

Environmental Science

Definition, Scope

Environment is everything that is (& was) in, on & around this planet, including the planet. The physical environment consists of everything that is non-living while the biological one includes all living organisms that used to or still exist on this planet.

Over the years the physical & biological environments of this planet have undergone changes which are generally covered by the term evolution.

Science is a generic term which tries to investigate & explain various phenomena which govern living & non-living worlds & tries to formulate laws which are the foundations of the environment. The basis of science is actual observation & experimentation & trying to predict the future course of evolution based on immutable & empirical laws.

Physical sciences examine & investigate the non-living physical world while biological sciences investigate the living world. Social sciences evolved as human beings came out of the animal stage, formed social relations & societies leading to various cultures & civilizations. These examine human behaviour & actions through a panorama of time & in various physical & cultural settings.

Behavioural science examines the behaviour & actions of non-human beings. Moral sciences provide a code of conduct & a philosophical basis to enable brainy human beings to lead a conflict-free & intellectually fulfilling life.

When environment & science ~~are~~ are conjoined, they cover a far wider area than is generally visualised. This should be welcome as only ~~such~~ such a comprehensive vision can lead to a holistic approach. After all human beings have now realised that it is in their interest to see & act in such a way that whatever exists ~~in, on & around~~ on & around the planet is sustained & not wantonly destroyed.

If our contemporary world is considered env. science will have to focus on the changes brought about by human beings in the physical & biological worlds & their impact on ~~the~~ nature & especially on the services provided by nature free of charge such as pollination, the hydrological cycle, the maintenance of the atmospheric balance, the organisation of the ocean ecosystem, etc. Technology now provides powerful tools which enable people to divert energy & matter flows for their conveniences denying their benefits to many a non-human being. As such the character & essence of the technology need to be examined. Env. Science can help in formulating & bringing into practice appropriate technology which will reconcile the interests of human & non-human beings. The appropriate way to make these things real is shown by the science of ecology which ~~complements~~ complements env. science.

What is the basic aim? - Well-off families.
Importance of the Env? of nature conservation?
Of love towards all the non-human creatures?
I find school children quite aware of all these things.
They are even aware of the importance of waste minimization,
of not creating litter, of the importance of organic farming, of
avoiding the use of insecticides etc.

Is this awareness sufficient? Is this going to achieve the
aim of education? Indeed what is the final aim of educating
oneself? Is our education potent enough to counter the myriad
things that impact the minds of students outside the school? I
refer mainly to the TV and now also the internet!

What is the message that penetrates the minds of everybody?
through the media? They all goad you to increase your consumption.
They want you to constantly increase your wants, tickle your senses
so that they can sell their products. If you cannot and will not
respond, they know that they are going to be ruined. If you cannot
increase your consumption their system is going to collapse. They
know it for sure! What is the consequence of a constant increase
in consumption? It impacts innumerable eco-systems, few of them will
be able to withstand this constant pressure from human beings.
They deteriorate, begin to wilt, lose their biodiversity, their organizational
structure, their resilience & stability.

Man's impact on nature - Habitats - Take them out to see
what man is doing. They should be repelled by the filth that they see.
It must be connected to waste creation by the present econ. system.

Eco-tourism is a form of increasing consumption.

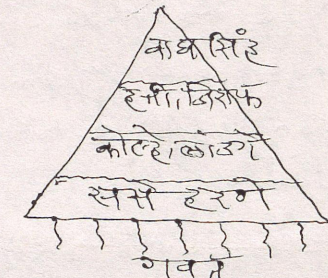
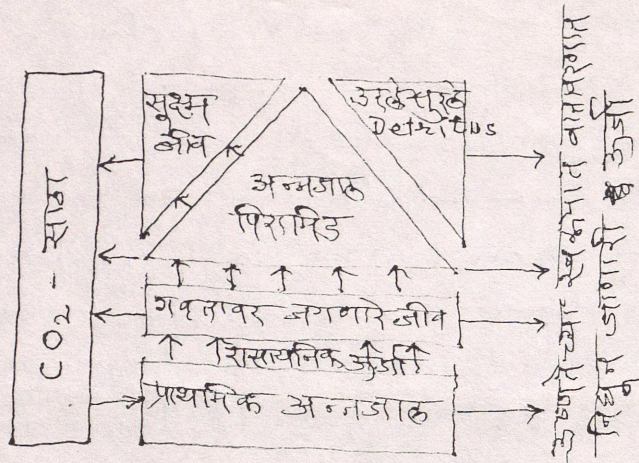
Bountiful nature alone gives basic necessities. Bring about equity
& abolish poverty. Environmental awareness should lead to social awareness.
Responsibility. Counteract pressures from market. Understand its great & damaging
influence.

2

and wasted material ~~are~~ have to be included in the cost of production. An entrepreneur will always try to reduce costs to increase his profits. This is reflected in low prices of natural resources, labour & waste disposal. As labour laws have tightened, entrepreneurs try to reduce costs by going in for cheaper materials, cheaper energy sources and cheaper or no waste disposal. All these result in increased entropy of surroundings and pollution. Consider destruction of surroundings through road-building, indiscriminate expansion of cities, unplanned & wrong housing construction, creation of entertainment complexes & resorts not to say anything about industries that emit pollution gases and ~~at~~ release effluents. Pollution and destruction of nature are the result.

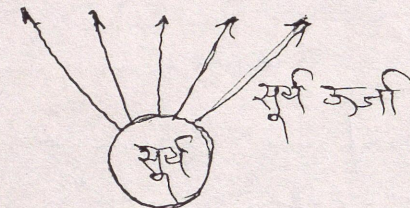
Increase in costs also has another impact. Because costs tend to grow it becomes imperative to produce high-value goods where profit margins are high, not necessary, life supporting, essential articles where profit margins are low. Economic growth thus becomes greater & greater production of high value luxury goods, branded articles and status symbols. After liberalization in the '90s that exactly what happened in India. Production of cars, sweet-meats, prepared food, luxury furniture, luxury consumable goods, liquor & wine went up. More land, water & other natural resources were diverted to this ~~type~~ type of production. The production of necessities like grains other ~~than~~ rice and wheat, coarse cloth, simple housing, good quality drinking water not only suffered but their prices went up.

