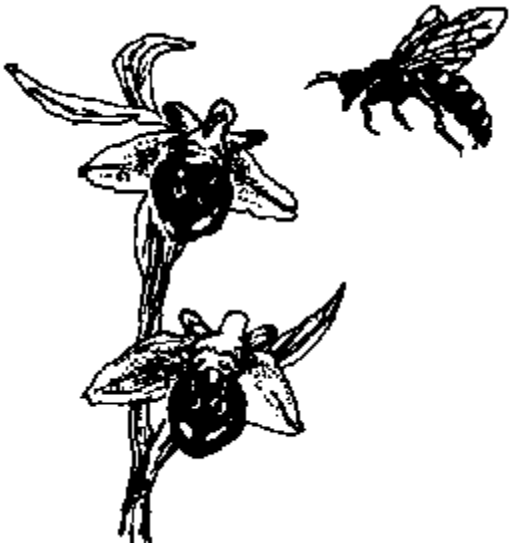
Threatened: Species in any of the above categories.

Wasp or orchid?

An orchid found in the Western Ghats looks so similar to a wasp that even the wasps are confused.

The labellum of Cottonia pedunculare is very similar in size, shape, colour and smell to a female wasp. The orchid starts flowering in April and May, when male wasps emerge from the ground.

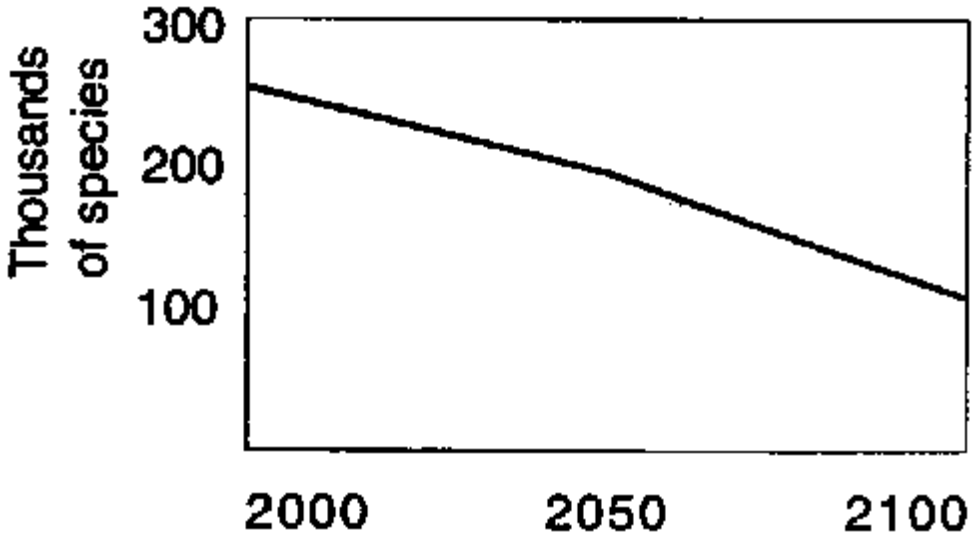
The disguise is so perfect that the male wasp takes the labellum for a female wasp. It mates with the flower, pollinating the flower in the process.



Wasp or orchid?

Ecological disaster?

As many as half the current 250,000 species of flowering plants could be extinct by the year 2100.



Ecological disaster?

Threatened flowering plants of the Western Ghats of Maharashtra

Plant species	Region of occurrence	Status	Uses

Abutilon ranadei	Amba Ghats, Vasota fort	Endangered	Ornamental
Aponogeton bruggenIi	Kudal, Konkan	Endangered	Aquarium, ornamental
Arisaema murrayIi	Mahableshwar	Endangered	Ornamental
Begonia trichocarpa	Highest peaks of Westem	Endangered	Ornamental
Brachystelma malwanensis	Malwan, Konkan	Endangered	Food
Camptorrhiza indica	Ratnagiri, Konkan	Endangered	Ornamental, potential use in plant breeding
Ceropegia vincaefolia.	Konkan caves, Kas plateau	Rare	Ornamental, food
Ceropegia sahyadrica	Gaganbavada, Ambdi	Rare	Ornamental, food
Ceropegia vincaefolia	Kanheri caves, Kas plateau	Rare	Ornamental, food
Chlorophyllum borivillianum	Kanhari caves	Rare	Ornamental
Chlarophylum glaucum	Western Ghats	Rare	Ornamental, food
Curcuma decipiens	Konkan	Endangered	Medicinal
Crinum brachynema	Mahableshwar	Endangered	Ornamental
Cryptocoryne cognate	Ratnagiri, Malwan	Rare	
Dipoadi saxorum	Kanheri caves	Endangered	Food
Dipcadi concanense	Ratnagiri, Deogad, Malwan	Rare	Ornamental, food
Decashistia trilobata	Western Ghats	Endangered	
Dendrobium microbubon	Western Ghats and Konkan	Endangered	

Eulophia ramentacaea	Western Ghats	Endangered	Ornamental
Frerea indica	Purandar forest?	Endangered	Ornamental
Habenaria caranjensis	Western Ghats	Probably extinct	

Prepared by Dr. S. Yadav

6.3 Medicinal resources from the forest and sea

Since the dawn of civilization, people have cultivated and collected plants from wild sources to seek remedies for their ailments.

The first written evidence of the use of medicinal plants dates back to the Atharva Veda. Charak Sanhita, Sushrut Sanhita and Kashyap Sanhita mentioned the use of plants (from both land and sea) to treat human ailments. The Ayurvedic system of treatment developed and flourished in India. The other major Indian systems of medicine Siddha, Unani and folk medicine also rely heavily on plants. Over 80% of remedies of these systems are plant-based.

Tribal and rural communities possess a rich ethno-botanical knowledge base. Of the 20,000 species of flowering plants found in India, about 2,000 are thought to be used for medicinal purposes.

Many scientists have studied medicinal plants in India. Pioneering work on the plants of Goa was done by Garcia da Orta (1563), Dalgardo (1898) and Dada Vaidya.

Despite their importance, most medicinal plants are obtained from the wild; only a handful (generally those with export potential) are cultivated on a large scale.

The Western Ghats are very rich in medicinal plants, but environmental degradation mean that plants that were previously easily found now grow only in undisturbed areas. Some plants, such as asparagus, are cultivated on a large scale, but naturally growing wild varieties has become rare.

Forests are the primary storehouse of medicinal plants. But they are disappearing at an alarming rate, taking with them a wealth of wild species. Consequences are:

• Many medicinal plant species are threatened with extinction as a result of genetic erosion.

• The availability of medicinal plants has decreased to such an extent that the tribal and rural communities no longer have easy access to medicinal plants for their health care needs.

• Due to shortages of genuine crude drugs there is widespread substitution and adulteration in herbal medicines, often leading to clinical failures. The credibility of herbal medicine suffers.

A lack of knowledge of local flora and the belief in the fast relief provided by allopathic drugs mean that medicinal plants and knowledge of how to use them are vanishing. It is increasingly important to educate local people on the conservation of medicinal resources in the forests.

Writings on medicinal plants through history

1563 Garcia do Orta, the personal physician to the Viceroy of the Portuguese colonies in India, described more commonly used medicinal plants from Goa in Coloquios dos Simples e Drogas e Cousas Medicinais da India.

1578 Acosta presented plants from Cochin and Goa in Tratado das Drogas e Medicinais das Indian Orientaias.

1824 Roxburg published Flora Indica, referring to plants from this region.

1898 Dalgardo's Flora de Goa e Savantvadi.

More recent publications include:

1954 Vaidya's Estudo Sobre e Historia da Farmacia Ayurvedica

1966 V. D. Vartak's Enumeration of Plants from Gomantak

1985 Rao's Flora of Goa, Daman, Diu, Dadra & Nagar Haveli.

"There is no single thing in the world that is not a medicine" Avurveda

Research on medicinal plants

The Government has set up special institutes and projects to work on various aspects of medicinal plants. They focus on a few commercially important species, such as

Plantago ovata, Catharanthus roseus, Papaver somniferum, Cassius angustifolia, and Rauvolfia serpentine.

Institutions studying medicinal plants include the Indian Council of Agricultural Research, Central Institute of Medicinal and Aromatic Plants, Lucknow; Regional Research Laboratory, Jammu and Jorhat; National Botanic Research Institute, Lucknow; Central Council for Research on Ayurveda and Siddha (Ministry of Health); and various universities and institutes.

The sea is also being tapped for its rich resources. Many algae and seagrasses have been found to contain essential alkaloids or active constituents which could be used in drugs.

Conservation

Various methods must be used to help conserve our plant medicinal resources.

Personal level

• Individuals should use local or home medicines for minor ailments.

• Home remedies given by elders should not be neglected; on the contrary, they should be used after confirming their effects from ancient literature.

• Individuals should learn to identify and use medicinal plants found locally.

Community level

• School and college groups should visit forests with experts to learn to identify and use medicinal plants.

• Nurseries to grow wild medicinal plants should be taken up by schools, colleges and clubs.

National level

• Incentives or subsidy may be given to individuals who grow medicinal plants.

• Techniques like tissue culture for medicinal plants should be practiced, and not left merely as an academic exercise. Research should be applied, not confined to the laboratory.

• Legislation should be passed and implemented to conserve and protect medicinal resources.

• Political parties should include the conservation of natural resources in their election manifestos.

Medicinal uses of selected plants

The uses below are taken from various Indian medical systems. Caution is necessary when using these plants to treat diseases: incorrect use or dosage levels can be dangerous. Prescribing medicinal plants should be left to those with experience and knowledge of diseases and corect dosages.

Abutilon indicum (Petari)

Though different morphologically from Sida spp., it has similar functions in strengthening the body.

Acacia sinuta

A powder from the pod fruit is widely used to treat dandruff. Roots are emetic.

Achyranthes aspera

Improves digestive secretions and helps reduce flatulence. It is useful in kidney diseases, especially kidney stones. It expels cough from the lungs and is used to treat piles.

Aegle marmelos

Lord Shiva is often decorated by the leaves of this plant. A leaf extract is used to cure jaundice. The tender leaves are used for dysentry, fruit syrup for indigestion, fruit juice for cough, and roots for piles, sleeplessness and psychological disorders. Many diabetic patients are benefited by the leaves.

Andrographis particulata (Kiraitem)

It is given for infants to relieve griping, irregular stools, and loss of appetite. It is prescribed in cold and fever.

Asparagus racemosus (Asparagus, Sosro)

A well-known. versatile medicinal plant, it used as a galactogauge (to increase milk secretions in mothers). It also works as a diuretic. It is used to treat bleeding diseases such I as dysentry and diarrhoea, eye disorders, paralysis and infertility. It is also used as a tonic to increase body weight.

Asparagus racemosus

Azadirachta indica

Many parts are used as medicine for various skin diseases, liver disorders, allergic reactions and indigestion. The principal alkaloid, azadiractin, is a good insecticide.

Bauhinia variegate

Used to treat lymph node infections in the cervical region. The skin of the bark is used externally and internally. The flowers are used to stop bleeding, as in dysentery and bleeding piles. It is also used to treat chronic wounds.

Bombax malabaricum

Its powder gives vigour and vitality to the body. Flowers increase urination. The gum is useful in treating all diarrhoeas.

Butea frondosa

Its flowers are useful in to treat kidney stones and urinary disorders.

Caesalpinia crista (Vakeri)

Root is anti-inflammatory and is good for tumours and removing placenta. Leaves are used as anthelmintic and are also used in elephantiasis and smallpox.

Caesalpinia digynia

Tubers and roots are used to treat diabetic wounds.

Calotropis gigantea (Rut)

Juice of leaves is used as anthelmintic, laxative and cure for piles. Leaves are useful for removing pain from joints. It contains resin. Juice contains enzyme similar to papain. Latex is toxic.

Capparis zeylanica (Katya Ghosvel)

Root is used as sedative. It is used to relieve sun burn.

Careya arborea (Kumayo)

Bark is used in tumours, dyspepsia, piles and epileptic fits. It is also used in dry cough. Used with honey to treat excessive menstrual flow. Also a laxative.

Casearia esculenta (Satanguem)

Root is recommended for liver troubles and popularly used for diabetes.

Cassia fistula (Balo)

Leaves act as purgative and are used to treat boils, abscesses and ear disorders. Fruits are a mild laxative. Seeds are used in jaundice. Root is useful in skin diseases.

Clerodendrum serratum

Root decoction works well against malarial fever and as an anti asthmatic. An ointment prepared from the leaf and butter cures eye disorders. A root paste made with honey is used to correct ear infections.

Crateara religiosa

Used mainly for breaking urine stones. Its skin and bark are useful for lymph-node infections. It reduces fat and increases the quantity of urine.

Datura meter

Seeds are used to stop vomiting. Leaves are used for mumps and gonorrhoea.

Dioscorea bulbifera

Bulbs and rhizomes are used to cure dysentry, piles, and skin diseases.

Eclipta alba

Used externally and internally to treat burns and skin lesions. It improves respiration in cases of cough.

Erythrina variegate

The skin is used to treat high fever, insomnia and dysentery. The leaves are used in menstrual complaints, difficulty in urination. It is also used to treat earache and toothache.

Ficus benghalensis (Wad)

Wide medicinal uses. The latex is used to cure arthritis; a decoction of bark, garlic and turmeric is given to diabetic patients to reduce blood sugar. A decoction of young shoots is used to cure dysentery when the sputum contains blood. Ripe fruits are used in diabetes, and young shoots are used as a uterine tonic.

Ficus glomerata

Roots are used for various urinary diseases and menstrual complaints. Fruits boiled with milk are used as anti abortive.

Ficus religiosa

The ripe leaf is given with betel leaf to cure jaundice. Fruit are used to treat urinary disorders. Frequent eating of ripe fruit induces infertility in women.

Gloriosa superba

Seeds are rich in colchecine alkaloid and the rhizome is used as an analgesic. Leaf extract act as a wormicide and the paste of rhizome is applied externally for smooth delivery.

Gmelina arborea (Shivan)

Root is used in abdominal pains and fevers. Fruit promotes hair growth.

Gymnema sylvestris

An emetic, it is mainly used in diabetes to lower the sugar level. The leaf has anti-inflamatory and wound-healing properties. Snuffing of dried leaf powder clears the nose.

Helicteres isora (Allay)

Bark is used as expectorant. It cures scabies when applied externally. Root is useful in diabetes.

Hemidesmus indicus (Uparsal)

A versatile plant, used to treat more than 20 diseases. The root is used to treat urinary tract infections, kidney and skin disorders. It is also used as an appetizer, rejuvenator and galactogogue, and to treat epileptic fits in children. It cures syphilis.

Holarrhena antidysenterica (Kudo)

The plant is rich in alkaloids and has an antidysenteric action. It has been shown to have antiamoebic properties. Flowers are used as blood purifier; the root and bark with buttermilk is given as an appetizer and digestor. The leaves regulate menstruation. Seeds with honey and saffron are said to favour conception.

Ixora parviflora (Dhavi Pitcoli)

Roots are given to females in cases of white discharge.

Mallotus philippinensis

The hair-like structures from the fruit are used as a laxative. This plant is useful in treating worms, skin diseases and wounds.

Momordica dioica (Faglin)

Leaves are used in headache and urinary infections. Roots are useful for diabetes.

Oroxylum indicum (Dhonduk)

Bark is used for liver troubles. Seeds are used as purgative.

Paederia foetida (Modashi)

Roots are given for dysentery, piles and rheumatism. It contains essential oils and alkaloids.

Piper longum

A good rejuvenator, used to increase appetite and build vigour after diseases such as typhoid, and to treat various diseases of respiratory and digestive systems. More than dozen remedies can be prepared to treat arthritic diseases, scialica, etc

Piper nigrum

An excellent household remedy used from time immemorial as an appetizer, digestive and antiflatulant. It was a first and best remedy for cholera. It is also useful in curing skin disorders and piles.

Plumbago zeylanica

Roots are digestive and appetizing in nature. They are useful in acute skin diseases, diseases of bones and joints, and piles.

Plumbago zeylanica

Pterocarpus marsupium (Asan, Raktaragado)

Bark is a pain killer and anti-inflammatory. Leaves are used for skin diseases.

Randia dumetorum

An emetic. Its smell is nauseating, so it is used in Ayurveda to remove excess cough. It is also used as fish poison.

Rauvolfia serpentine (Adaki)

Roots are used for painful affections of bowels and as a remedy for snake bite. Rauvolfia lowers blood pressure and is used to treat herpes, insomnia and insanity. Uses are mainly attributed to alkaloids.

Rhyllanthus emblica

An important ingredient of triphala churan and chavanprash and a rich source of vitamin C. Hair oil is prepared from fruit. It is a good appetizer, wound healer and rejuvenator. It is also used to treat several chest disorders.

Ricinus communis

A laxative. The roots are used to break urinary stones and to stop diarrhaea. Seeds are laxative, roots have the opposite effect. Roots are also very good painkillers.

Rubia cordifolia

Used to treat skin diseases, gout, urinary diseases, diabetes, jaundice and intestinal disorders.

Santalum album

Perhaps the "coldest" remedy in Ayurvedic medicine. It is used to treat burning sensations such as burning urination. It is used in high fevers and to treat excessive thirst.

Saraca asoka

Root bark stops bleeding. It is used in gynecological disorders where excess blood is lost.

Semecarpus anacardium

A frontline remedy in cancer treatment. It is antiseptic and antidysentric. Its decoction is given to cure asthma.

Sida cordifolia, Sida rhombifolia

Used to strengthen the body.

Solanum indicum

Leaf and ginger extract is used as antiemetic. Smoke of fruit is used to treat dental disorder, a root decoction as a diuretic, and leaf paste to treat skin diseases. It is also an excellent remedy for cough.

Stephania hernandifolia (Padvel)

Roots are very useful in urinary diseases. It is also given in fever and dyspepsia.

Sterculia urens (Dhavorukh)

Germ is used for diabetes and liver troubles.

Strychnos nox-vomica (Kajro)

Seeds are used as appetizer in small doses and against snake bite. It is also given in colics. Juice of wood is useful in cholera.

Syzygium cumini

The seed powder lowers the urine sugar; a bark decoction is used to cure throat infection and toothache; a leaf extract is given with goat milk to cure childhood dysentry. A preparation made by keeping chopped leaves with iron for a long time is used to treat anemic patients.

Terminalia arjuna

The plant has wound-healing properties and is a good cardiac tonic. It is widely used in treating fractures.

Terminalia bellirica

The skin is used to treat a dry or hawking cough. It is one' of the ingredients of triphala. Research shows that this plant possesses antibiotic properties.

Terminalia chebula

Thousands of Ayurvedic recipes contain hirda. It is very good for the eyes, skin and digestive system. It is used as laxative.

Terminalia chebula

Tinospora cordifolia (Amkutvel)

The bitter tonic obtained from this plant can cure various fevers. The plant can also be used to increase blood haemoglobin and to treat jaundice and various skin diseases.

Tylophora asthmatica

A leaf or root decoction is used in small concentrations used to cure asthama. It is emetic in nature and poisonous at high dosages. It also has a sedative effect.

Urginea indica

The bulbous root is used to correct heart diseases. It is also used in allopathic drugs to cure heart disease.

Viburnum foetidum (Narval)

Roots are used as emmenagogue. Leaves are useful in menorrhagia.

Vitex negundo (Lingad)

An analgesic; the leaves are applied externally to reduce arthritic pain. A leaf decoction brings the uterus at normal size after delivery; the seeds are used to correct skin disorders.

Vitex negundo (Lingad)

Vitis quandrangularis

Contains calcium oxalates, carotene and vitamin C. It is given internally in the patients with fractures, asthma and increased menstrual flow.

Woodfordia floribunda

Gynaecological complaints like whites are cured by this plant. Its flowers are used in many Ayurvedic preparations. Large-scale cultivation can support bee-keeping and honey making.

Sea products

Pearls, corals, corry and shanka

These are medicinally superior to plants. All are rich in organic calcium, which is easily assimilated by our body. Pearls and corals are "cold" in nature, so are used in diseases with burning, such as hyperacidity and burning urination. Shanka is an

excellent antacid. All are used to treat ricketts. Sepica officina is used to treat ear infections.

Prepared by R. V. Gaitonde, T. M. Patil, V. S. Haldavnekar and Kasturi Desai

6.4 Poisonous plants

Eating some plants can cause illness-and can even kill you. So beware of plants you do not know!

Some plants are poisonous if consumed in large amounts, but can be used as medicines in smaller amounts. About 700 plant species in the world are known to cause illness or discomfort to people and animals.

Since the dawn of civilization, people have cultivated and collected plants to cure ailments. Ancient texts such as the Atharva Veda mention the use of medicinal plants.

Randia dumetorium

Why are plants poisonous?

Poisonous plants contain chemicals that react in harmful ways with our bodies. These chemicals include glucosides, acids and alkaloids. &me plants have evolved poisons as a defence mechanism-to prevent them from being eaten by insects and other animals.

Mucuna gigantia

Do not eradicate poisonous plants!

The aesthetic value and usefulness of poisonous plants far overshadow their poisonous effects.

People, especially children, need to know which plants are poisonous. They should not eat or even touch certain household ornamentals, garden plants or wild species.

If someone is poisoned

In general, it is best to make the person vomit. Mix some teaspoons of salt in a glass of water. Make the victim drink the water until he or she vomits.

For skin irritations, wash the skin with clean water and mild soap. Gently rubbing the juice from aloe over the skin can help ease the irritation.

If these remedies do not work, take the person to a clinic. Take with you part of the plant that caused the problem to help the doctor decide on the best treatment.

How to identify poisonous plants

There is no hard and fast rule to identify poisonous plants. In general, beware of

• plants with white latex or coloured sap.

• mushrooms and toadstools: especially brightly coloured ones

For more information:

Baser, B. D., Indian medicinal plants

Cooke, T., Flora of Bombay

Dastur, Medicinal plants of India and Pakistan

Jain, S. K., Medicinal plants

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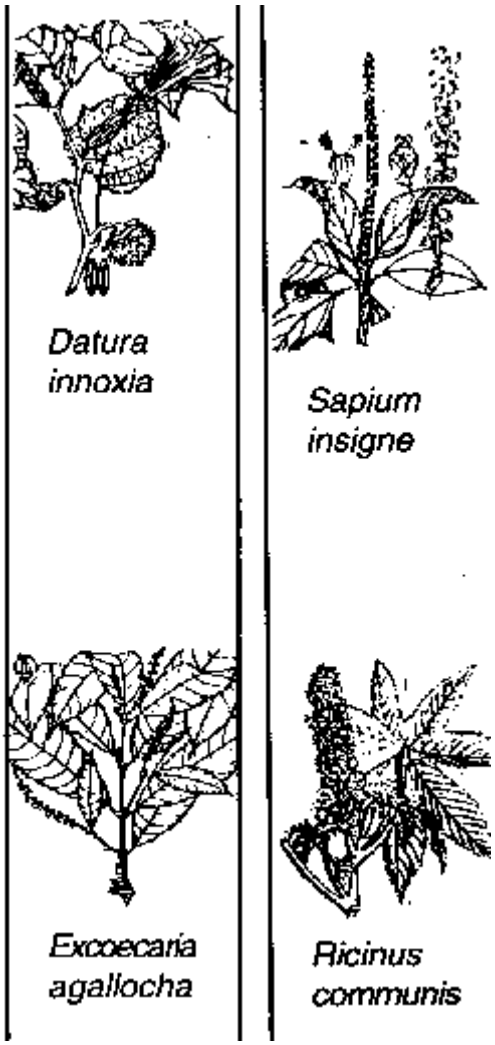


Poisonous plants

List of poisonous plants found in Goa

Plants	Poisonous parts	Symptoms
Abrus precatorius (Gunj)	Seed	Powerful oedema, strong swelling
Allamanda cathartica and other members of Apocynaceae(Kaner), Korno	Bark, leaves,	Cathartic (voids bowels)
Alstonia scholaris, Parthenium (Satwan) Eupatorium (Congress Grass) and some	Pollen grains	Asthma

grasses		
Anthurium, Dieffenbachia, Philodendron and other members of Araceae	Leaves and stem	Irritation, skin dermatitis
Argemene maxicana(Firengi dutro)	Seeds	Purging, vomiting
Calotropis gigantea (Ruhi)	Latex in all parts	Irritation
Caryota urens (Billa Mard)	Pulp of the fruit	Irritation
Catharanthus roseus (Sadaphooli)	Foliage	Diarrhea
Croton tiglium	Seeds	Purgative
Datura innoxia (Dutro)	Leaves and seeds	Sedative
Euphorbia antiquorum and other species of Euphorbia (Nival)	Latex in all parts	Irritation
Exoecaria agallocha (Kharo-uro)	Latex or acrid juice	Blisters, purgative, causes abortion
Sapium insigne (Uro) Semicarpus anacardium (Bibbo) Girardinia zeylanica (Khaskulio), Mucuna pruriens and other plants having stinging hair	Leaves and fruits	Dermatitis
Hydnocarpus laurifolias (Khasti)	Seeds	Purging and vomiting
Jatropa multifida (Chini-erandi)	Foliage and fruit	Vomiting, diarrhea
Lantana camera (Ghaneri)	Berries	Bloody diarrhea,

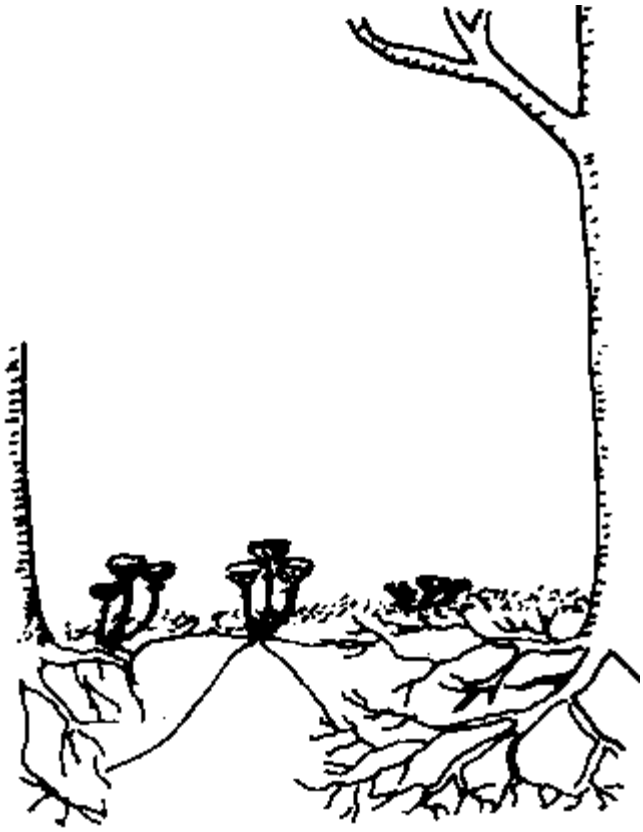
Lasiosyshon eriocephalus(Dant paddi)	Stem, leaves, bark	Drops out teeth
Rauwolfia serpentine (Aadki)	Roots	Nasal congestion, lethargy, Parkinsonism, mental depression
Ricinus communis (Erand)	Seeds	Vomiting, colic convulsion
Strychnos.nux-vomica (Caro)	Seeds	Convulsions, paralysis and death

Prepared by KasturiDesai

6.5 Fungi: Biodiversity, ecology and use

Fungi are vital parts of the ecosystem, but we know very little about them. About 70,000 species of fungi are recognized and described of the 1.5 million extant taxa. That means only about 5% of the fungal world is known to us.

Fungi are extraordinarily diverse in form, structure, function and habitat. Nearly all are microscopic. The body of a fungus is composed of a filamentous web-like structure, the "mycelium"



Fungi

What are fungi?

Fungi may rival flowering plants in their species diversity. They outweigh the animal kingdom in their variety of form and struc ture.

Fungi are an integral part of the ecosystem. They are present in land, forests, soil, water, air--everywhere.

They are a unique group of organisms in the living system. Fungi are not plants because they have no green chlorophyll. They depend for their sustenance on living (or dead) plants, animals or other organisms.

The fungi break down a huge range of organic substances: chitin (the external skeletons of insects), keratin (skin, hair, horn, and feather), cellulose (most plant debris), lignin (wood) and even petroleum, plastic and DDT. They are the world's number one recyclers!

Common fungi include breadmould, watermould, yeast, mush rooms. puffballs. rusts. smuts. ergot. blights. and mildews

Fungi in history Fungi such as mushrooms and morels have been known to humans from early times. Vedic and mythological writings refer to fungi, e.g., Soma of Aryans. Fungi have attacked crops since the dawn of agriculture: e.g., rusts, smuts and blights of cereals; mildews; the Irish potato famine; the Wollo famine of Africa.

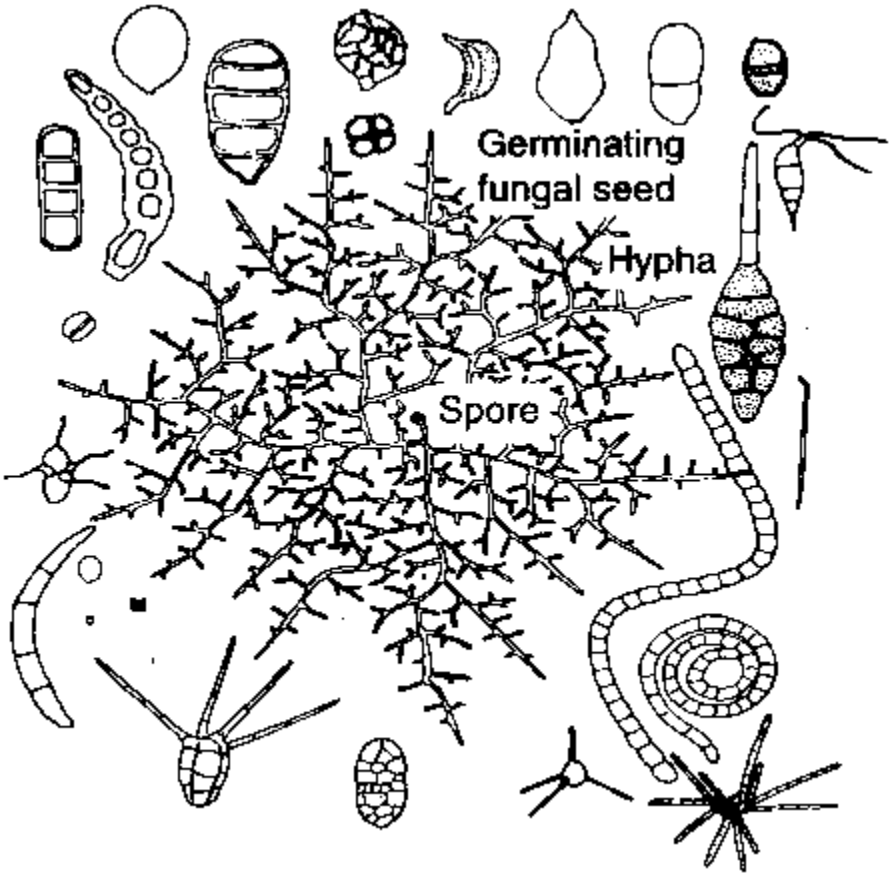
Fungal spores: Fungi reproduce by forming tiny spores, the fungal equivalent of seeds. Every breath we take is laden with fungal spores. A single mushroom produces millions of spores. Spores:

• Are dispersed by wind, water, insects or other animals.

• Survive unfavourable conditions for long periods.

• Come in a dazzling array of forms.

• Vary in diameter from 0.5 to 50 rum.



Fungi

Fungi in Western Ghats forests

Luxuriant forests flourish on the warm, humid, western side on the Western Ghats escarpment. Although about 13,000 species of fungi have been recorded, the mycota of this region are still largely unknown. More research is needed to explore the fungal riches of the region.

Mycorrhizae: Symbiosis between plants and fungi

Mycorrhizae are fungi which exploit large volumes of soil and have an intricate association with plants to meet their basic need: energy-rich carbon compounds. They take phosphorus from the soil and pass it on to plants-in exchange for photosynthates from the plants.

Mycorrhizal plants perform well in infertile soils, withstand heavy metal and acid rain pollution, mining soils, extremely acid or alkaline soils, and so on. They help plants

overcome the shock of transplanting, so are very valuable in afforestation programmes.

Although about 300,000 plant species are believed to have mycorrhizae, only 130 species of mycorrhizal fungi have so far been described.

Western Ghat forests are gene banks of mycorrhizal fungi. We should look for them, study them and put them into use in agriculture and forestry.

Biological control of mosquitoes using fungi

One day, it may be possible to control mosquitoes using fungi.

Mosquitoes carry various human diseases-such as malaria, dengue fever and Japanese encephalitis. They breed and lay eggs in stagnant ponds and ditches. About 6 species of fungi are known to infect mosquitoes.

The bacteria Bacillus thuringiensis and B. sphaericus are used to control mosquitoes. It may be possible to develop certain fungi to control these insects, too.

Western Ghat streams, fields, ponds and other natural water bodies are storehouses of these fungi.

Decomposition of dung

We may turn up our noses, but dung is an important energy resource in forest and grassland ecosystems.

Some fungi are specialist dung decomposers. Dung cannot be decomposed completely without fungi.

Fungi are intimately involved with herbivorous animals. An example is Pilobolus. Several species are known from the Western Ghats. This fungus can shoot out spores onto vegetation up to 3 meters away. The spores germinate only if they pass through the gut of herbivorous animals.

Litter decomposition in forests Fungi and other organisms degrade the leaves, twigs and other organic litter that fall to the forest floor all year round. Different fungi decompose different substances. In general: Mucoraceous fungi decompose sugar Ascomycetous forms decompose cellulose (e.g., leaves) Basidiomycetes decompose lignin (e.g., tree bark).

Fungi in poetry The great Persian poet Omar Khayyam wrote... "A loaf of bread, a jug of wine, and thou!" Bread and wine are both made with fungi.

Saprophytes: live on dead and decaying plant and animals.

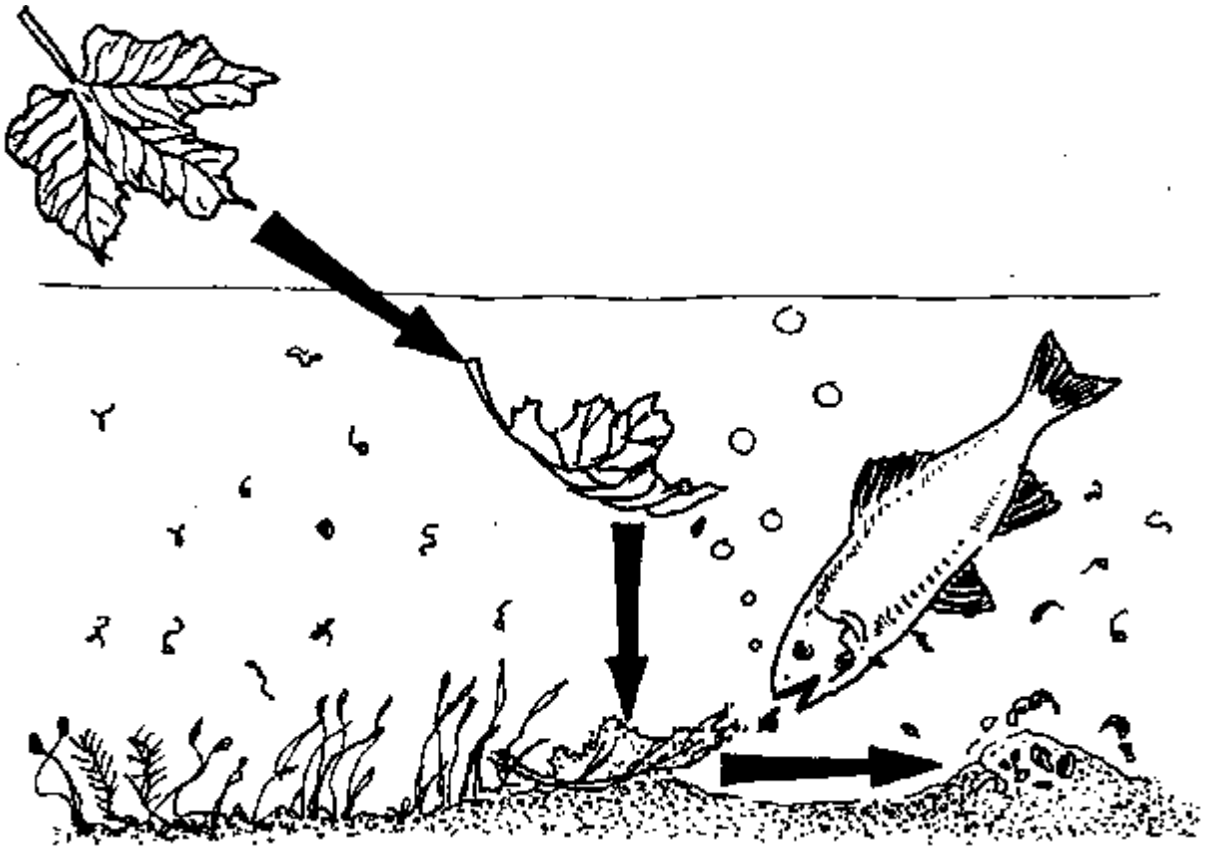
Parasites: live on living plants, animals and other organisms.

Mutualists: live in symbiosis with algae (lichens) and plants (mycorrhizae).

