

UNIT I Systems Perspective

Introduction

Environment, the Oxford English Dictionary says, is the sum total of influences, which determine and modify the character and development of life. It is all that moulds humanity and is, in turn, moulded by humanity. To appreciate environment, therefore, one must view the whole system. A system is a set of connected, interdependent objects that forms a complex unity. So, one must begin with visualising the components, the objects, which would constitute the environment. These may, of course be defined variously from different perspectives. For our purpose, we will focus on institutions, people, knowledge, artefacts, geosphere (including the sub-components of atmosphere, hydrosphere and lithosphere), biosphere (including the sub-components of ecosystems, biological populations), energy, material and information flows as the system components. All these components and their sub-components are in continual flux, interacting and influencing each other, over space and over time.

Uttara Kannada: A Case Study

Let us consider a concrete example to appreciate this system approach. For this, let us move to Uttara Kannada, situated near the centre of the hill chain of the Western Ghats, where the coastal strip is at its narrowest (Fig. 1). At one time, before the Second World War this was a thinly populated, highly malarious district with an

extensive forest cover. The Second World War was a trigger for launching a serious war on this dreaded disease. So, during the war chemists came up with the new organic molecule of Dichloro Diphenyl Trichloroethane (DDT) that was highly effective in control of mosquitoes. India became independent at the end of the war, and ten years after the war ended, DDT was pressed into service to eradicate malaria throughout the country. *Terais* at the foot of Himalaya, Wynaad in Kerala, and Uttara Kannada were some of the erstwhile highly malarious regions that were made free of the dreaded disease. The decades of 1950s and 60s were a time when India's human population began to register a rapid increase, when it was vital to step up food production, and when the country launched on a serious drive to industrialise and to enhance irrigation and power production.



Fig. 1: The position of the district of Uttara Kannada

Development at all Costs

Uttara Kannada was a district rich in forest resources, manganese ore and with its high rainfall, in potential for generation of hydroelectricity and provision of irrigation water. As soon as the impediment of malaria was removed, there were concerted attempts to develop these resources. The country was in a hurry to catch up on attaining independence, and the prevailing philosophy was “development at all costs”. These supposedly acceptable costs included environmental costs, and industry was supplied resources at highly subsidised rates and permitted to pollute with impunity. In the organised sector, the district quickly attracted manganese mining, a ferromanganese plant, a paper mill, several irrigation projects and a major hydroelectric project complex. It also attracted an influx of cultivators who largely took to paddy cultivation in the wetlands, and of herders maintaining buffaloes and cattle in the forest tract. While the activities in the organised sector were officially sanctioned, and indeed supported with provision of resources at highly subsidised rates, the activities of cultivators and herders entailed encroachment on state forest land and therefore were illegal.

Failures to Sustain Development

This was not a sustainable pattern of development and it largely passed on the costs associated with environmental degradation to the weaker segments of the society. Thus the paper mill that was supplied bamboo at a nominal price of Rs 1.50 per tonne, quickly ran out of bamboo resources of the district. It however had the option of bringing in raw material from as far away as Meghalaya or switching to farm grown eucalyptus. In the process, the quality of rural housing that depended substantially on the local bamboo suffered, as did the basketweaving community. The release of paper mill effluents in the Kali river rendered its water unfit for use by villagers and their cattle, and resulted in fish kills. When farmland was submerged under river valley projects, the farmers were initially resettled on forest lands without any proper compensation or rehabilitation measures having been put in place.

To begin with, the buffalo-cattle keeping herders of Gavli community migrating from Maharashtra Western