Production of high value goods means production of goods that are not essential for human survival but are the result of human culture, disparities in income & creation of wealth in a society. In economics they are called intermediate goods, goods which are not basic necessities. You will find today shops full of goods which are not basic necessities but which are trendy, which satisfy current fashions & cater to the needs of the rich. On one hand their production entails creation of newer & newer wants through advt. and on the other concentration of wealth in certain sections of the society. The developed nations are always searching for newer and newer markets by trying to impose free trade on others while protecting their own producers. As costs increase and as pollution laws become more strict, production in developed countries becomes costlier & pollutive industries are then shifted to less developed countries where labour costs are low and pollution control is lax. This entails great destruction of nature and environment in less developed countries. That is exactly what we are experiencing today. As costs increase, necessities become dearer, poor people have to fall back increasingly on whatever that is available from nature. That means indiscriminate use of whatever nature that is left remains after development. Nature suffers doubly. It is exploited by the rich to satisfy their

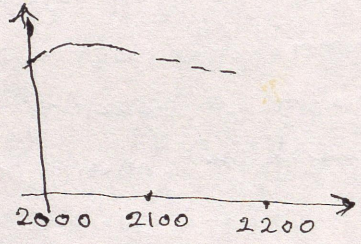
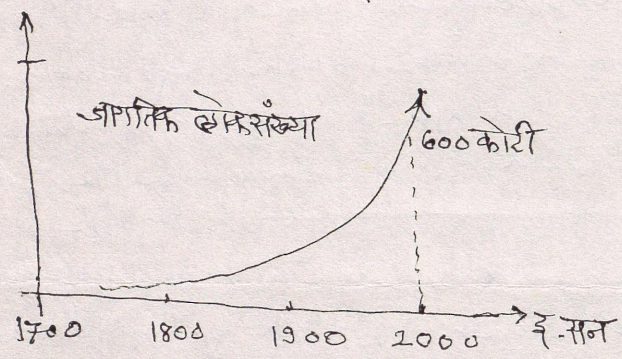


अन्नजाळ पिरामिड (Trophical Pyramid)

जेव्हा वाघ सिंच कमी होय का लक्षात तेव्हा ती संपूर्ण पिरामिड विघडल्याची सूरू असते.



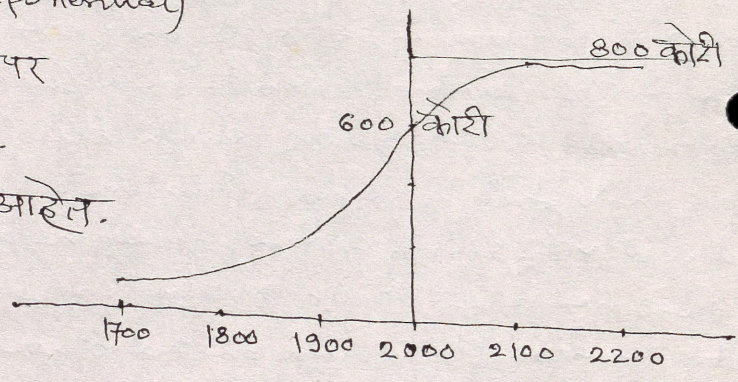
परिसंस्थां मधून सूर्य ऊर्जेचा प्रवास



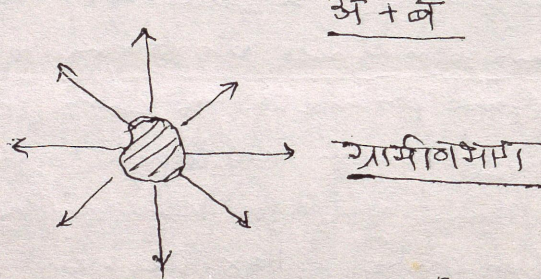
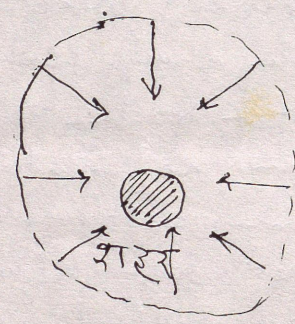
लोकसंख्या आवाक्यात आणल्यास ती स्थिर राहण 800 कोटीच्या घरात स्थिरावेल

लोकसंख्येची वाढ [अ] घातांकानुसार (x^n) (Exponential)

- वेगवेगळी - पदार्थांचा, वस्तूंचा वापर
 - ऊर्जेचा वापर
 - कचरापट्टी निर्मिती
- ही सर्व पण अशीच वाढत आहेत. लोकसंख्येपेक्षाही जवळ.



अ + ब



शहराची रचणूक, आक्रमण - नोकऱ्यांनी संधी, वैविध्यपूर्ण जीवन, व्यक्तीगत स्वास्थ्य, मनाक जातीयवाद, रोकड पैसा

ग्रामीण भागातून स्थलांतर (बेभरवशाची) बेकारी, असुरक्षित जीवन, आरथीर शोती, भूमीहीनता, प्रखर जातीयवाद, सरंजामी व्यवहार, सर्व गाव तुमच्या खाजगी आयुष्यात डाकवणार

III

The Economic and Social Significance of Environmental Education

I

Schools of environmental sciences have been established in many universities now. As a subject environment has been included in the syllabi from the middle school level upwards. While at the school level the emphasis is on the flora and fauna and health and hygiene, at the postgraduate level it is on pollution control and adoption of clean technologies. Activists in the environmental field on the other hand like the society to adopt an alternative lifestyle based on limited consumption of natural resources and energy. Sustainable development is their goal.

Environment can, at its worst, be a jumble of many disciplines which appears to be the situation today; or it can be a vibrant body made up of many elements drawn from different disciplines but with a life of its own. When there are no genuine teachers manning the environmental science departments, what is dished out to students today is a hopeless patchwork and not a neatly woven fabric. Students pass out with little knowledge

and half-baked ideas, and as you know little knowledge is a dangerous thing.