Three types of fungi

Fungi in stream ecosystems

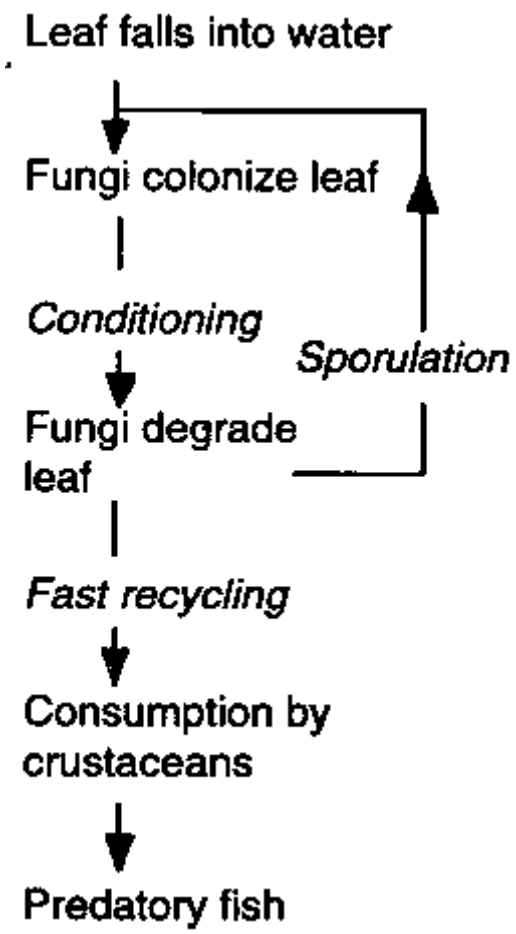
Many rivers flow from the Western Ghat hills to the sea. Several types of aquatic fungi are important in the stream ecosystem.



Fungi in stream ecosystems

Invertebrates such as crustaceans living in the stream cannot directly consume leaves that fall into the water. Fungi colonize these leaves and condition them so they can be eaten by invertebrates. These crustaceans in turn form food for fish in the stream.

Aquatic fungi are sensitive to organic pollution. They are unable to tolerate water contaminated by material such as nitrogenous fertilizers, fungicides and insecticides.



Fungi in stream ecosystems

Prepared by Dr. D. J. Bhat

6.6 Conserving fungi

There is a strong bias in most people's thinking about biological. conservation. We worry about the future of giant pandas in China, orang-utans in Indonesia, tigers of India and the mountain gorillas in Africa. Humans seem to have an emotional investment in these and other large animals. We also worry about trees and flowering plants. Large sums of money are raised and spent to save such species.

But when it comes to fungi, what do we find? Here is a whole kingdom made up of hundreds and thousands of species!

Fungi:

• Carry out most global recycling.

• Are vital to crop production through mycorrhizal relationships with plant roots.

• Give us penicillin, griseofulvin, cyclosporine, anticancer taxol and other medicines.

• Enrich our diet with their tasty fruit bodies.

• Enable us to make bread, wine and some of the best cheeses.

In situ conservation

Like other organisms, fun&i can be conserved both in situ (in their natural environment) and ex situ (outside this environment). Ex situ conservation of fungi normally means in test tubes in the laboratory.

Nowhere in the world is there a single plot of ground dedicated solely to the preservation of fungal biodiversity. A suitable site for such a reserve could be in the moist forests of the Western Ghats in southern India, where the fungi enjoy a long fruiting season, display exuberant biodiversity, and play a vital role in the dynamics of the ecosystem. The decomposers on fallen trees and on all kinds of plant litter; their penetrative and digestive talents; the mutualistic abilities of symbionts (e.g., the mycorrhizae and lichens); the tree-killers; parasites; leaf-spots and the cannibals! Many more hitherto unknown fungi await recognition from the Western Ghat "hotspots". Preservation of these forests should be our priority task.

Fungal hotspots

"Hotspots" of fungal diversity along the Western

Ghats include the following forests:

Goa

• Bhagwan Mahaveer Wildlife Sanctuary, Molem

• Cotigao Wildlife Sanctuary, Cotigao

Karnataka

• Kaiga forests, North Kanara

• Sharvati river valley, Genusoppa

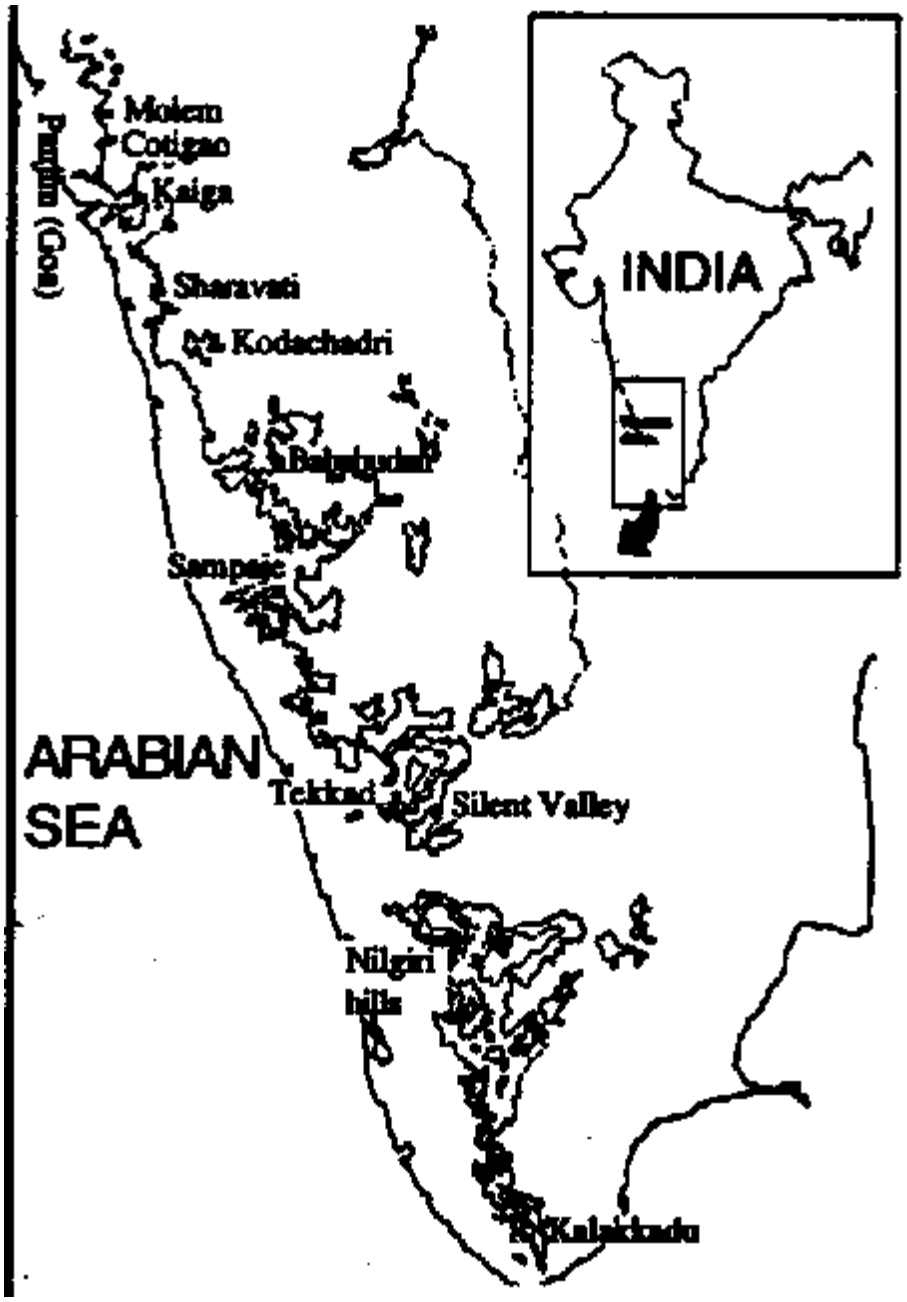
• Kodachadri hills, Shimoga

• Bababudangiri, Chikmagalur

Kerala

• Nilgiri hills range

• Mundandurai Wildlife Sanctuary, Kalakadu



Fungal hotspots

Culture collections

Fungi are small, simple organisms, so they can be conserved in the laboratory relatively easily. They must be kept in a nutrient medium of agar (a jelly-like substance made from seaweed) and other ingredients. The best combination of ingredients for the medium depends on the type of fungi to be maintained.

The fungi are first grown in glass petri dishes containing nutrients. They are then transferred to test tubes containing nutrients and are stored at low temperature. The cultures can be maintained for hundreds of years.

International organizations help conserve fungal cultures. Most of the cultures isolated from Western Ghats fungi have been deposited at the International Mycological Institute in the United Kingdom. The Indian Agricultural Research Institute, New Delhi, maintains the national culture collection.

The world's chief collections of fungal cultures are in Washington, D.C. (United States of America), Baam (the Netherlands) and Kew (United Kingdom).

Fungi in biotechnology

Fungi are used extensively in biotechnological processes. For example, breweries all over the world use yeasts with biotechnoloigcally engineered genes. The flavour of the beer has a lot to do with the strain of yeast.

Fungal culture collections contain many novel genomes, so will have much use in biotechnology for' medicine, food, -agriculture and industry.

Yeast

To grow yeast, you will need

• 1 packet starter yeast

• 1 tablespoon sugar

• 200 ml warm water

Dissolve the sugar in water. Sprinkle the yeast on top. Leave the jar in a warm room. As the yeast begins to use the sugar, the jar will fill with foam. Foam is formed as the

yeast changes the sugar into CO_2. Baker's yeast is the earliest known biotechnological use of fungi.

What is bread?

Bread dough is mixed with a little sugar and yeast. Each yeast cell feeds on the sugar, swells up and splits into two new cells. Each new cell in turn feeds, swells and splits, forming millions of new yeast cells. These cells form and form carbon dioxide bubbles inside the dough, making the dough rise. When the bread is baked, the bubbles are filled with air. Without yeast to change the sugar into CO_2, the dough won't rise. Yeast adds flavour, too.

Fungi in biotechnology

Prepared by Dr. D. J. Bhat

6.7 Edible mushrooms

Mushrooms are beneficial higher fungi. They have been used as food ever since the hunting-and-gathering stage of our prehistoric forebears.

A majority (80-90 %) of the edible mushrooms belong to the taxonomic order Agaricales.

India's mushroom biodiversity

Mushrooms in India are very diverse but not well known. India has from 1105 to 1208 species of mushrooms belonging to 128130 genera. Of these, only 300-315 species belonging to 75-80 genera are considered edible.

The Western Ghats have a wealth of mushroom flora: 700-750 species belonging to 70-75 genera. Of these, only 70-80 species are known by local communities in Maharashtra, Karnataka, Goa, Kerala and Tamil Nadu to be safe for human consumption.

Among all the popular edible mushrooms, the species of the termitophilic genera Termitomyces, Podabrella, the wood decomposer Pleurotus, and the ectomycorrhizhal Boletaceae are dominant.

Wild edible mushrooms have interesting local names. These are derived from either the habitat (e.g., Roen olmi = termite hill mushroom), shape (Khut olme = mushroom with crutch, Fugo = balloon), colour (Tamdi olmi), size or occasionally the fruiting season (Shit) olmi, which fruit during winter).

Fungi as friends and foes of humans

As friends	**As foes**
Biotransformations	Plant diseases
Antibiotics	Animal and human mycoses
Plant growth hormones	
Industrial enzymes	Mycotoxins
Mycoproteins	Spoilage
Biological control	Allergens
Mycorrhizal associations	

Mushroom diversity in Western Ghats states

State	**Genera**	**Species**	**Edible spp.**
Gujarat	5	5	0
Maharashtra	45	171	50
Goa	36*	87*	87
Karnataka	30	43	15
Kerala	41	88	75
Tamil Nadu	63	220	35

* Edible species only

World mushroom biodiversity

Order Agaricules

	World	**India**
Genera	230	128+
Species	6000+	1200
Edible sp.	2000	300+

Edible mushrooms

Termite hill mushrooms

As their name suggests, termite hill (or "termitophilic") mushrooms grow on termite hills. Termites cultivate these mushrooms and eat them to obtain enzymes and nitrogen. People harvest the mushrooms which emerge from the underground fungal combs and market them in large quantities.

The entire life cycle of these popular mushrooms is considered ecological magic by local termite-hill goddess worshippers. The mushrooms have given rise to many interesting taboos and folk-beliefs. For instance, the termite hills are closely guarded and revered as the abode of a popular local goddess. These beliefs once checked the exploitation of mushrooms and destruction of the termite hills, but a sudden spurt in consumer demand for wild termite hill mushrooms (especially in Goa) is threatening this conservation ethic.

Almost half the above-ground plant litter in the Western Ghats forest and bamboo groves is recycled by Termitomyces. This is a vital way the soil nutrient reservoir is enriched.

Termites and the gods

The termite hill goddess is venerated in Konkan, Goa and Kanara and is known as "Santeri", "Bhumikon, "Shantala" or "Shantadurga". Every temple has a holy termite in the sanctum sanctorum.

Termite hills

Termitophilic mushrooms of the Western Ghats

The Western Ghats have world's largest gene pool of

Termitomyces. This diversity is threatened by overexploitation and subsequent extinction.

Genera	**World (spp.)**	**W Ghats (spp.)**
Podabrella	6	4
Termitomyces	41	25
Sinotermitomyces	3	—

Termite hills

Each hectare of forest in the Western Ghats has about 810 termite hills. In mixed forests, termites invade between 21 and 79% of trees. Termites turn over large amounts of soil by plastering on trees and the ground.

The plant material taken inside the termite hill ends up in the "fungal comb". Each comb weighs 28-31 kg.

The Termitomyces fungus in the comb decomposes 167 to 341 kg of organic matter a year.

Fungi and their "masters"

The biodiversity of Termitomyces fungi parallels their "masters" or partners-the termite species that cultivate them for food.

Dominant termite species*	**Dominant fungus species**
Odototermes horni	Termitomyces striatus
O. obesus	T. heimIi
O. feae	T. currhizus
O. wallonensis	T. mammifornis
O. redemand	T. clypeatus
O. malabaricus	T. microcarpus
O. brunneus	Podabrella microcarpa
Macrotermes sp.	
Microtermes sp.	

* all of Macrotermitinae subfamily of higher termites

Termites

Significance of biodiversity

• The Western Ghats mushroom flora closely resemble flora of Africa and South America. This affinity is related to geodynamical events like plate tectonics.

• Saprophytic or decomposer mushroom genera such Lepiota and Macrolepiota marasmius, opportunistic parasites such as Pleurotus and Lentinus termite, cultivated fungi such as Termitomyces, and ectomycorrhizal partners such as Russula help maintain the ecosystem by catalyzing the mineralization of organic matter.

• Carnivorous mushrooms species control nematode populations.

• Edible mushrooms provide a seasonal source of food to tribals. Wild mushrooms and their habitats such as termite hills have become fountainheads of folk belief systems and interlinked cults.

Threats to mushroom biodiversity

• Lack of comprehensive surveys.

• Habitat destruction (e.g., deforestation).

• Mega-projects (e.g., dams, highways, railway tracks).

• Shifting focus of urbanization and industrialization towards the hills from overcrowded coastal areas.

• Monoculture plantation such as eucalyptus, rubber and oilpalm.

• Kumeri, or "slash-and-burn" cultivation.

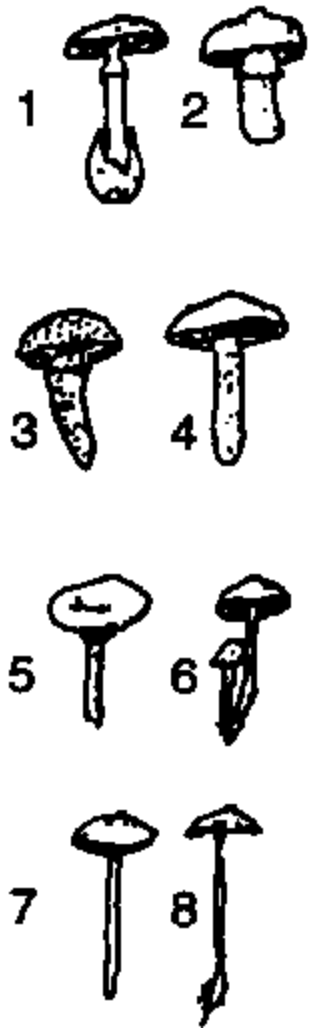
• Land use change and land development.

• Pollution.

• Artificial vegetation breaks.

• Increasing demand for wild edible species.

• Lack of public awareness and indifference of local authorities.



Common hymenophoral habit type in Agaricales

1 Amanitoid

2 Agancoid

3 Pholiotoid

4 Tricholomatoid

5 Clitocyboid

6 Collyboid

7 Mycenoid

8 Marasmioid

Edible mushrooms are balanced protein foods

Species	**Water %**	**Protein%**	**Fat %**
Button mushroom (Agraicus sp.)	89	4.0	0.2
Dingri/oyster mushroom (Pleurotus spp.)	90 *	3.0	0.7
Termite hill mushroom Termitomyces sp.)	91	4.0	0.2
Paddy straw mushroom (Volvanella spp.)	88	4.5	0.5

% on fresh weight basis.

These species also contain thiamine, riboflavine, niacin, calcium, iron and phosphorus.

Ghost lights

Mycelium and fruiting bodies of bioluminescent mushroom species such as Lampteromyces, found in Western Ghat forests, emit a faint blue-green or violet light, occasionally illuminating entire forest at night. This "ghost glow" helps in spore dispersal.

Suggested conservation measures

• Extensive survey, documentation identification and cataloguing of mushroom species.

• Market surveys to establish exploitation consumption/trends

• Field studies to identify "hot spots".

• Notification of endangered species and habitats.

• Demarcation of "micro-bioreserves" of fungi/mushrooms.

• Detailed plan for controlled exploitation of non-endangered species on basis of phenological studies.

• Ex-situ conservation in the form of dried herbarium, spore-deposits and mycelial (tissue) cultures.

• Domestication of wild edible species e.g., Termitomyces for commercial cultivation.

• Establishment of valuable mushroom germplasm banks.

• Development of wild species mycelial culture to manufacture bioactive molecules, enzymes, polysoccharides, protein pellets, flavour and natural mycodyes, e.g., melanin.

• Culture of ectomycorhizal species as bioinoculants for use in agroforestry.

• Public awareness campaign through the mass media.

• Aesthetic use of mushroom biodiversity for nature promotion, e.g., in philately, models, cards and games.

• Removal of techno-legal ambiguities in existing eco-conservation and forest protection laws to incorporate concerns regarding fungal and mushroom biodiversity.

• Involvement of local communities and NGOs in a biodiversity awareness drive.

Ban on collection

A ban on wild mushroom collection in sanctuary areas of Goa was imposed after considerable lobbying. Despite political pressures, the forest department of Goa stood its ground and has enforced the ban since June 1992. Goa is the first state in Western Ghats to impose and enforce such a ban, aimed primarily to conserve the rich, diverse and precious edible Termitomyces gene pool.

Natural, biodegradable hair dye from fungus

Antromycopsis, a non-fruiting mushroom, produces drops of sticky viscous, black fluid on tips of its erect. mycelial bundles. This was found to be made of melanin. Non-toxic and insoluble in water, it could be manufactured in large quantities for use as hair dye.

Popular Goan mushroom dishes

Hot and spicy mushroom bhaji

Fried mushrooms

Mushroom kebabs

Omelettes, pizzas, mushroom sauce, pickles

Mushroom biryani and pulaos

Wild edible mushrooms are cooked in many ways in Goal. The nutritional value of mushrooms as sugar-free, protein-rich food supplement is well known. Although the demand for edible mush

rooms is rising due to the growth of tourism, only a few species are cultivated on a minor scale. Pressure on the wild population of edible mushrooms remains unabated.

Prepared by Dr. N. Kamat

6.8 Microbial biodiversity of salt pans

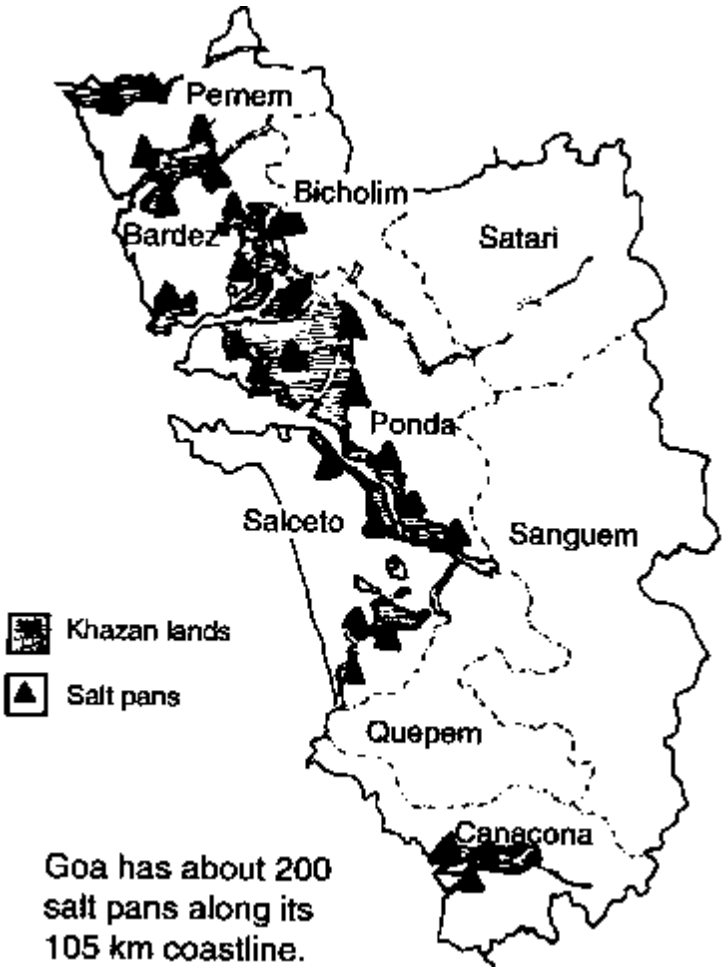
Salt pans are rectangular soil-based basins, protected by mud bunds. They are used to collect and evaporate water from the sea or estuaries to make brine and eventually

crude crystalline salt. Common salt is not pure sodium chloride; it contains varying amounts of sodium, potassium, calcium and magnesium

Ecology and seasonal cycle

Salt pans in Goa are inundated by tidal waters and monsoon runoff. They undergo three seasonal phases: submerged (June to November), shallow (December to February), and drought (March to June).

The light intensity, temperature, pH and oxygen content of the water and sediments change from season to season. Such extreme physicochemi cal changes are detrimental to normal life, but allow microorganis ms capable of adapting to survive.



Salt pans in Goa

Goa has about 200 salt pans along its 105 km coastline.

Salt-loving microbes

Salt-loving microorganis ms are called "halophiles". They include fungi, diatoms, bacteria and cyanobacteria, which occur as free forms or in associations called "mats". Two types, halophilic archaebacteria and cyanobacteria are of special interest due to their significance to the ecosystem and economic potential.

Halophilic archaebacteria

This unique group of bacteria is one of the oldest forms of life on earth. They can adapt to major changes in temperature, oxygen, salinity and acidity, unlike true bacteria, plants and animals.

Some archacbacteria have photosensory pigments that enable them to use the sun's energy to grow and reproduce.

Salt lovers

• Slightly halophilic: tolerate 5-7% NaCI (salt) content.

• Moderately halophilic: tolerate 8-14% salt content.

• Extremely halophilic: tolerate 14-35% salt content.

As evaporation increases the salinity of a salt pan, only extreme halophiles called halophilic archaebacteria grow.

Types of halophilic archaebacteria

Halobacteria:

Rods, disks, cups, squares, rectangles and triangles.

Halococcus:

Spheres.

Haloarcula:

Change in shape as they grow.

Types of halophilic archaebacteria

In 1980, these remarkable organisms were assigned to an exclusive biological kingdom, "Archaebacteria".

Cyanobacteria

Cyanobacteria have pigments which harness light energy and fix carbon. Some also fix nitrogen and increase soil fertility.

These microorganisms occur in a wide range of forms: spheres, hemispheres, cylinders, elliptical, filaments-branched and unbranched.

Halophilic cyanobacteria:

• Fix atmospheric nitrogen and enrich the nitrogen economy of the neighbouring khazan (saline) paddies.

• Fix atmospheric carbon as biomass which is then available as feed to shrimp cultures of khazan land.

• Take in carbon dioxide and give out oxygen.

Economic importance

Both halophilic archaebacteria and Cyanobacteria could be harnessed for agricultural and industrial use, for instance, to produce biogas. With their ability to adapt to toxic levels of chemicals and physical stress, they could also be used to remove heavy metals, crude oil and suspended matter from polluted water.

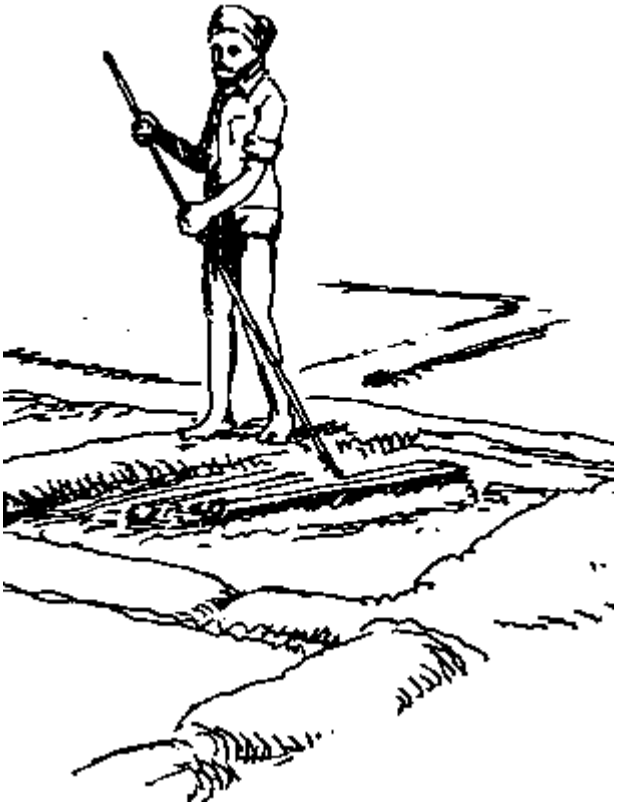
Potential uses of halophilic micro-organisms

	Halophilic archaebacteria	**Cyanobacteria**

Biomass	Beta-carotenes, detergents, oil recovery	Food (nutrient supplements), livestock feed production, textile dyes, food colours, biofertilizer production.
Pollution control	Heavy metal adsorption, oil degradation	Heavy metal removal, oil degradation, water recycling
Non-conventional energy	Photochemical energy, biogas	Hydrogen fuel cells, biogas production
Electronics	Artificial light-sensitive - pigments	

Salt pans under threat

Goa's salt pans are becoming extinct due to use of land for housing, roads, railways and aquaculture. Pollution (such as oil and grease) from barges and other boats, monsoon runoff from mining areas, and industrial effluents in estuarine waters put a heavy stress on even the tolerant halophilic microorganisms. These pollutants may also contaminate the salt produced in the pans.



Salt pans under threat

Conservation

Salt pans are an important ecological niche for microorganisms involved in the cycling and fixing of oxygen, sulphur, carbon and nitrogen.

• Salt pans should be protected from encroachment and pollution.

• Research is needed to isolate these unique microflora and conserve them for biotechnology research and industrial use.

Prepared by Dr. I. Furtado

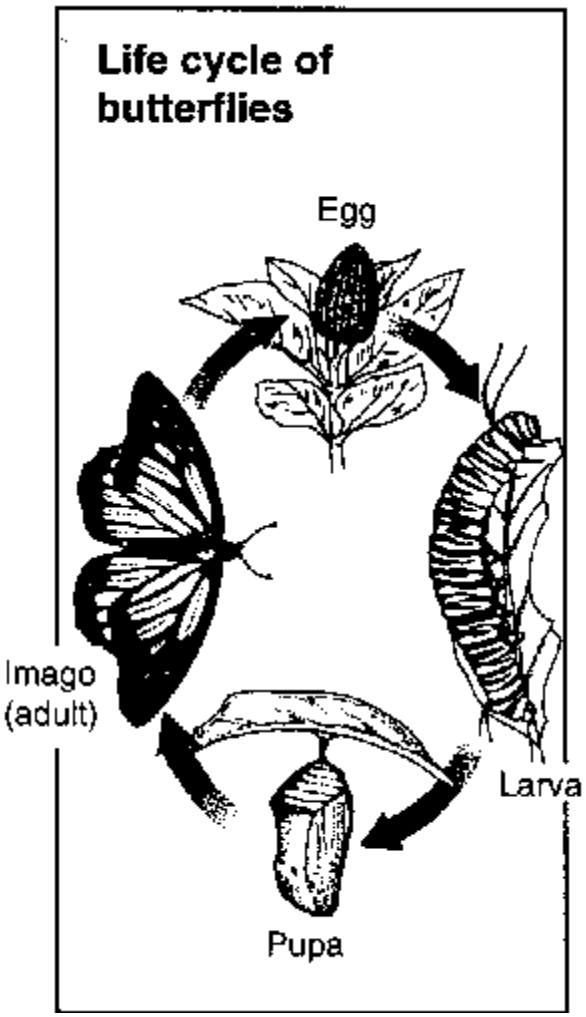
7. Invertebrates

7.1 Butterflies

Insects are the most abundant group of animals. They account for nearly three quarters of all life forms on earth. Their body is divided into three segments: head, thorax and abdomen. All insects have three pairs of legs and usually two pairs of wines.

Butterflies are among the most beautiful and frequently seen insects. The zoologoical order of Lepidoptera (Lepidoptera "scale wing") includes butterflies (sub-order Rhopalocera) and moths (sub-order Heterocera). Lepidoptera contains as many as 120,000 species: 100,000 species of moths and 20,000 species of butterflies.

Seven percent of the world's butterflies occur in India (1,400 species). In India, the maximum butterfly diversity occurs in the Western Ghats and Eastern Himalayas. The wide range of habitats in the Western Ghats is the reason for the rich butterfly fauna that occurs here. All ten butterfly families found in India are represented in the Western Ghats, and practically all butterflies recorded in South India occur here. Nilgiri and the hill ranges of the Kanara region of Karnataka are particularly rich. Both the largest Indian butterfly (Common Birdwing) and the smallest (Southern Grass Jewel) occur in the Western Ghats.



Butterflies

Value of butterflies

• Butterflies pollinate flowers and help plants produce fruit and seeds.

• Some species of butterflies are poisonous. They are being studied to produce ecologically safe pesticides. Certain species are used for experiments in genetic engineering.

• Butterflies-and especially caterpillars, their larval form-are important sources of food for other animals such as birds.

• Butterflies add color to wilderness areas in the Western Ghats.

• Some butterfly caterpillars are pests on cultivated crops.

Suggested reading

Gay, Kehimkar and Punetha. Field guide to common Indian butterflies. WWF-India.

Wynter-Blyth. Butterflies of the Indian Subcontinent. Bombay Natural History Society.

Mimicry in butterflies

Some butterflies mimic other species to protect themselves from predators. Two types of mimicry are:

• Batesian mimicry: Edible species look like inedible species. E.g., the Common Mormon mimics the Crimson Rose.

• Mullerian mimicry: Two or more inedible species look alike. E.g., the Striped Tiger and Plain Tiger look similar.

Inedible species are normally brightly colored (red and black, orange, blue and black). They contain toxic chemicals.

Some butterflies and larvae resemble non-living things. For instance, the Oakleaf butterfly resembles a dried leaf; the Common Mormon larva resembles a bird dropping.

Life cycle of butterflies

Threats

• Habitat destruction in the Western Ghats is probably the single most important threat to butterflies. Some butterflies rely only on certain plants; for instance, the Plain Tiger lays its eggs on the Giant Milkweed-larvae hatch and feed only on these plants. If a plant species disappears, the butterfly species that depends on it may also be eliminated.

• People like to collect butterflies as ornaments and wall hang ings. Over-collection, especially of large, colorful butterflies, threatens many species. Both commercial and casual collectors are to blame.

Conservation

• Preserve the habitat in the Western Ghats. This is no doubt the best way of saving many species of butterflies.

• Educate people on the role and importance of butterflies and discourage collection.

Butterfly farms

Butterfly farms are a unique and interesting way to introduce butterflies to people and breed endangered species in captivity.

A butterfly farm is an enclosed area which houses a variety of butterflies. Conditions to sustain these beautiful insects are artificially provided. Visitors can enter the farm and experience the thrill of butterflies sitting on their shoulder or head. Singapore, Malaysia, Papua New Guinea, the United Kingdom and the United States have butterfly farms.

Some butterflies of the Western Ghats

Common Birdwing

Common Mormon

Common Rose

Five-bar Swordtail

Emigrants

Lemon Pansy

Gray Pansy

Common Leopard

Tamil Lacewing

Black Rajah

Eggflies

Southern Rustic

Common Evening Brown

Common Pierrot

Southern Grass Jewel

Striped Tiger

Common Crow

Orange Tips

Blue Mormon

Crimson Rose

Common Banded Peacock

Common Jezebel

Grassyellows

Yellow Pansy

Common Sailer

Tree Nymph

Common Nawab

Baron

Castors

Tawny Coster

Bushbrowns

Common Cerulean

Plain Tiger

Blue Tiger

Skippers

Red Helen

Butterfly or moth?

Butterfly

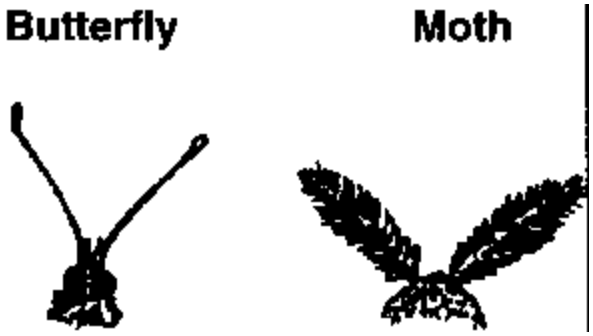
• clubbed antennae

• most are diurnal

Moth

• tapering or feather-like antennae

• most are nocturnal



Butterfly or moth?

Prepared by Srinivasan Karthikeyan

7.2 Honeybees to conserve biodiversity

Bee-plant relationships

Bees and plants have co-existed since time immemorial. Bees depend for their food on plants: nectar provides them with carbohydrate, while pollen supplies protein. Most bees also depend on plants for shelter. In return, bees help with the vital process of plant reproduction. They cross-pollinate flowers, diversify the genetic background of seed, and help plant species reproduce and survive.

Bees can distinguish colours, shapes and scents of flowers. They cannot see red but do perceive ultraviolet light. Bees can reach the concealed nectar in flowers that have intricate structures. Their sense of time means they can accurately visit flowers when nectar is secreted and pollen grains are produced.

Bees have adjusted themselves to evolutionary changes in flowers. They have in turn influenced the evolution of flowers, causing the flowers to become more complex in colour, shape and structure, reducing the number of floral parts, and influencing the production and protection of nectar.

Many flowers have complicated ways of providing access to pollen and nectar. These reward pollinat ing insects but discourage others. The floral structures and the chemical composition of the food are adapted to the senses of certain pollinating insects. Protein-rich pollen and glucose-rich nectar are most sought after by trees

Bees need a clean and healthy environment. The existence of natural bee colonies is a good indicator of a healthy environment. Individual bees can also be useful in detecting air pollution.

Bee-plant relationships

Four species of honeybee

India can boast of being a centre of origin of the world's honeybee species. Out of the five honey-producing bee species, four have occurred in India since ancient times. They are also found in the Western Ghats.

Apis dorsata-the rock bee or giant bee

This wild bee constructs single, huge, vertical wax comb exposed to light. The nest hangs on tall tree branches or towers, or underneath bridges or on rock cliffs. It contributes nearly 75% of total honey production of India. It migrates with the season to seek food and shelter.

Apis dorsata

Apis florea-the garden bee or little bee

This wild bee constructs a single, small, vertical comb in bushes exposed to light. It produces small quantities of honey. It also migrates depending upon the availability of food and shelter.

Apis florea

Apis cerana-indica the Indian hive bee

This hive bee constructs several vertical parallel combs in dark enclosures like hollows in tree trunks or in the ground. It is relatively stationary and can be kept in wooden hives for commercial production of honey and pollination services.

Apis cerana

Trigona irridipenis-stingless bee or dammer bee

Like the hive bee, this wild species occurs in dark enclosures, but it does not construct parallel combs. It builds nests comprising of clusters of cells meant for brood rearing and storage of honey and pollen. These bees are very small-little bigger than mosquitoes.

Trigona irridipenis

Upset balance

Bees are part of the delicate balance in the ecosystem. Human interference can upset this balance and disturb bee populations. On the Mahabaleshwar Plateau, for instance, natural honeybee colonies are reduced to dangerously low levels. In the 1950s and 1960s, natural bee colonies were abundant on the plateau; later local beekeepers found it difficult to procure natural colonies. Deforestation has depleted honey production to such an extent that traders now have to procure honey from other states. What applies to Mahabaleshwar is also the case in many other honey-producing regions in the Western Ghats.

Reduced numbers of colonies of Apis cerana, the Indian hive bee, are also due to human interference. In the 1970s, thousands of colonies were lost in an epidemic of a bacterial disease. An exotic species, the European honeybee (Apis mellifera), was imported into the Mahabaleshwar region, thereby introducing European foul brood

disease. More recently, an outbreak of a viral disease took a large toll of bee colonies in many parts of Karnataka and Kerala.

Like the Indian hive bee, the wild migratory species A. dorsata and A. florea are also endangered by deforestation and thoughtless honey collection. Crude honey collection methods not only reduce the quality of honey but also damage hives and harm the bee population.

Beekeeping in Goa, Karnataka and Maharashtra

	Goa	**Karnataka**	**Maharashtra**	**India**
No. of beekepers	28	29,340	2,623	242,644
No. of colonies	22	139,916	4,041	1,075,241
Honey (kg)	18	602,570	78,244	928,429
Honey per colony (kg)	0.6	4.2	19.4	8.6

The queen is the only fully developed female in the colony. It lays eggs which hatch to increase the population.