Ghats to the north prospered, with abundant grazing on the forest floor enhanced by the initial opening up of the forest canopy to supply raw material to the forest-based industry. The forest was at first rich in bamboo and its loppings provided good fodder. However, the bamboo was rapidly depleted after the establishment of the paper mill. Meanwhile, there were other consequences of the World War II. DDT had been developed to help the troops fighting in the jungles of South-East Asia to protect themselves against malaria. These forests had been invaded by *Eupatorium*, a composite weed of South America. Many Indian soldiers from the southern state of Kerala were part of the British army fighting in South-East Asia. Therefore, some seeds of *Eupatorium* reached Kerala as they returned home at the end of the war. This *Eupatorium* promptly began its northward march and reached Uttara Kannada some 25 years later. The opening of its forest canopy following excessive industrial exploitation had created ideal conditions for *Eupatorium* to establish itself and it rapidly took over the forest floor. The large biomass of the annual *Eupatorium* fuelled intense forest fires in the dry season, suppressing regeneration of trees. All these changes meant a drastic reduction in the availability of grazing for livestock. Buffaloes require substantial quantities of fodder, cattle can manage with a little less, while goats can survive under much worse conditions. Consequently, the composition of livestock of Uttara Kannada district shifted from a dominance of buffaloes and cattle to that of goats with a more adverse influence on forest growth. As the economic conditions of the herders deteriorated, they shifted from selling of butter, to selling of milk, and then to that of *Khoya* using firewood extracted from forests. In parallel, there was substantial extraction of raw material for polyfibre and plywood industries as well, at highly subsidised rates, and at levels that were unsustainable. All of this meant far-reaching changes in the forest cover with a drastic reduction in the standing biomass of trees. The larger, shade tolerant, evergreen tree species were replaced by smaller, sun loving deciduous species and weedy plants like *Eupatorium*.

Nature Conservation

At the same time, substantial tracts of forests were diverted for river valley projects, in particular, the

giant Kali hydroelectric project involving a number of reservoirs. The forests thus submerged, as also the land deforested to set up the paper mill township were rich in wildlife, including elephants. To compensate this loss of wildlife habitat, a large wildlife sanctuary, encompassing nearly half the district was established. This affected many habitations, and the difficulties were compounded by escalating crop raiding by elephants, and other wild animals affected by a loss of habitat and its fragmentation. The resulting protests by people led to a reduction in the area of the wild life sanctuary to less than 15 per cent of its original extent. Uttara Kannada also harboured a large number of sacred groves with primaevial vegetation, some as large as 400 hectares. These enjoyed considerable immunity from human interventions on grounds of religious beliefs. However, they had no official sanction, nor was their role in the conservation of biodiversity recognised. As the state-owned forests were depleted, these sacred groves represented rich sources of raw material, especially of evergreen species favoured by the plywood industry. Consequently, they were clear felled and replaced by monoculture plantations of fast growing exotic species. In parallel, the freshwater biodiversity was adversely impacted by the effluents from the paper mill and the ferromanganese plant, along with sewage from Hubli city.

Systems Perspective

This example illustrates well how vital is the systems perspective in understanding of the environmental issues. We propose to view the system in terms of interactions of institutions–people–knowledge–concerns–activities–artefacts–geosphere–biosphere–energy, material–information flows. Consider the post-Second World War story of Uttara Kannada district from this perspective. This Second World War was a conflict amongst the institutions of nation states over access to resources of the world. In particular, it was a struggle amongst the industrialised nations for resources of the non-industrialised world being governed as colonies. The scientific manpower of the warring nations was drawn into it to help enhance the efficiency of the war activities. This scientific establishment had developed knowledge of mosquitoes as vectors of malaria. The warring nations had concern for the health of people—often from

colonies—serving as soldiers, suffering from malaria in the South-East Asian corridors of war. The geosphere-biosphere complex of South-East Asia was so structured as to favour large mosquito populations, and prevalence of endemic malaria. In many ways these paralleled the conditions in the geosphere-biosphere complex of Uttara Kannada, which also supported endemic malaria. But British rulers of India did not have the level of concern for the health of ordinary people of colonies as they had for the health of soldiers. The concern for the health of soldiers led to manifold scientific activities including chemical research that led to the discovery of an artefact, the organic molecule DDT, as an effective mosquito control agent. The global material-information flows after the war led to effective malaria eradication programmes in Uttara Kannada district because the institution of independent Indian state was concerned far more about the health status of its citizens, leading to activities like Public Health programmes. The successful execution of the malaria eradication programmes opened up Uttara Kannada district to a whole new set of human activities that radically altered its environment (Fig. 2).