Let us ask ourselves, therefore, why environmental science? Does it have any relevance to real life or is it just a fad of some weird environmentalists? I can straight away answer this question without any difficulty. Environmental science does have great significance in real life for:

- (a) environmental solutions are cost effective, i.e., are inexpensive or cheaper than the others; and
- (b) their benefits are larger in terms of quantity and quality for they bring distributive justice, i.e., promote equitable distribution of wealth and lessen social disparities.

Technological solutions are often the antitheses of these things.

Let us first take the cost—to show that we are quite matter-of-fact people and not indulging in dreams or fanciful thinking. Money is our God and we want everything, all environmental services to be measured in terms of money. To begin with, however, I would like to remind you of something more solid, more enduring than money. I would like to take you to the realm of physics, the immutable and inalienable laws of physics governing the universe.

Even before we became slaves of money, we were and still are the slaves of these laws. They ordain that both matter and energy can neither be created nor destroyed. Matter can be transformed and recycled by using energy. Man tries to convert matter that is in a high state of entropy—or in a highly disorganized state—into matter in a low state of entropy—or in an organized state. But 100 per cent transformation of disorganized matter into organized one is not possible. For example, 100 tonnes of iron ore does not yield 100 tonnes of iron or steel. At every stage of transformation some matter and

energy are lost, i.e., they go into an unusable state. At each stage of production some matter passes off as waste and some energy is lost as heat. Each stage of production involves cost in terms of wasted matter and escaped energy. Normally, these costs are not taken into account while fixing the price of a commodity. Waste and heat are just passed out into the surroundings—to land, water and the atmosphere. It is assumed that they can be safely absorbed by nature without any harmful effects. The individual manufacturer or trader or even a common man hardly bothers about these costs.

We all dump our garbage into the surroundings. That is, we make the society as a whole bear the cost of garbage disposal. The society as a whole, say a city or a megalopolis, or even a village, dumps the garbage and waste in the surrounding open land or water. All the municipalities and corporations have garbage dumps; we nonchalantly release all sewage into streams and rivers and never bother that someone else has to pay the costs in terms of damaged health, diseases and reduced welfare. In all new apartment buildings, we see boards telling visitors that they must not park their vehicles inside but have to park them on the street. The cost of providing parking space within the compound is transferred to the society, leading to greater congestion of traffic on the street. When we drive recklessly or do not obey traffic signs and lights, we are living at the expense of others, actually begging them to be more considerate so that we can survive. If they will not be tolerant, there will be more accidents and the motorbike heroes will be dead horses. When we intimidate others through force and arrogance, we are actually living on their generosity. If they resist both of us are likely to perish.

My point is that all human activities result in invisible costs that are borne by nature or other elements in society, most of the times by the economically and politically weaker sections of the society. In economics these costs are called externalities—

they are external to the production process and not taken into account in calculating profits. Matter, while undergoing transformation to less entropy, creates higher entropy in the surroundings. If this entropy is accounted for, the cost of production will be greater than the price. That is, there will be no profit. That is why all manufacturers and traders and even all of us ensure that we do not have to account for these externalities. Manufacturers will always try to avoid installing pollution control equipment. If they are asked to produce 4-stroke engines which are less polluting, instead of 2-stroke engines, they will offer some excuse or the other to postpone the date of converting to 4-stroke engines. That is, in order to continue to reap profits they will ask the society and customers to bear the cost of pollution. We always try to avoid economizing garbage and try to be as economical in our efforts as possible to dispose it off!

Man is supposed to be a rational animal, i.e., always minimizing costs and inflicting them on others or on nature!

Profits arise because all costs are not borne by the manufacturers or traders. There is no profit in nature. If there is it will be very small and temporary. Profit means inflicting costs on others. We will see how this comes about.

Profits can be made through greater efficiency, i.e., making the worker produce more without considering what effect it will have on his health or by economizing on energy use or raw material use. This again depends upon how much one can spend on research; and one can spend more on research if one had in the past made great profits! Capital accumulation and savings are the bases of economic development and they are possible if there is enough disparity of incomes in a society, i.e., again, some sections of the social order are able to inflict costs on other sections. This works on the international plane too. Developed nations of today have in the past succeeded in

transferring many of their costs on to the developing nations. Even today they are doing this successfully.

Costs are reduced when technology finds a new source or a new way to utilize natural resources. Then a great expansion in natural resource consumption follows with corresponding increase in externalities. Otherwise economic growth and development always brings about escalation of costs and prices. The most developed nations are the costliest countries to live in. Japan and West European countries have the highest cost of living. USA comes next only because nature is still bountiful there. Technology is costly, technological development is expensive. Costs can be reduced only by making nature bountiful. Technology reduces cost only when it develops a new process or a new source of tapping nature.

India was at one time one of the cheapest countries to live in as many of our wants and necessities were supplied by nature free of cost. Economic development deprived us of nature, provided us with machine-made goods which are costly and put us on a course where incomes are chasing prices.

I emphasize that economic development is costly. It is costly not only in terms of higher costs and prices, but also in terms of loss of health, family relations, care of children and the aged and creation of a highly stressful lifestyle. I do not want to say that in societies before the present, all these relations were ideally organized. What I want to say is, if we correctly interpret nature and care for it, a tremendous opportunity exists to reorganize social relations and reduce present disparities and tensions. How? Let us see.

Economic progress depends on the creation of a surplus. Surplus is generated when all the costs incurred are less than the value of the output. A surplus is only created by plants which utilize the freely available sun's energy to produce food. In his hunter-gatherer stage man was totally dependent on this food

and incurred no costs except his own efforts. There was no fictitious surplus which is generated by inflicting losses on someone. So there was little internal social tension and such tribal groups are considered by sociologists as the epitome of happiness. Agriculture on virgin land, fed by gravity irrigation and replenished annually by riverine sediment produced abundant surpluses. These could sustain an army of non-agriculturists in a society. They were administrators, politicians, rulers, priests, warriors, artists and craftsmen. When the above conditions were not there, the size of the surplus was reduced or a fictitious surplus was generated by those in power by assuming that once the basic wants of the farmer were met, what remains was the surplus. The farmer had to be satisfied with only his basic wants fulfilled. All other classes may indulge in luxuries. The farmer always has to remain poor in order that the others in the society enjoy the surplus. That is why I call this a fictitious surplus. It inflicts a permanent loss on farmers.