Queen

The workers are the bees seen busily going in and out of the hive carrying food. They are females, but are not fully developed sexually. They do not lay eggs. Whether an

egg grows into a queen or worker depends on the food given to the larva that hatches from the egg.

Workers

The drones are male members of the colony. Their sole function is to mate with the queen.

Drones

Maintaining biodiversity

Capacity to produce honey, disease resistance, low tendency to abscond or migrate, and mild temper leading to few stings are a few desirable traits the beekeeper seeks in bees. It is possible to breed superior strains of Indian hive bees. Local bee species should be used rather than imported exotic bees which may introduce diseases.

Suitable techniques for collecting honey and wax from wild bee species (Apis dorsata, A. florea and Trigona irridipenis) are needed. The Central Bee Research Institute in Pune has been successful to a great extent in this regard. Besides honey, all three

species produce wax, pollen, royal jelly and bee venom. These species are immensely important in pollinating flowers. A. dorsata has a longer flight range, while A. florea can work on smaller flowers. Apis indica can be kept for pollination in agricultural or horticultural fields.

Beekeeping

Indian hive bee colonies can be procured and kept in modern wooden hives at desired locations, called apiaries. These locations should have ample flowers, shelter and a water source nearby. Little investment is necessary for the hives. Bees use readily available natural food. They do not compete with any agricultural animal for food and do not damage flora.

With an initial investment of about Rs 4000 for ten boxes and bee colonies, a beekeeper can earn around Rs 2000 per year by producing honey or multiplying bee colonies. Products such as beeswax can also be sold. Children, aged persons, men and women can maintain bee colonies. It requires no hard work or large amounts of time.

Chemical composition of pollen and honey

Pollen	
Carbohydrates	35%
Proteins	20%
Fats	15%
Vitamins B. C, D, E	
Water	15%
Minerals	10 types
Free amino-acids	10 types
Enzymes	10-15 types
Honey	
Fruit sugars	
(fructose)	40%

Glucose	35%
Sucrose	4%
Minerals, proteins, vitamins, acids, colouring matter, flavors	1%

Prepared by K. K. Kshirsagar

7.3 Mulberry silkworms

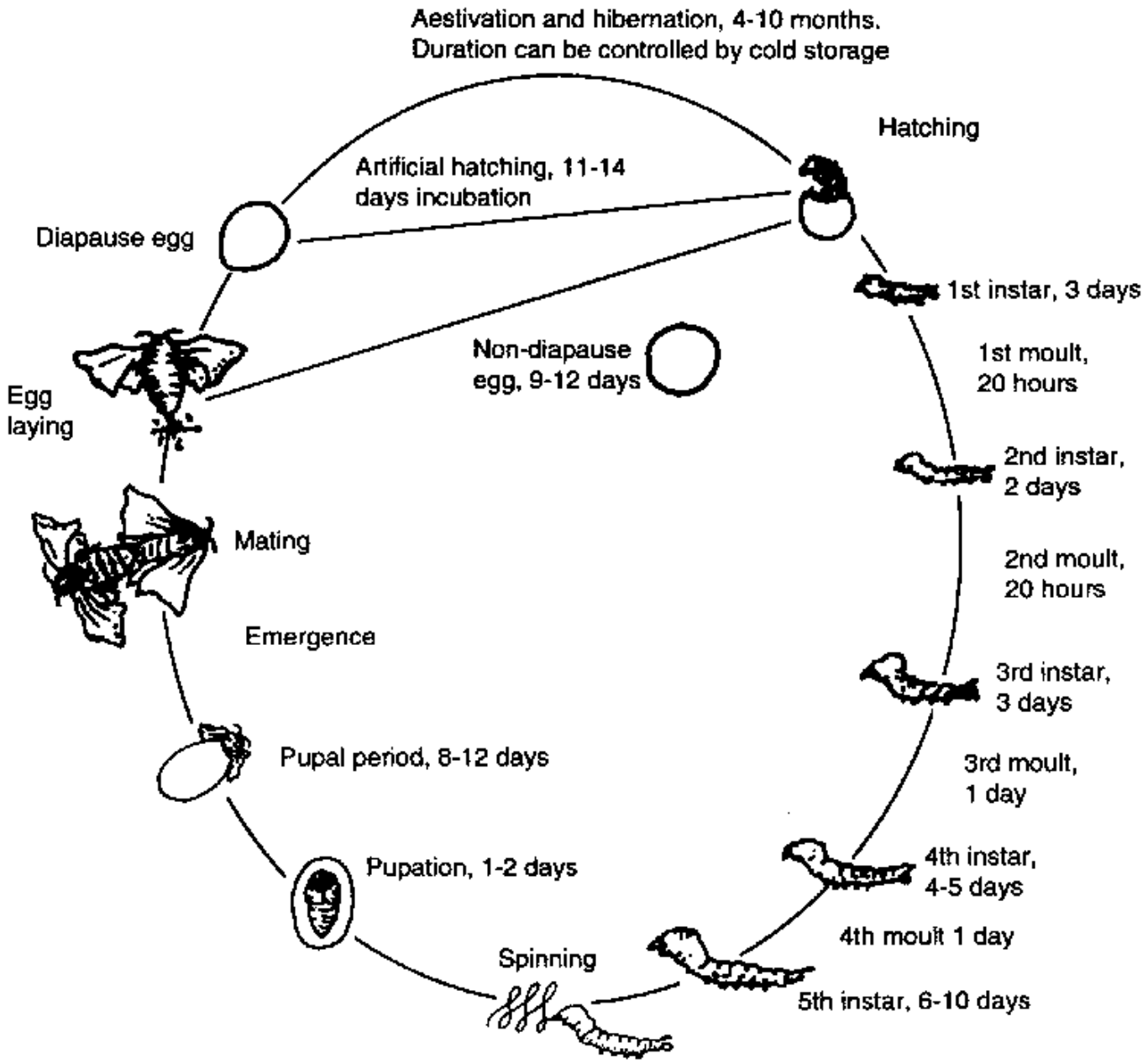
Silk-that beautiful, light cloth made into the most expensive saris-has humble origins. It is produced by insects called silkworms as a vital part of their growth.

Silkworms are the larvae or caterpillars of silk moths. When the time comes for the larva to change into its next growth stage, a pupa, it secretes a long thread of sticky silk. It forms this into a cocoon around itself. Inside the protective cocoon, the larva gradually metamorphoses. After 8-12 days, a moth emerges.

Silkworms are fed a diet of mulberry leaves grown especially for this purpose. The practice of raising silkworms is called "sericulture". This industry has led to the diversification of silkworm races and of the mulberry trees used to feed them. It has not so far led to major negative impacts on the wild races of either the silkworms or trees.

Industrious insects

Many insects are useful to humans, but only two are reared on a large scale: silkworms and honeybees.



Life cycle of the silkworm

Ten species of butterflies produce silk, but only five spin silk that can be wound onto a reel: the Mulberry silkworm, Eri, Muga, Tasar and Anaphe. By far the most important is the Mulberry silkworm, which produces 92% of the world's silk output. This silkworm is the only species widely reared for commercial use. It has been domesticated for so long that it can no longer survive in the wild.

The silk from silkworms is used for making cloth because of its beauty, strength, softness and durability.

Silkworms

The Western Ghats has a wide range of silkworm races. The most commonly used is Pure Mysore, or PM for short. This race is hardy and resists diseases.

Silkworm races differ in certain important characteristics of interest to sericulturists:

• Voltinism: The number of generations completed by an organism in a year is known as "voltinism". Univoltines complete one life cycle (from egg to adult to egg) in one year. Bivoltines complete two such cycles, and multivoltines (or polyvoltines) complete more than two. In the Western Ghats region, people use bivoltine silkworms such as Kalimpong-A (also known simply as KA), as well as multivoltines (such as Pure Mysore).

• Moultinism: This is the number of times the larva moults during its lifetime. Different races of silkworms moult as many as six times or just twice. In the Western Ghats, only those that moult four times are used because they are most economical.

• Place of origin: Silkworm races are classified as Japanese, Chinese, European and Southeast Asian. Western Ghat sericulturists make use of all except the European races because these require colder temperatures.

• Cocoon shape: Different silkworms spin cocoons of different shapes. Silkworms spin round, oval, dumbell- and spindle-shaped cocoons. All of these types are raised in the Western Ghats.

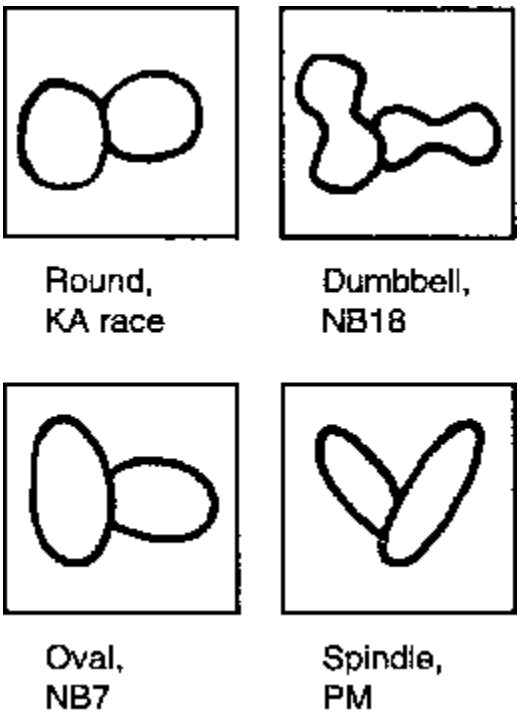
• Cocoon colour: Different silkworms spin cocoons of various hues: white, green, yellow, golden and flesh. In the Western Ghats, KA, NB7 and NB4D2 races spin white silk; PM spins green cocoons.

Silk

The cocoons of insects and webs of spiders consist of light, but extremely strong threads. A mulberry silk thread is stronger than a steel wire of the same thickness.

The raw silk is spun into threads and woven into very light, fine cloth. Because silk is highly elastic, it can be woven into a wide range of cloth types, including satin, crepe and voile.

The Western Ghats states-Maharashtra, Karnataka, Kerala, part of Tamil Nadu and, of late, Goa-produce more than 60% of India's silk output. Silviculture is also being introduced in new areas, such as Sirsi Siddapur (North Kanara).



Cocoon shapes and silkworm races

Breeding silkworms

Sericulturists face various problems with existing types of silkworms:

• Lack of seasonal and regional silkworm races.

• Lack of hardy, productive, disease-resistant silkworm races.

• Shortage of bivoltine breeds (that produce two generations a year).

More silkworm breeds should be bred to give rearers a choice of the most suitable race for particular situations. Some 34 desirable characteristics have been identified. Breeding is difficult because almost all of these characteristics are controlled by more than one gene. This makes ii impossible to develop a silkworm race with all the good characters. Researchers are trying to breed races that have just one or two of tile desired characters. For instance, CAC and HR14 races are hardy and bivoltine; NCD has superior dumbbell-shaped cocoons; CDS2 is temperature tolerant. It is also necessary to conserve existing local races of silkworms to conserve the biodiversity of this important species.

Mulberry silkworm species

Bombyx mandarina (wild ancestor)*

Bombyx mori (currently used commercially)*

Bombyx textor

Bombyx croesi

Bombyx fortunatus bombyx arracanensis

Bombyx sinensis* (B. meridionalis)

Theophila religiosa

Rondotia menciana

* Found in the Western Ghats

Origins of silk

The silk industry originated 45 centuries ago using wild silkworms in North China along the banks of the Huang Ho river. In 195 AD sericulture was introduced to Korea and other places.

But Indian scholars point to ancient Sanskrit literature that refers to silk as chinon shuka. This appears to show that silkworms were domesticated independently in the foothills of the Himalayas.

Prepared by Dr. I. K. Pai

7.4 Spiders

Colourful web-weavers-and scary to some-spiders are little known or appreciated creatures. Like insects, they are invertebrates (they have no backbone). But they are not insects; rather, they are arachnids, related to scorpions, ticks, mites and king crabs.

There are 30,000 species of spiders distributed over 60 families worldwide. In India there are about 43 families of spiders.

Spiders inhabit a wide range of ecosystems because they can tide over periods of food shortage and take advantage of periods of abundance. In the Western Ghats, they are

found in a variety of microhabitats-tree bark and trunks, rock crevices, under leaves and stones, below bushes, on walls of houses, in tunnels and burrows, and near water.

Spiders as big-control agents

Spiders are important biological control agents of animal and plant pests. The giant crab spider (Heteropoda venatoria) prefers cockroaches and other insects. Wolf spiders relish brown planthoppers-a pest dreaded by rice farmers.

Threats to spiders

• Many pesticides kill beneficial spiders as well as insect pests. Indiscriminate use can lead to increases in pest numbers because spiders and other predators are wiped out. Some species of spider may be endangered because of such use.

• As with all species, the destruction of habitat through deforestation and other changes may reduce the number of spiders.

• Many people are afraid of spiders. Instead of being seen as friends and vital parts of the ecosystem, spiders are often indiscriminately killed.

Conservation approaches

• Raise the general awareness of the important role spiders play in the Western Ghat ecosystem.

• Study spiders' role as big-control agents in agriculture.

• Explore various uses of silk-for instance, for fishing nets. The use of webs in bulletproof vests is being studied.

• Do not destroy forest patches-the home of many spiders.

• Study the role of spiders in maintaining the stability of an ecosystem and their relation to other forms of life.

Arachnids vs insects

Arachnids	**Insects**
8 legs	6 legs

2 body	3 body
parts:	parts: head,
cephalothorax,	thorax,
abdomen	abdomen
6-8 simple	Compound
eyes	eyes
No antennae	Antennae
Young resemble adults	Young differ from adults
Mature by moulting	Mature in stages

Arachnids Insects

Arachnids vs insects

Uses of spider silk

• Tribal people in Australia and Papua New Guinea use the web of Nephila sp. to make fishing nets.

• Some tribal people in Maharashtra mix spider silk with jaggery to make native medicine to control fever.

• Spider silk is used as a healing agent in Unani medicine.

Some common spiders of the Western Ghats

Name	**Family**	**Look for them...**
Mygalomorp spiders	Thraphosidae	On the ground, in tree hollows and burrows
Argiope sp.	Araeneidae	Tree trunks, bushes
Gasteracantha sp.	Araeneidae	Low bushes and in trees
Herennia spider	Araeneidae	Walls of houses in forest, trunk of tree
Giant Wood spider	Araeneidae	Trees and bushes in thick forests
Social Web spider	Eresidae	Trees and bushes
Two-tail spider	Hersilidae	Tree trunk and walls of houses
Heteropoda spider	Heteropodidae	Cracks and crevices, in houses
Wolf spiders	Lycosidae	Base of tree trunks, under stones, in shrubs, on grasses, in tunnels and burrows
Lynx spider	Oxyopidae	Plant leaves, grass, shrubs
Dancing spider	Pholcidae	Tree hollows, corners of houses
Jumping spiders	Salticidae	Tree, bushes, inside houses
Tetragnatha spiders	Tetragnathidae	Inside wells, grasses near water
Crab spiders	Thomisidae	On flowers

Spider facts

• All spiders are carnivorous and feed only on living prey.

• Spider silk is a kind of protein, used not only for trapping prey but in egg cases, nest lining and as a food source.

• All spiders are poisonous to their prey. Only a few are highly venomous and can kill a human being.

• Spiders may live from several months to ten years in their natural habitats.

• All spiders are solitary except for the group known as "social web spiders", which live in colonies.

• Certain species of sunbirds use the nests of social web spiders for their nests.

Spider myths

The term Arachnidae is derived from the Greek Arachne, meaning spider. The legendary Arachne wove exquisite tapestries. She was invited to a weaving competition with the Goddess Athene, whom she defeated. The enraged Athene tore the tapestry and Arachne killed herself. It is said that Athene changed Arachne to a spider so that she could continue spinning beautiful tapestries!

Spiders are also mentioned in Hindu mythology as worshippers and protectors of Lord Shiva.

The jumping spider anchors itself to the ground with a silk thread before it jumps on its prey.

The jumping spider

By R. Bhanumati

7.5 Conserving natural enemies of mosquitoes

Mosquitoes are some of nature's most unloved creatures. Their bites itch, and they transmit dreaded diseases like malaria, filaria, dengue and Japanese encephalitis. Mosquitoes have enormous reproductive potential: if left unchecked, a female mosquito could produce 8 billion other females in only two months.

Fortunately, nature has provided a variety of biological control agents-pathogens, parasites and predators-that affect every stage of the mosquito's life cycle. They vary from micro-organisms to mammals such as bats, and even pitcher plants. Besides these natural enemies, abiotic factors such as temperature, humidity and rainfall also limit mosquito populations. The net result is to inflict considerable mortality on each generation of mosquitoes.

Threats to big-control agents

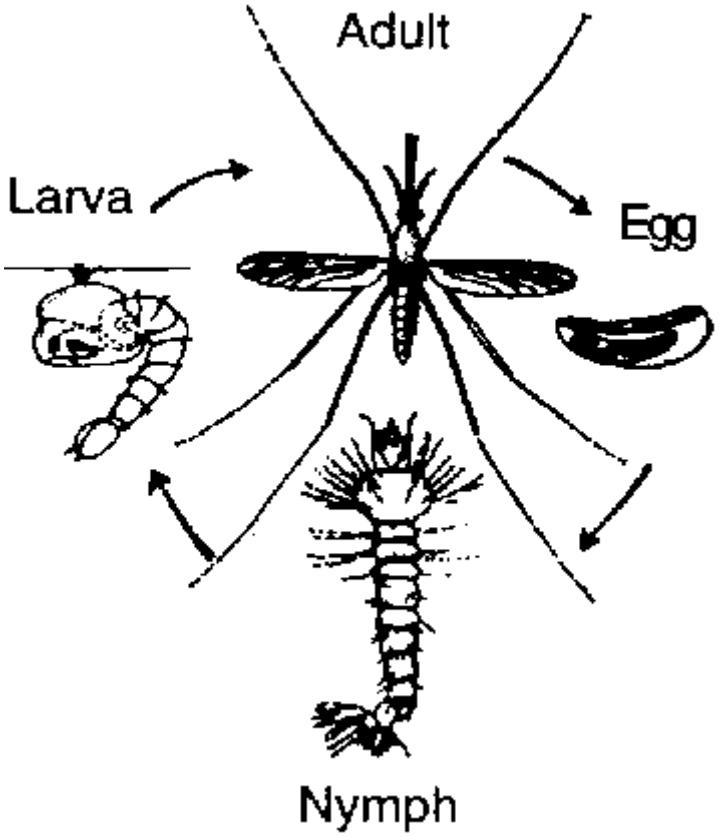
In the quest to eliminate insect pests of crops and insects that carry diseases, humans have resorted to the indiscriminate use of insecticides to support both agriculture and health.

Initial successes were tremendous. But through repeated use, the target insects (including mosquitoes) have gradually acquired physiological resistance to these insecticides. Many insecticides have a very broad-spectrum action, so they kill the natural enemies as well as the pests. And some pesticides enter the food chain, accumulate in the bodies of certain organisms, and disrupt the food web. These effects have caused incalculable harm to the natural enemies of mosquitoes and other insect pests.

Conserving, propagating and using biological control agents have gained tremendous importance. Chemical insecticides should be used only when absolutely essential, and then with extreme caution.

Promoting natural enemies

Mosquitoes have many natural enemies, but of this long list, only a few can be used on a large scale. These include toxins of bacteria (Bacillus sphaericus and Bacillus thuringiensis israeliensis) and certain types of fish.



Mosquito life cycle

Mosquitoes galore

A female mosquito lays on an average of 150 eggs every alternate day. Imagine a female lays eggs on 4 occasions in her life span (i.e., a total of 600 eggs) and half of the eggs hatch into females and the other half into males. After the 4th generation (i.e., in about two months), each female would theoretically produce 300 x 300 x 300 x 300 females, or about 8 billion females!

Natural enemies of mosquitoes Plants (Utricularia) Viruses Bacteria Fungi Protozoan parasites Nematodes (Romanomermis) Dragon fly adults Spiders Insects (Nepa sp., Notonecta sp.) Larvivorous fishes Frogs and toads Turtles Geckos House lizards Swallows Bats

Fish

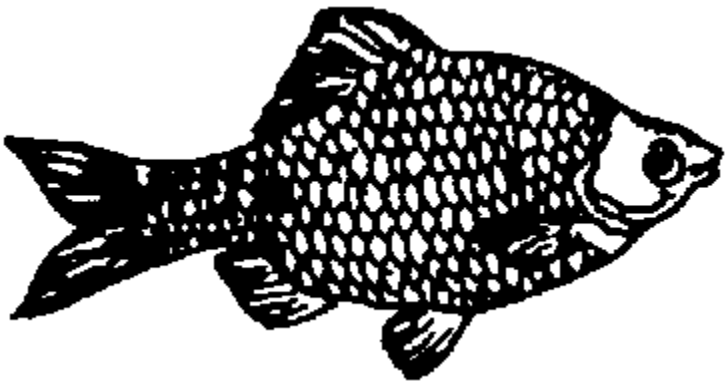
Several indigenous species of fish have been identified and tested against mosquito larvae in Goal A small fish, Aplocheilus block) or "kankatre", is very effective at controlling mosquitoes and malaria. This fish is found throughout Goa in estuaries,

fishponds, backwaters, lakes and streams. It is a much better predator of mosquito larvae than exotic species of fish such as Gambusia affinis (mosquito fish) and Lebistes reticulates (guppy). Aplocheilus block) is easily identified by the white spot between the eyes. Four to five fish per square metre surface area of water effectively control mosquitoes.

Another very agile, hardy and good larvivorous fish is Rasbora daniconius, or "dadiyo". These fish occur naturally in groups in ponds and streams. They are easily identified by a prominent dark line running from the operculum to the tail fin. People in Goa keep this fish in wells to keep the water clear of debris and the well walls free of algae and ferns. That they also predate upon mosquito larvae is not so well known. Two or three fishes per square metre of surface area can control mosquitoes in ponds, wells and tanks.

Aplocheilus blocki

Rasbora daniconius



Puntius ticto

Aplocheilus lineatus

Number of mosquito larvae consumed per day

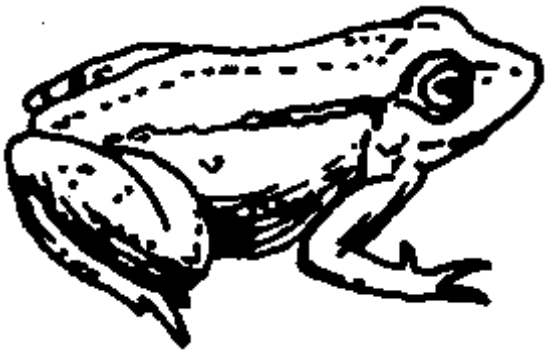
Fish species	**Max size (cm)**	**Larvae eaten per day, per gram fish weight**
Aplocheilus block)	4	201
Lebistes reticulates	5	112
Gambusia affinis	8	138
Aplocheilus lineatus	10	78
Puntius ticto	10	126
Heteropneustes sp.	15	88
Oreochromis mossambicus	18	128
Rasbora daniconius	20	86

The bigger the fish, the more mosquito larvae it eats. But it is better to keep many small fish than a few large ones. The table above shows that in relation to their size, smaller fish eat more larvae than do bigger fish.

Frogs

Frogs are well-known big-control agents of insects. Adult frogs prey upon flying insects by shooting their sticky tongues out at the prey. The tadpoles devour aquatic insects, including mosquito larvae. Unfortunately, the number of frogs is dwindling

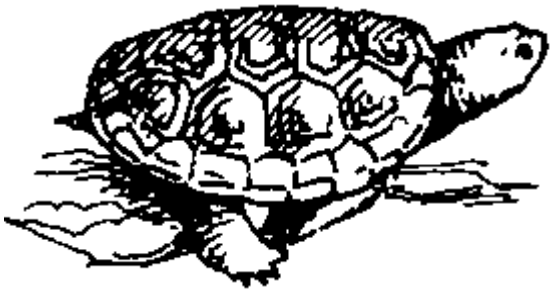
because of insecticide use. Frogs are also hunted for their hind legs, which are considered a delicacy. Frogs can control mosquitoes in ponds. rice fields, lakes and water tanks. They are effective against mosquito vectors of Japanese encephalitis, particularly during the monsoon.



Frogs

Turtles

Many villagers in Goa keep freshwater turtles in their wells. The people believe they bring good luck and help keep the well water clean. Scientists in the Malaria Research Centre in Goa have found that turtles also control mosquitoes. In laboratory studies, fist-sized juvenile turtles can consume about 5000 mosquito immatures per day. Unfortunately, turtles are hunted for their flesh and carapace; their numbers have been dwindling very rapidly.



Turtles

Lizards

Lizards are often hated in the household as they are thought to be scary. A careful watch would show that they prey on various insects, including adult mosquitoes.

Lizards

Spiders

Spiders spin webs on walls, in corners and in dark, secluded places to trap their prey. Adult mosquitoes can often be seen trapped in the webs.

Spiders

Need to conserve natural enemies of mosquitoes

Research has shown the usefulness of larvivorous fishes and bacterial toxins in controlling mosquitoes and the diseases they spread. But we need to conserve and use natural control agents of mosquitoes at the household level. These friendly creatures face a constant dual threat from chemical insecticides and humans. It is common in Goa to see people hunting frogs for their hind legs immediately after the first pre-monsoon showers. The hunters fail to realise that killing frogs during this breeding season prevents them from producing offspring. Public awareness needs to be created to stop the slaughter of these friendly animals. Similarly, turtles also need to be protected. People should also use insecticides in a very selective and judicious manner to avoid harming big-control agents.

Some indigenous big-control agents of mosquitoes

Bio-control agents		**Scientific/common name**	**Mosquito stage**

			affected/killed
Pathogens	Viruses	Polyhydrosis	Larvae
	Bacteria	Bacillus sphaericus	Larvae
		Bacillus thuringiensis	Larvae
	Fungi	Coelomomyces indicus	Larvae
		Lagenidium giganteum	Larvae
		Metarhizium anisoplae	Larvae
		Tolypocladium cylindrosporum	Larvae
Parasites	Protozoa	Verticella microstoma	Larvae
	Nematodes	Romanomermis culcivorax	Larvae
	Mites	Hydracarine mites (Water mites).	Adults
Predators	Aquatic plants	Utricularia sp.	Larvae
	Coelentrates	Hydra cylindrica	Larvae
	Insects	Dystcidae larvae	Larvae
		Hydrophilidae larvae	Larvae
		Dragonfly adults	Adults
		Nepa (water scorpion)	Larvae
		Notonocta (water boatman)	Larvae
		Belostoma (giant water bug)	Larvae
		Hydrometra (water stick)	Larvae
		Gerris (pond skater)	Larvae
		Toxorhynchites splendens	Larvae

		(mosquito larvae)	
	Spiders	Many species	Adults
	Larvivorous fishes	Aplocheilus block)	Larvae
		Aplocheilus lineatus	Larvae
		Rasbora daniconius	Larvae
		Danio asquipinnatus	Larvae
		Puntius ticto	Larvae
		Puntius amphiblus and many	
		other species	Larvae
	Amphibians	Rana tigrina	Adults & larvae
		Bufo sp.	Adults & larvae
	Reptiles	Common house lizards	Adults
	Turtles	Larvae	
	Birds	Swallows	Adults
	Mammals	Bats	Adults

Prepared by Dr. Ashwani Kumar

7.6 Vermicomposting

Earthworms are among the most ancient of terrestrial animal groups. Originally they were marine animals. Fossils of Polychaete worms have been found in South Australia in Precambrian sediments 630-570 million years old. Today's earthworms belong to the Oligochaetes. The limits of evolutionary and ecological diversity must

be defined by inherent limitations of their mechanical "design" and behavioral and physiological adaptability.

Earthworms are traditionally used in domestic compost heaps and earth toilets. People are now looking for ways to dispose of domestic and industrial wastes without polluting the environment. This has sparked interest in using earthworms for large-scale waste disposal. Worms are thus seen as a biological resource for rural development. Maintaining the diversity of resources such as worms will help ensure a resource base for future technologies such as vermicomposting.

Vermicomposting

The practice of using earthworms for composting is known as vermicomposting. Not all earthworms are useful for vermicomposting. Earthworms are classified into two groups:

• Humus-formers (detritivores) - useful for vermicomposting

• Humus-feeders (geophagous) - useful for soil turnover and tillage. Worms used for vermicomposting should have following characteristics:

• Able to live in active compost.

• Tolerate extreme changes in temperature.

• Multiply fast, undergo rapid incubation, and mature quickly.

• Digest well and have such enzymes as cellulase and chitinase in their gut.

Aristotle described earthworms as "intestines" of the earth. Charles Darwin wrote about earthworms, "it may be doubted where there are many other animals which have played so important a part in the history of the world as have these lowly organized creatures."

Humus former

• Surface dwelling

• Red color

• Feed on nearly 90% fresh organic matter and 10% soil

• Harnessed for vermicomposting

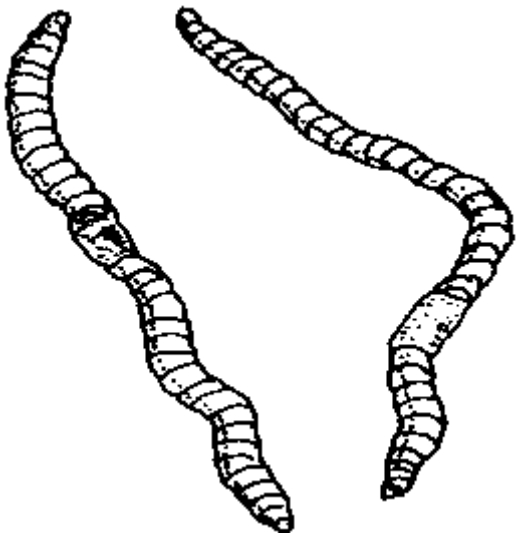
Humus feeder

• Deep burrowing

• Pale color

• Feed on nearly 90% soil and 10% nearly degraded or humified organic matter

• Useful in making the soil porous and mixing and distributing humus through soil



Humus former and feeder

Species useful for vermicomposting are:

Exotic species	**Indigenous species**
Eisenia fetida	Lampitto mauritii
Eudrilus euginea	Perionyx excavatus
	Dravida vilsii
	Dichogester bolavii

Effects of vermicomposting on indigenous species

It is not possible to use both exotic and endemic humus-forming species for vermicomposting. Exotic species multiply very rapidly and outgrow the endemic species.

However, using humus-forming exotic species for vermicomposting can be useful. Fast turnover of organic matter by these humus-formers produces food rich in bacteria and humus for the indigenous humus-feeders. The humus-feeders can then multiply very fast under vermicompost heaps and after the compost is added to the field, stimulating their soil processing activities such as aeration, tunneling and soil turnover.

Vermicomposting for rural sanitation

Earthworms can be used to process human faeces. Vermiculture may be particularly useful for treating sewage in rural areas. Research has shown that some types of bacteria found in faeces, Serratia marcessens and Escherichia coli, are killed when they are ingested by the earthworm L. terrestris. The worms reduced numbers of the pathogen Salmonella erteriditis to a level of 2000-fold less, possibly because of competition from the endemic microflora of the worm gut.

Earthworms aerate sewage sludge and speed its drying, thereby favouring aerobic bacteria. Since most human enteric pathogens are anaerobes, sludge condtioning by earthworms can be beneficial from the public health standpoint. More research is needed on the effect of vermicomposting on other enteric bacteria, pathogenic viruses and parasites.

In villages in India, vermicomposting of latrine waste mixed with other agricultural waste can help dispose of sewage and produce valuable compost that can increase soil fertility and agricultural production.

Vermicomposting for rural sanitation

Vermicomposting of sewage sludge

• Aerobic sludge ingested by E. fetida is decomposed and stabilized about three times as fast as non-ingested sludge.

• Objectionable odors disappear more quickly.

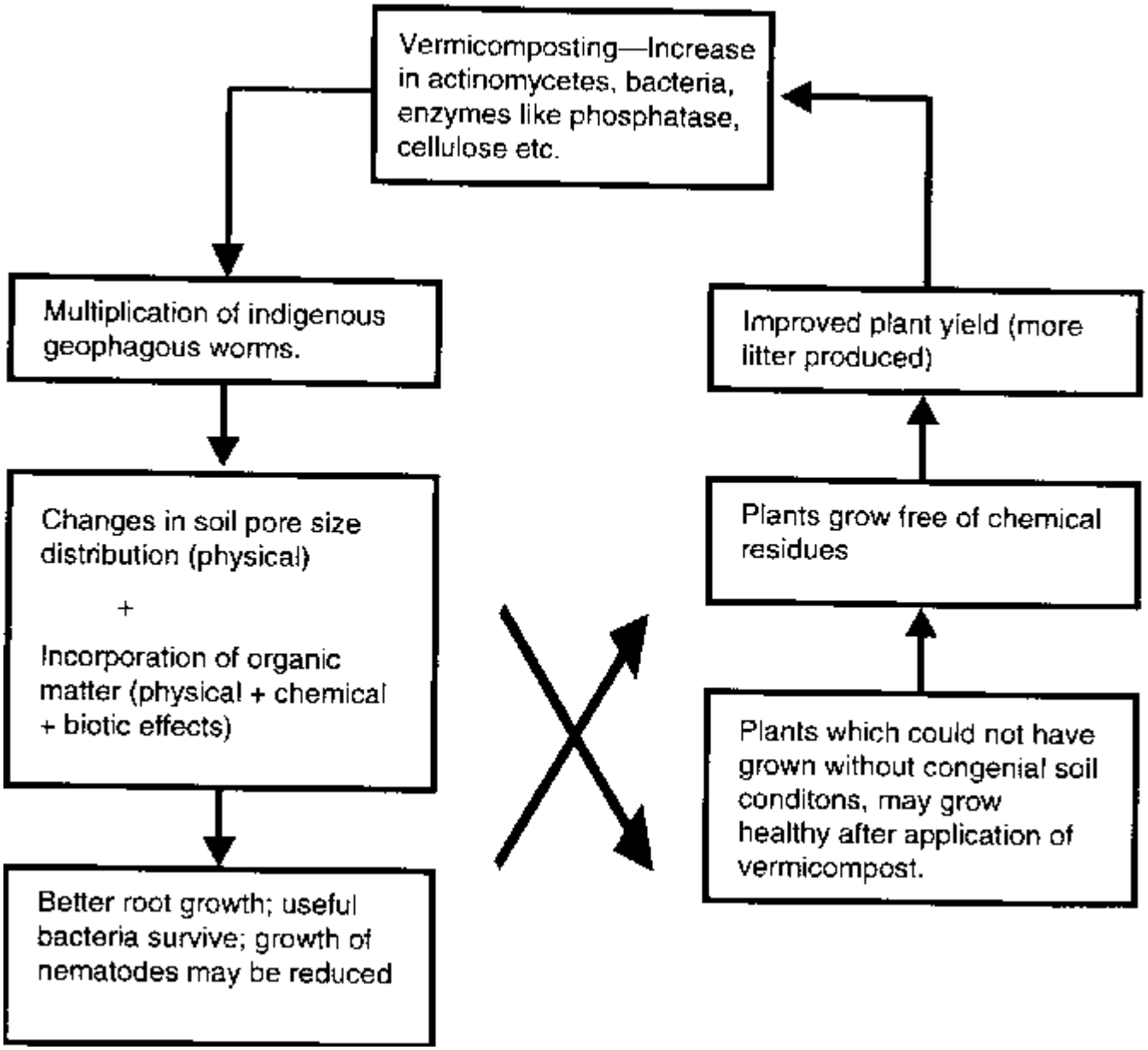
• Marked reduction in populations of Salmonella enteriditis and other Enterobacteriaceae.

• Anaerobic sludge and sun-dried sludge is toxic to E. fetida.

• Sewage sludge can be, mixed with cellulosic and lignin-rich wastes.

• Earthworms, which accumulate heavy metals and agrochemicals from sewage, may be environmentally hazardous if used as protein source.

Practical applications of biodiversity



Symbiotic relationship between detritivorous worms and micro-organisms

Vermicomposting potential

• Population of India is 8,000,000.

• The average person produces an average of 1/2 kg of excrete every day.

• 4,000,000 kg of night soil, if vermicomposted, would yield 2,000,000 kg of humus-rich organic compost a day.

• Considering the night soil of the 70% of the population living in villages, nearly 1,400,000 kg vermicompost could be prepared every day.

Prepared by Dr. Jambbekar

8. Reptiles, birds and mammals

8.1 Snakes

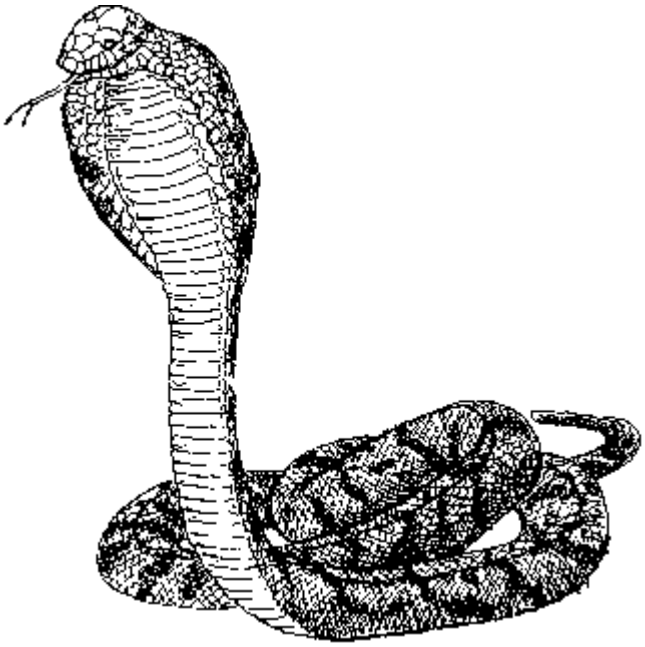
Snakes, lizards, crocodiles and turtles are all reptiles. Snakes appeared during the Cretaceous period, about 125 million years ago. They became more common when their main food source-small mammals-became widespread.