Consider another set of interconnected events with manifold impacts, beginning with the institutions of supply of milk and milk products in the unorganised sector. A significant component of these institutions were people in the colonies of Gavlis; herders that had maintained populations of buffaloes and cattle in malaria-free forest ecosystems of Maharashtra Western Ghats for many generations. They had developed the knowledge, the set of activities, the artefacts suited to the prevailing conditions of that geosphere-biosphere. A very small numbers of Gavlis did live in the Uttara Kannada district when it was still malarious. No sooner had malaria been eradicated, the news reached, the information flowed to Gavli colonies, north of Uttara Kannada. These people had concern for better fodder for their livestock populations, and had acquired the knowledge that there were extensive fodder rich territories, now free of the constraining factor of malaria. This triggered large scale movements of Gavlis and their livestock into Uttara Kannada.

For Gavlis bamboo was an important resource in many ways; as a house construction material, as raw material for fabrication of a variety of implements, as lopped leaf fodder in the dry season. *Bambusa arundinacea*,

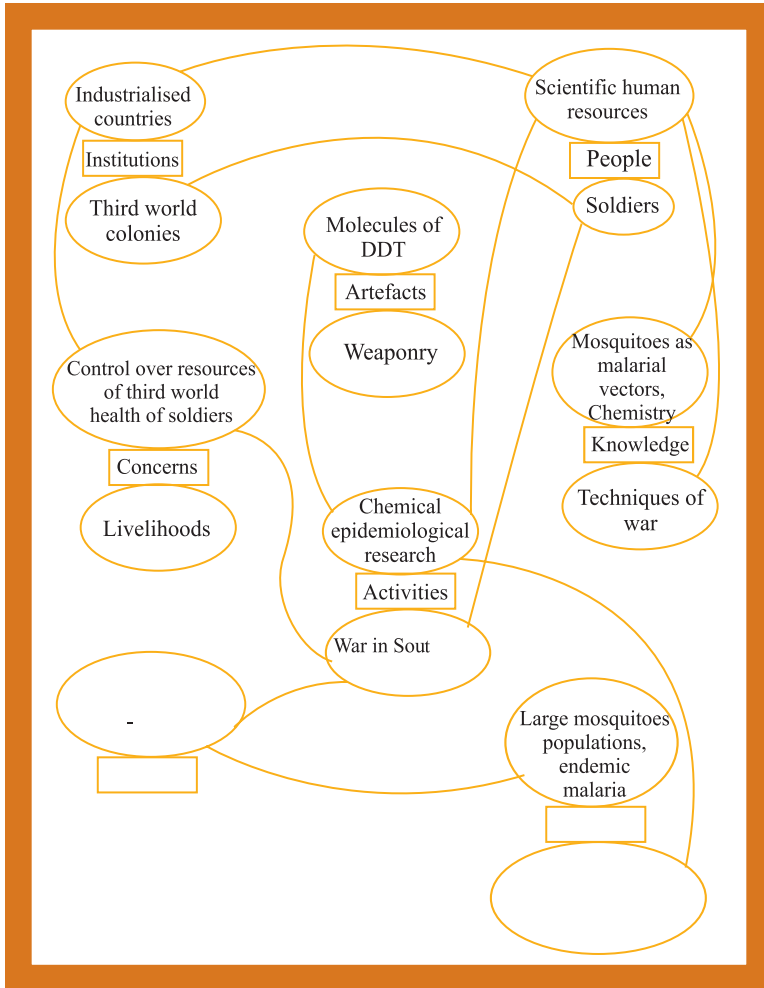


Fig. 2: Operation of the system that led to the discovery and use of DDT to control malaria during Second World War

the predominant bamboo species of Uttara Kannada, naturally develops a thorny covering at its base. Gavlis possessed the knowledge that this covering is important to protect new shoots from being destroyed by porcupines, monkeys, pigs and cattle. Their harvesting activities, motivated by the concerns to sustain bamboo populations therefore entailed cutting bamboos above the thorny covering, leaving the thorns intact. Basket wearers and other local people also did so. Into this scene was brought in the activity of bamboo harvest by the new institution of the paper mill. This was based not on traditional, but on modern, supposedly, scientific knowledge. The mill's knowledge was not grounded in careful scientific studies,

but rather driven by its concerns to harvest bamboo at as little cost as possible. They did not appreciate the natural role of thorns and viewed it as a nuisance, and paid their labourers to undertake so-called “clump cleaning” activities of removal of the thorny basal cover. This exposed the bamboo clumps to severe destruction of young shoots and became a major cause of rapid decline of bamboo populations of Uttara Kannada district. Since bamboo was a very important component of the biosphere, its depletion radically altered the environment of Uttara Kannada (Fig. 3 and 4).