That modern agriculture is not cost effective, has been abundantly proved. As soon as the farmer starts using energy other than his own muscle power, be it bullocks, water lifts, pumps and fuel-driven machinery, his input-output ratio becomes negative. If he recycles some matter, then it becomes barely positive. By bringing irrigation by gravity, recycling animal and human wastes, China, Taiwan and Philippines have succeeded in keeping these ratios positive such as 1:9.8 or even 1:18, i.e., one unit of energy gives 9.8 or 18 units of output. This makes for a real surplus. In south India where irrigation water was cheap and water lifts were operated by human effort, the input-output ratio was 1:1.7, i.e., barely positive. But in UP where bullock power is used, it was 1:0.96, i.e., negative. In advanced agriculture where they use heavy machinery, inorganic fertilizers, pesticides and canals, the ratio becomes heavily negative, from 0.47 in Britain and the Netherlands to 0.05 in USA. Still we are told that these countries produce large

agricultural surpluses! No doubt that their per hectare production is very high, but how is this sustained? It is sustained by heavy state subsidies. The state subsidizes irrigation water, seeds, fertilizers, electricity, oil, transport, machinery, distribution and what not! With the introduction of modern farming the role of subsidies in India is increasing. Today, the total value of all the agricultural subsidies is around Rs. 20,000 crores every year. Government subsidizes the consumer also by enforcing levies and not allowing agricultural prices to rise. If they rise this fictitious surplus will be wiped out. Industry and all other non-agricultural sectors will be affected. There will be chaos in the country.

Enormous subsidies are given to industries also. The bigger the industry, higher are the subsidies. Industries prosper by manipulating tremendous concessions from the state. State offers them cheap land, cheap raw materials, cheap power supply, cheap water and allows them to use outdated production systems, pollutive techniques, and waste disposal at their sweet will.

Modern industry and modern agriculture can only keep their costs down because of huge subsidies. If subsidies are withdrawn, their costs will rise so much that nobody will be able to buy their products. With liberalization some of the subsidies are being withdrawn, prices are rising, we are all feeling their pinch and there is greater tension and violence in the society than in the past. With subsidies withdrawn, it pays only to produce higher priced goods such as cars, refrigerators, air-conditioners, luxury apartments, resorts, chocolates, liquor, fast food, aerated beverages, etc. The market today is flooded with these intermediate products while basic necessities are becoming hard to get. The market cannot provide cheap housing, wholesome food, good quality drinking water, health care, fodder, timber, etc., at a price which the majority can afford. A buyer's market is coming into being, but most buyers

lack purchasing power and are now lured into buying high-priced goods through credit cards, hire purchase schemes and deferred payments. A recession is slowly gathering strength.

The whole system works on subsidies. Where do they come from? They come from our own pockets. They come by denying the society and the nation good education, good health care, pure air and water, and all those things that enhance the quality of life. The state spends very little on these things. To feed modern agriculture and industry the state makes us live in highly polluted cities, making us undergo health hazards, provide us toxic air and water and poor education. But, the lure of machine-made goods is such that we gladly, willingly accept these conditions. By praying at the altar of economic development, we day-by-day continue to degrade the quality of our life.

Moreover, to achieve this so-called economic development, we have incurred enormous international debts from the World Bank, IMF and a host of other international institutions. Can we ever repay them? Even to pay for the annual interest we are asked to make more sacrifices in the quality of our life. The remedies pronounced by the authorities are that we must produce more and export more. In the present circumstances producing more means spending more on water availability, land availability, worker efficiency, import of costly machinery and technology from abroad, etc. In other words, more subsidies! Exporting more means pumping more food into the stomachs of the already rich and fat people of Europe and USA and denying food to our own people. No wonder they are becoming more and more fastidious in their choice and are rejecting our consignments under some pretext or the other. And what we do by exporting more? Import petrol and petroleum products to produce the same high priced goods that only the rich in India can afford. That means greater social disparities, robberies, murders, gang wars, etc.

How do we get out of this vicious circle? Let us go back to environment and ecology. That will clarify many of the notions and provide solutions that are cost effective and easy to practice. In nature surplus is always small and temporary. An ecosystem in perfect equilibrium, say, the rain forest of the Amazon, is a biologically closed system. Whatever is produced is consumed and recycled through decomposition. All animals living in the forest gear their reproductive activity and consumption to take advantage of the small and temporary quantity or surplus produced. They do not over-reproduce and most of them cannot store the surplus for future use. But the number and variety of food chains and food webs in nature are so great that even small and temporary surpluses can sustain tremendous biota. If an imbalance or anomaly arises nature corrects itself by controlling population and food. Now, man, to bring about huge and permanent surpluses, goes against nature, simplifies the complex natural systems and reduces the number of food chains and food webs. By these actions he undermines the foundations of his resource base or sources of surplus. Then, these huge surpluses do not last long and man's civilization crumbles. History is replete with such examples. We must imitate nature to make our surplus continuous. The surplus should come from a variety of sources and should be the result of many and complex food chains and webs. We should not simplify or standardize, but go back to multiplicity and variety. Only by re-establishing nature in all its glory and complexity, can man come out of the vicious circle in which he has landed himself today.

In this scenario the students of environmental science have a great responsibility and a vital role to play. It is they who are the educators of tomorrow. It is they who should and can lead the society away from the high consumption, high growth and high destruction model of today's politicians. They must assume the leadership and galvanize others to follow the path of

wisdom and sustainable living. They must explain to their colleagues, friends and even their opponents that profits and pursuit of unlimited profits are against nature and will surely lead to self destruction. It is their duty to make society revive nature which alone can give economic sustenance, peace of mind and a sense of belonging to millions and not pursuit of unfettered economic growth. Let us remember what Gandhiji had said long ago. He was the first real environmentalist India has produced. This is what he said:

God forbid that India should ever take to industrialism after the manner of the west. The economic imperialism of a single tiny island (England) kingdom is today keeping the world in chains. If an entire nation of 300 million (now 1000 million) took to similar economic exploitation, it would strip the world bare like locusts.