India has 218 species of snakes. Although they are widely distributed, they are not often seen because of their living habits.

Snakes of the Western Ghats

The most important snake in the Western Ghats is the King Cobra, Cophiophagus hannah. The longest poisonous snake in the world, it feeds on other poisonous and non-poisonous snakes. It is the only snake to build a nest of decaying matter to lay its eggs. The decaying matter generates warmth which incubates the eggs.

Many species of pit vipers, such as the Bamboo Pit Viper, the Humpnosed Viper and the Malabar Rock Viper, are common in the Western Ghats. A majority of shield tails (uropeltids) live in the region, as do the larger specimens of the Indian Rock Python.



Cophiophagus hannah

Value of snakes

Rodent control

Snakes are often feared and persecuted. But they play a very important role in the ecosystem by controlling rodents. A pair of rats can produce nearly 800 descendants in one year. India's estimated 8,000 million rats cause a loss of Rs 50,000 million a year by eating and damaging crops. Even large, concrete cereal godowns are not rodent-proof. The Rat Snake (Ptyas mucosus) has proved very effective in controlling rats in these godowns.

Medicine

Researchers have found that a solution of cobra venom is useful in treating intractable pain due to cancer, neuritis, migraine and other disorders.

Snake venom itself is used to produce anti-venom for treating snake bites.

Food and skin

Snakeskins have been used since time immemorial to make various products. Snakes are a source of food for many people of in Indochina. In the USA, canned rattlesnake can be found for sale. In the past, using snakes for food and skin has not upset their

numbers. But modern commercial use and illegal trade may result in over-exploiting the resource beyond its natural ability to recover.

Snakes play a vital role in the ecosystem. Instead of being feared and persecuted, they should be appreciated, treated with respect, and conserved.

Myths about snakes

• Snakes such as cobras can recognize an individual and take revenge.

• Cobras live for 125 years.

• Old cobras have hairs.

• Snakes drink milk from cows' udders.

• Snakes can hypnotize their prey.

• Snakes are slimy.

• The John's Earth Boa has two mouths.

• The bite of the John's Earth Boa can cause leprosy.

All these popular beliefs are false. They show the lack of accurate knowledge about snakes among the general public.

The truth about snakes

• Snakes do not have eyelids.

• Snakes do not have an efficient sense of hearing. They lack external and middle ears. They hear mainly by detecting vibrations carried through the ground.

• Snakes use their forked tongue for smelling.

• The sensory pit (a thermal detector on each side of the head) helps the snake find warm-blooded prey.

• Snakes are exclusively carnivorous.

Cobras and religion

In India the cobra is intimately associated with Indian folklore, religion and art. The Nag (cobra) is worshipped on two days each year-Nagpanchmi and Anant chaturdesi. The Vedas refer frequently to snakes. Lord Krishna used Mount Meru for churning the ocean using the coils of the great serpent "Shesh Nag" to obtain the "Nectar of Divinity".

Snakes are worshipped in many temples in South India. The cobra is considered the Goddess of Fertility. Many childless couples come and pray by making cobra carvings on granite stones.

Ways to increase the snake population

• Conserve wildlife.

• Preserve rare species.

• Conserve aquatic life.

• Conserve habitats, such as forests.

• Avoid killing snakes.

Prepared by Bhalcandra Mayenka and Srinath

8.2 Crocodiles

India has three species of crocodiles: the mugger or marsh crocodile (Crocodylus palustris), estuarine or salt water crocodile (Crocodylus porosus) and the gharial (Gavialis gangeticus).

The first two species find a home in the Western Ghats. The gharial is confined to the rivers of northern India.

In Goa, a wild population of marsh crocodiles inhabits the mangrove-lined Cumbarjua Canal. It is the only type of crocodile found in this part of the Western Ghats.

Clues for identification

The marsh and the estuarine crocodile rarely occur together in nature. It is difficult to distinguish the two. Look at the shape of the head and the arrangement of scales on the neck.

Mugger or marsh crocodile, Crocodylus palustris

• Amphibious reptile

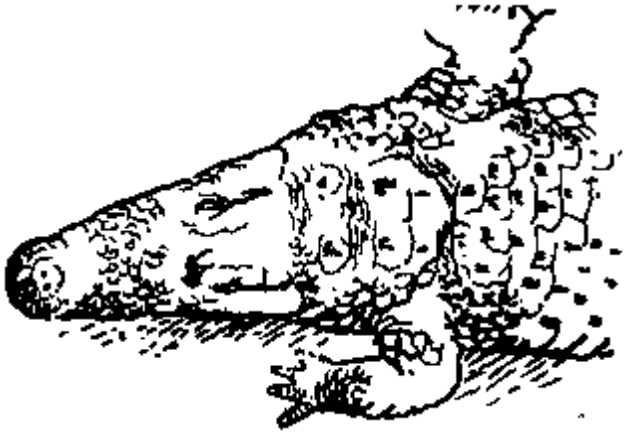
• Lives in a wide variety of habitats: hill streams, rivers, lakes, ponds, swamps and even estuaries.

• Olive-black coloured back and yellowish-white belly

• Distinguished from the estuarine crocodile by its broad snout and presence of four distinct sharply raised scales behind the head.

• Timid but can be approached closely.

• Both the sexes look similar.



Crocodylus palustris

Estuarine or saltwater crocodile, Crocodylus porosus

• Confined to estuaries and coastal sea water.

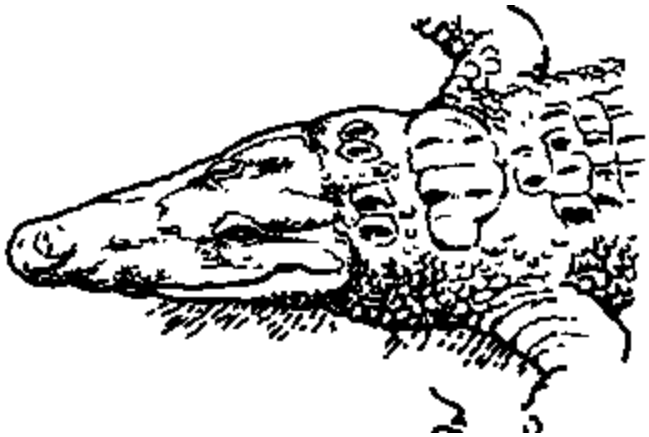
• Striking resemblance with mugger, but the two rarely occur together.

• Snout is more pointed than mugger.

• Distinct ridges in front of eyes.

• Very irritable and attacks people habitually.

• Believed to be extinct on the west coast of India.



Crocodylus porosus

Causes of decline

Attitude. Folklore and religious scriptures have fortified myths. Fisherfolk regard crocodiles as a threat to their traditional fisheries. The reptiles' ecological role is not understood. All crocodiles are thought to eat people. Religious scriptures, such as the story of Gajendra Moksha of the Vishnu Purana, project crocodiles as being in league with evil spirits. In the Bible, the crocodile has been depicted as a fire-spitting evil creature called the Leviathan.

Habitat loss. Mangrove forest is a vital part of crocodiles' environment in some parts of the Western Ghats. But the mangroves are steadily disappearing as they provide fuelwood and fodder. Browsing pressure and expanding human settlements also reduce the crocodiles' habitat.

Agricultural activity. Local people collect the fertile, alluvial soil of mudflats to enrich the soil in their fields. Embankments built to reclaim land interfere with crocodile breeding.

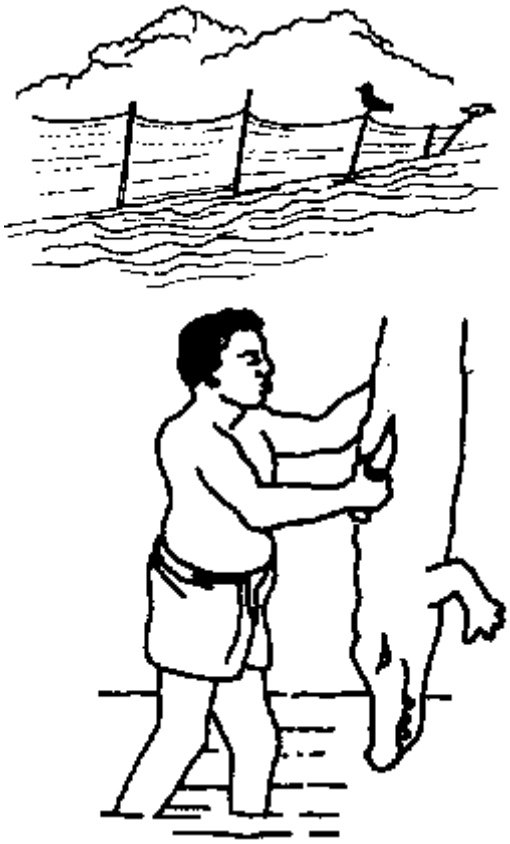
Traditional fisheries. Fishing nets are death traps, especially for juvenile crocodiles. Angling and catching crabs and mudskippers can disturb crocodile habitat.

Nest poaching and predation. Both people and water-monitor lizards predate on crocodile eggs. Tribal people, in particular, relish the eggs.

Hunting for trade. Nomadic tribes hunt crocodiles and trade the skin, meat, viscera and eggs. Some tribals use various parts of the animal to treat human diseases. Such claims have not been experimentally verified.

Accidents. Crocodiles can be wounded or killed by boat propellers. They may stray into nearby rice fields or even houses and be killed by the alarmed farmer or resident.

Unplanned development. Construction work causes siltation of the water and blocks light, affecting biological productivity. Construction noise can disturb the crocodiles. Poorly planned wildlife tourism, particularly by the private sector, can also disturb the reptiles. Pollution from industrial effluents and fecal contamination due to inadequate sanitary facilities can degrade the habitat.



Causes of decline

Crocodile myths and facts

Myth: Crocodiles harm fisheries

Fact: Crocodiles are at the apex of foodchain in their habitat and play the ecological role of a predator as well as that of a scavenger.

• Crocodiles hunt predatory fishes which feed on shoals of commercially important fish. By keeping these predators in check, they can actually increase the fish catch.

• Crocodiles scavenge on dead animals and fishes that otherwise would pollute the water and depress fish numbers.

Food chain for crocodiles

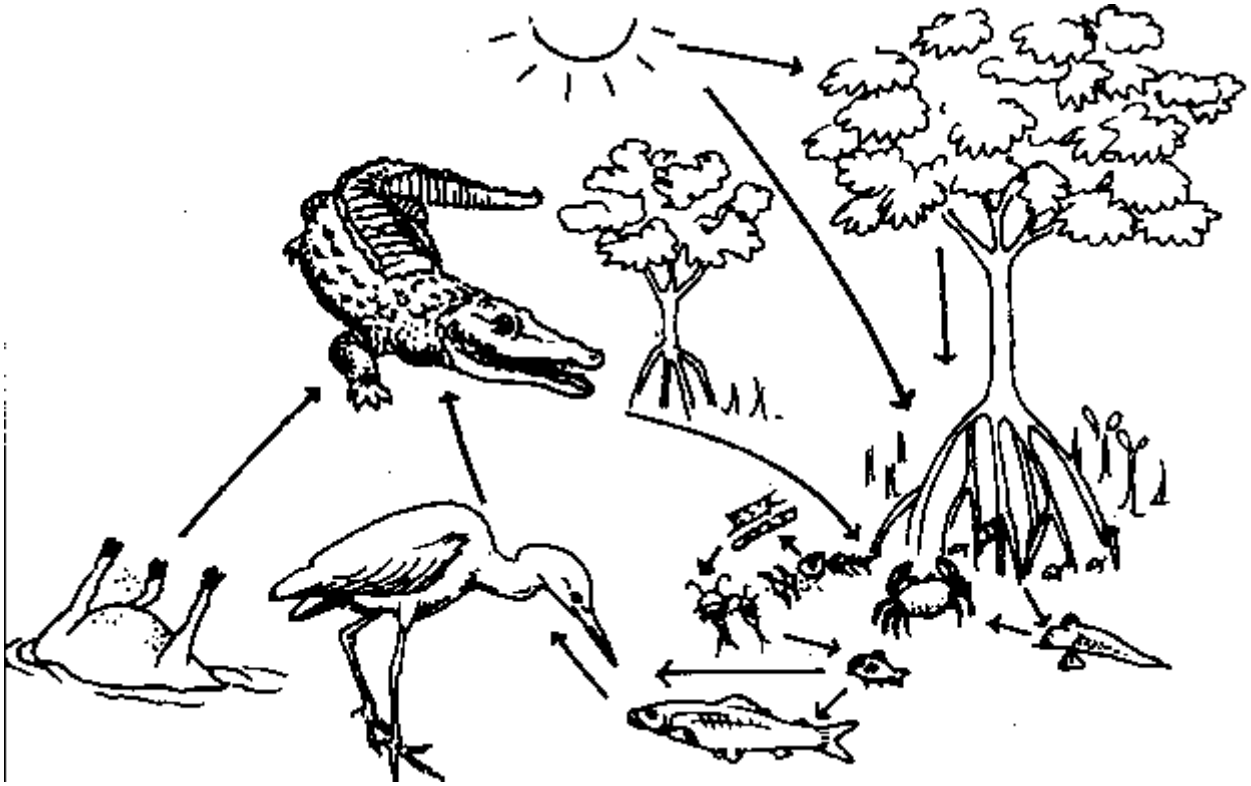
Myth: Crocodiles have no commercial value.

Fact: Crocodiles are a valuable natural resource with immense potential for commerce if used on a sustainable basis

• Crocodile farming and crocodile ranching can generate employment-especially for tribals who have field knowledge of their behaviour.

• Crocodile skin can be made into bags, belts, wallets and shoes, and has a good export potential.

• Crocodile tourism: Crocodile habitats have a tremendous potential for wildlife tourism.



Food chain for crocodiles

Crocodiles in religious rites

In many parts of the world, the fear of crocodiles has been supported by religious rites and beliefs.

A stone crocodile is worshipped at the Sun Temple of Konark in Orissa.

In Gujarat, three tribal communities worship Mugger Dev.

In Kathiawar, a crocodile is the mount of the deity Khodlyar Mata.

Crocodiles in warfare

Historical literature shows that almost 40 years before the Portuguese conquest of Goa, crocodiles infested the "Island of Tiswadi" and that they had been defending the island.

Soldiers used to keep crocodiles to help defend land.

Conservation

It is possible to manage the environment to conserve crocodiles. Indeed, the reptiles have returned to many formerly disturbed habitats.

• Retain and manage habitat. This is the ideal way to manage all wildlife. For crocodiles, mangrove cover should be monitored and laws banning mangrove clearing enforced. Alternative fuels should be sought where mangroves are used for firewood.

• Generate funds. To support conservation if crocodile farming could be encouraged. Farming could be done by the Forest Department or tribal cooperatives.

• Restock the wild population by rearing animals in captivity and releasing them in suitable environments.

• Assess environmental impacts of development activity.

• Organize wildlife tourism.

• Promote traditional conservation. The tribal practice of crocodile worship could be promoted as a way of creating public awareness and seeking compassion for the animal on spiritual grounds.

• Generate public awareness through the mass media and signboards near the crocodile habitat.

• Research and monitor wild and captive crocodile populations.

Crocodile farming: Captive breeding of crocodiles

Crocodile ranching: Collection of eggs and juveniles from the wild and growing them to an exploitable size.

Crocodile worship: Mannge Thapnee

The villages of Bhoma and Durbhat on the

Cumbarjua Canal in Goa observe the tradition of crocodile worship with unshakable devotion. A fowl is sacrificed to a crocodile dummy made of clay. This ceremony is known as

Mannge Thapnee.

Mannge Thapnee

Prepared by Manoj Borkar

8.3 Birds

Some 1,200 species of birds have been recorded in India. The Western Ghats region has about 500 species. Some birds, such as the Bluewinged Parakeet, are found only in the Western Ghats. Others are also found elsewhere in India.

There are currently 44 species of birds considered "threatened" in India.

Mixed hunting party

A "mixed hunting party" is a peculiar phenomenon of the Western Ghats. There may be no bird sound or activity for hours; then suddenly, the observer may be surrounded by birds of all descriptions: bulbuls, drongos, minivets, flycatchers, warblers, woodpeckers and cuckoo-shrikes, to name a few. They are foraging at all levels in the forest, from the ground to the tree canopy. Then, as suddenly as they appeared, they fly off-together.

The mixture of species in the hunting party increases the number of insects that are flushed into the open- meaning more food for everyone.

30 birds of the Western Ghats

Rufous Babbler, Turdoides subrufus

Small Green Barbet, Megalaima viridis

Bluebearded Bee-eater, Nyctyornis athertoni

Fairy Bluebird, Irena puella

Yellowbrowed Bulbul, Hypsipetes indicus

Common Hawk Cuckoo or Brainfever Bird, Cuculus varius

Greater Racket-tailed Drongo, Dicrurus paradiseus

Crested Serpent Eagle, Spilomis cheela

Tickell's Flowerpecker, Dicaeum erythrorhynchos

Paradise Flycatcher, Terpsiphone paradisi

Great Pied Hornbill, Buceros bicornis

Grey or Sonnerat's Junglefowl, Gallus sonneratii

Threetoed Kingfisher, Ceyx erithacus

Scarlet (or Orange) Minivet, Pericrocotus flammeus

Hill Myna, Gracula religiosa

Indian Jungle Nightjar, Caprimulgus indicus

Brown Fish Owl, Bubo zeyonensis

Bluewinged Parakeet, Psittacula columboides

Common Peafowl, Pavo cristatus

Nilgiri Wood Pigeon, Columba elphinstonii

Indian Pitta, Pitta brachyura

Jungle Bush Quail, Perdicula asiatica

Malabar Shama, Copsychus malabaricus

Shikra, Accipiter badius

Red Spurfowl, Galloperdix spadicea

Yellowbacked Sunbird, Aethopyga siparaja

Malabar Whistling Thrush, Mylophonus horsfieldii

Whitebellied Tree Pie, Dendrocitta leucogastra

Malabar Trogon, Harpactes fasciatus

Indian Great Black Woodpecker, Dryocopus javensis

For more information, see the Handbook of the birds of India and Pakistan by Dr. Salim Ali.

Mixed hunting party

Microhabitats in the forest

Forest opening

Openings in the forest generally have no large trees and are covered with grass and small shrubs. Birds like Junglefowl, Peafowl, Spurfowl and Quails often come to an opening to feed on grass shoots, grains and insects. Birds of prey such as the Shikra and Hawk Eagle keep an eye out for such birds venturing into a clearing. They usually perch on outstretched branches of lofty trees or trees with dense foliage.

Stream

Overhanging branches of bushes and trees on the banks of a forest stream are favourite haunts of Flycatchers, Warblers, Babblers and other insectivorous birds. The Malabar Whistling Thrush is often seen on boulders. It feeds on snails, worms, crabs and frogs.

Waterhole

A small pond or a waterhole in the forest is an important source of water for birds, especially during hot, dry summer days. Flycatchers, Robins, Pigeons, Hawks, Eagles, Orioles, Bulbuls. Junglefowl and many other forest birds visit the waterhole to drink and bathe. A small bush or a bamboo thicket around the waterhole can be used as a natural hide to observe birds without disturbing them.

A dry, standing tree

Even a dead standing tree in the forest attracts a number of birds. Drongos and Bee-eaters are often seen on such trees, keeping watch for flying insects. Green Pigeons basking and preening their feathers in the early morning hours are a common sight in forest areas. Barbets and Woodpeckers find such trees ideal for digging their nests. Such trees give the observer an unobstructed view of the birds.

Flowering trees

Flowering trees like Silk Cotton, Flame of the Forest, Bauhinia and Indian Coral offer excellent opportunities to birdwatchers. These trees lose their leaves at certain times of year, making it easy to observe birds. Bearing attractively coloured flowers, such trees come alive with the chirping and fluttering of Drongos, Bulbuls, Mynas, Rosy Pastors, Barbets, Minivets, Babblers and a variety of other birds which feed on nectar and insects.

Birds as indicators of biodiversity

Monitoring biodiversity can be difficult. So instead of counting every species in a given area, it is often preferable to use proxies or substitutes. One such method is the use of indicator species, such as a particular bird. Some birds are found only in certain habitats or ecosystems. If we see one of these birds, we know that its habitat and its associated diversity exists. And if we know how big a territory each individual bird occupies, we can make a rough estimate of the habitat area.

The Malabar Pied Hornbill is a good indicator of healthy mature, deciduous forests along the Western Ghats.

Malabar Pied Hornbill

Great Pied Hornbill

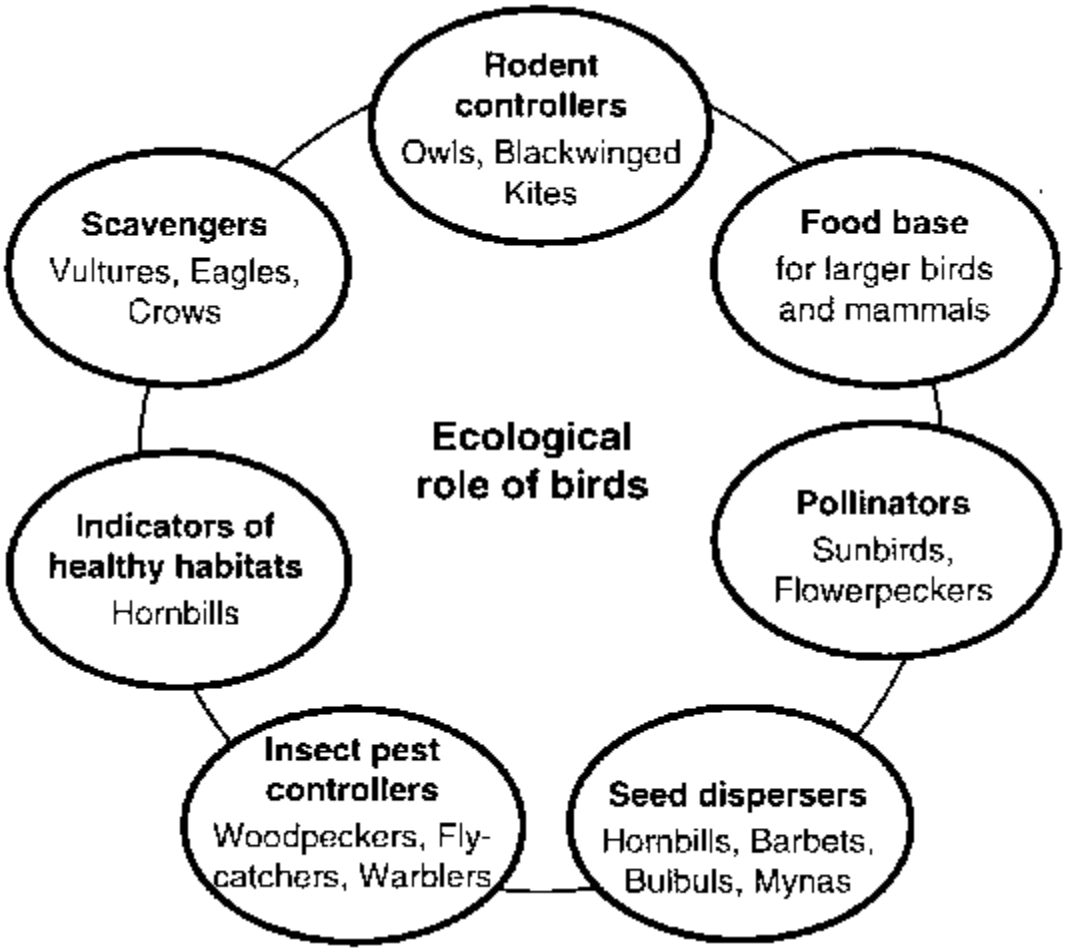
Ceylon Frogmouth

Broad-tailed Grass Warbler

Red-faced Malkoha

Greyheaded Bulbul

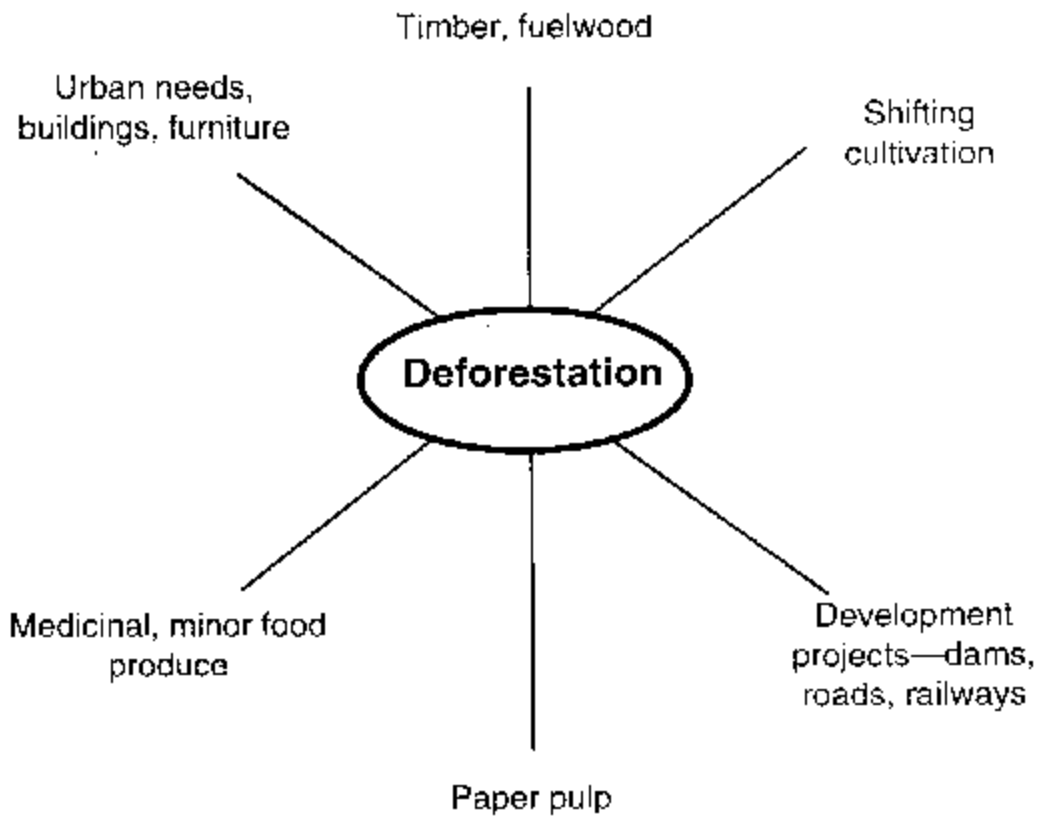
Ecological role of birds



Some endangered birds of the Western Ghats

Threats

Deforestation destroys the habitat of many birds and is a major threat to birds in the Western Ghats. Trapping of birds for the pet trade and hunting them for food add to the decline. Cattle grazing and man-made forest fires inhibit regrowth, making it difficult to restore degraded forests.



Deforstation

Plants, which attract birds

Scientific name	**Common English**	**Part of the plant used by birds**
Ficus benghalensis	Banyan	Fruit, cavities: Bulbuls, Mynas, Barbets, Owlets
Ficus religiosa	Peepul	Fruit, cavities: Owlets, Mynas, Parakeets
Ficus glomerata	Cluster fig	Fruit: Bulbuls, Hornbills, Barbets, Pigeons
Bombax malabaricum	Silk cotton	Flower nectar: Sunbirds, Rosy Pastors, Orioles
Erythrina indica	Coral tree	Flower nectar, petals, branches to dig into for nests
Butea frondosa	Flame of the forest	Flower nectar: Babblers, Bee-eaters, Bulbuls

Mangifera indica	Mango	Fruit, thick foliage to hide and nest: Mynas, Oricles, Shikra
Psidium guajava	Guava	Fruit: Parakeets, Koels, Barbets
Moringa oleifera	Drumstick	Pods, flowers: Sunbirds, Parakeets
Lantana camera	Lantana	Fruit, flower nectar, thorny branches to nest: Bulbuls
Eugenia jambolana	Black plum	Fruit: Barbets, Hornbills, Bulbuls
Caesalpinia pulcherrima	Peacock flower	Flowers, pods: Parakeets, Flowerpeckers, Sunbirds
Callistemon lanceolatus	Bottle brush	Flower nectar: Flowerpeckers, Warblers, Tits
Acacia nilotica	Babul tree	Pods, branches to nest: Bayas, Doves, Parakeets
Trachelospermum fragrans	Hill jasmine	Branches to nest, flower nectar: Sunbirds, Doves
Jasminum grandiflorum	Spanish jasmine	Flower nectar, branches to nest: Sunbirds, Sparrows
Russelia juncea	Corai plant	Flower nectar Sunbirds, Warblers
Tamarindus indicus	Tamarind tree	Branches to nest: Herons, Egrets, Ibises, Crows
Spathodea campanulata	Tulip tree	Petals, watery flowers, pods, branches to nest
Samanea saman	Rain tree	Branches and foliage as day roost and nest, flower nectar: Pigeons, Crows, Mynas
Polyalthia longifolia	Ashoka tree	Branches and leaves to nest: Munias
Boswellia serrate	Salai	Fnuits, branches to nest, papery bark as nesting material: Minivets
Carvia callosa	Karvi	Flower nectar, seeds as food, branches to nest

Bndelia retusa		Fruit: Bulbuls, Hornbills, Mynas, Barbets
Eucalyptus sp.	Eucalyptus	Flower nectar, branches to nest, bark as nesting material: Tree Pie
Malphigia sp.	Singapur cherry	Fruit (berries), flower nectar: Pigeons, Koels
Pithicolobium dulce	Manila tamarind	Fruit: Parakeets, Bulbuls, Mynas
Azadirachta indica	Neem tree	Fruit, branches to nest: Crows
Santalum album	Sandalwood	Fruit: Bulbuls, Koels, Mynas
Derris indica	Karani	Thick foliage for day roost: Mynas, Warblers

Prepared by Kiran Purandare

8.4 Mammals

Endemic species

The forests of the Western Ghats harbour many different mammals. There are about 60 species, including various endemic and endangered types.

Seven species of mammals are endemic to the Western Ghats. Two primates, the Liontailed Macaque and the Nilgiri Langur, are found only in a few forested patches in the Nilgiri area. The Nilgiri Marten (a weasel) and Nilgiri Tahr (a wild goat) are also found in these areas. The other endemic species are the Malabar Civet and the Grizzled Giant Squirrel, which are restricted to a few patches of the Western Ghats. The Small Travancore Flying Squirrel, a highly endangered species, inhabits the forests of Kerala. Porpoises (marine mammals) occur along the west coast.

Causes of decline

Habitat loss

Animals such as the Lion-Tailed Macaque and Nilgiri Tahr are in danger because of expanding grazing grounds, road construction in the primary forests, and destruction of forest cover.

Poaching and smuggling

Various endangered animals in the Western Ghats are hunted for various parts of their anatomy. Tigers and elephants are poached for their ivory, bones and fur. The Slender Loris is hunted for its eyes- due to a misconception that medicine prepared from the eyes can cure certain eye diseases.

Despite legal bans, poaching and smuggling of skin, fur, bones and ivory is still rampant. The Delhi police seized 162 kg of tiger bones and six skins in one raid in 1993.

Human interference

• Cattle grazing in the buffer zones around the forests spreads disease to wild animals like the gaur.

• Human settlements are encroaching on the forests.

• Vehicles, garbage and effluent discharges pollute the habitat.

• Mining in and near forested areas damages the ecosystem.

• Timber contractors clear large areas of forest.

Tourism

Heavy tourist pressure in and around the forested areas may disturb the animals

What is a mammal?

Mammals:

• are warm blooded

• breathe air using lungs

• have body hair

• produce milk and suckle their young

There are 370 species of mammals in India.

What is a mammal?

Predators

Mammals play an important role in the ecosystem. Predators like the tiger, leopard and wild dog occupy the highest level in the food pyramid. The destruction of a single carnivore like the tiger would upset the balance of the entire forest ecosystem.

Conservation

• The Indian Wildlife Protection Act of 1972 as amended in 1991 defines and restricts hunting, trading or capture of wildlife.

• Alternate sources of income and other appropriate activities should be encouraged to prevent cattle grazing.

• More viable wild areas should be protected by forming biosphere reserves.

• Pollution control laws should be effectively implemented.

• Effective buffer zones should be created wherever activities detrimental to forests are carried out, especially near sanctuaries and national parks.

• Research is needed on the habits and habitats of animals in the Western Ghats.

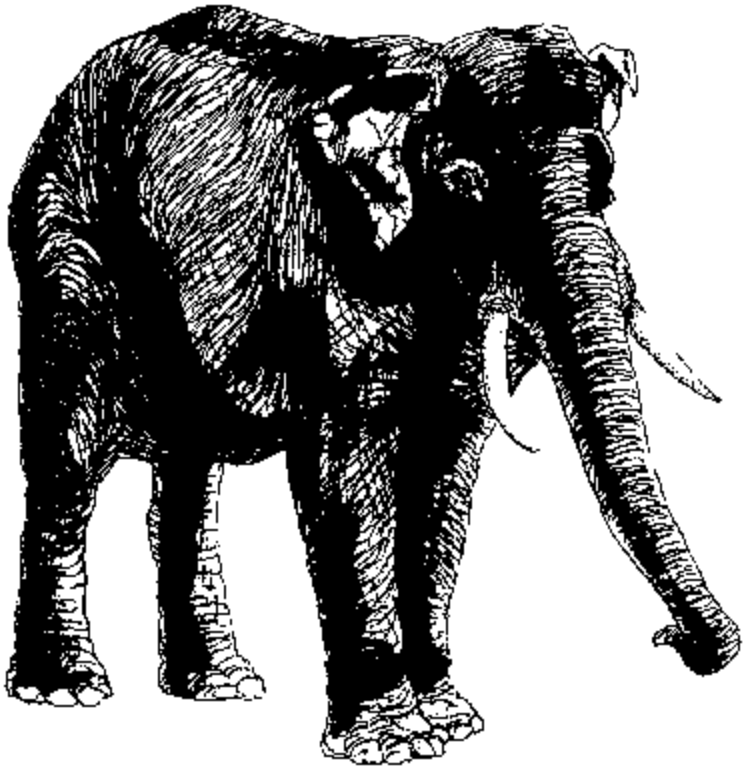
• Public awareness should be raised through films, lectures, talks, discussions, nature trails and other methods. Interpretation centres could help orient tourists towards conservation.

• Education programmes such as field trips, camps and treks should be organized for students.

• Awareness programmes should be arranged for local villagers to depict how their ancestors co-existed harmoniously with the forest and to show the dangers to their own survival if they upset the delicate natural balance.

Deliberate or accidental?

In Nagerhole National Park, world-renowned as a wildlife habitat, a massive forest fire in 1993 devastated several hectares of primary forest. It seems the fire was deliberately caused by local villagers to spite an overzealous forest officer who was strictly enforcing the wildlife laws.



Deliberate or accidental?

Endangered, endemic mammals of the Western Ghats

Lion Tailed

Macaque Macaca silenus

Black, shy, canopy dweller;

has cheek pouches; moves in

troops; endangered due to habitat loss.

Macaque Macaca silenus

Malabar Civet

Viverra megaspila

Grey with black markings;

ringed tail; nocturnal;

restricted to coastal areas;

stink gland.

Viverra megaspila

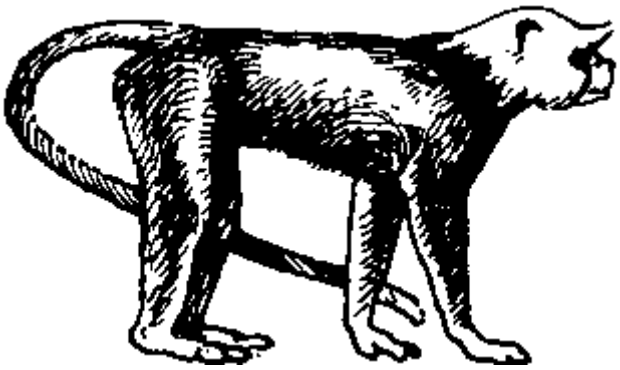
Nilgiri Langur

Presbytis johni

Black faced monkey;

long tail; leaf eater; most hunted

for medicine due to misconception.



Presbytis johni

Grizzled Giant Squirrel

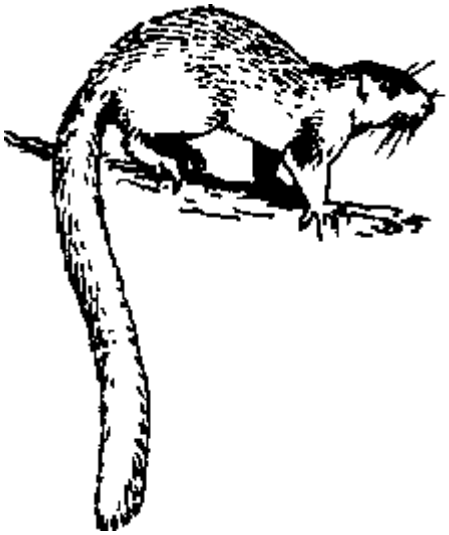
Ratufa macroura

Brownish-grey colour;

shy, canopy dweller; restricted to few areas

of Western Ghats;

endangered due to habitat loss.



Ratufa macroura

Small Travancore

Flying Squirrel

Petinomys fuscocapillus

Nocturnal; restricted to tropical

evergreen forests;

was feared extinct;

recently rediscovered in Kerala.