Ecological Organisation of Indian Society

Finally, consider the ecological organisation of the Indian society and its patterns of resource use from a systems

The diagram illustrates the systemic factors leading to the migration of Gavlis and their livestock. It features several interconnected components:

- Top Level:** "International information flow" connects to "Independent Indian state, Public Health Department" and "Govt. employees".
- Information Flow:** "Community level information flow" links "Institutions" (including the Public Health Department and "Gavli Community organisation") to "People" (including "Gavlis villagers").
- Malaria Control & Knowledge:** Nodes include "Mosquito control techniques", "Knowledge", "Malaria has been eradicated", and "Artefacts".
- Health & Concerns:** "Health of Indian People" leads to "Concerns", which includes "Health of Gavlis, fodder" and "Huts cattle sheds etc".
- Activities & Migration:** "Mosquito control activities" lead to "Activities", specifically "Migration of Gavlis with livestock".
- Environmental Impact:** "Reduction in mosquito and malarial parasite population" affects the "Biosphere", leading to "DDT residues in organisms vegetation changes due to grazing".
- Human Movements & Geosphere:** "Human movements" connect "Health of Gavlis, fodder" to "DDT residues in water" (part of the "Geosphere") and directly to the "Migration of Gavlis with livestock".

Fig. 3: Operation of the system that led to the migration of Gavlis and their livestock into Uttara Kannada

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- Societal and Institutional Factors:** Includes "Independent Indian state, Public Health Department", "Institutions", "Gavli Community organisation", "Govt. employees", and "People".
- Health and Knowledge:** Nodes include "Health of Indian People", "Concerns", "Health of Gavlis, fodder", "Mosquito control techniques", "Knowledge", and "Malaria has been eradicated".
- Material and Environmental Factors:** Includes "Artefacts", "Huts cattle sheds etc", "Mosquito control activities", "Activities", "Migration of Gavlis with livestock", "Reduction in mosquito and malarial parasite population", "Bioshpere", and "DDT residues in organisms vegetation changes due to grazing".
- Geographical and Movement Factors:** Includes "Geosphere", "Human movements", and "DDT residues in water".