The specter that the Mahatma visualized long ago is now becoming a reality and it is frightening. We are all locusts today, we should be real human beings tomorrow—protecting and conserving nature all around us, wise stewards not destroyers.

II

The task is by no means easy. The scale at which man is transforming and destroying natural ecosystems is mind-boggling. In an ancient country like India, except for the high-altitude, uninhabitable Himalayan ranges, and impenetrable jungles of Andaman Islands, almost all the land and coastal areas feel the impact of human presence and interference. Natural biological succession is nowhere allowed to take its own course. Man is constantly putting it back to create young ecosystems for only these can have high production efficiency. In order to progress, man therefore, needs to disturb the natural equilibrium process so that conditions for a young ecosystem are produced and maintained. If a system is allowed to mature, it will only have high

maintenance efficiency. If nature attains a physical and biological equilibrium, man will not be able to live in his present state. The history of man is nothing but a struggle to promote and maintain a disequilibrium in nature to his own advantage!

And he has been doing it very efficiently especially in the last couple of hundred years. Human beings now manipulate 70 per cent of the ecosystems of tropical and temperate biomes. They now appropriate over 40 per cent of the biomass of terrestrial ecosystems. When a single species consumes so much, a number of other species, common sense tells us, go abegging and cannot survive. However, the produce of so much resource utilization is by no means equitably distributed in human societies. In developed countries the use of natural resources is 100 to 600 times more per capita than developing countries. Moreover, this large-scale consumption is achieved through standardization, i.e., reducing and making uniform the sources of want satisfaction. Now 15 plant species and eight animal species provide 90 per cent of human food. The Green Revolution in India promoted only a handful of high-yielding varieties of rice and wheat all over the country. These are now cultivated over 70 per cent of the paddy land and 90 per cent of the wheat growing land. The great diversity in crop varieties that our country once possessed is being lost very fast as a result of this standardization. India once cultivated 50,000 varieties of rice alone, each variety geared to local micro-climate, water availability and soil structure. Even, at present, tribals in Nagaland grow 20 varieties of rice. Warlis in Maharashtra are also well-known for many varieties of rice that they plant. This great variety is a vital defence mechanism against pests and diseases. The larger the area under one variety of crop the greater the danger of pest eruption. In the Garhwal Himalaya it was once a common practice to plant 12 types of grain such as *rajma*, *udid*, *kulith*, *rajgira*, etc., in a single plot to avoid pest

attack. The maturity period of the crops varied, they absorbed moisture in different quantities and leguminous plants would provide nitrogen removed by the others from the soil. Soil structure and moisture-retaining capacity would thus be nurtured. On the other hand, the new high-yielding varieties require large inputs of inorganic fertilizers, they are prone to pest attacks and so need pesticides also. This increases the cost of cultivation.

I must tell you one of my own experiences in this respect. I was studying the role of birds in agricultural fields. I had selected two adjacent plots of about the same size for making observations. In one field the *desi* (indigenous) variety of *jowar* (sorghum) was planted, and in the other was the high-yielding variety. The former field was visited by only a few birds and the farmer did not have to protect his crop from them. The latter however, was under constant attack by so many birds that the farmer had employed ten labourers to drive them off. Imagine the per day cost of the wages of these labourers to the farmer. The high yield from this plot would be offset by the high costs he had to incur to get it.

Political leaders and administrators are prone to tell us that India has become self-sufficient in foodgrains largely due to the Green Revolution. But this has been achieved at great costs. These have enormously increased the prices of food. It has sacrificed the diversity of cultivars and degraded soils by altering their structure, destroying their humus content, moisture-holding capacity and made them susceptible to erosion. When I was in Haryana the farmers there were lamenting that almost 70 per cent of the agricultural land in the state had been damaged. We are paying a very high price for achieving self-sufficiency in food supply.

Standardization and import of foreign breeds have threatened livestock diversity in our country. Ten varieties of

goat, five of cattle and twelve of sheep are now threatened with extinction. One of the cattle breeds of India is now found only in Brazil where it was sent from our country. It has vanished from India. Some varieties of chicken are also fast disappearing. Moreover, they are threatened by cross-breeding and large-scale imports of poultry from abroad.

The drive to increase exports is also greatly affecting indigenous biodiversity by encouraging standardization. The rate of exploitation of renewable but exhaustible natural resources has increased tremendously. To increase marine fish production the Central Government liberally granted licenses to foreign companies to enter our territorial waters knowing full well that the catch from the continental shelf area under our jurisdiction was already declining. Already the number of fishing boats in the sea had increased enormously, and the traditional fisherman is facing severe competition and reduction in his catch. Still in 1992-93, 70 marine fishing and fish processing projects, many with foreign collaborations, were cleared by the government. The result has been tremendous pressure on fish populations. Their breeding has been greatly affected as fishing goes on throughout the year. My own investigations on the coast of Konkan reveal that 39 varieties of fish have become scarce and can no longer be caught in any quantity. Trade, commerce, increase in ship movements, in constructions along the coast and in the sea have also threatened marine biodiversity.

Trade in wild plants and animals for export is again being revived. In April 1993 a ban imposed on several items was lifted. These included orchids, extracts of *Saussurea lappa*, roots of *Diosgenin*, *Dioscorea spp.*, etc. Timber from many species can now be exported. Mining for granite also threatens a number of habitats and rare species. Harmful chemicals including insecticides have been given production licenses and that too to multinationals! This export thrust is going to bring about a

great ecological degradation and social inequality. It appears we are selling our country to the world in return for high consumption goods such as cars, refrigerators, air conditioners, chocolate, ice cream, liquor, etc. This is being achieved by depriving poor people of their own food—indigenous varieties of grain, animals and fish.

The students of environmental science have an unenviable task of bringing all this destruction to the attention of people, making them aware of how this degradation of natural resources and biodiversity is making everything costly, increasing the cost of living and hence the struggle for survival of the common man.