Petinomys fuscocapillus

Nilgiri Marten

Martes gwatkinsi

Looks like an otter;

hunts on trees;

predatory in habit;

restricted to Nilgiri Hills.

Martes gwatkinsi

Nilgiri Tahr

Hemitragus hylocrius

Mountain goat;

prefers rocky terrain;

found at higher elevations;

hunted for flesh.

Hemitragus hylocrius

Mammals found in the Western Ghats

Liontailed Macaque Macaca silenus Ed,En

Bonnet Macaque Macaca rediata

Common Langur Presbytis entellus

Nilgiri Langur Presbytis johni Ed,En

Slender Loris Loris tardigradus En

Tiger Panthera tigris En

Leopard Panthera pardus En

Leopard Cat Felis bengalensis En

Rustyspotted Cat Felis rubiginosa En

Fishing Cat Felis viverrina En

Jungle Cat Felis chaus En

Malabar Civet Virerra megaspila En,Ed

Small Indian Civet Viverricula indica

Common Palm Civet Paradoxurus hermaphroditus

Brown Palm Civet Paradoxurus jerdoni

Common Mongoose Herpestes edwardsi

Ruddy Mongoose Herpestes smith)

Stripednecked Mongoose Herpestes vitticollis

Brown Mongoose Herpestes fuscus

Striped Hyena Hyaena hyaena

Jackal Canis aureus

Indian Wild Dog Cuon alpinus En

Sloth Bear Melursus ursinus En

Common Otter Lutra lutra

Smooth Indian Otter Lutra perspicillata

Clawless Otter Aonyx cineria En

Nilgiri Marten Martes gwatkinsi En,Ed

Indian Tree Shrew Anathana ellioti

Grey Musk Shrew Suncus murinus

Flying Fox Pteropus giganteus

Fulvous Fruit Bat Rouseltus leschenaulti

Shortnosed Fruit Bat Cynopterus sphinx

Bearded Sheath Tailed Bat Taphozous melanopogon

Indian False Vampire Megaderma Iyra

Great Eastern Horseshoe Bat Rhinolophus luctus

Salim Ali Bat Latidens salim alii En

Indian Pipistrelle Pipistrellus coromandra

Painted Bat Kerivoula picta

Indian Giant Squirrel Ratufa indica

Grizzled Giant Squirrel Ratufa macroura En,Ed

Common Giant Flying Squirrel Petaurista petaurista

Dustystriped Squirrel Funambulus sublineatus

Small Travancore Flying Squirrel Petinomys fuscocapillus En,Ed

Threestriped Palm Squirrel Funambulus palmarum

Indian Gerbille Tatera indica

Indian Field Mouse Mos booduga

Whitetailed Wood Rat Ratus blanfordi

Longtailed Tree Mouse Vandeluria oleracea

Common House Rat Rattus rattus

Bandicoot Rat Bandicota indica

Indian Porcupine Hystrix indica

Blacknaped Hare Lepus nigricollis

Indian Elephant Elephas maximus

Gaur Bos gaurus

Nilgiri Tahr En,Ed Hemitragus hylourius

Fourhorned Antelope Tetracerus quadricornis

Chital Axis axis

Sambar Cervus unicolor

Barking Deer Muntiacus muntjak

Mouse Deer Tragulus meminna

Indian Wild Boar Sus scrofa

Indian Pangolin Manis crassicaudata

Porpoise Neomeris Ph oc o e n o ides

Legend:

En -Endangered

Ed -Endemic

Prepared by R. Bhanumathi

8.5 Animal diversity in prehistoric rock-art

Since their hunter-gatherer stage of prehistory, people have used rock-paintings, scrapings or engravings-as a major medium to depict their lifestyles, beliefs, dreams, fears and fantasies.

World rock art dates from about 50,000-5,000 B.C. In India, 36 centres of rock art have been identified. Most are located in central and south India.

Animal and plant biodiversity as depicted in rock art provides a glimpse of ecological resources of the past ages and throws light on paleoclimatic and environmental changes.

Exhaustive studies on animal forms in India's largest rock art complex, Bhimbetka, have provided useful insights. The rock paintings show giraffes, ostriches, rhinos and hippos-animals now extinct from that region.

In May 1993, researchers discovered the first evidence of rock art in the Western Ghats-at Usgalimol-Kevon-Dhandode, on the banks of the Kushavati river, 30 km from Margao (South Goa). This rock art is in the form of engravings on manganese-

containing laterite. It is a rich treasure opening a door to our knowledge of macrofauna of this part of the Western Ghats.

These 100+ engravings (known as petroglyphs) have been tentatively dated to 2500-6000 B.C.

Over 90% of the engravings depict wild animals in the foothills of the Western Ghats. Not much is known about this "earth mother goddess" (a primitive form of Durga or Shakti) worshiping society of the prehistoric hunters. However a careful analysis of the rock-art site and the animal forms depicted therein reveals several clues.

• The rock-art appears to show a paleoenvironment which was far richer in ecological resources such as forest and resident fauna.

• People of this period had an intimate knowledge of animal forms, habitats, mating season, locomotion and behavior.

• Some animals (e.g., gaur, wild humped bull [zebu]) were dominant and were widely hunted.

• While no carvings of weapons have been found, some animals are shown bearing wound marks, as if inflicted by composite weapons (i.e., stone + wood).

• Wild asses and horses are absent, as is sloth bear.

• Hunting was done through "mass chase" by trapping the animal in a lagoon-like waterhole, located close to the carving site.

• Carvings of wild dog and jungle cat imply probable efforts of their domestication.

• Some animals, e.g., elephant, Indian wild dog, zebu and wild goat, are not depicted and may not have existed in the area.

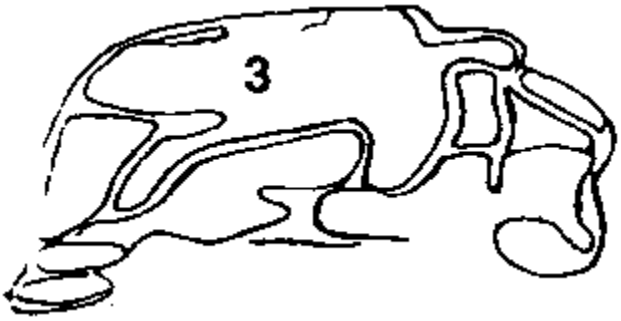
• The art includes a puzzling carving: of a look-alike of Rhinoceros deccanensis, known to be extinct about 20-25,000 years ago (i.e., in the late Pleistocene)-well before the art is thought to have been carved.

• Animal fauna may correspond to the environment of the period intermediate to sea-level regression (18,000 B.C.) and the Holocene transgression (6,000 B.C.), as recorded globally and on the west coast.

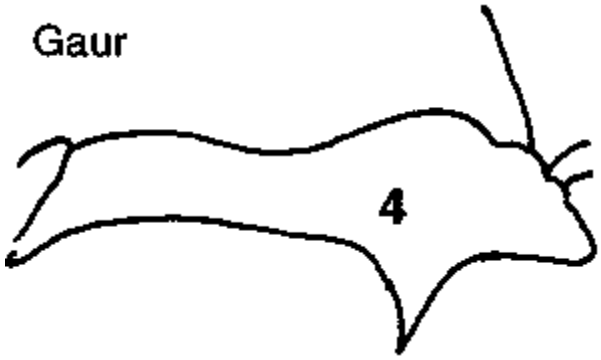
• Animal diversity depicted at Usgalimol gives useful information when compared with the one found in Bhimbetka rock paintings, and the present diversity of the Western Ghats.

Common Langur

Wild Hare



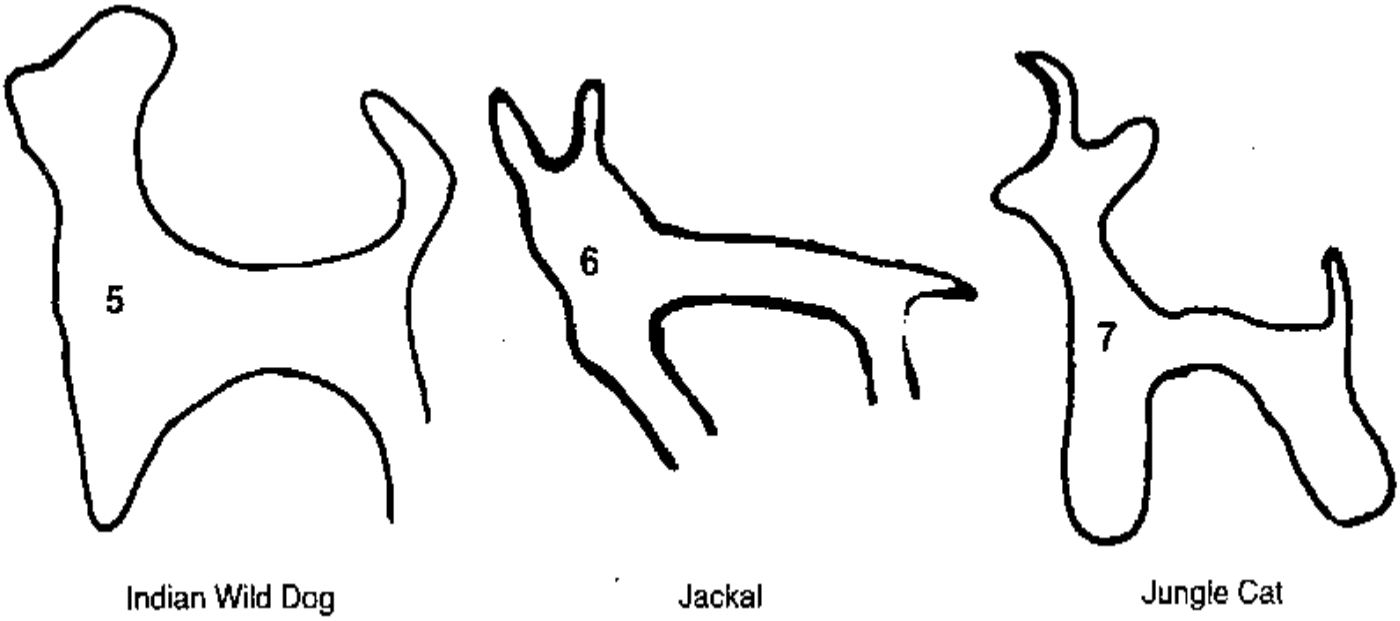
Elephant



Gaur

Significance of animal diversity

Although prehistoric humans faithfully left imprints of familiar animals in rock art, those which provided food for them occupied centre stage. The rock art at Usgalimol gives us insights into the life of the wandering hunter-food gatherer tribes of the pre-historic Western Ghats. The implied purposes of animals as cited show the first steps of humankind's evolution of primitive language and religion. Animal diversity has always fascinated humankind, but this fascination is deeply rooted in the trying and testing periods of human evolution. Besides capturing prehistoric animal diversity, the rock art also provides a useful cultural link to bridge the present with the past in the context of the current concerns about animal diversity.

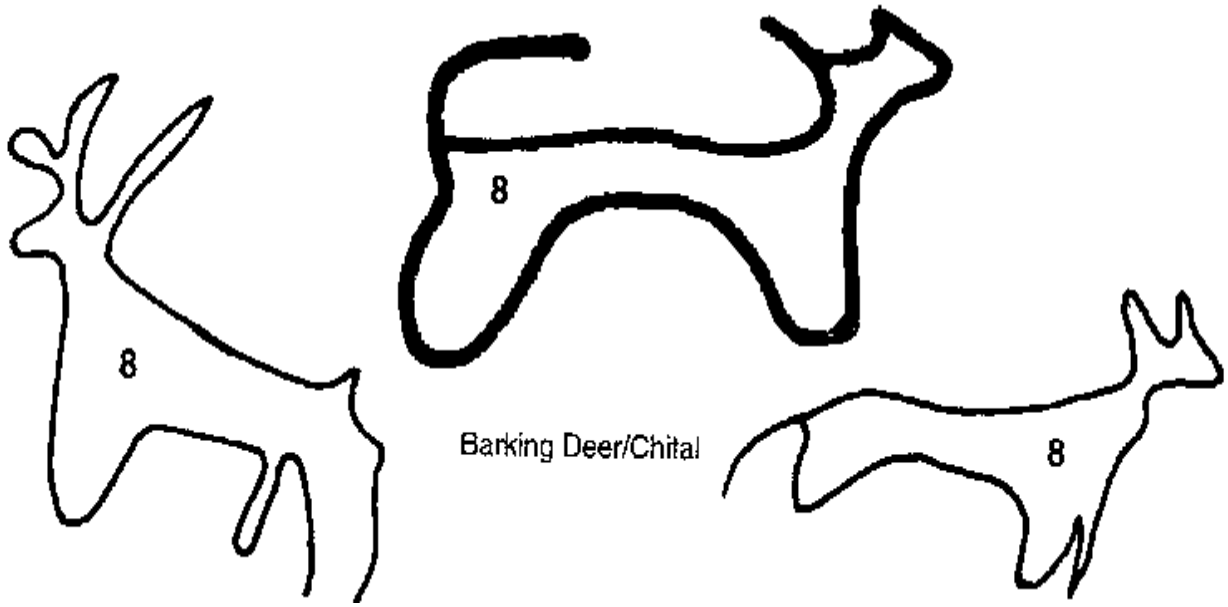


Significance of animal diversity

Animal diversity through the ages

Animal	**Usgalimol rock art**		**Bhimbetka rock art**	**Presently found in**	
	Figure	**Freq.**		**Goa**	**W. Ghats**
Common langur	1	+	-	+	+
Wild hare	2	++	-	-	+
Elephant	3	+	+		+
Gaur	4	++++	++	+	+
Indian wild dog	5	++	-	-	+
Jackal	6	+	-	+	+
Jungle cat	7	+ +		+	+
Chital	8	++++	+	+	+
Barking deer	8	+ + + +	+	+	+
Indian wild bull (zebu)	9	+ + + +	+	-	+
Antelope	10	+ +	+	-	+
Wild goat	11	++	-	-	+
Indian wild boar	12	+	+	+	+
Striped hyena	13	+	+	-	+
Giraffe	-	-	+	-	-
Ostrich	-	-	+	-	-
Rhinoceros	-	+/-?	+	-	-
Hippopotamus	-	-	+	-	-

+, ++, etc. indicate frequency of occurrence - indicate absent



Animal diversity through the ages

Animals at Usgalimol

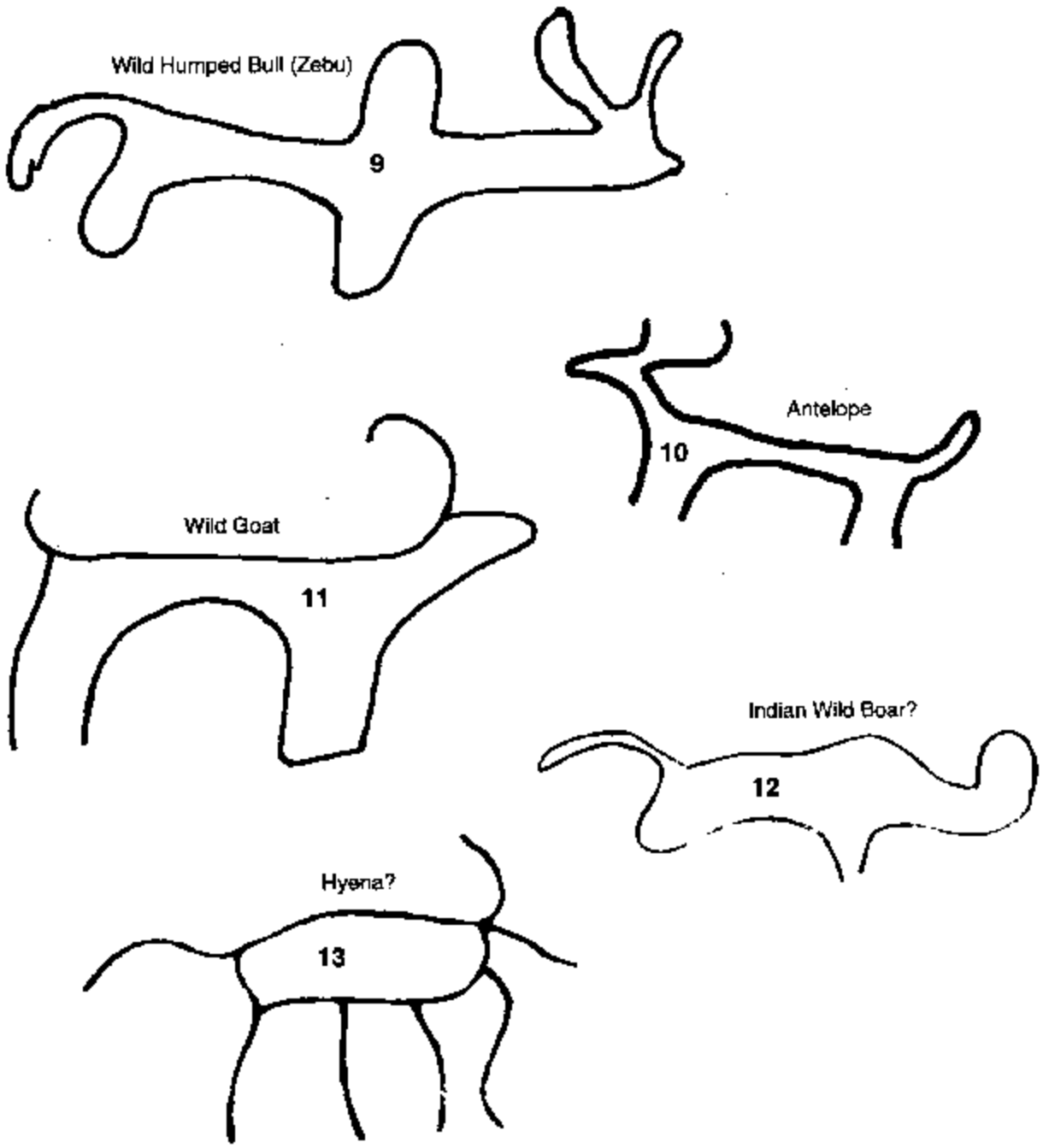
The carvings appear to fall into four categories:

• Animals hunted as game for food: figures 3, 4, 8, 9, 12

• Animals probably domesticated for hunting or pets: figures 5, 7, 11

• Animals with ritualistic uses such as in shamanism or sorcery: figure 3

• Animals used only for artistic purposes: figures 1, 13



Animals at Usgalimol

Prepared by Nandkumar Kamat

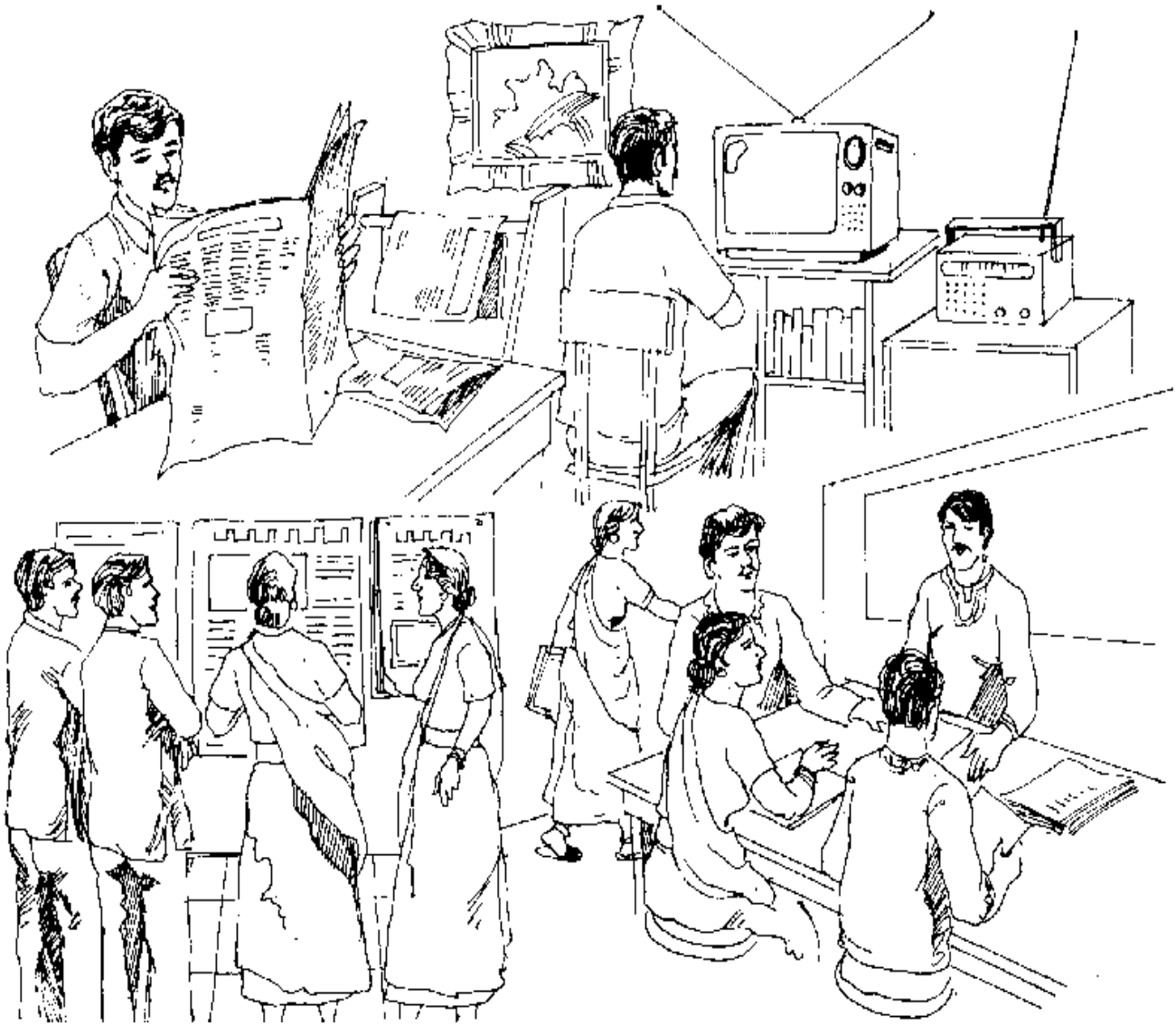
9. Appreciating and conserving biodiversity

9.1 Biodiversity and the media

The conservation movement is a movement for the people, by the people and of the people. But how to reach the people? National, state and local governments have been slow to respond. Media, both print and electronic, have a major role to play.

Environmental education, awareness and training play a vital role in evolving strategies for conservation protection and management of environment. The media can help build public awareness on actions they can take, for instance, tree planting and people-oriented strategies to regenerate India's wastelands.

The mass media are not the only methods: seminars, workshops, rallies, training courses, public meetings, padayatras, exhibitions, essay contests, debates, paintings and poster competitions, folk dances and street theatres need to be organized at regular intervals to spread the message of conservation.



Biodiversity and the media

Despite the importance of environmental issues, the media pay them scant attention. The coverage is often distorted, unscientific and negative, aimed at creating an issue to sell the paper. This situation needs to be corrected through training and motivation.

Journalists are key gatekeepers in the information dissemination process. There is a need to educate and motivate them in environmental concepts and in local and regional issues.

A common complaint is that information in the media is incorrect. Often the coverage is based on press releases issued by the interested parties for their own motives. Reporters must be aware of the dangers of such manipulation. Sound interaction

among official agencies, NGOs, nature clubs, scientists and the media can ensure that accurate information is published.

NGOs can help ensure accuracy in the media's coverage by establishing a syndicated feature service to disseminate stories. Newspaper "stringers" (part-time reporters) should be given guidelines on how to cover environment-related stories and encouraged to seek out such stories. Broadcast media should be encouraged to record on location in the field rather than in the studio. The media should report activities of interest and related to the community.

Methods of promoting conservation

Survey of flora, fauna, forests, wildlife

Surveys

Environmental impact assessment

Eco-regeneration

Assistance to organizations implementing environmental and forestry programmes

Environmental legislation

Formulation of environmental policies

Research

Extension, education and staff training

Dissemination of environmental information

International cooperation

Creation of public awareness on the environment

Prepared by Jagdish Wagh

9.2 Role of non-government organizations in conservation

Genesis of voluntarism

The non-violent movement for national independence under the leadership of Mahatma Gandhi had as a broader goal the restructuring and development of Indian society through the people's own initiative.

The post-independence era has seen the adoption of the Western model of development. It has also seen a steady destruction of biodiversity in the Western Ghats, for instance through the construction of large dams and the expansion of industry and transport networks.

Before the movement to save the Silent Valley in the 1970s and early 1980s, voluntary groups were limited in the scope of their activities.

The first eco-organizations, such as the World Wildlife Fund-India (now the World Wide Fund for Nature), worked for the protection of wildlife. Radical groups such as Bhoomisena in Manor-Dahanu, Maharashtra, fought for the rights of tribes.

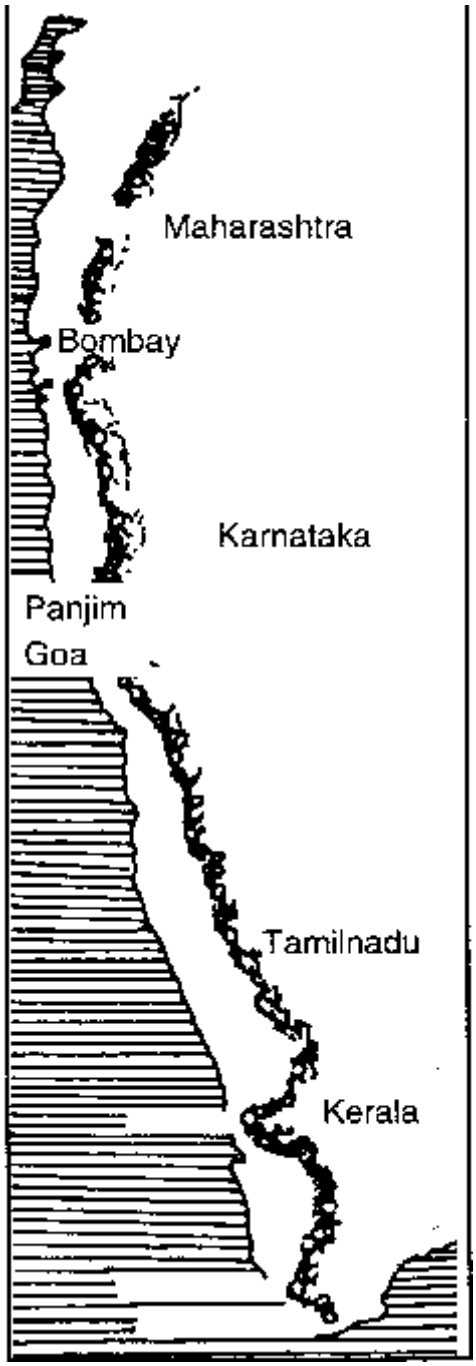
The emergence of the Chipko Movement in the Himalayas sparked voluntarism in the Western Ghats to protect its biodiversity from threats from so-called development activities.

Genesis of voluntarism

History

1800-1820	The British took control of the Western Ghats after annexing the territory of Tipu-Sultan and Marathas.
1806	All teak in Malabar was reserved for commercial use by the British. This was the first show of interest in commercial forestry by the British.
1830-1880	Massive deforestation by the British for ship building and for railway construction and operation.
1853	First railway built between Thane to Bombay in the Western Ghat region. First successful Indian cotton mill started in Bombay.
1864	Government Forest Department formed to control the forest. Dietrich Brandis, a German, was appointed first Inspector General of Forests.
1865	Indian Forest Act passed to establish state monopoly rights over forest resources. This was replaced by more comprehensive legislation in 1878.
1917-	First World War. 228,076 tons of timber (excluding railway sleepers) were

1918	supplied by the specially created "Timber Branch" to help Allied military operations in Egypt and Iraq. Approximately 1.7 million cubic feet of timber (mostly teak) were exported annually during the war.
1929	Silent Valley identified by the British as a dam site.
1940	Second World War. Timber Directorate set up in Delhi to channel supplies of forest produce from the provinces. Impact of the war on Indian forests was severe, especially in the Himalayas and Western Ghats.
1947	A non-violent movement led by Mahatma Gandhi freed India from British colonial rule. Gandhi saw that technology should be an instrument to improve human skills and not to replace them. He advocated self-sustained development activities. Independence freed India from imperialistic exploitation of its natural resources.



Western Ghats.

Institutions

Government

The Indian government began major construction activities, expanded the rail and road networks and boosted industrial growth. This resulted in the destruction of vast

areas of tropical forests and depletion in biodiversity. Since 1970, government policies have changed gradually to give more consideration to ecological balance.

Nongovernmental organizations

The detrimental effects of development on the environment have aroused the people's voice to save their environment and their own lives. NGOs emerged to protest against projects that depleted natural resources. This pressure has resulted in the formation of 510 wildlife sanctuaries throughout the country.

NGO efforts to conserve biodiversity

Silent Valley

Silent Valley is well known for its biodiversity. For instance, more than 20 genes for pest resistance have been found in traditional rice varieties grown in the valley.

In the late 1970s, the valley was threatened by a proposed 120 MW hydroelectricity project. In 1929, the British had identified the valley as a dam site. A technical survey was completed in 1958, and work began in 1976 with the cutting of forests near Kunti river. Public awareness had been built by the success of the Chipko Movement in preventing the destruction of natural resources in the Himalayas. Despite strong government resistance, NGOs such as WWF and Kerala Shastra Sahitya Parishad launched a campaign to save the Silent Valley. The campaign succeeded in 1983 when Prime Minister Indira Gandhi announced the scrapping of the project and the establishment of a national park in the area.

Bedthi dam

Similar issues emerged at North Canara, Karnataka. The state government was determined to construct a hydroelectric dam at this site. This would have destroyed a vast area of traditional horticulture, and evergreen hill forest. In 1980, farmers in the surrounding area organized a massive campaign against the project, resulting in its withdrawal in 1982.

Types of NGOs

NGOs work in a wide range of areas: protection of forests and water resources; promotion of clean environment; watershed development; poverty alleviation; afforestation; people-oriented forest policy; literacy; natural farming; protection of indigenous seeds, plants and animals; culture regeneration of rural and tribal communities.

Three broad categories of NGOs are:

Nature and technical groups: Impart educational and technical training in various facets of nature and technical aspects of the environment.

People's groups: Mainly formed by local people to conserve their natural surroundings.

Popular movements: Movements by activists and. the people to protest developmental activities which destroy biodiversity, and to conserve and regenerate natural resources.

Growth

The enormous growth in voluntarism in the Western Ghats has checked the speed of destruction to biodiversity. NGOs have helped ensure local people's participation in sustainable development.

Appiko Movement

The Appiko Movement, the Kannada version of the Chipko Movement, started in 1983 to protect the Salkani forest near Sirsi, Karnataka. The state Forest Department had begun clear-felling of the forest in September. About 160 men, women and children hugged trees marked for cutting. This campaign continued for almost six weeks. Some 12,000 trees were saved by this movement, and the destruction of biodiversity was halted in the area. The campaigners later began a massive afforestation programme to revegetate the area.

Save the Western Ghats March

In November 1987, two groups of marchers started from the northern and southern ends of the Western Ghats. After a 100-day march, they met in Goa in February 1988. The march highlighted the heavy depletion of forest in the north compared to the south. It also focused attention on the mushrooming development projects threatening the biodiversity of the region. The conference following the march extended its support for people's actions against dam construction in Pulingam (Kerala), the damming of the Sharavati in Utter Kannada and the Kaiga Atomic Plant. It also supported local struggles for common land and other movements and efforts.

Actions to stop destruction of biodiversity

• Halt development activities that cause deforestation.

• Undertake local-level projects for ecological sound development: jointly by government and NGOs.

• Revegetate eroded areas by planting indigenous species.

• Reserve natural water sources (springs, lakes, ponds, nallas) as public assets.

• Implement watershed development programmes with the active involvement of local communities.

• Promote natural (organic) farming and agro-based industry as sustainable alternatives to modern farming. Stop use of chemical fertilizers and pesticides. Develop seed banks in each village to protect local species.

• Start non-conventional energy programmes to improve daily life of the rural poor and reduce the amount of fuelwood cut from the forests.

Issues addressed by NGOs

• Water crisis

• Depletion of indigenous species of flora and fauna

• Soil erosion

• Deforestation

• Air and water pollution

• Growing migration

• Marginalization of rural poor and tribals

• Unprecedented population growth

Actions to stop destruction of biodiversity

Prepared by Kumar Kalanand Mani

9.3 Watershed management

A watershed is the area drained by a single stream or river. Watersheds can be as large as the Ganges drainage basin, which covers much of northern India, to as small as the area feeding a tiny stream or tributary of a larger river.

Watershed management integrates technologies to develop and conserve land, water and plant resources within the natural boundaries of a drainage area. It aims to reduce erosion and sedimentation which can reduce soil fertility and degrade lakes, streams, rivers, estuaries, and coastal regions.

Why a watershed approach?

What happens upstream affects areas downstream. For instance, deforestation and erosion in the hills can silt rivers and cause flooding downstream. And the amount of water percolating into the soil high in a valley determines the flow of springs and rivers lower down. That makes it useful to study watersheds as a whole and implement conservation practices over the whole area rather than piecemeal.

Soil erosion

Soil erosion is a serious problem in many areas of the Western Ghats. Removal of the topsoil by erosion lowers soil fertility and therefore the the biodiversity it is able to support. The topsoil washes downstream and is deposited in reservoirs, ponds and

river beds, reducing the efficiency of irrigation systems and exacerbating floods. The suspended sediment in the water reduces the level of photosynthesis in the water and harms aquatic life.

Conserving water

When rain falls to the ground, part percolates into the soil, part stays on the surface and evaporates, and part runs off the surface to swell streams and rivers.

Some of the portion that percolates into the soil is used by plants. The rest becomes groundwater, which in turn feeds wells and springs.

Conserving water

Reducing runoff

The best way to conserve moisture is to control the amount of rainfall that normally runs off the land. Keeping water on the surface for a longer time allows more to percolate into the soil. This recharges the water table and water bodies and increases the amount available for agriculture and other uses.

Various methods can be used to increase percolation:

• Bunds (ridges) that run along the contour and check water flowing downslope. Plant vetiver grass on these bunds to prevent erosion.

• In situ conservation using basins, furrows, broad-based ridges and furrows, and random tie ridges.

• Check dams and structures to control the formation of gullies.

• Small ponds in individual farmers' fields to harvest runoff and make it available for farm use.

• Percolation ponds to collect excess water and recharge groundwater. The water in the percolation tank helps maintain the water table and stabilize irrigation supplies.

• Irrigation tanks to collect excess runoff for use in irrigation.

Using groundwater

Groundwater can be used in various ways. Wells and boreholes are traditional methods. Small sub-surface dams can be constructed and groundwater pumped out for use.

Water budgeting

The water stored and conserved in the soil should be used in the best way-for instance, by selecting crops and varieties that require little water. These will often be indigenous cultivars. Reducing water use allows the remaining soil moisture to be used for other crops such as fodder, green manure, tree and horticultural crops.

Appropriate crop management techniques and improved irrigation systems, such as sprinkler and drip, can also conserve moisture.

The ideal land use depends on numerous factors: climate, slope, soil type and elevation, as well as socio-economic considerations. Possible uses include annual cropping, agroforestry, horticulture, silvipasture, and various other combinations. A well-planned and adequately managed watershed will combine many different systems to ensure that resources are optimally used. Some possible systems and their components are briefly described below.

• About 5334 million tonnes of productive soil are lost in India each year.

• 150 million ha suffer from erosion.

• 6.6 million ha are converted to wasteland.

• 6 million ha are affected by submergence.

• 4.5 million ha suffer from salinity.

• 4 million ha suffer from shifting cultivation

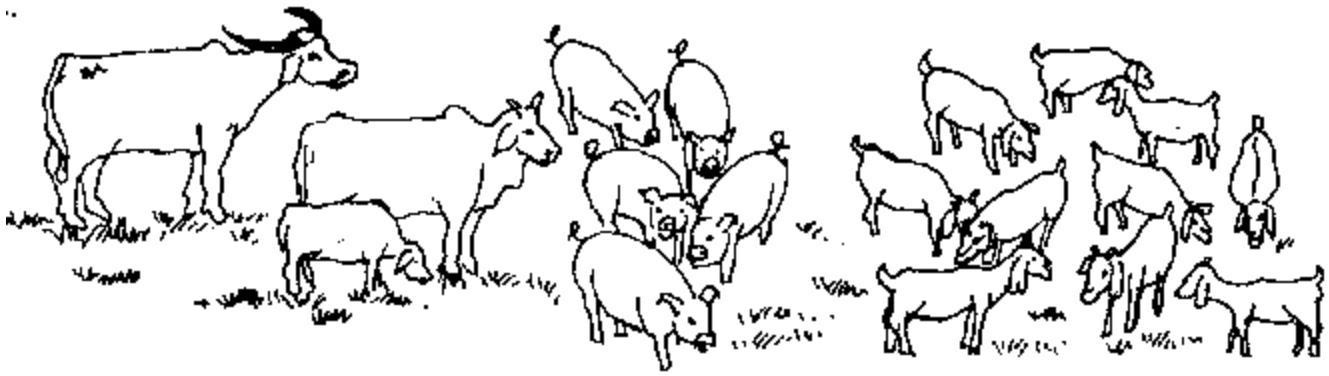
• 2.5 million ha are affected by alkalinity.

Rice-based cropping

Many crops and other enterprises can accompany rice, either as intercrops or as crop sequences. For instance, a rice crop can be followed by vegetables, pulses or groundnuts. Fish can be kept in the rice fields, and trees, fodder or annual crops can be grown on bunds.