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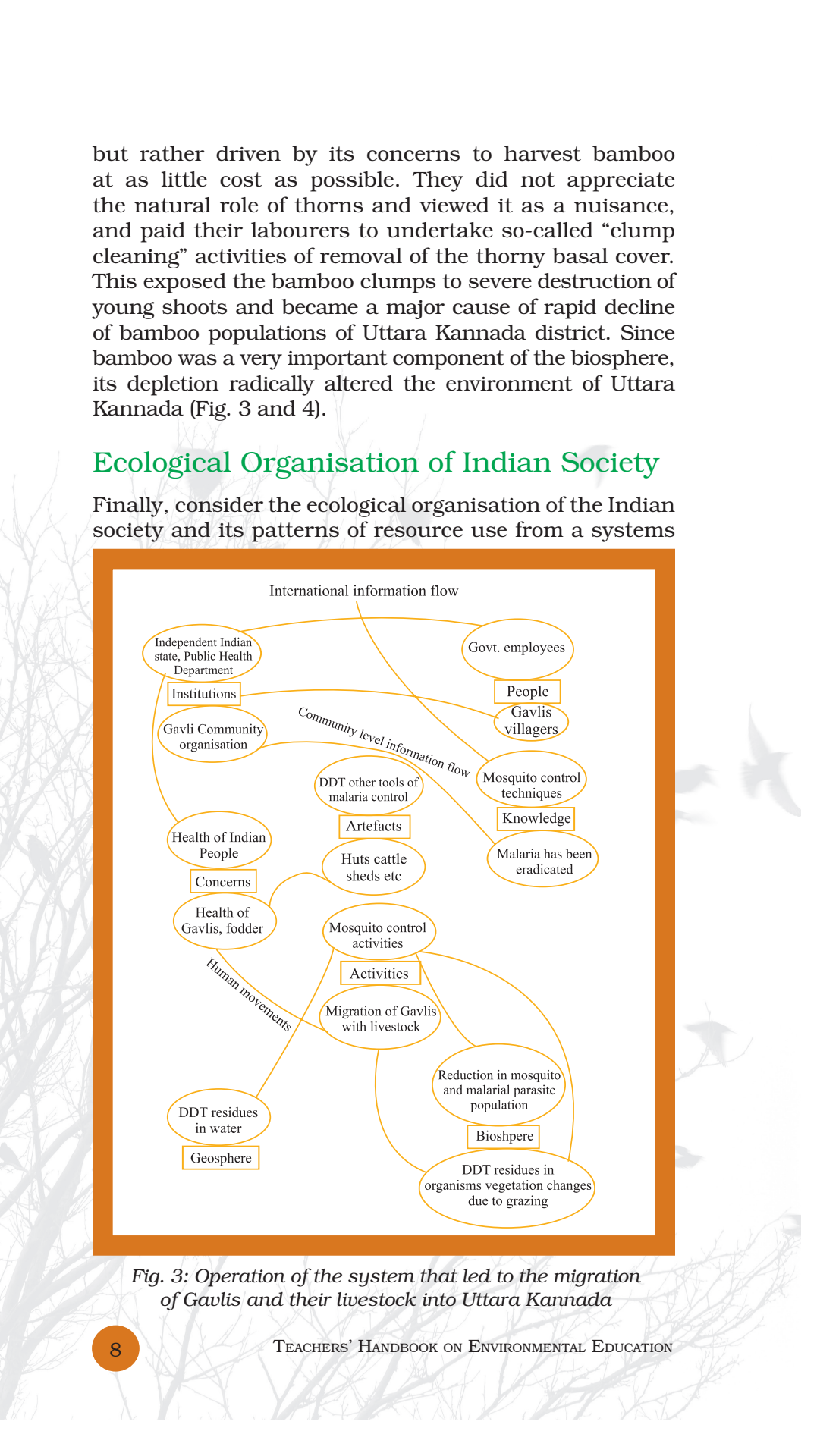
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- Malaria Control & Knowledge:** Nodes include "Mosquito control techniques", "Knowledge", "Malaria has been eradicated", "Artefacts", "Huts cattle sheds etc", and "DDT other tools of malaria control".
- Health & Concerns:** "Health of Indian People" leads to "Concerns", which includes "Health of Gavlis, fodder".
- Activities & Movements:** "Mosquito control activities" lead to "Activities", specifically "Migration of Gavlis with livestock". "Human movements" also influences this migration.
- Biosphere & Geosphere:** The "Biosphere" node links to "Reduction in mosquito and malarial parasite population" and "DDT residues in organisms vegetation changes due to grazing". The "Geosphere" node links to "DDT residues in water".

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The diagram illustrates the systemic factors leading to the migration of Gavlis and their livestock. It starts with international information flows influencing both government departments and local people. At the community level, health concerns and knowledge about malaria control (including DDT use) are shared. These factors lead to mosquito control activities and the reduction of parasite populations. Simultaneously, human movements involving DDT residues in water and geosphere occur. The combination of reduced parasites and environmental changes (like vegetation alteration due to grazing) ultimately results in the migration of Gavlis and their livestock into Uttara Kannada.

Fig. 3: Operation of the system that led to the migration of Gavlis and their livestock into Uttara Kannada