Of course, this destruction has not gone totally unnoticed. Vigorous efforts have been initiated by some organizations to document and inventory biodiversity. Madhav Gadgil is directing a mammoth project to document the biodiversity of the Western Ghats. His colleague Kailash Malhotra is collecting information on how tribals and local communities use a variety of plant and other natural resources. Forest departments are experimenting with joint forest management. An experiment in evolving village wildlife sanctuaries is being proposed for the North-East. Experiments of setting up People's Sanctuaries have been initiated in Arunachal Pradesh and near Pune. A National Environmental Awareness Campaign has been launched by the Ministry of Environment and Forest. Legislation is being drafted to protect biodiversity and loss of it due to patents.

But, in my view, all these efforts lack a holistic view of the situation and actual conservation action is, therefore, not taking place. Besides, as it always happens in the government, different departments work at cross-purposes, canceling each others' good work. It has been amply demonstrated that Ministry of Environment and Forest (MoEF) and Agriculture Ministry, MoEF and Commerce Ministry, MoEF and Tourism

Department, take decisions that conflict with each other. For example, the MoEF had declared the coast between Murud Janjira and Deogad on the Maharashtra coast a no-entry zone for industries, while the Government of Maharashtra wants to bring in chemicals, steel, ship-building and other heavy industries including large-scale prawn-breeding in this zone. The cabinets at the Centre and in the states, influenced as they are by several vested interests, fail to evolve a comprehensive holistic policy. This is the case not only in India but all the countries of the world. The time has now come for academic institutions to take a lead in evolving a holistic approach and convince the people of it. Again I wish to emphasize that it is not an easy task. For even among the academic community experts seldom agree. Some of the well-known academicians are the champions of the high economic growth along the western model and believe that technology is a complete substitute for nature. It is the responsibility of the schools of environment to hold discussions with others and try to convince them of the need to save nature. Seminars and symposia should be interdisciplinary and multidisciplinary and not between the same people discussing the same issues among themselves.

The basic tenet that I want to profess is that we must try to integrate wildlife protection, nature conservation and biodiversity conservation with normal human activities. The common man's idea that these are elitist activities inimical to his survival should be repelled by convincing him to consider them as normal like agriculture, industry and trade. All individuals from the humble farmer to a millionaire must view these as essential for human life. All agencies from village to national level should view them similarly so that they allocate land, water and finance to these ends as easily as they allocate them for settlement, promotion of industry, tourism and export. How is this to be achieved?

It is important at first to dispel the notion that biodiversity

is concentrated only in national parks and sanctuaries, or in remote and inaccessible areas such as Arunachal and Andamans or the Himalayas and Western Ghats. It is, no doubt, adventurous and exciting to visit these places and young people are especially eager to go there. But this has fostered the notion that biodiversity is something which has nothing to do with the normal life of mankind. Yet all these remote, inaccessible areas barely cover 5 per cent of the area of any country. In India, national parks and sanctuaries constitute only 4.3 per cent of the total land mass. That means, over 95 per cent of the land area is under the influence of man. What about the biodiversity in this vast area. Do man-dominated ecosystems allow any biodiversity? Even in an advanced country like Germany it was found that 232 arthropod species inhabited the forests, while a cornfield harboured 239. The biomass of pasture was found to be constituted of 20,000 kg/ha of plants, 4,000 kg/ha of fungi, 1,000 kg/ha of arthropods, 2 kg/ha of mammals and 0.03 kg/ha of birds. Only 35 to 40 per cent of the total number of species were found in protected areas while 60 to 65 per cent species were found outside them! Personally I find it extremely interesting to observe which species can be found outside protected areas. For, it is these which may be slowly adapting to changes in their surroundings and may have greater chances of survival.

After all, whether or not a protected area will be able to maintain its biodiversity is largely determined by the surrounding land use and socio-political factors. Many people are keen to visit Sacred Groves or Devrais which appear as scattered islands of biodiversity in a man-dominated landscape. Many eminent botanists have expressed the fear that these islands would not survive if the surrounding land use is not consciously changed to integrate them. A reserve surrounded by intense human activities is likely to harbour less diversity than one with a well-managed buffer zone.

Inside a reserve a continuous belt of uniform habitat such as primary forest may contain less biodiversity than one with a lot of edges and ecotones. Indeed, it has been found that a tropical forest that included some crop production has a larger number of insect species than a primary forest; and insects are essential for cross-pollination of crops and also forest trees. It is, therefore, essential to realize that human activities properly handled are not inimical to wildlife and forests. This has to be realized by our official planners as well as wildlife scientists.

While town and other planners seldom consider wild nature, wildlife scientists who study rare and endangered species seldom take into account existing and future land-use plans made for them by other agencies and people's wishes in their recommendations. How their recommendations will affect other species, resident human population and current exploitation of natural resources are seldom looked into. They, therefore, either remain on paper or arouse intense local opposition. The best example is the plan envisaging a marine national park near Malvan on the West Coast. It has aroused so much opposition that nothing came of it and the coastal biodiversity suffers as a consequence.

We also lack the tradition and imperative of public debate. Official plans are seldom thrown before the public for review and criticism. As such, people are taken by surprise which triggers off opposition. Today, the government is bent upon making more and more areas open for industrial development. It wants to amend the Forest Conservation Act; it wants to redraft provisions of green zones; it wants to open up fragile and ecologically sensitive areas for economic development destroying the poor man's resource for the production of luxury goods.

The process of debate, planning and implementation must start from below. Young people and students from the

environment schools can start the process in their own villages. Model village development has already been pioneered by Anna Hazare and others. Such schemes must be supplemented by biodiversity conservation. Each village should be surrounded by a biologically safe buffer where indigenous plants and all the biota they can support are safe. It actually does not require a plantation. All that is needed is protection to a sizable area. Nature takes its own course. Individual farmers can come together to promote a mosaic of habitats on their land such as hedges and windbreaks, tree and shrub growth, wetland and grassland and a variety of crops. This will benefit them by meeting their primary needs and will reduce expenditure on fertilizer and insect control.