Dryland farming on slopes

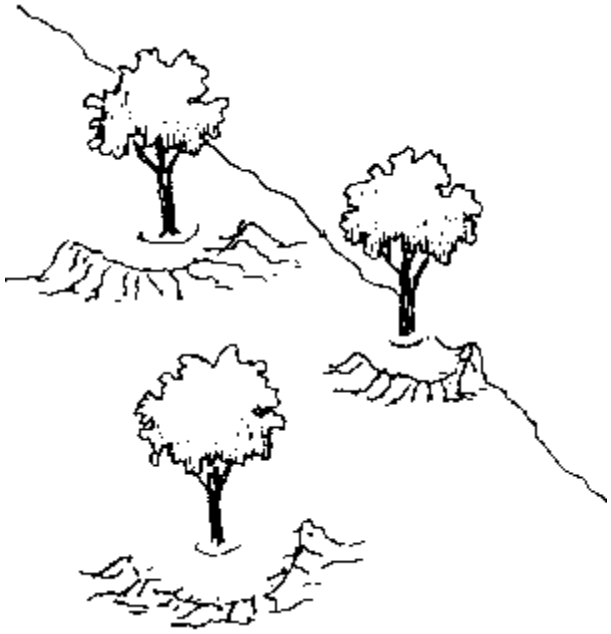
Bunds and terrace risers can help check erosion on steep slopes. Such land can be planted to food crops; the terrace risers can be used to grow fodder crops such as perennial grasses and legumes. One hectare of land cropped in this way can support 1.18 livestock units. Contour bunds are constructed at vertical intervals of 0.5 to 5 m. Bench terraces can be constructed on the lower slopes, with a vertical interval of less than 1 m. Besides promoting crop diversity, such a system retains about 80 to 90% of the rainfall and reduces soil loss to below 2 tonnes/ha/year.



Livestock unit example

Horticulture

For horticultural production, the slope should not be more than 60%. Contour bunds at 2-m vertical intervals, half-moon terraces at the fruit tree locations and grassed waterways control runoff and erosion. Bench terraces on the lower slopes can be used to grow vegetables. Such a system retains about 70 to 80% of the rainfall and reduces soil losses to below I tonne/ha/year.



Horticulture

Integrated agricuIture-aquaculture

Farmers can choose among various livestock-based farming options. These include rice-fish culture with freshwater fish species like Rohu, Katla and Mrigal. Prawns can be grown in pens on the shallow margins of estuaries and canals. They can be cultured in both fresh and brackish water. Brackish-water culture should also integrate fish species like Chanos chanos (milk fish), Etroplus suratensis (kalunder) and mullet.

Livestock

Livestock options include duck-fish culture, dairy farming, poultry and rabbit raising, and beekeeping. Biogas plants and vermiculture can provide extra income.

Perennials

Trees and other perennials can be used in many ways: grown as plantations, planted as intercrops with annual crops or in pasture land. Useful perennials include coconut, cashew, banana, papaya, pineapple and pepper.

Watersheds, large and small

Catchment: A primary river is a long river draining more than 100,000 ha. It has a number of tributaries of first, second, third, fourth or even fifth order. The primary river generally discharges its load to the sea.

Sub-catchment: The secondary river is a tributary of primary river; it drains more than 40,000 ha.

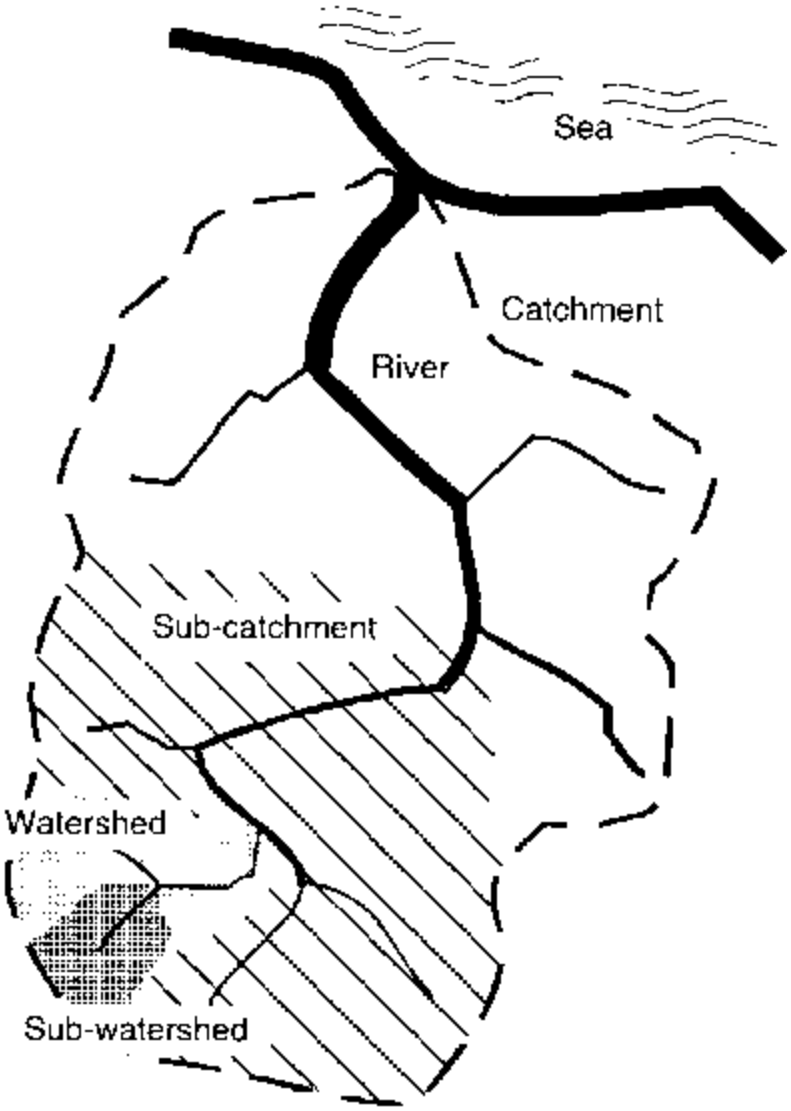
Watershed: The tertiary stream is a tributary of a secondary river; it drains 4000 to 40,000 ha.

Sub-watershed: A quarternary stream is a tributary of a tertiary; it drains 2000 to 4000 ha.

Mini watershed: A pentad streamlet is a tributary of a quarternary; it drains 400 to 2000 ha.

Micro watershed: A hexed streamlet is a tributary of a pentad; it drains less than 400 ha.

Watersheds vary in many ways: size, shape, relief, drainage, geology, soil, climate, surface conditions, land use, groundwater and sociological aspects. No two places area exactly alike, so each watershed has its own distinctive characteristics or "watershed attributes". These define the potentials and problems of the watershed.



Watersheds

Prepared by H. R. Prabhudesai

9.4 Energy conservation and alternatives

The economic growth and development of a country is directly dependent on its energy production and utilization. The crucial dilemma facing less-developed countries is how to reconcile development and poverty alleviation goals with responsible management of their environment-especially since such goals will require increased use of energy and raw materials.

Energy is used mainly for power generation, transportation, heating and cooking.

Energy sources

Major sources of energy are:

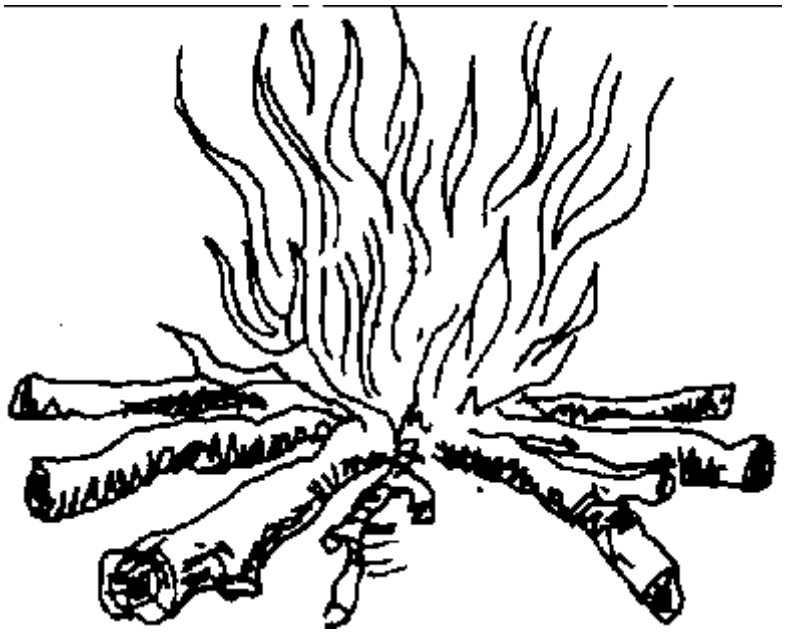
• coal, oil and natural gas (fossil fuels)

• hydroelectricity

• nuclear power

• wood and charcoal

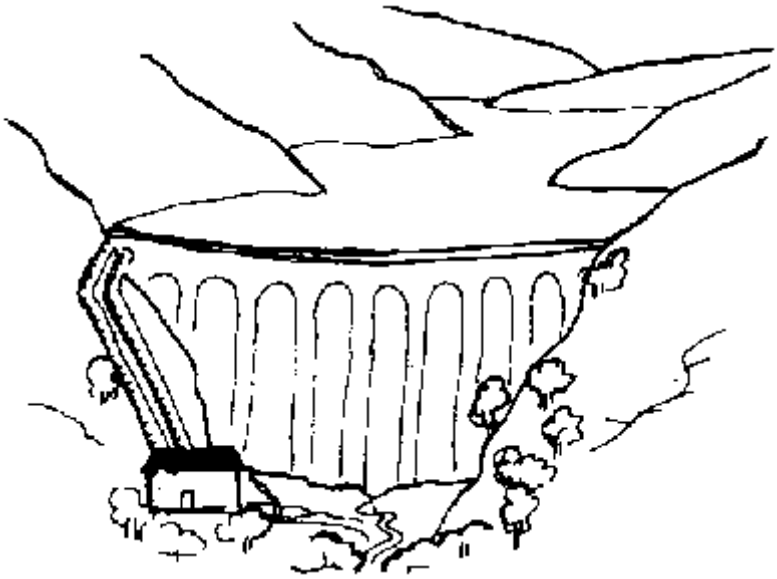
Fossil fuels are exhaustible. World oil and natural gas supplies may last for barely another 25 years. Coal will last longer- about 150 years-but supplies will eventually run out.



Source of energy

Energy production causes pollution. Burning of wood or fossil fuels (especially coal) causes emission of gases such as carbon dioxide, sulphur dioxide and nitrogen oxides. These gases accumulate in the troposphere and cause global warning (the "greenhouse effect") and acid rain (with its adverse effects on forests and ecology). Despite stringent controls, the radiation hazards associated with nuclear power plants are well

known. Hydroelectricity does not cause pollution, but the construction of dams drowns ecosystems and places pressure on the natural environment.



Source of energy

Until adequate, economic alternatives are developed, it is essential to minimize environment pollution associated with energy use, and conserve energy so as to minimize oil importsand save foreign exchange.

Technology can mitigate some of the environmental effects of burning fossil fuels.

• Sulphur can be removed by flue gas desulphurization and furnace sorbent injection techniques during the combustion of coal.

• Nitrogen oxides can be removed by selective catalytic reduction.

• Toxic suspended particulates can be removed by electrostatic precipitators.

Natural gas power stations are less polluting than coal- or oil-based plants. Controlling emissions from natural gas plants costs seven times less than in other plants.

Energy conservation

Energy can be conserved in various ways: reducing transmission and distribution losses, improving plant efficiencies, introducing efficient energy management programmes, and through technological innovations such as energy-efficient lamps.

For instance, compact fluorescent lamps save 3/4 of the energy used by standard incandescent bulbs. Education for home users and energy audits for industries can also help cut losses.

Energy can be saved in transport through developing engines with lower fuel consumption, improved maintenance and retrofitting (incorporating improvements in existing engines).

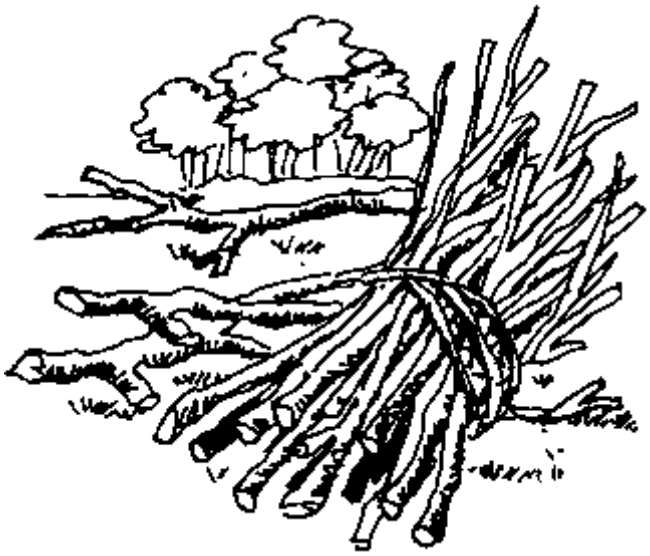
Agriculture consumes over 27% of India's electricity. More than half of the country's 10 million electric pump sets operate at only 50% efficiency. Replacing valves, suction and delivery pipes can improve overall efficiency by 30%, saving over 3 million tonnes of coal a year.

India's 8 million diesel pumps require 8 billion litres of diesel annually. A 30% saving in diesel would reduce diesel imports by 1.2 million tonnes.

At present about 30% of natural gas produced is flared off. This is the equivalent of wasting about Rs 50,000,000,000 per year of resources. Natural gas can be better used through various technological improvements, including using gas turbine plants, producing energy intensive fuels (methanol, olefins, gasoline, kerosene), and using engines that burn compressed natural gas for vehicles.

Wood

In rural India, fuelwood is the main source of energy for both domestic and industrial use, contributing about 69% of total energy consumption. Wood is extensively used as fuel for small-scale industries such as tea and coffee processing, lime kilns, brick making, liquor production and food processing. Fuelwood production is a major cause of deforestation.



Wood

Fuelwood use can be reduced-and deforestation slowed-by turning to other sources of energy, using improved chullas, promoting afforestation, and improving and democratizing forest management.

Alternative energy sources

Various non-conventional source of energy are renewable and environmentally friendly.

Solar

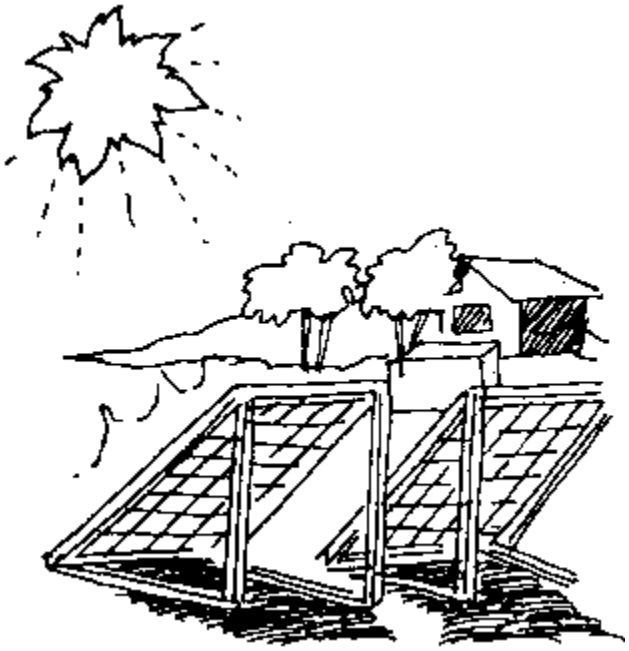
Energy from the sun can be used in several ways:

• photovoltaic technology to generate electricity.

• solar ponds for electricity generation and heating.

• thermal (heating, cooking, drying, refrigeration, etc.)

• photoelectrochemical processes.



Solar source of energy

Geothermal

Geothermal energy taps the heat of the earth's interior. It is restricted to areas with natural sources such as hot springs and geysers, or to sites suitable for drilling geothermal wells.

Ocean

The oceans can produce energy by harnessing waves, wind and tides, and through "ocean thermal energy conservation", which exploits the temperature differences between warm, surface water and cold, deeper layers of the oceans.

Biological

• Solid wastes (garbage, municipal wastes, and crop residues such as rice husks and cow dung) can generate biogas.

• Energy-intensive plantations can be used to produce ethanol. Possible crops include marine plants, freshwater aquatics, woody crops, sugarcane and sweet potatoes. Ethanol can be used directly as a fuel or in gasohol (a mixture of ethanol and petrol).

• Catalytic processes can convert biomass to methanol, and methanol to gasoline.

Source of energy

Nuclear fusion

The process of mimicking stellar energy on earth is used in hydrogen bombs. Its controlled use for energy production is still in an experimental stage.

Hydrogen

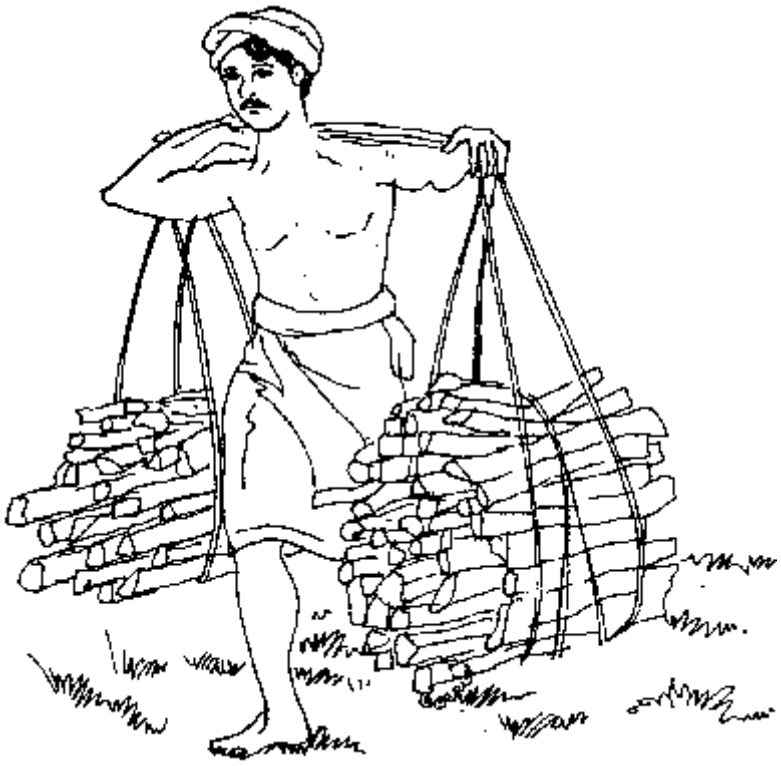
Hydrogen burns without producing pollutants: its only byproduct is water vapour. It can be directly used as a fuel or for power generation through fuel cells. Hydrogen is a secondary energy source, produced using primary energy sources from hydrocarbons or by electrolysis of water.

Alternative vs conventional energy

These alternative energy technologies are at various stages of development, with some still only in the experimental stage. They cannot yet compete on price with other sources. But they are environmentally friendly and the raw materials are free or cheap.

Conventional power plants (such as coal, hydroelectricity and nuclear), on the other hand involve huge capital investments, heavy maintenance costs, and can have disastrous environmental effects.

All in all, solar-photovoltaic energy (backed up by wind/ocean and biomass energy), clearly emerges as a leader and protector of the environment. Hydrogen is the projected universal fuel of the 21 st century.



Alternative vs conventional energy

Prepared by Julio Fernandes

9.5 Nature trails

Many of us live in cities and towns, without close contact with nature. Nature trails allow us to discover the wonders of biodiversity: animals from ants to elephants, plants like strangler figs and tree ferns.

To appreciate biodiversity, you need to make careful observations and record these in a field diary.

Why nature trails?

Lectures, even on a subject as fascinating as nature, can be boring. Experiencing nature directly can help bring the subject alive. You need to study an area closely and unhurriedly if you want to understand the diversity and complexity of our environment and its importance to ourselves.

Nature trails are treks through natural areas. Trails can be anywhere: in the forest, hills and mountains, along rivers or roads, in sacred groves, on the seashore, through marshes, in private estates, and even in school grounds and public parks.

When on a trail...

• Walking is best. Dense vegetation, rivers and hills are no obstacle. Walk slowly and quietly-so you see more.

• Wear loose-fitting, comfortable clothes. Clothing must not be flowing or flap about, because it gets caught on vegetation and attracts animals' attention. Dark brown, green or grey colours are best. These colours help camouflage you so you do not disturb animals and birds and can see them better.

• Wear a hat or cap in hot, open areas.

• Carry a water bottle.

• Wear comfortable, tightly laced shoes or boots with rubber soles so you do not make noise or slip.

• Carry binoculars for detailed observation. A 7x50 pair is a good all-round choice: it has good magnification (7) and good light-gathering power (50/7=7). This means you can use it in poor light. A 7x35 or 8x30 is good only for daylight viewing, but is lighter and more convenient.

• Use a camera to record what you see. The best all-purpose camera is a 35mm SLR (single-lens reflex), because you see exactly what you are photographing when you look through the viewfinder. The best all-round lens is a 70-210 zoom with macro. You can use this to photograph anything from small insects, flowers and plants to birds, large animals and landscapes.

• Make notes with a notepad and pen or pencil. You cannot remember all you see and hear on a trail. Make notes of everything. You can supplement the notes with sketches, bits of hair, feathers or leaves.

• Carry a small first-ad kit.

• The all-important rule is: "Mouth shut; eyes, ears and nose open". Point out anything unusual to others and (if possible) explain it immediately. Any talking must be done in whispers. Even low murmurs must be avoided as the sound carries.

When on a trail...

Observing birds

Listen and look for the following calls and other noises:

Whistles:	**Bulbuls, thrushes, robins**
Chirps and twitters:	Babblers, sparrows and finches
Screeches:	Owls
Croaks:	Crows, herons, egrets
Cackling shrieks:	Woodpeckers and kingfishers
Moans and boomings:	Pigeons, doves
Drumming on wood- slow, single beats or rapid, merging beats:	Woodpecker

Wingbeats	
Slow, swishing:	Eagles, owls, storks
Rapid whirring:	Partridge, spurfowl
Fast, loud flaps:	Pigeon, parrots, doves
Loud swishing:	Hornbill

Camouflage and mimicry

Many creatures are camou flaged or mimic other animals, plants or objects for safety-so look around carefully.

A length of vine may turn out to be a snake

A bird dropping-a caterpillar or spider

A dry twig-a stick insect or caterpillar

A small tree stump-a lizard

A dry leaf-a leaf insect or butterfly

Coloured flowers may contain similarly coloured spiders

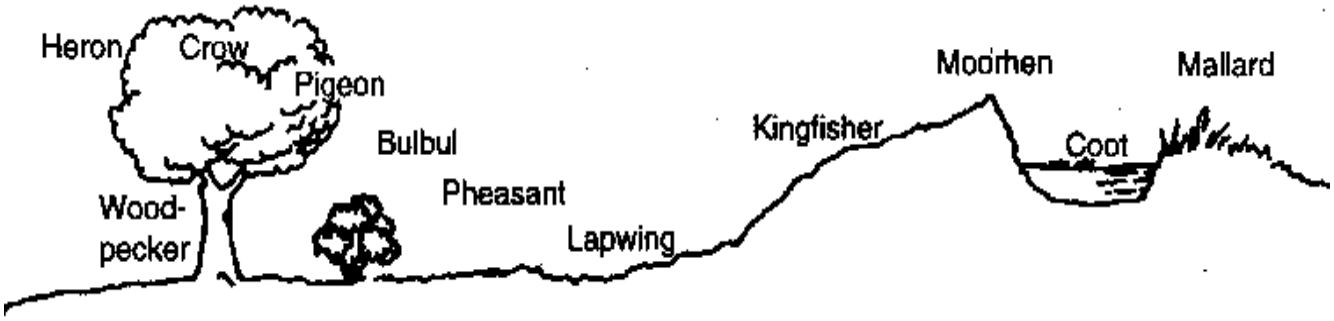
Tree bark may contain moths, cicadas or spiders

Grass may hide spiders or stick insects

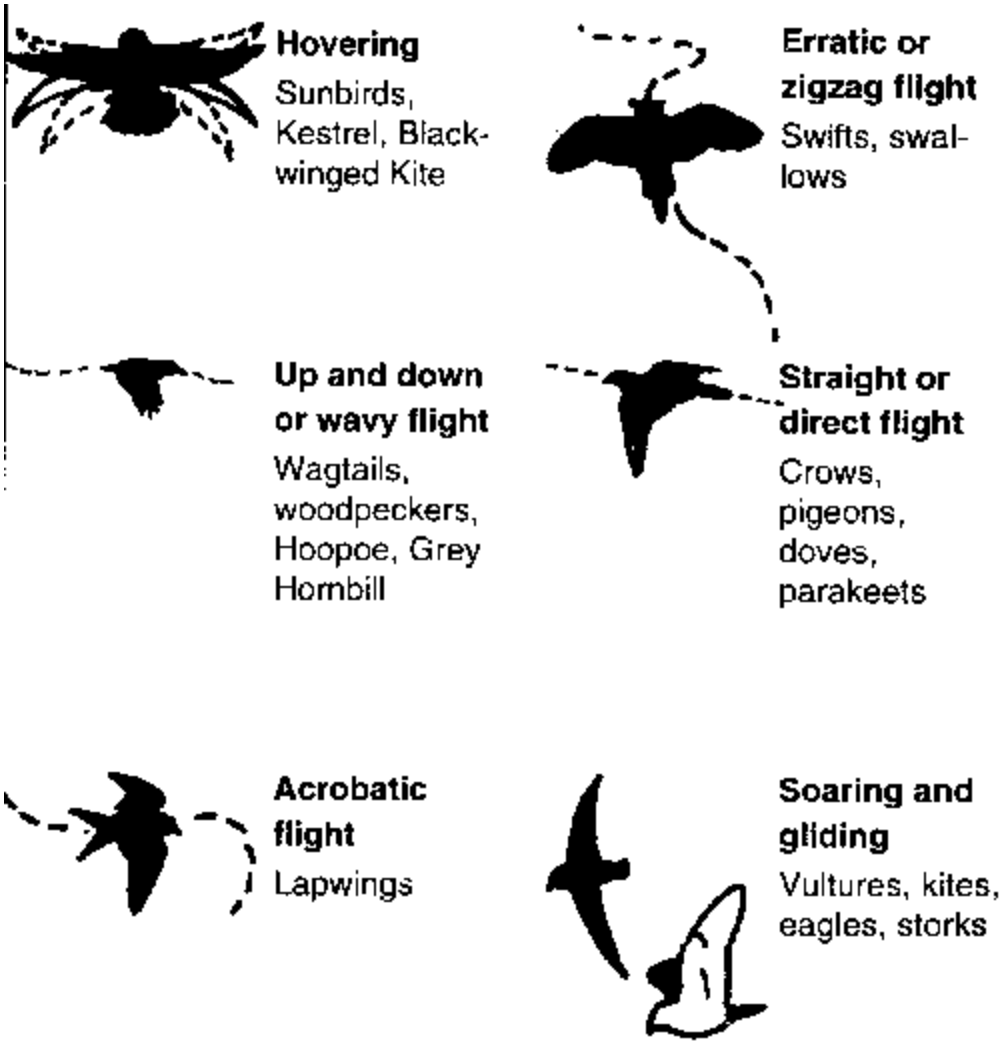
Gravel may contain lizards, moths or spiders

Leaves may conceal caterpil lars, butterflies or moths

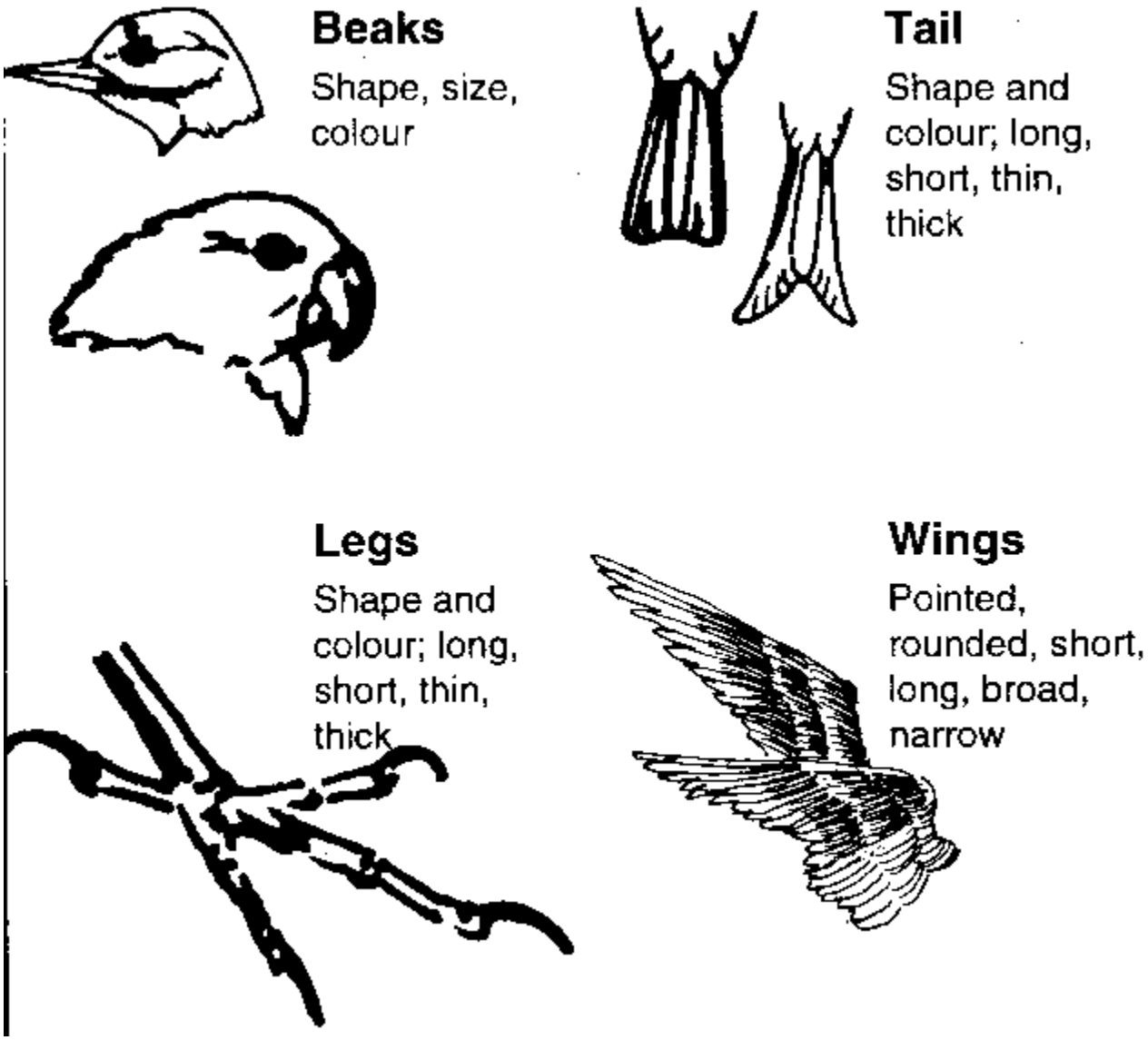
Look for small invertebrates' homes: some spiders build webs in places like tree hollows, gaps in rock, between twigs of bushes, sometimes between two separate trees, hollows in the ground, pits, or under culverts. Spiders, scorpions, centipedes, beetles and other invertebrates can be found in rock piles, dry and wet leaf litter and under stones, rocks and dead trees.



Where birds nest



Bird flight patterns



Prominent characteristics of birds

Caution

• Remember to replace dislodged objects, or you may destroy some creature's home.

• Do not touch anything you are not sure about. Many small creatures are poisonous and can sting or bite.

• Look out especially for snakes, bears and elephants if these are known in the area. However, usually even these animals are not dangerous unless provoked.

• Always take an experienced guide with you. Do not walk ahead of the guide. He or she can spot danger before you can.

• Collect droppings, fallen flowers, feathers, bits of bones, small skulls, etc., in plastic bags. Do not kill living creatures to collect. Also, do not collect anything that is rare. Living things may be handled carefully for observation but should be released immediately afterwards in the correct habitat.

• Transfer all field notes to a journal in sufficient detail.

• Above all, walk quietly. Avoid talking, do not walk on dry leaves and loose stones, and walk with light footsteps.

• Do not litter any area in the forest.

Observing mammals and reptiles

Most mammals and reptiles are seen less often than birds. But you can often find evidence of their activities. Some clues:

Footprints, dragmarks	**Identification, direction of travel, mode of travel**
Wallows:	Identification
Droppings:	Identification, food eaten
Nests, dens, burrows:	Identification
Calls (mammals only):	Identification, behaviour
Smoothened bark:	Rubbing-posts for elephants
Shredded bark:	Deer antler rubbing-posts
Scratch marks on trees:	Identification

Observing plants

Like animals, plants are important components of biodiversity. Plants are the base for all life forms. Flowers which occur seasonally help in identifying the tree species. A basic categorization of plants is easy.

Trees

• Large size, thick, woody stem and leafy crown.

Shrubs

• Medium size with thin, woody stem.

Herbs

• Small, with non-woody stem.

Climbers, creepers, vines

• Weak woody or non-woody stem, cling to other plants for support.

Observing plants

Unusual plants

Dead matter on the forest floor is ideal for finding mushrooms and other fungal plants. Bracket fungi grow like shelves on dead logs and stumps. These plants are saprophytes. not parasites: they live off dead matter.

Cacti are adapted to dry, harsh environments. They have fleshy stems containing water. Most have thorns or spines for protection.

Growths of moss-like plants on rocks and tree trunks are neither fungi nor algae alone, but a combination of both, called lichens.

Look for epiphytes such as orchids high up in trees in moist areas. These plants have specialized roots that dangle in the air and absorb moisture and minerals from the air.

Look for plants that feed on other plants. They have no true roots but draw water or food from the host. Examples are Loranthus and devil's vine.

Unusual plants

Prepared by R. Bhanumathi

9.6 Sacred groves

Sacred groves are pockets of more or less climax vegetation preserved for religious grounds in remote areas. Scattered throughout India, these patches of vegetation are dedicated to forest gods or other deities, and are revered by the local inhabitants as the deity's sacred territory. They are repositories of plant and animal wealth that have

been conserved over centuries. The groves range in size from a small group of trees to large tracts of forest. Occasionally they spread over hundreds of hectares of forest.

Sacred groves represent a traditional form of nature worship. The local people consider the forest, with all its floral and faunal diversity, as their provider, taking care of their needs and welfare. It is therefore worthy of reverence and worship. People believe that the presiding deity would be offended if any form of life-plant or animal-in the deity's dwelling place is harmed. Breaking even a dead twig in a sacred grove might result in serious illness or violent death. These patches of forest have thus been protected and conserved by successive generations of local people. They are in effect traditional nature sanctuaries where all living creatures are afforded protection.

Sacred groves

The presiding deity is often of an extremely primitive nature- for instance, an unshaped stone smeared with red paint. The deity, generally female and representing the mother goddess, lies in the open, away from any human settlement.

Undisturbed since ancient times, these groves are a haven for birds, animals and plants that might otherwise have become locally extinct. The well-preserved vegetation in the sacred groves often contrasts with the barren surroundings. A typical

grove surrounds or adjoins a stream fed by a perennial spring. As trees outside the grove are cut down, the springs they protect may dry up soon after the end of the rains. The sacred grove then becomes the last refuge, not only of plants and animals, but even of life-giving water.

In the sacred grove

A visit to a sacred grove will prove interesting and educational for school students and other groups. But you should be extremely careful to protect the sanctity of the grove. Students can collect information about the types of animals and plants. For instance, they can measure the girth, height and leaf structure of trees. They can collect fruits and seeds on the ground to raise seedlings. They can find out why the grove has been protected and study how it relates to the surrounding area. But care should be taken to respect the living flora and fauna, as well as the religious beliefs that govern the area.