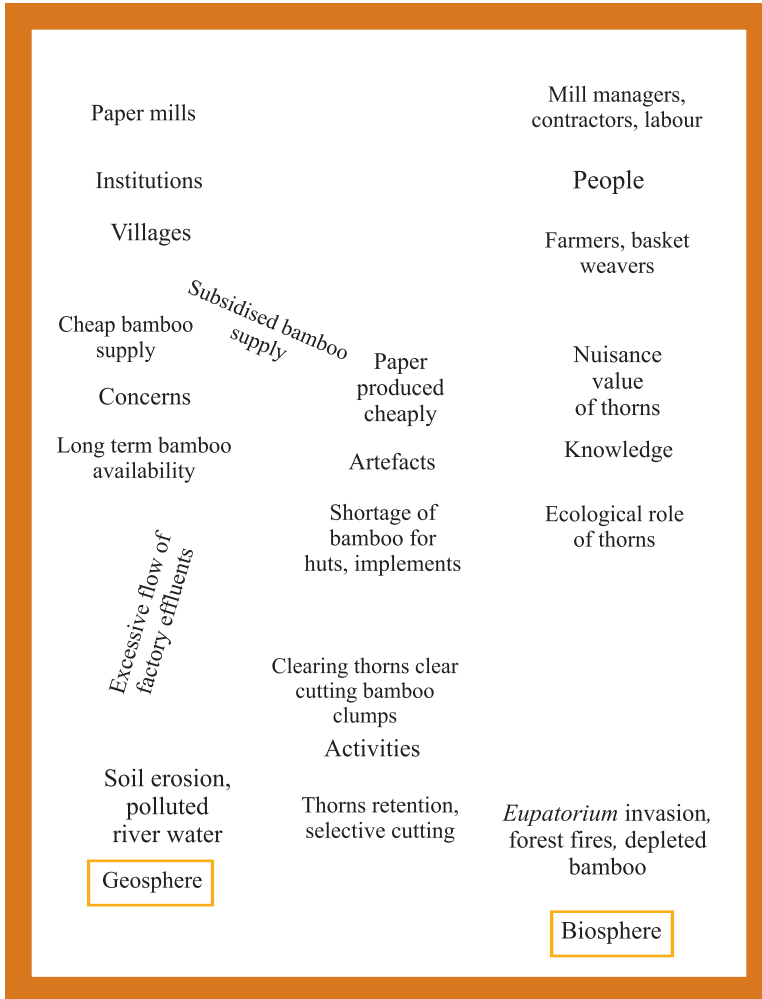


Fig. 4: Operation of the system relating to harvest of bamboo by the paper mill and villagers

perspective. For this purpose, one may divide the people of the country into four major classes in the context of their relationships to the resource base, namely, (a) rural poor, comprising small and marginal farmers practicing rainfed agriculture, herders, artisans, forest produce collectors, artisanal fisher folk and landless agricultural labourers, (b) rural well-off, primarily owners of good sized irrigated agricultural land, (c) urban poor, primarily those subsisting on wages in the unorganised sector, and (d) urban well-off, primarily employed in the organised sector. Figure 5 depicts the functioning of each of these four classes.

The first class, the rural poor, belongs to the category of ecosystem people in the terminology of Dasmann. They

obtain the bulk of resources they use from a rather limited resource catchment surrounding their habitations. Their ecological footprints are small. The urban and rural well-off, on the other hand, access resources from a vast catchment; water from reservoirs hundreds of kilometers away; energy from petroleum brought in from all over the world; consumer goods, fruits and nuts from all continents. Dasmann terms them “biosphere people” – people who use resources of the whole biosphere. They have large ecological footprints. Gadgil and Guha suggest that it may be more appropriate to call them “omnivores”. The fourth category of urban poor largely derives from people who have out-migrated from rural areas because of their inability to obtain an adequate livelihood, largely because of environmental degradation. Gadgil and Guha call them “ecological refugees”.

This societal organisation has a number of consequences. One of these is the widespread prevalence of sequential exhaustion of non-renewable and sequential over-exploitation of renewable resources. Mining provides a classic example of the first category. Miners first exploit the ores closest to the surface and in the most easily accessible localities. They, of course, did so in Uttara Kannada district as well. However, renewable resources such as groundwater, fish or forest raw materials need never be overexploited. The actual patterns of exploitation are an outcome of interplay of many factors in the whole social-economic-political-physical-biological system.

Prudent and Profligate Resource use

People, by and large, are concerned with and pursue self-interest. They are unlikely to be motivated to use renewable resource populations in a prudent, sustainable fashion: (a) if their resource catchments are vast, so that degradation of any particular portion affects them very little; or (b) if they have open before them possibilities of substitution as any one resource element is depleted; or (c) if their control over the resource base is tenuous, so that others may, at any time, deplete a resource they value, even if they use it in a restrained fashion. Indeed, exhaustive use is highly likely when any one of these three conditions obtains. It is only when people perceive their resource catchments as limited, possibilities of substitution of exhausted resource elements as not readily feasible, and their own control over the resource



Fig. 5: The ecological organisation of the Indian society

base as secure, will they be motivated to use the resources in a prudent fashion.