Another important thing is to rejuvenate our rivers and streams. Unless several villages come together to maintain a minimum base flow and revive the habitats in the basin and along the banks, this task cannot be achieved. But once achieved, this will confer greater benefits than costly dams and canals. Even cities can contribute substantially by rejuvenating their rivers.

Village and city planning must also be integrated. From cities to villages must be a gradient of low human activity and vice-versa. In one of the seminars, I had mooted the idea that there should be some restriction on how much hinterland can be appropriated by cities. Villages surrounding a city come under its influence and the city dictates what the village should do and produce. Land prices go up, pollution comes in and village life suffers. It is upto the villages to maintain their own identity.

In Maharashtra cities are becoming more and more conscious of maintaining and improving their green character. Probably our cities may contain more tall and mature trees than the countryside. People are planting trees and protecting them. In Pune Municipal Corporation, officials find it difficult to fell a

tree. People immediately protest and go to court. Such cities are offering a refugium to birds and smaller biota. In Pune, a breeding and roosting colony of night herons is thriving. A people's bird sanctuary has taken shape within 12 km of the city. Even in Mumbai where tall trees remain, they sustain flycatchers and thrushes. Kolhapur people, I am sure, can narrate similar things. Nature responds if people take care. The residents of cities must get legal powers to limit the size of the city. No citizen would like to see his city turn into a megalopolis where living becomes a nightmare.

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That modern man has brought about in different biomes, especially those of two ~~topics~~ ^{biomes}. The present teaching does not emphasize the acute ^{chronic} scarcity of water that a tropical environment always implies. The results ^{are} fragile soils, transpiration losses, & quick ageing of sites that is mineralization & production of dust. To avoid these we need different cover types (i.e. different plant communities), measures for soil moisture retention, energy dissipaters & cooling structures which will protect soil & water losses. The adoption of technology & our need for agriculture, industry, transport cannot be decoupled with our need to protect the essentials of different biomes that our country has been endowed with. Education then will have to promote an entirely different set of prescriptions & policies than are being currently professed.

The technological ~~man~~ ^{human} being has brought about fundamental changes in the distribution of not ^{only} plants & animals but also physical forms & geographical features of the world. ^(Simmons 25) The processes of deposition & erosion & consequent distribution of living forms have been changed to the detriment of all except the upper class human beings. The teaching must emphasize how such actions spurred by modern technology have affected essential ecological services or life support systems which were an unmix'd blessing to all ^(Dorst 15) living beings on the planet before the Industrial Revolution. The necessity of maintaining and improving life support systems such as

- 1) Maintenance of the quality of atmosphere
- 2) Amelioration of the climate
- 3) Operation of the hydrological cycle
- 4) Recycling of nutrients
- 5) Assimilation of waste
- 6) Preservation of soils & maintenance of soil fertility
- 7) Pollination of plants including crops
- 8) Maintenance of the marine ecosystem & provision of sea food
- 9) Maintenance of sewer bank (Daily G.C.)

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The high & intensive ^{exploitation} of nature & natural resources facilitated by modern technology has affected all these eco-services. Consequently energy flows, nutrient cycling, biological productivity, population dynamics, biological succession, biotic diversity & environmental stability have been fundamentally modified by human beings leading to death & extinction of many life forms.

(Simmons & Gibil)

Understanding of earth's tolerance limits to expanded human activity can be promoted at local, regional & national levels. At the local level it should mean sustaining such land forms as hills & Vales, slopes and floodplains and natural resources such as soil, forest, natural water flows (streams), shrubland & grassland and agriculture & artisanal raw materials. Students in the age class 7-14 yrs can be taken out of the classroom to assess these ^{and} can also be actively involved in actual conservation & quality enhancement work. Understanding of these things at regional & national levels should promote a landscape approach in developmental planning. Such an approach not only takes account of the conservation & quality enhancement of different eco-systems & eco-services inherent in a landscape but also considers their inter-relationships throughout the region & inter-regionally. For example, as rivers imply a continuum from source region to sea, development of water resources at a place or in a region is likely to adversely affect other places or regions. A landscape approach tends to avoid such irregularities and reduce regional disparities.

(Brammer & R.T.T.)

Nature at local level is at best a resource while at regional & national levels it is treated as a supply depot and a sink. Overexploitation of resources such as forest, and freshwater & marine fish and pollution of soil & water & atmosphere may occur at any level and cannot be checked & managed without understanding the threshold values of different eco-systems & eco-services. Any use beyond the threshold will undermine the very existence of ~~the~~ these systems & services. We are still far from a real understanding of these thresholds. It is here that traditional practices &

(Chopra K.)

waters provide a guide line. These guard eco-systems & services against overuse, both as a supply depot & as a sink. Modern education should not belittle the importance of traditional knowledge especially in the field of nature & resource conservation. Especially in fragile environments where a small disturbance may cause an avalanche of degradation, traditional knowledge serves as a beacon of light. (Edla, p. 5.)

If conservation of nature & natural resources is properly incorporated in the curriculum of primary & secondary schools, it will form the basis of multi-~~pl~~ livelihoods operating essentially at local level. ~~The~~ Geography, history & science can be combined & their inter-relationships explained, into a single subject such as livelihood science. This can be supplemented by artisanal practices & field work wherever necessary. This will stem the tide of dropouts, that vast reserve of manpower who had left education either after the 10th or the 12th standards. As they have little skills either in their hands or brains, they remain unemployed and become a ready target to be exploited by extremist elements.

Such an overhaul of the system will require fashioning of special educational tools. Such necessity will further promote research in the environment and nature in all its forms. What is necessary is not pure environmental research, but one which will probe social and economic consequences of each and every ~~human~~ ~~economic~~ activity. (Gopal, 1976)

Change may not immediately be necessary in the present mode of teaching languages & mathematics, though valuation of nature's services & natural resource systems may have to be added as the economy responds to livelihoods based on nature emerge. (Pearce D.)