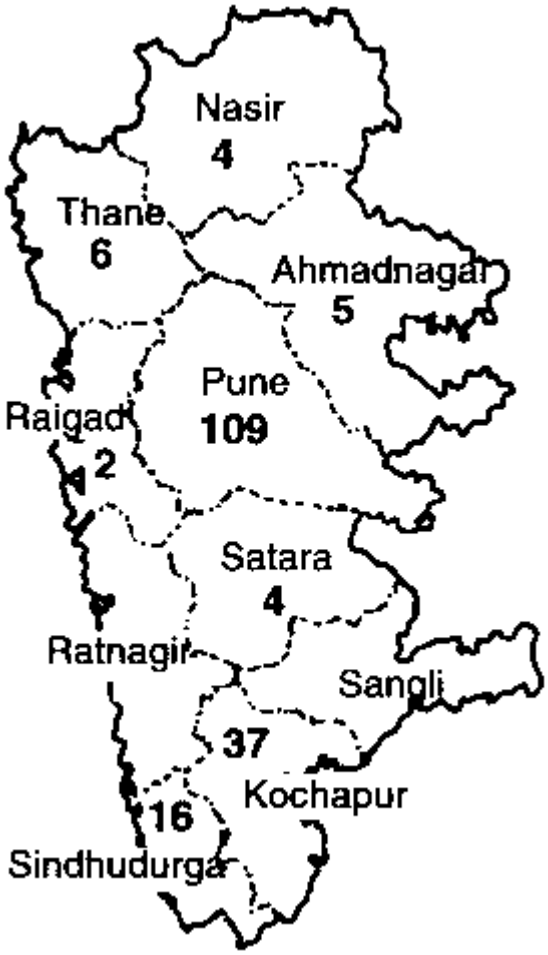
Distribution of sacred groves along the Western Ghats

• 350 sacred groves in the Western Ghats of Maharashtra

• 28 large sacred groves

• 790 plant species recorded

• 352 genera recorded



Distribution of sacred groves along the Western Ghats

By Dr. V. D. Vartak and Dr. M. C. Suryanarayana

9.7 Rehabilitation of iron ore mine wasteland in Goa

Ecosystems and plant succession

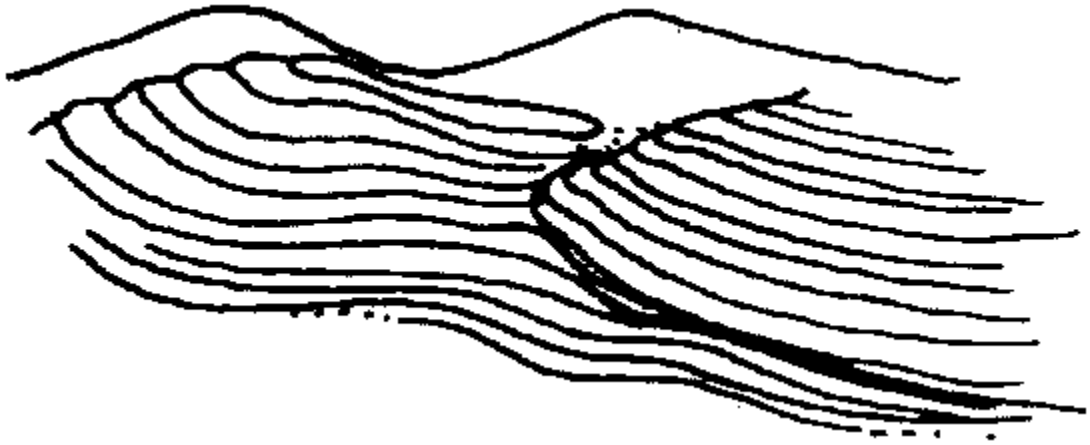
Vegetation is closely related to the soil in which it has its roots, the associated fauna, and the surrounding environment. All these elements interact and support each other to form an ecosystem. Although ecosystems are sensitive to the outside influences, they are self-sustaining. Once properly established, they need no further support. This is because they cycle materials which maintain the vegetation and other organisms.

Ecosystems change over time. After a major disturbance such as a landslide or fire, vegetation will gradually develop naturally. Grasses are replaced by shrubs, which in

turn give way to trees and their associated vegetation. This process is termed plant succession. Reaching the final, stable stage (called the climax vegetation) can take hundreds of years.

Mining produces a major disturbance in the ecosystem. The topsoil is removed, leaving bare rock, making it hard for vegetation to become reestablished. The reject materials may be contaminated with heavy metals. This means that natural succession will be even slower.

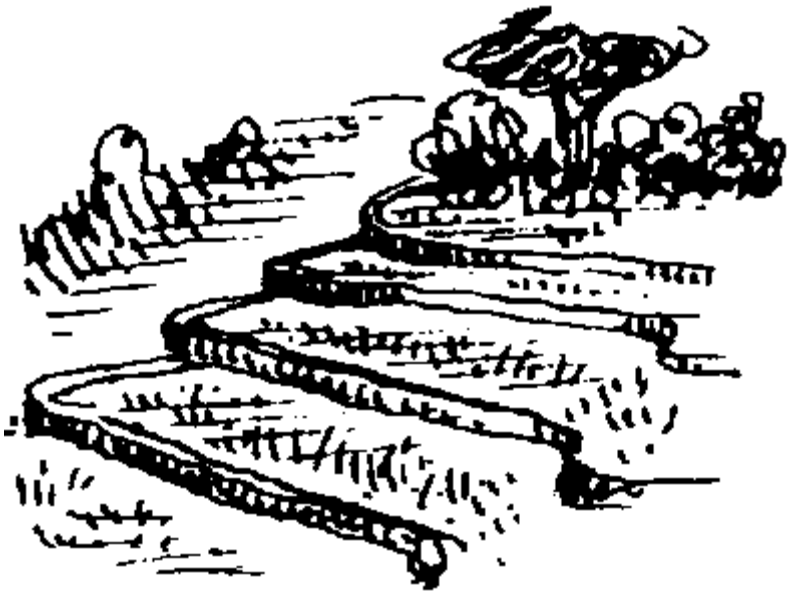
Normally, natural processes would gradually recolonize the mine sites and spoil heaps, building up the soil and reclothing the landscape in vegetation. However, this can take a long time. Meanwhile, the unprotected surface is subject to erosion, clogging rivers and lakes with silt.



Ecosystems

Rehabilitation measures

• Reducing the angle of slope of the spoil dumps is essential. Terracing helps reduce erosion, hold water and improve the local microclimate.



Rehabilitation measures

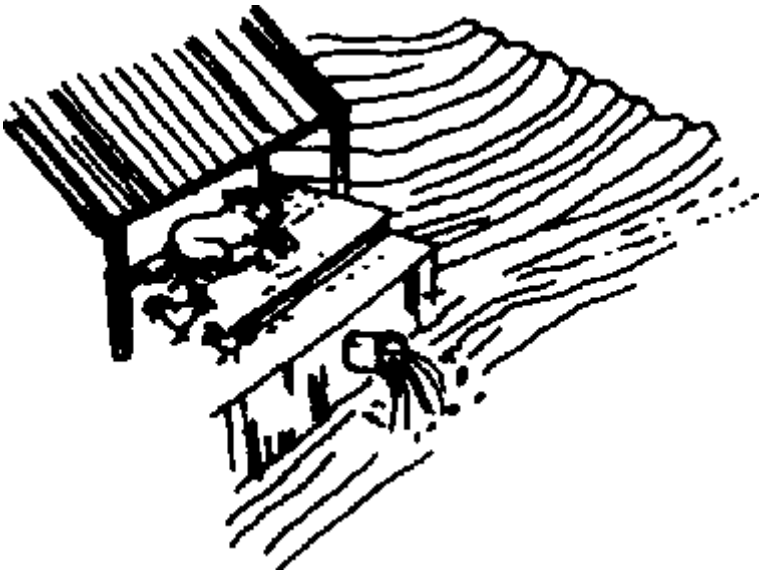
• Removing and storing topsoil for reuse would make it easier to reestablish vegetation. Topsoil contains organic matter, plant nutrients, seeds and useful microbes.

Rehabilitation measures

• The soil becomes compacted because it has a high clay content and mining uses heavy machinery. Compaction tends to reduce moisture infiltration and results in poor plant growth. This problem can be overcome by ripping the surface with deep lines drawn by a crawler tractor, followed by cultivation. Ripping improves aeration, water retention, root penetration and erosion control.

Rehabilitation measures

• Rejects and tailings are deficient in organic materials. Adding organic materials like sewage sludge, seaweed, green manure and farmyard manure improves the soil status and helps plants become established. These organic materials contain enzymes responsible for mobilization of nutrients to plants. They also help in the development of beneficial microflora (algae, fungi and bacteria) and microfauna.



Rehabilitation measures

• Mine rejects and tailings are deficient in macro and micronutrients. This severely limits plant growth. Adding normal agricultural fertilizers considerably improves plant growth. The amounts to be applied can be calculated from a soil chemical analysis.

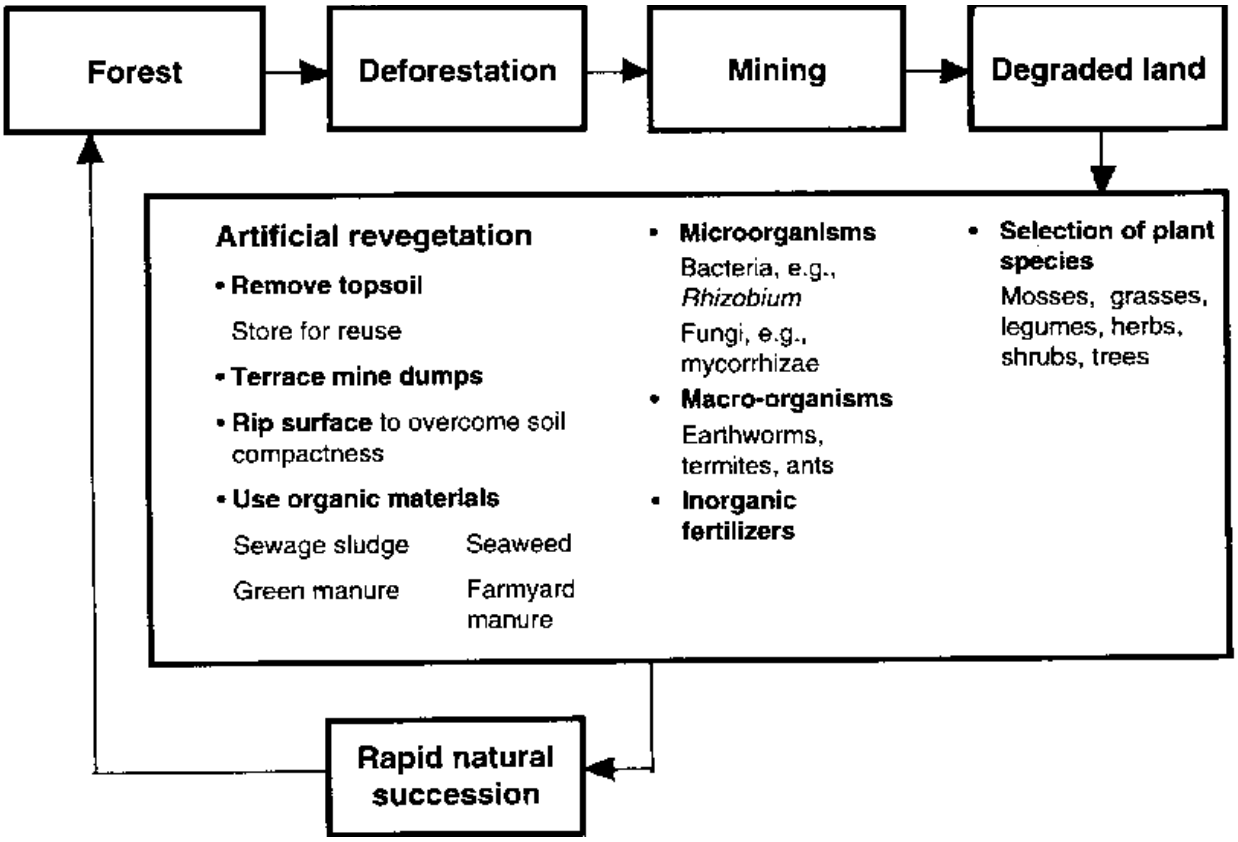
Rehabilitation measures

Accelerated succession

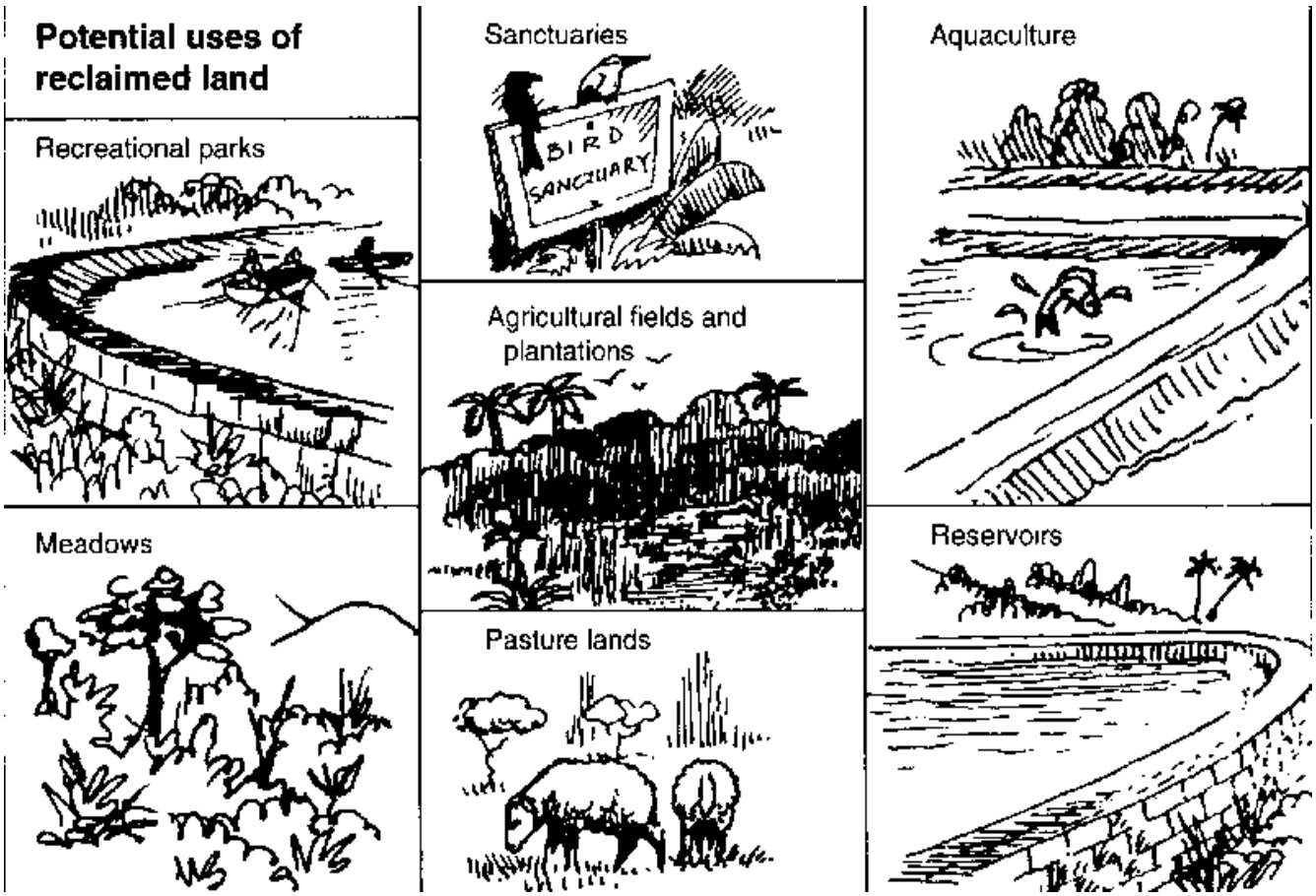
Rehabilitating mining sites is a way to speed up and control the vegetative succession. It aims to achieve vegetation cover within a few years, so that the later succession will be quick. The ecosystem should be self-sustaining, increasing the area's biodiversity.

Accelerated succession

Achieving a self-sustaining ecosystem in degraded areas requires careful planning before mining starts. The mining industry need not degrade the environment if imagination, care and scientific skill are applied.



Rehabilitating iron ore mine lands in Goa



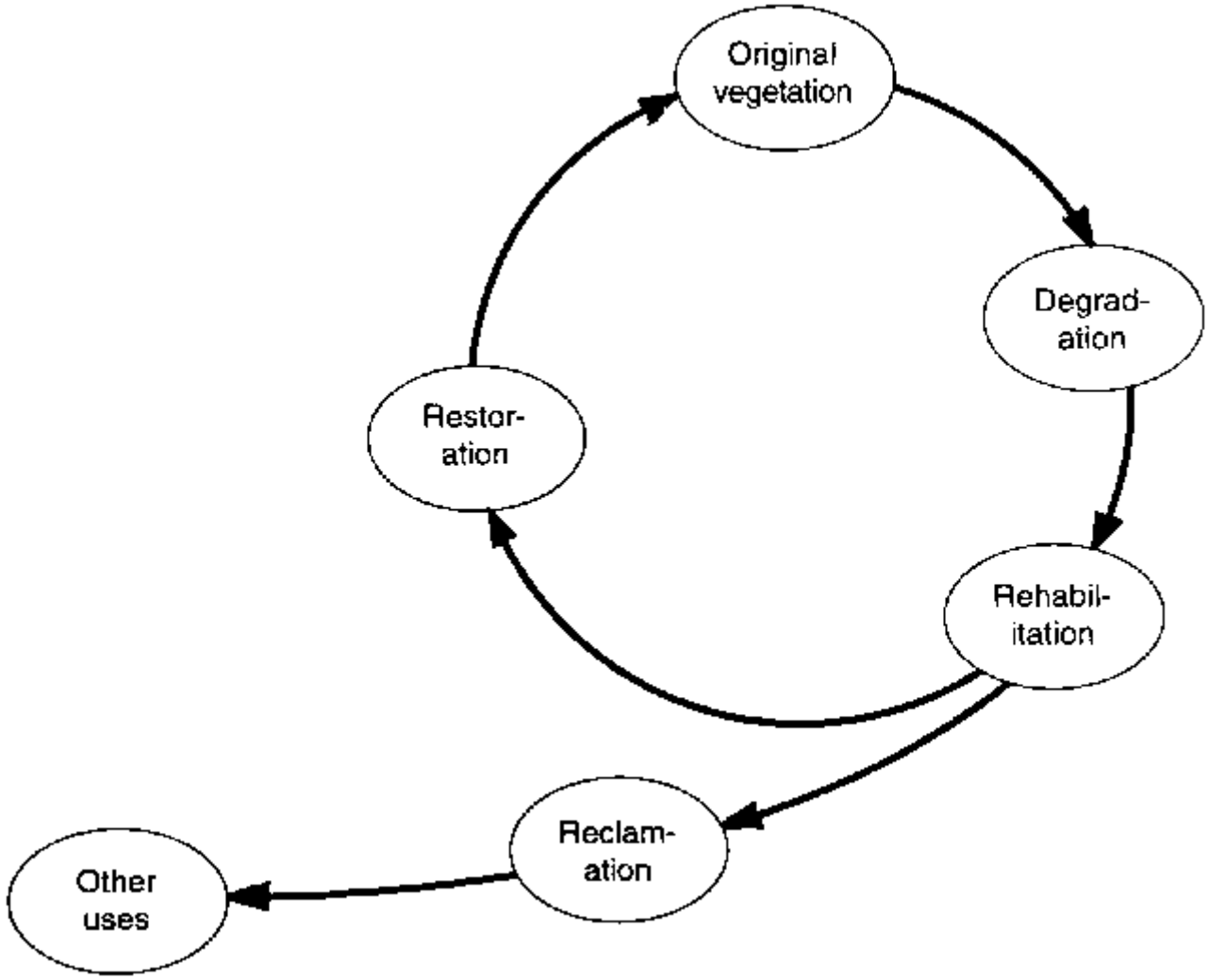
Potential uses of reclaimed land

Rehabilitation strategies

"Rehabilitation" is a broad term which may include restoration or reclamation. It means resuming a site to a stable condition-such as forest or pasture. A rehabilitated site does not necessarily have the same land use as before mining.

"Reclamation" means rehabilitating an area for productive use such as farming or fisheries.

"Restoration" means returning the land to its previous state before mining-such as restoring the original forest cover.



Rehabilitation strategies

Prepared by Bernard F. Rodrigues, Mahesh Patil, Joe D'Souza,

A. V. Veeresh, Marina Souza, Meena Miranda and Belinda Lobo

9.8 Reforestation to restore mining areas

Planting trees is one alternative for rehabilitating land after ore lying beneath the surface has been extracted. While it is impossible for humans to completely recreate the pre-existing vegetation, tree planting can help re-establish protective vegetation and accelerate the natural succession that will eventually restore a rich community of plants and animals in the area.

Careful study and planning is necessary before an area is reforested. The studies should include physical, hydrological, chemical and biological factors as well as vegetation mapping.

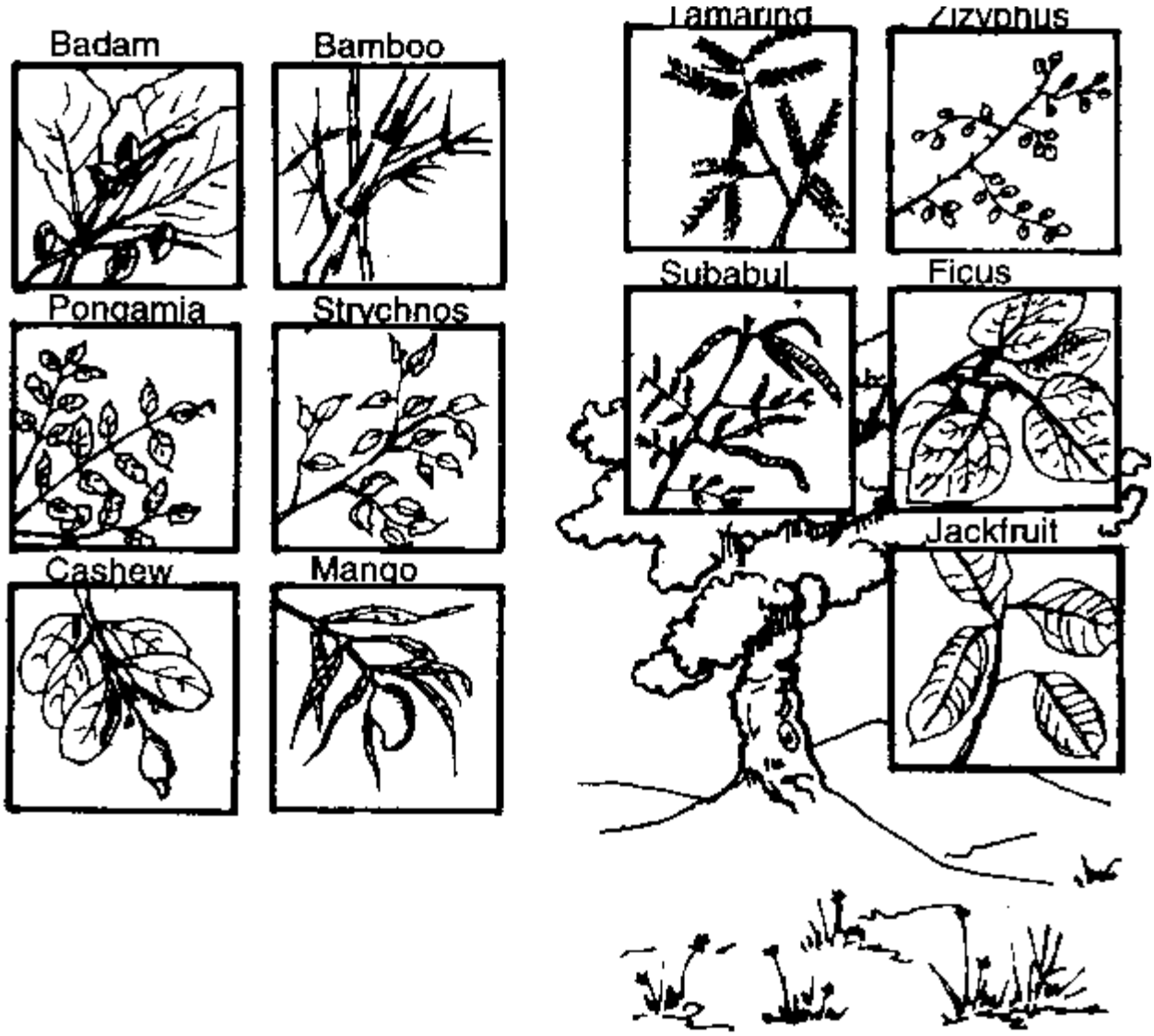
Plant species

Choosing plant species

The choice of plant species depends on many factors, including their use and the role they play in the ecosystem.

Meets demand, solves problems

This is the key to all further efforts in planning and organizing forest activities. The species introduced should meet the needs of the humans in the area. They should also attract insects, birds and other wildlife to increase the biodiversity.



Meets demand, solves problems

Adapted to site conditions

Detailed information may be necessary to discover what species are suited to the site. Studies may be needed to collect data on:

• Climate: summer and winter temperatures, total annual rainfall, number of rain days, wind velocity and direction, etc.

• Soil: nutrient status and deficiencies, soil type and structure, organic matter, pH, etc.

Easy and safe to establish, low inputs

Seeds, seedling or other planting materials of the selected species must be available. Species that can be sown directly are preferred to keep costs low. They should be tolerant to conditions on the dumps, and the plant community should be able to regenerate and maintain itself.

Fast growth, high yields

This refers mainly to exotics but to some extent also to local species. Multiple uses are important, including suitability for intercropping in agroforestry. Leguminous plant species should be used for intercropping as they increase soil nitrogen levels due to their ability to fix atmospheric nitrogen.

Compatible with other land uses

Species chosen should have multiple uses-for instance, fruit, timber, windbreaks and pulp.

Compatible with other land uses

Low risks

Plants should be resistant to pests, fire, and other threats. Species that are weeds in farms should be avoided.

Low risks

No legal restrictions

Phytosanitary regulations, laws protecting endangered plants and land tenure regulations must be observed.

No legal restrictions

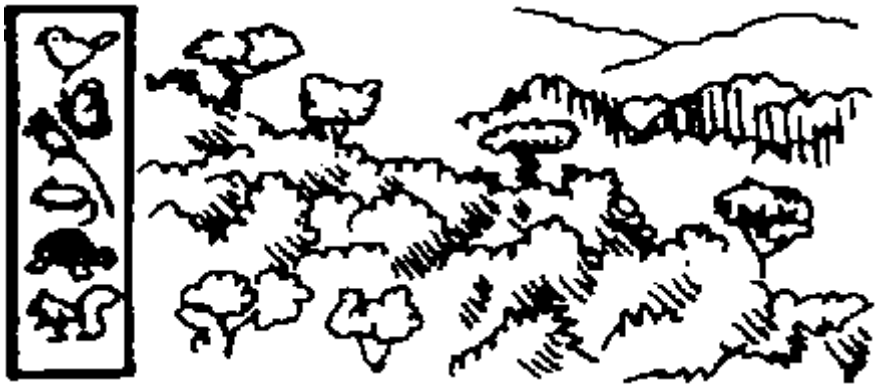
Accepted by people

Local people are key to the sustainability of the new vegetation. The species to be introduced should be acceptable to them. Demonstrations and other extension activities may be necessary to introduce them to the new species.

Benefits of trees

The species in the tables overleaf attract several birds and monkeys. Nectar-bearing trees are a haven for Sunbirds, Flower-peckers, Mynas and Drongos. Trees of the Ficus family are homes to gall-wasps which help in pollination; their seeds do not germinate unless they pass through the digestive tract of birds and mammals.

Decomposing fruit attract several insect species, which in turn attract insectivorous birds. Growing these plants would help to bring back the diverse life forms in the area before mining began.



Benefits of trees

Tree species for reforestation of mining dumps

Plant name	**Common name**	**Uses**
Acacia catechu	Kath	Medicine, fuel wood and timber
A. chundra	Tambdi khair	Fuelwood and substitute for catechu
A. nilotica**	Gum arabic	Medicinal, timber, fuelwood, fodder and improves soil
Adenathera pavonia	Ratan gunj	Ornamental shade
Aegle marmelos	Bo	Medicinal
Albizzia lebbek	Shirish	Fuelwood, timber, fodder and medicinal
Alstonia scholaris	Satvan	Timber, medicinal and fuelwood, blackboards
Anacardium occidentale*	Cashew nut	Nut edible, fodder and medicinal
Artocarpus	Jack fruit	Fruit edible and as a timber heterophyllus **

Azadirachta indica*	Neem	As a fuel wood, medicinal and timber
Bambusa arundinacea**	Bamboo	Poles used in construction
Bauhinia purpurea**	Baktakanchan	Ornamental, as a fuelwood
Bombax ceiba**	Silk cotton	Capsule: floss for mattress filling
Careya arborea	Kumblyo	Medicinal and as a timber
Cassia fistula*	Laburnum	Medicinal
Ceiba pentandra**	Silk cotton	Floss for filling mattress
Dalbergia latifolia (Syn. D. emarginata)	Shisam	Timber and fuelwood
D. sisso	Rose wood	First grade timber
Delonix regia*	Gulmohar	Ornamental and as a fodder
Dendocalamus strictus**	Great bamboo	Used as poles
Dodonaea viscose	--	Fodder and for improving soil
Emblica officinalis	Amla	Drupes edible and medicinal
Erythrina indica**	Corol tree	Ornamental and improves soil
Ficus asperrima**	Kharrat	Leaves for filling purpose
F. benghalensis**	Banyan	Leaves as fodder
F. callosa**	--	Ornamental
F. glomerata**	Rumad	Ornamental and religious
Garcinia indica	Kokum	Pulpy berry edible and medicinal
G. xanthochymus	Jharambi	Fuelwood
Gliricidia septum	--	Improves soil, rat poison

Helicteris ixora*	Murud sheng	Medicinal
Holorhena	Kudo	Medicinal antidysenterica*
Hydnocarpus laurifolia	Korut, Kashti	Medicinal
Leucaena glauca	Subabul	Fuelwood, medicinal, soil improvement
Mallotus albus		Leaves used as wrappes
Mangifera indica**	Mango	Edible drupe, fuelwood, timber and medicinal
Memecylon wightii	Anjan	Fuelwood
Mimusops elengi*	Bakul	Ornamental and fuelwood
Morus alba	Mulberry	Leaves fed to silkworms
Parkia biglandulosa		Fuelwood, fodder, soil improvement
Peltophorum pterocarpum		Ornamental
Phyllanthus reticulatus		Medicinal
Prosopsis juliflora		Fuelwood, fodder and medicinal
Santalum album**	Sandalwood	Carving, medicinal
Sapium insigne	Dudla	Fruit as fish poison
Sterculia urens	Caraya gum	Gum used for various purposes
Strychnos nux-vomica	Kajaro	Medicinal
Syzygium cumin)**	Jambul	Fruits edible and medicinal
S. zeylanicum	Bhensa	Fruits edible
Tamarindus indica**	Tamarind	Fruits edible, timber, fodder and fuelwood
Tectona grandis*	Teak	High quality timber
Terminalia arjuna*	Arjuna, Matti	Medicinal and timber

T. bellerica*	Ghotina	Medicinal and timber
T. catappa*	Badam, Indian Almond	Medicinal; fruits edible
T. chebula*	Hirda	Medicinal and timber
T. paniculata*	Kindal	Timber
T. tomentosa*	Ain	Timber
Trema orientalism*	Gol	Fuelwood, preparing coal
Vitex negundo		Medicinal
Zizyphus jujube**	. Bor	Fruits edible and medicinal
Zrugosa	Chunna	Fruit edible; fuelwood
Pongamia pinnate**	Karanj	Medicinal

* useful as wildilfe habitat

** very useful

Prepared by Dr. A. V. Veeresh,

S. G. Tome and B. F. Rodrigues

9.9 Mining: Social and environmental impacts

Seventy percent of the mining in Goa occurs in forested areas. The state has around 1 billion tonnes of ore rejects in dumps, and several abandoned mines as pits. Every year

36-40 million tonnes of rejects are added to dumps. This causes environmental problems and threatens biodiversity in forests and rivers.

Groundwater and rivers

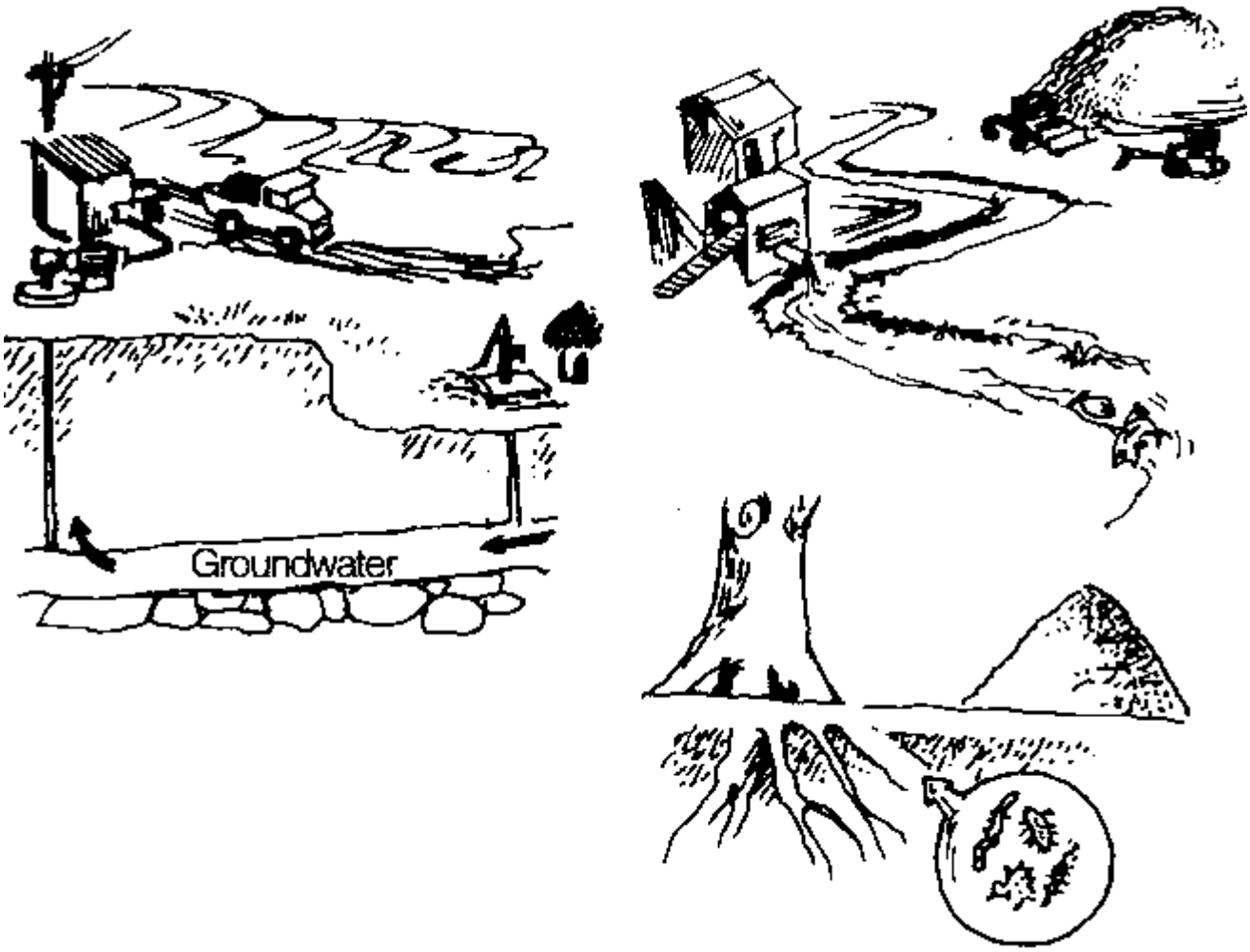
Mining lowers the groundwater level, leading to water scarcity. Springs dry up, affecting the supply of water to rivers. Biodiversity in forests and rivers is harmed.

Runoff from the mines during the monsoon carries large quantities of material to the rivers. Tributaries passing through mining zones contain higher concentrations of total suspended matter than do other streams. During the early monsoon the river and estuarine waters contain very high concentrations of such matter. The high turbidity reduces the amount of light to plankton, affecting the overall biological productivity of the water.

Mine materials and mine tailings settle in the estuarine zone (280,000 tonnes per year in the

Mandovi and Zuari in Goa), changing the geomorphology of the estuarine bed and increasing saline water intrusion upstream. The silt makes the bed shallow and suffocates the fauna living on it.

The silted water contains less oxygen, adversely affecting fisheries and lowering employment in fisheries. In Goa, many fisherfolk are displaced by silting of ponds and river beds.



Groundwater and rivers

Toxic chemicals

Various micro-organisms, including nitrogen fixers, ammonifiers celluloytic bacteria and phosphorus solubilizing bacteria recycle essential nutrients and make them available to plants. Toxic mining rejects harm these microorganisms, reducing the nutrient supply to plants and affecting the food chain and plant and animal biodiversity.

Assessing impacts

Environmental impact assessments must be carried out before mining is undertaken. Care has to be taken to include social costs while calculating the cost/ benefit analysis of a proposed mining project.

The deforestation and erosion of soil in India has resulted in loss of 6,000 million tonnes of soil. This corresponds to Rs 7,000 million in terms of nitrogen, phosphorus and potassium lost due to mining and other development activities.

Important heavy metals

Iron (Fe)

Manganese (Mn)

Chromium (Cr)

Nickel (Ni)

Cobalt (Co)

Zinc (Zn)

Lead (Pb)

Agriculture

Mining harms dams and irrigation schemes by reservoirs with silt and clogging canals. Sediment covers fields, lowering soil fertility, reducing bioproductivity and forcing farmers to incur the cost of desilting.

The toxic effects of rejects also lead to the production of kernel-less rice. In Goa, mining has reduced rice output by over 60% in the mining belt. More farmers have lost their livelihood due to mining than there are workers employed by the mining industry.

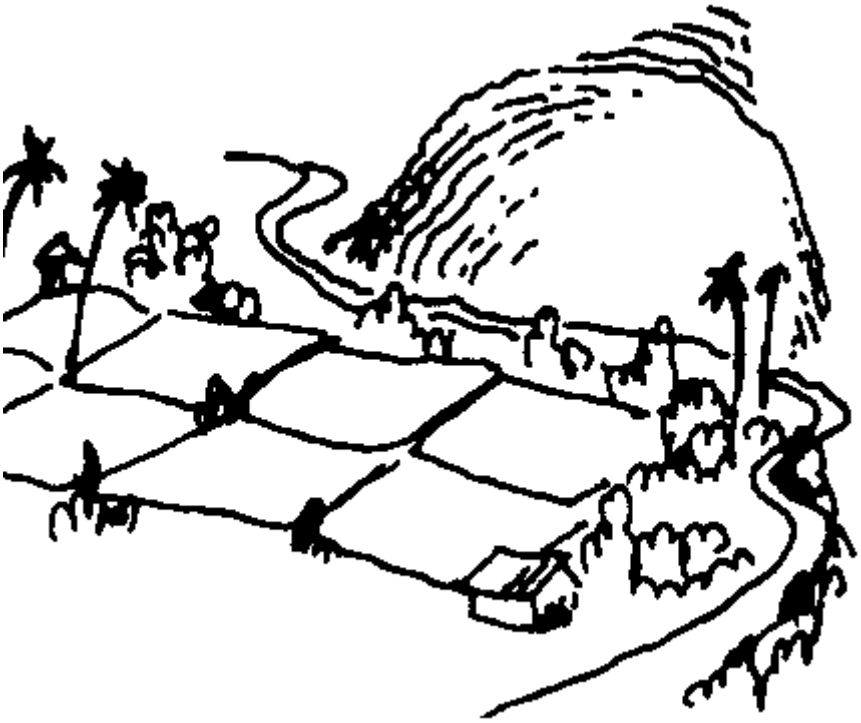
Agriculture

Noise and dust

Mining activities, especially explosions, may scare away animals and birds. Dust from mining, ore transportation and deposition causes respiratory problems in humans and lowers the rate of photosynthesis of plants. This affects animal and plant health and hence biodiversity.