Ecosystem people, rooted in a locality, and retaining control over their resource base are most likely to fulfil all the three prerequisites for sustainable resource use; and therefore to behave in ways conducive to conservation of biodiversity of their own localities. The small scale, rural communities of India, with their manifold local traditions even today engage in a number of practices of restraint on the use of biological resources such as sacred groves. On the contrary, none of these conditions obtains in case of activities of modern institutions of biosphere people such as paper mills. The modern organised sector depends upon extensive use of energy sources other than firewood, animal and human muscle power, especially fossil fuels along with hydroelectric

and nuclear power. These additional sources coupled to sophisticated machinery, processes and systematic efforts at generation and application of new knowledge imply tremendously greater possibilities of resource processing, transport and use for the elite controlling this technological apparatus. In consequence, their resource catchments are vast, so that degradation of any particular portion affects them very little. At the same time, they have open before them many possibilities of substitution as any particular resource element is depleted. Under these circumstances, the organised sector has no motivation for sustainable resource use.

The modern industrial system has set up resource demands vastly greater than at the pre-industrial stage. Along with advances in storage and transport, this means a great pressure on the resources of the countryside resulting in large energy and material outflows. These outflows have progressively depleted the resource base accessible to village communities. The technologies accessible to the elite also render many of the activities, earlier undertaken in a decentralised fashion on a small scale, obsolete. Thus, oil pressing and cotton spinning, river transport and country boat fishing, basket-weaving and lime making, nomadic sheep rearing and dispensing herbal medicines have all become unviable as village level activities. With the diverse natural resource base depleted and with many traditional activities no longer viable as a source of livelihood, members of the multiplicity of subgroups in rural India have increasingly come to focus on a single, terribly overcrowded activity – cultivation of land, either as owners or as wage labourers, with consequent degradation of agricultural tracts.

State Subsidies

While the ecosystem people of Indian countryside thus find themselves in a bind, the elite has been vigorously pursuing a process of development that focuses on intensification of resource use all over the country. This intensification primarily takes the form of organisation of state subsidised flows of resources to three sectors dominated by the elite – the industry, organised services including bureaucracy, and intensive agriculture. The state supported flows of resources are organised by a three-way alliance of the beneficiaries of subsidies (the industrialists, larger landholders in irrigated tracts, urban

population in the organised sector), the administrators of the subsidies (the bureaucracy), and those who decide on who benefits at whose cost (the politicians). But subsidies ultimately have to be at somebody's cost and the victims inevitably are the people excluded from this alliance; the small landholders, landless agricultural labourers, village artisans, tribals and nomads, and finally urban slum dwellers derived from an exodus from amongst these people to the cities.

The subsidies are huge and manifold, and have operated at the expense of the capital stock of country's resource base and of the ecosystem people still largely dependent on the natural resources of their immediate vicinity. Thus paper mills receiving bamboo at less than one thousandth of its market price have rapidly exhausted bamboo stocks; the sufferers are large communities of basket-weavers. Landlords pay little for the electricity that runs their pumpsets and city dwellers receive water at 5 per cent of what it costs the state to bring it to them; at the same time small peasants whose lands are submerged under dams to provide this water and power are totally inadequately compensated. Union Carbide was subsidised by not having to bear the cost of adequate compensation to victims of Bhopal gas tragedy—the poor slum dwellers.

Given the large magnitude of subsidies nobody has a stake in efficient resource use – neither the consumers who are any way not paying for what they receive, nor the bureaucracy or public sector who are in charge of managing the resource base. All of this means that the process of development has been a highly wasteful one with its fruits remaining by and large in the hands of narrow elite. The elite that has thus cornered the benefits of developments is highly localised, in the tracts of green revolution and in a few metropolitan cities. The oceans of poverty surrounding these islands of prosperity are quite naturally at loggerheads with it.

Rays of Hope

Fortunately, there are forces opposing these tendencies, forces that are gathering strength, as democracy strikes deeper and deeper roots in India's open society. Out of these forces have come experiments like Joint Forest Management (JFM) and thousands of spontaneously formed Village Forest Committees of Orissa, which

have locally turned around the tide of environmental degradation.

There is no doubt that reversing the present trend of inefficient resource consumption is one of the most important and essential pre-requisite if we wish to protect the rights of our future generations and attain the ardent objective of attaining sustainable development. Education can play a vital role in this endeavour by preparing well sensitised responsible citizenry, with a good understanding of various forces operating in the environment and their consequences.