Laterization

The Western Ghats have a large number of lateritic plateaus. Wherever such plateaus are exposed by deforestation for any reason, including mining, the process of laterization begins. The laterite becomes harder and harder.



Laterization

Plants cannot grow on such a surface.

Measuring pollution

The extent of pollution of rivers and estuaries can be measured using the index of geoaccumulation. This index compares the level of an element (such as a heavy metal) with the general level prevailing in the environment.

$$Igeo = \log_2 Cn/1.5 \times Bn$$

Igeo = Index of geoaccumulation

Cn = Measured concentration of element

Bn = Geochemical background value

(post-archean average shale)

Igeo	**Grade**	**Class**
>5	6	Very strongly polluted
4 - 5	5	Strongly to very strongly polluted
3 - 4	4	Strongly polluted
2 - 3	3	Moderately to strongly polluted
1 - 2	2	Moderately polluted
0 - 1	1	Unpolluted to moderately polluted
<0	0	Practically unpolluted

Heavy metal pollution

Mandovi and Zuari rivers, Goa

	Index of geo-	Pollution class

	accumulation		
Fe_2O_3	River	2.184	Moderately to
	Estuary	1.545	strongly polluted
MnO	River	3.740	Moderately to
	Estuary	2.981	strongly polluted
Cr	River	3.155	Strongly polluted

High Cr values are associated with high Fe values

Prepared by Dr. Joe De Souza, Dr. G. N. Nayak.

9.10 Resource utilization in Uttar Kannada district

Uttar Kannada district

Uttar Kannada district of Karnataka State lies in the central part of the Western Ghats. The district is typical of the whole region. It has three main agroclimatic zones: coastal, hills and eastern transitional.

This is a region of gently undulating hills rising to about 600 metres and merging with the Deccan plateau. The coastal strip is narrow. The total area is 10,220 km², of which 7000 km² is forested. The population is 1,200,000 people, of whom 75% live in villages.

The district has four main west-flowing rivers. Their small but numerous tributaries in the hill zone make the region ideal for watershed approaches in development and management.

Resource utilization and management

Resource utilization in Uttar Kannada should follow three main principles:

• The development, management and utilization of resources should be on the basis of watersheds.

• The approach should be an integrated one.

• The criteria should be people's co-existence with the nature and the sustainable utilization of natural resources.

Only by properly managing natural resources can we preserve or improve on biodiversity.

Forest lands in Uttar Kannada

Reserved Forest	5000 km^2
Minor forest	1500 km^2
Protected forest ("Betta" lands)	500 km^2

Conservation areas

Areas of strict preservation

These areas should be set aside for strict nature conservation. Nature should be left to its own course: there should be no human interference. Even dead logs must be allowed to rot. Traditional sacred groves, natural springs and other water bodies are to be identified and preserved: This will provide information on natural processes (such as climatic change) which may affect biodiversity.

Extractive reserves

Biodiversity in these reserves is to be protected. Local people may be allowed to benefit from non-wood forest resources. But this extraction must be in a sustainable manner and leave sufficient opportunity for rejuvenation. Timber, fuelwood and industrial needs may also be met from these reserves by harvesting and removing excess outputs.

Multipurpose areas

These areas should support water resources, timber production, wildlife, pasture and tourism on a sustained basis. The emphasis is on the use of resources through economic activities for local and regional development. Integral to this is the role of local people in the management of such areas.

Privately owned area

The role of private land in conservation is often overlooked. Through zoning and other forms of regulation, private lands can be developed in such a way as to support surrounding conservation efforts. A watershed approach will help ensure the proper integration of public, private and communally held lands for conservation.

Technology options

Energy-saving devices such as "Astra" chulas, gobar gas plants, solar and other non-conventional cookers should be popularized. Appropriate housing technologies should be provided. Kissan and school nurseries for trees are to be encouraged. These activities help reduce energy consumption by reducing waste and increasing efficiency in use. Nurseries can help speed up natural forest regeneration.

Sustainable agriculture

The dependency on forest resources for agriculture and horticulture should be minimized. Farmers must be encouraged to cultivate their own land intensively and in a sustainable manner, for instance by growing fodder grasses and trees, cropping fruits and vegetables, using multi-storey and mixed crop patterns, and mulching crops.

Soil and water conservation

Soil conservation and water management measures should be introduced. Better drainage systems and other measures of water management such as water recycling and the proper use of percolation tanks should be emphasized.

Animal husbandry

Various practices can improve livestock husbandry. These include stall feeding, controlling livestock populations, improving breeds, growing fodder in waterlogged areas and at the edges of cultivated land, and cultivating fodder trees. Co-operative marketing systems can be established, and better management practices can be introduced through extension and training.

All of these technologies can help improve the productivity of land, thereby reducing the need for new land. This reduces pressure for the conversion of existing natural areas, thus promoting the conservation of biodiversity.

Human resource management

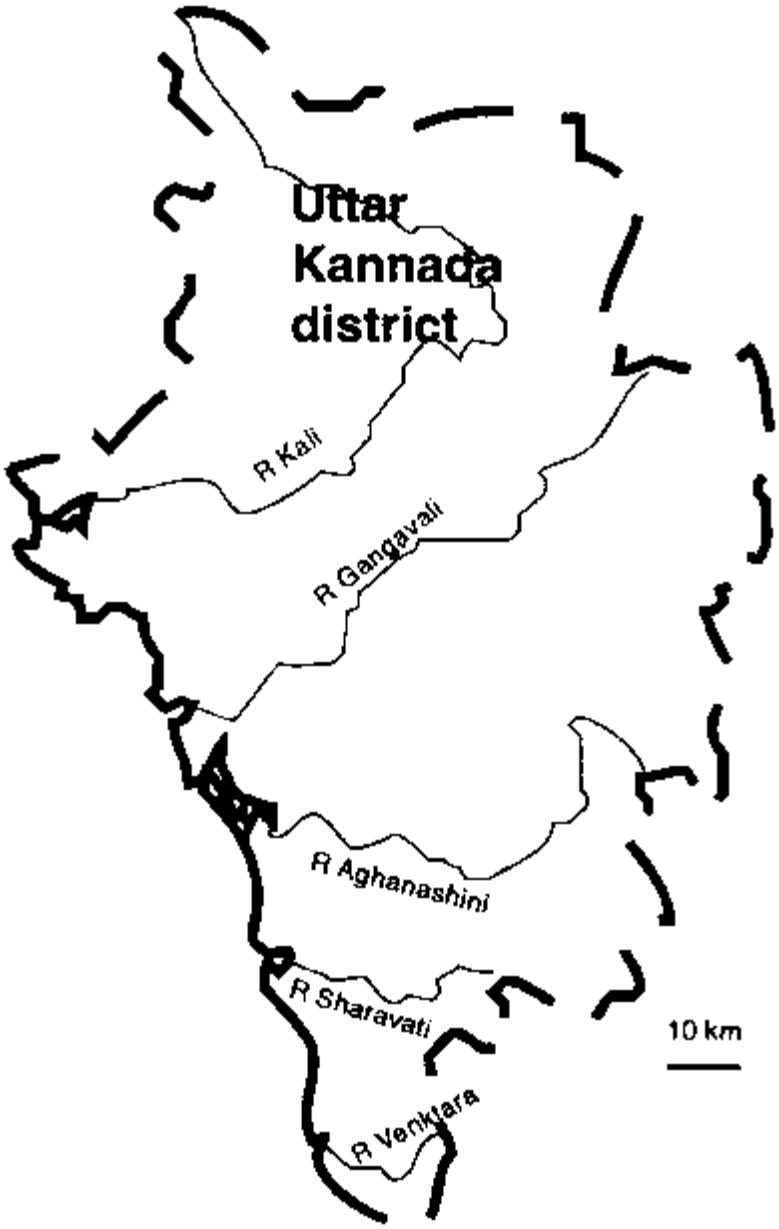
Centralized, bureaucratic practices in both natural resource management and human resources management should be reduced. The active and effective involvement of local people in particular and the general public is necessary in planning and implementing natural resource management policies. Cooperative organizations should be established and involved in marketing. Other non-government and voluntary organisations, including youth clubs and educational institutions, must also be directly involved.

Village-level natural resource management committees should be set up so that local people can participate in planning, developing, managing, protecting and utilizing the natural resources. There should be an environmental policy implementing and enforcing forum at the district level.

Old but useful customs-and traditions must be suitably utilized in managing and developing both natural and human resources. Examples are the practice of "Pavitra Vana", indigenous herbal medicines, religious customs in preserving certain rare species of fruits and flowers, and traditional methods of cultivation and preservation which have proven sustainable over the years.

A new process of technology transfer must be envisaged. To bridge the gap between the lab and village, we must establish village technology demonstration centres. Educational institutions at village centres can play a vital role in this respect.

Public awareness-raising and education should be done on a massive scale. The services of educational institutions and other non-government voluntary organizations should be properly utilized for this. Both rural and urban people should be trained in ways to conserve biological resources and the environment.

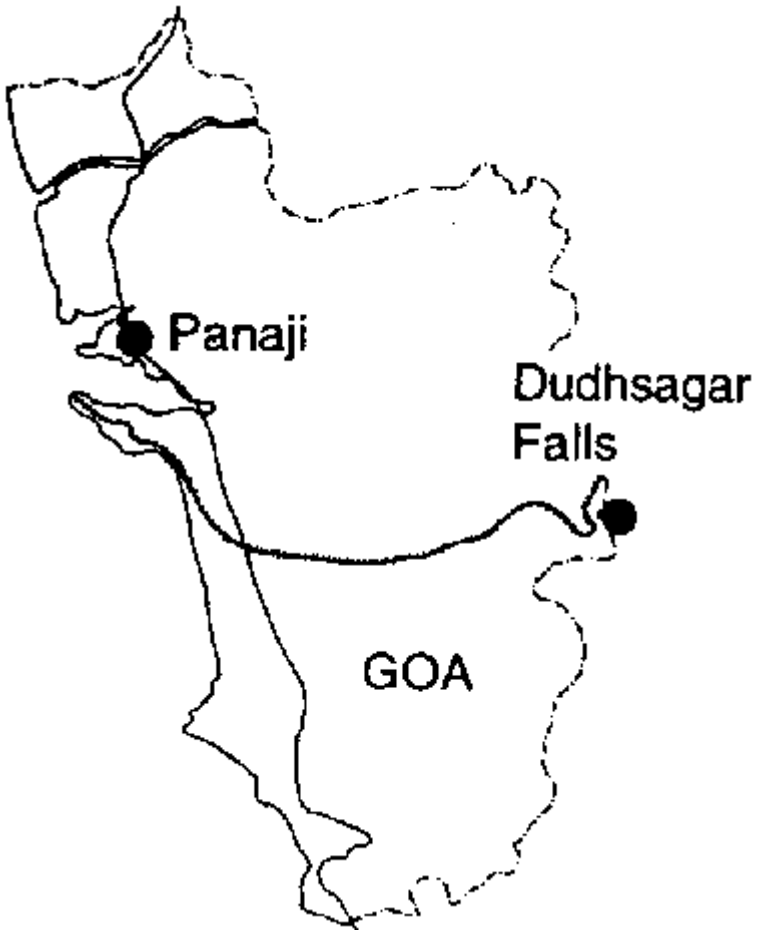


Uttar Kannada district

Prepared by Raghupati Hegde

9.11 Biodiversity of Dudhsagar valley

The Dudhsagar valley in Sanguem Taluka, Goa, has a total area of 12 km². A railway line goes around the valley, almost encompassing it. The valley gets its name from the river Dudhsagar, which is formed by the union of the Katla and Palna rivers which originate at an altitude of 800 m near Castle Rocks in Uttar Kannada district. The Dudhsagar forms rapids and the well-known Dudhsagar falls.



Dudhsagar valley

The valley is part of the Mahaveer Sanctuary of Molem. It is a dense, mixed jungle, providing shelter and food for a variety of wildlife.

Plants

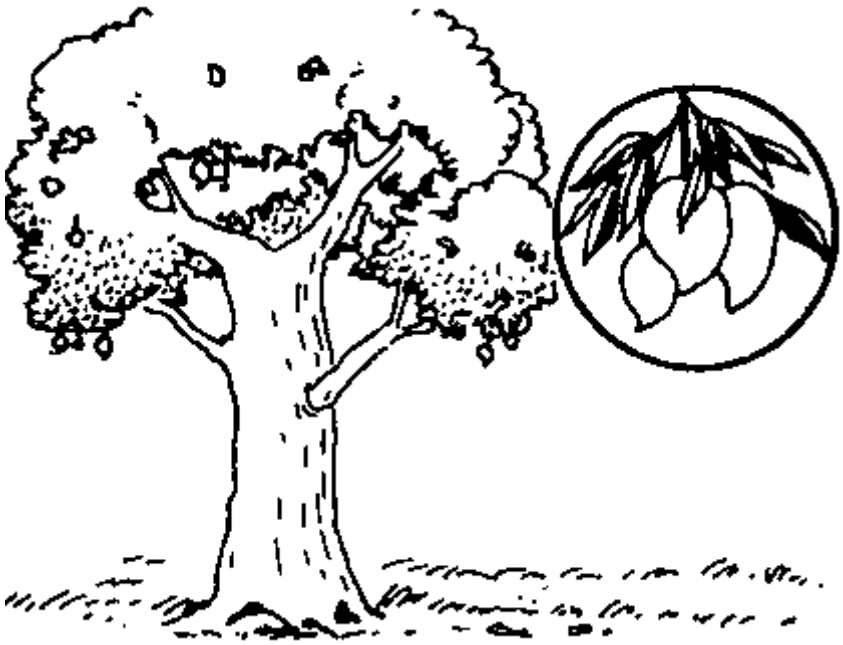
The valley bears a rich flora. Some 85 genera and an equal number of plant species have been recorded. The dominant species are listed below.

Trees Xylia xylocarpa, Mangifera indica (mango), Grewia tiliaefolia, Ficus racemosa (fig), Syzygium cumin) (jambol nuts), Emblica officinalis (sour nuts), Lagerstroemia microcarpa, Terminalia arjuna (arjuna), T. chebula, T. crenulata, T. paniculata.

Climbers Asparagus sp., Calamus pseudo-tenuis, Calycopteris floribunda, Cyclea peltata, Derris sp. Elaeagnus conferta, Smilax sp.

Shrubs Clerodendron viscosum, Ixora coccinia, Leea indica, Murraya paniculata, Vitex negundo.

In addition there are several grasses, ferns, orchids, cane palms, as well as wild plantains.



Plants

Mammals

Ten mammalian species are commonly found: Bonnet Macaque Macaca radiate. (10/km²) Common Langur Presbytis entellus. (6-81 km²)

Jungle Cat Felis chaus.

Asiatic Wild Dog Cuon alpinus dukhunensis (A pack of 6-7 found/12 km²)

Wild Boar Sus scrofa.

Gaur Bos gaurus.

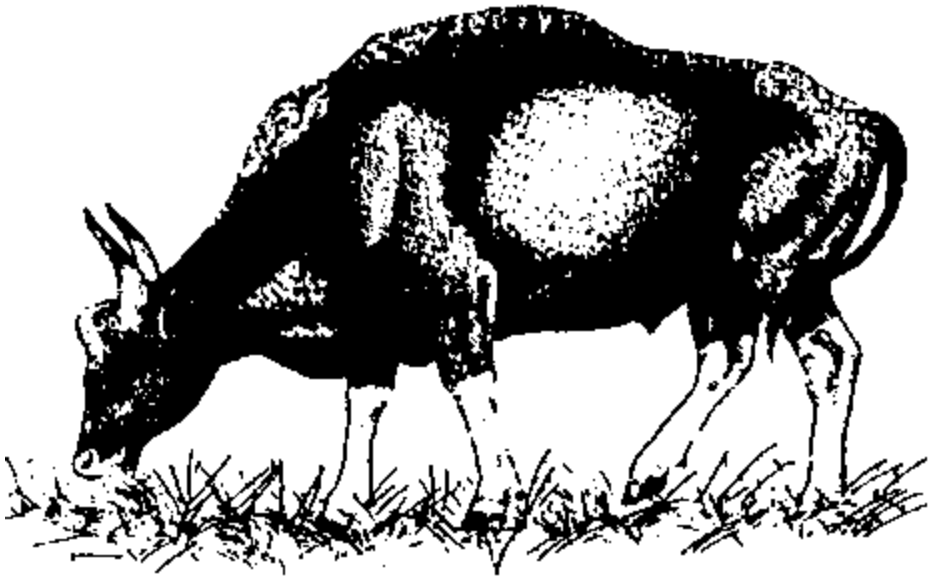
Giant Squirrel Ratufa indica (30/12 km²)

Ground Squirrel Funambulus tristriatus.

Indian Blacknaped Hare Lepus nigricollis.

Sloth Bear Melursus ursinus.

Population density figures are personal observations; they tally with those observed by the wildlife warden in Goal



Mammals

Birds

The valley has a very rich avifauna. Fifty-one species have been recorded. The dominant species are: Bee-eater Merops orientalis Black Drongo Dicrurus adsimilis Blue Kingfisher Alcedo atthis Brahminy Kite Haliaster indus Brown-breasted Flycatcher Muscicapa muttui Cattle Egret Bubulcus ibis Grey Drongo Dicrurus leucopheus Indian Myna Acridotheres tristis Golden Oriole Oriolus oriolus Tailor Bird Orthotomus sutorius Woodpecker Picoides mahrattensis

Arthropods

Fourteen groups of arthropods are found in the valley. They are: Chelobethi, Chilopoda, Coleoptera, Copepoda, Collembola, Diplura, Diptera, Dictyoptera, Gamasids, Hemiptera, Hymenoptera, Isoptera, Orthoptera, and Isopoda.

The mean population density is 2916.2/m^2

Soil fauna

The soil fauna comprises nematodes, Microoligochaetes belonging to the family Enchytraedae, Oligochaetes, and arthropods.

Nematodes: Population density shows altitudinal variations. The mean density at 241 m is 7082.5/m^2.

Enchytraedae: Hemienchytraeus sp., 130 worms/m^2

Oligochaetes: Three dominant species are found: Megascolex insignia, Megascolex travancorensis and Drawida ghatensis. 50 worms/m^2

Dudhsagar River

The river water is rich in plankton. Fishes such as Tilapia and Labeo are found, as are black tadpoles of unknown species during the monsoon and early post-monsoon period.

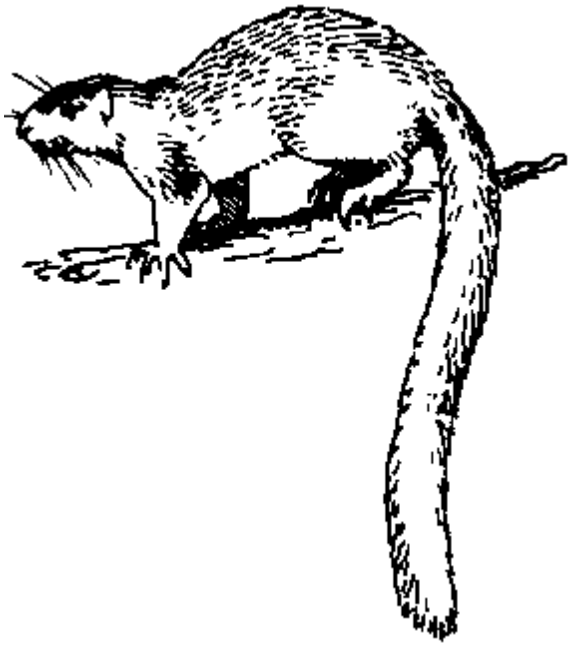
Giant Squirrels

They build nests on the tree tops and a pair stays in these. Squirrels are sometimes killed for flesh and hide. Hides are displayed on the walls.

The squirrels are very sensitive to changes in food, humidity and water.

These animals are seasonal breeders. They have two utera. One uterus becomes functional in one season and the other in another season.

In the nonbreeding season, the males can withdraw the testes into the abdomen.



Giant Squirrel

Prepared by Dr. P. V. Desai

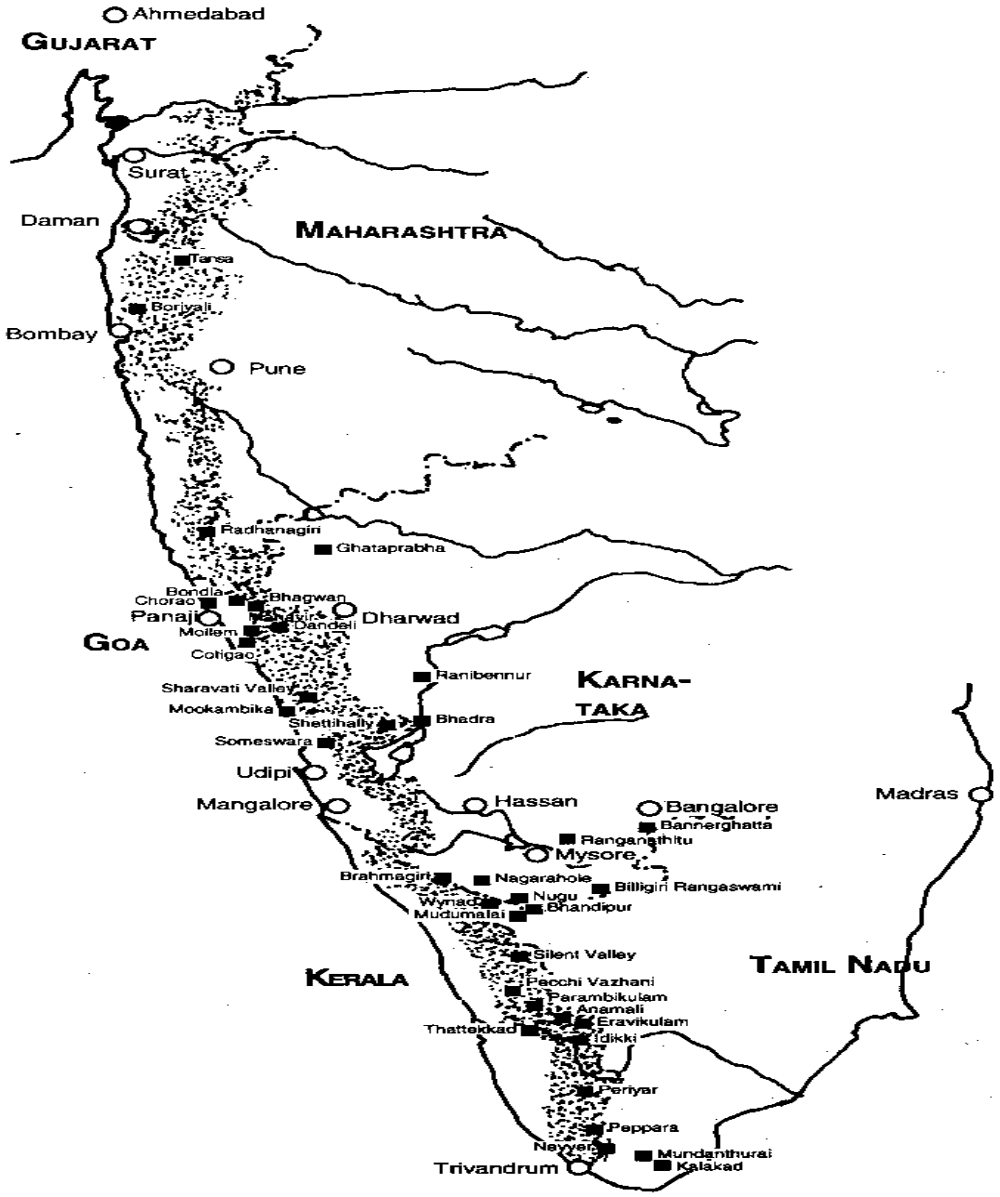
10. Reference

10.1 National parks and sanctuaries in the Western Ghats

Borivali National Park, Maharashtra -- Though only 36 square miles (93 square kilometers), this is one of the most visited parks in all Asia, situated only 21 miles (33 kilometers) north of Central Bombay. There are two small lakes and also the Kanheri Caves. The main attraction is the variety of birds to be seen. October to May are the best months in which to visit.

Nagarahole National Park, Karnataka -- This park borders Bhandipur National Park; a reservoir formed by the damming of the Kabini River separates the two parks. This is an excellent park for wildlife viewing, and even the elusive leopard is often seen here. Other frequently sighted animals include elephant, gaur, chital, barking deer, common langur, bonnet macaque and otters. Tiger, sloth bear and mouse deer may also occasionally be seen. The birdlife is notable, with around 250 species on the check list. October to April are the best months to go. Kutta, 2.5 miles (4 kilometers) away, is the nearest town, and Mysore is only 60 miles away (97 kilometers).

Mudumulai Sanctuary, Tamil Nadu -The flora and fauna are similar to that of the neighbouring Bhandipur National Park, so this is another fine area in which to view elephants and other ungulates of southern India. On the northeast slopes of the Nilgiris, this undulating hill country is well watered and contains a profusion of water-courses. Some more unusual species that can be seen here are chousingha, giant squirrel and wild dog. There is good birdlife, including the striking Malabar great balck woodpecker, Malabar gray hornbill, crested serpent eagle, barbets, mynas, parakeets and cuckoos. The best months for visiting are March to June and September to October. It is bisected by the Mysore-Ooty highway; the hearest town is Gudalur, ten miles away.



National parks and sanctuaries in the Western Ghats

National parks and sanctuaries in the Western Ghats, 1987

Maharashtra	**Area (km^2)**
Borivali National Park	94
Devlagaon Dehckuri Blockbuck Sanctuary	
Radhanagiri Sanctuary	
Tansa Sanctuary	
Salim Ali Bird Sanctuary	
Goa	
Bhagwan Mahavir National Park	54
Mollem Sanctuary	205
Bondla Sanctuary	
Cotigao Sanctuary	105
Chorao Bird Sanctuary	
Karnataka	
Bhandipur National Park and Tiger Reserve	690
Bannerghatta National Park	104
Bhadra Sanctuary	490
Billigiri Rangaswami Sanctuary	324
Brahmagiri Sanctuary	
Dandeli Sanctuary	572

Ghataprabha Sanctuary	29
Mookambika Sanctuary	
Nagarahole National Park	573
Ranganathitu Bird Sanctuary	16
Ranibennur Black Buck Sanctuary	
Sharavati Valley Sanctuary	431
Shettihally Sanctuary	395
Adichuncha Nagiri Sanctuary	
Arabithittu Sanctuary	
Nugu Sanctuary	
Someswara Sanctuary	
Kerala	
Eravikulam National Park	97
Idikki Sanctuary	
Neyyer Sanctuary	128
Parambikulam Sanctuary	285
Pecchi Vazhani Sanctuary	125
Peppara Sanctuary	53
Periyar Tiger Reserve and National Park	777
Silent Valley National Park	go
Thattekkad Bird Sanctuary	25
Wynad Sanctuary	344
Tamil Nadu	

Anamali Wild Life Sanctuary	955
Kalakad Sanctuary	224
Mudumalai Sanctuary	322
Mundanthurai Sanctuary	567

Anamalai Wildlife Santuary, Tamil Nadu -- A very fine sanctuary of evergreen forest and high-altitude temperate grassland. Nilgiri langur and the very rare lion-tailed macaque may be seen in the forests, while Nilgiri tahr inhabit the higher reaches. Elephant, sambar, gaur, spotted deer, wild boar and giant squirrels are some of the park's more visible animals, but mouse deer, flying squirrels, civets, flying lizard and king cobra also live here. The birdlife is also excellent, with hornbills, malkhohas, fairy bluebirds and racket-tailed drongos.

All months are rewarding, although it is best to avoid the wettest season, June to August. Pollachi is the nearest town, 21 miles (34 kilometers) away and Coimbatore is only 46 miles (74 kilometers).

Eravikulam National Park, Kerala -- A beautiful area consisting largely of high rolling grass hills. The hills are home to India's largest population of Nilgiri tahr. Other animals to be found are Nilgiri langur, lion-tailed macaque, elephant, tiger, leopard and giant squirrel. November to May are good months to visit. The nearest town is Mannar, only ten miles away.

Periyar (Thekkady) National Park, Kerala -- This hilly tiger reserve embraces the Periyar River, which was originally dammed in 1867 for irrigation purposes. Boat travel on the reservoir is the only means of transport in the park and provides one of the most delightful methods of viewing the elephants for which the park is known. Otters, birds, fish and snakes inhabit the aquatic lakeshore belt, while in the forests bonnet macaque, nilgiri langur, mouse deer, sambar, barking deer and gaur are some of the main herbivores. A population of the rare lion-tailed macaque is still found here, and on the upper slopes a few Nilgiri tahr remain. The best time to visit is between October and April, and especially the latter two months, when water levels are low and the animals tend to spend more time near the lake. The nearest town in Kottayam, 71 miles away (115 kilometers).

Source: Joanna Van Gruisen, 1992. Wildlife of India

10.3 NGOs in the Western Ghats states

This listing, extracted from WWF-India's Directory of Environmental NGOs in India, attempts to identify those groups whose areas of work include any aspects of biodiversity conservation. Existing directories and listings present NGO work in the whole range of environmental activities, not classified by biodiversity alone, and our listing is based on inferences drawn from statements made by the NGOs themselves, pertaining to their work. Also, the fields of work indicated here do not necessarily indicate the entire scope of an NGO's work; they refer only to those activities that have more immediate concerns with biodiversity.

More exhaustive information can be found in the latest edition of the directory, available from the WWF-India Secretariat, 172-B Lodhi Estate, New Delhi 110 003. Reference copies should be available with WWF State/Divisional Offices in the region, whose addresses are also listed in this directory. The directory may also be available with most of the NGOs listed, which receive copies as part of WWF-India's networking support.

Agency	Address	Work related to Biodiversity Conservation
Goa Research Institute for Development (GRID)	9 Despamont Building, Santa Inez, Panaji - 403001, Goa	To disseminate information on issues such as fisheries, toddy tapping.
Nirmal Vishva	Sarjotishi Colony, Khadpabandh, Ponda - 403401, Goa	Suggestions for the Tree Protection Act of Goa; to encourage tree planting; launching local need-based forest development schemes.
World Wide Fund for Nature-India, Goa Divisional Office	Block B, Flat B-02, Hillside Apartments, Fontainhas, Panaji - 403001, Goa	Education programmes and field projects.
Centre for Environment Education	Thaltej Tekra, Ahmedabad - 380005, Gujarat	Production of education material on biodiversity and conservation; teacher training, feature service, graphics library, consultancy in interpretation and design.
Association for Community and Rural Development for Social Action and Transformation (ACRESAT)	Sujjalur, Malavalli Taluka, Mandya - 571424, Karnataka	Campaigning against the dangers of monocultures.
Dharwad Environmental Association (DEA)	Hembli Galli, Hosyellapur, Dharwad - 580001, Karnataka	Survey of flora and fauna in the Kali river Hydro-electric Project area.
Educator Manufacturer Association (EDMA)	138, Gangadhara Chetty Road, Bangalore - 560042, Karnataka	To develop low-cost, high-utility teaching aids and play materials meant specially for the Indian student.
Indian Rural Reconstruction Movement (IRRM)	506, 9th Main, 4th Cross, HAL 2nd Stage, Indiranagar, Bangalore - 560008, Karnataka	Involved in genetic resources conservation and multiplication of indigenous seeds.
Life Environment Awareness Foundation (LEAF)	26, 27, 9th Main, Raj Mahal Vilas, Bangalore - 560080, Karnataka	LEAF Wildlife Research Centre (Research HQs at Mysore, Computer Division at Bangalore); LEAF Data Bank and Library, Bangalore. Wildlife surveys in the open plains of Mysore. Wildlife research and tribal eco-development in Bandipur (Karnataka) and Mudumalai (Tamil Nadu).
Merlin Nature Club	13, 8th Cross, 30th Main, Sarakki ITI Layout, JP Nagar I Phase, Bangalore - 560078, Karnataka	To establish a data bank about regional biodiversity; field surveys of various species of fauna and avifauna; consultancy services.
The Tree Lovers Karnataka	1, Edward Road, Bangalore - 560012, Karnataka	To promote tree planting and protection; to help create and preserve vegetative cover where required.

NGOs in the Western Ghats states

Vishvaneedam International Sarvodaya Centre (Vishvaneedam Foundation)	13th Km, Magadi Road, PO Vishvaneedam, Bangalore - 560091, Karnataka	Educating people about indigenous plant varieties; advising on methods of cropping; herbal treatment (both human and veterinary).
Wildlife Association of South India (WASI)	17/1, Victoria Road, Bangalore - 560047, Karnataka	To establish, implement, and administer projects for wildlife preservation, breeding, and the restocking of forests with games, and the water with fish; protecting the Mahseer fish in the Cauvery river; constructing hatcheries and breeding tanks for freshwater fish; rearing grey junglefowl and partridges.
Centre for Ecological Sciences	Indian Institute of Science, Bangalore - 560012, Karnataka	Studies and consultancy projects on theoretical and field aspects of conservation.
World Wide Fund for Nature-India, Karnataka State Office	Kamla Mansion, 143 Infantry Road, Bangalore - 560001, Karnataka	Education programmes and field projects.
World Wide Fund for Nature-India (Data Centre for Natural Resources)	Kamla Mansion, 143, Infantry Road, Bangalore - 560001, Karnataka	A documentation centre and data bank for natural resources.
Academy of Development Science (ADS)	Village & PO Kashele, Kayat Taluka, Raigarh - 410201, Maharashtra	Educating rural people on the characteristics and uses of local flora, documenting medicinal plants of the Western Ghats; promoting nurseries and herbal gardens in rural areas.
Ahmhi Amachya Arogya Sathi	At & PO Kurkheda, Gadchiroli - 441209, Maharashtra	Promoting indigenous health-care systems; and use of herbs as medicines.
Akhil Bharat Krishi-Goseva Sangh	PO Gopuri, Wardha - 442114, Maharashtra	To protect cows; to breed good bulls.
Bombay Natural History Society (BNHS)	Hornbill House, Opposite Lion Gate, Shahid Bhagat Singh Marg, Bombay - 400023, Maharashtra	To collect data on natural history throughout the Indian subcontinent; to disseminate knowledge of flora and fauna by means of lectures, literature, field trips and expeditions; to study wildlife-related problems and recommend management plans to conserve wildlife and its habitat.
Chetna-Vikas	PO Gopuri, Wardha - 442001, Maharashtra	Preservation and propagation of indigenous genetic plant resources.
Ecological Society (ECOSOC)	1 B Abhimanshree Society, Pashan Road, Pune - 411008, Maharashtra	Restoration of forest and wetlands; survey of wetland birds; conducting research in restoration of bio-diversity.
Four Eyes Foundation	798, Bhandarkar Road, Pune - 411004, Maharashtra	Undertaking topographical survey of Susala Island; enumerating the island's biodiversity.
Green Future Foundation (GFF)	515/5/14, Anjali, Ekbote Colony, Pune - 411042, Maharashtra	Afforestation; collection and identification of plants; raising a nursery of medicinal and indigenous plants.
Nisarga Seva Sangh (NSS)	152 Lendra (West), Ramdaspeth, Nagpur - 440010, Maharashtra	Conducting a survey of Vidarbha's zudpi jungles; promoting ornithological research on waterfowl, cranes; identification of resident birds of Vidarbha.
Save Mahabaleshwar Panchgani Association (SMPA)	Stone House, Mahabaleshwar - 412806, Maharashtra	Documentation of the area and data on local flora and fauna.
The Soonabai Pirojsha Godrej Foundation (Environment Cell)	Godrej Bhavan, 4-A Homi Street,Bombay - 400001, Maharashtra	Conservation of ecosystems such as mangrove swamps in and around Bombay.
Vidarbha Nature Conservation Society (VNCS)	49, Lakshmi Nagar, Nagpur - 440022, Maharashtra	To carry out projects on wildlife, flora and pollution control; to study the medicinal plants of the area and to protect them; protested against the unscientific and illicit felling of trees in biosphere reserves.
World Wide Fund for Nature-India, Maharashtra & Goa States Office	National Insurance Building, 2nd Floor, 204, Dr D.N. Road, Fort, Bombay - 400001, Maharashtra	Education programmes and field projects.
World Wide Fund for Nature-India, Kolhapur Divisional Office	1220 E, Rajaram Road, Kolhapur - 416008, Maharashtra	Education programmes and field projects.
World Wide Fund for Nature-India, Nagpur Divisional Office	Kale Bhuwan, Opp. St. John's School, Mohan Nagar, Nagpur - 400001, Maharashtra.	Education programmes and field projects.
World Wide Fund for Nature-India, Pune Divisional Office	Rohan Apartments, Plot No.1, Flat No. 6 (Second Floor) L.I.C. Colony, Kothrud, Pune - 411029, Maharashtra	Education programmes and field projects.

NGOs in the Western Ghats states (continued)