~~Today science & technology dominate graduate & post-graduate education. Languages & social sciences suffer from inadequacy of students. Pure sciences offer employment to only a few brighter students while all others have to satisfy themselves with whatever technical input they can imbibe.~~

The real challenge is how to incorporate practical outdoor work & field training in today's highly class-room oriented curriculum. Probably a complementary ^{role} can be ascribed to rural & urban schools. Rural schools can offer urban students nearness to natural eco-systems & natural resources which urban schools can provide rural students gadgets & equipment to carry out scientific experiments and audiovisual educational aids. The present pressure on students of completing tests & examinations & carrying out library based projects can be replaced by an imaginative exchange programme in which rural & urban students will experience something which they have not experienced before.

Today science & technology dominate graduate & post-graduate levels while languages, social sciences suffer from inadequacy of students. Pure sciences offer opportunities to only a few bright students. All others have to satisfy themselves with whatever technical input they can imbibe. Pure sciences attempt to increase our understanding of ^{the workings of} nature & natural systems while technology tries to find out how these systems can be made to work more or less exclusively for the benefit of human things. It promises power, dominance over nature and seemingly unlimited increase in material comforts for humans.

But "the modern world, stamped as it is with the image of the machine, must learn to look technology in the face and read its essence soberly and without illusion". (Fruiger J.G. 1949). The essence of technology is what I call the ecology of technology. Every student must be given to understand ecology of technology, what in truth technology implies. In brief technology tries to redirect natural flows of energy & materials towards human things to the exclusion of all other living forms. In human history the earliest & most vivid example of this redirection is agriculture. The farmer decides that the flow of sun's energy falling on a piece of land which is normally used by a number of plants & animals, will be used exclusively by a single plant beneficial to human beings. As competition from

other plants is excluded, the selected plant (crop) starts favourably & offers the farmer abundant yield. But this abundance is also available to the natural enemy of the crop & the crop is attacked by pests. Technologies then always produce side effects. (Origin of Agr.)

There are other sides of technology which we tend to ignore & never make them explicit to the student-body. It has been well said, "Technical progress comes on earth, not alone with its machines & ~~scrap~~^{workshops} but also with junk & scrap.... All technical knowledge is marked by an impersonalism that necessarily results from the purely material facts that it deals with." Moreover, "even the smallest-mechanical process consumes more energy than it produces, how could the sum of all these processes create abundance? ... It leads to an economy of deficit which grows the more strikingly obvious, the more triumphantly the perfection of technology progresses." (The Student must understand that "the designer of a machine never gets beyond the degree of efficiency described by Carnot's cycle. This is assured by the 2nd Law of Thermodynamics. (July H. & Boulding K.N.)

(Toungler 7.6 365)

Why all these facts ignored & never given the weight & importance that are their rightful due. It is probably because all technological progress then becomes merely pretence. It is entirely based on debts, on heavy subsidies from nature & from sections of human society who have to sacrifice their livelihoods. This technological bias is widespread & pervades especially the politicians, economists & administrators who manage our so-called development. This is the economy of deficit - which is the inevitable result of all-out-technological development - is starkly evident in India since 1990.

As Prof. Amit Bhaduri said in his address to IVCTA, "Despite near double digit growth for more than a decade and a half, available estimates suggest that more than one-third of the Indian population live in sub-human poverty (a recent World Bank estimate puts nearly 42% as absolutely poor by international standards)

more than 3/4 of the population has a daily purchasing power of less than Rs. 20, nearly half the children are undernourished & many crippled by undernourishment, anaemia is on the increase among women, and food deprivation in the countryside has not decreased.

According to the Economic Survey of the Govt. of India (2006-07) total employment in the organised sector declined from 25.2 m. in 1977 to 26.4 m. in 2004.

One can add to this the declining employment in the agri. sector, the worsening of agri. labour, ^{over} the increase in no. of self-employed is nothing but discharged industrial workers & those who cannot find any employment, eking out living by selling tinsel goods which means long hours of work, little earnings, lack of any social security & protective cover of labour laws. So much for the recent technological progress of our country.

The economy of deficit is nowhere more apparent than in India.

What is the alternative? If the technology that is currently taught in colleges & universities is harmful to the environment & the economy & consequently to the people at large, it will have to be phased out & replaced by one that is beneficial to most of our countrymen.

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Alternatives like Appropriate technology, soft technology, bioengineering & bio-based technology come to mind. Students must be given to understand very clearly what any use of energy implies. In any process where energy is used, input is always greater than output, normally investment does not justify the product obtained. Investment is lowest when fossil fuel is used as most of the work of making energy available in a usable form is done by nature. This is the reason why most of the technology uses fossil fuels. But its known stocks are limited, & the cost of discovering new stocks is enormous. The use of alternative sources of energy such as solar, wind, tide etc. also means that input costs are greater than the value of the product obtained. This is so because making such alternative energy available requires an investment which is usable

higher than the value of the product. For example, the solar cell making requires ^{energy} ~~energy~~ (again based on fossil fuels) which is greater than ^{the energy} what the cell will produce during its 'entire life'. Alternative energy sources become viable only if the entire operation is heavily subsidised.

The real alternative will be to ~~to~~ minimise the use of energy, especially minimising use of fossil fuels. So that this extremely cheap source will last another 1000 years! We need to promote technology that minimises energy use. Again biomass development appears to offer the cheapest alternative. We need to develop all types of plant biomass, ^(Mushrooms, Ketal) Almost half the land area of the country is degraded.

All this area can be restored by sowing appropriate cover types indigenously. To work this out Restoration Technology is available & is being extensively used in developed countries. It is cheaper in terms of investment and is labour intensive creating opportunities for enormous job creation. For example, European countries have taken up large projects to revert their rivers & streams to their natural conditions. ^(Mansir 5.12 P. 107) England has the classic example of the river Thames in England. Besides U.K. have cleaned up all their streams.

USA has a law ~~prote~~ which lays down a policy of no net loss of any water body, especially wetlands. There are bodies like Society for Ecological Restoration, Wetland Managers Inc. etc. Similar organizations exist in Europe.

There are unlimited opportunities for creating alternative livelihoods & jobs in the use of such biomass related technology. Our educational institutions must make ^{(Chhaya M.) 2004} available instruction in ~~this kind of~~ these fields. Restoration of Nature is the key concept here. Besides creating more jobs such restoration will confer such benefits as conservation of soil, quality enhancement of water & atmosphere & lessen the ~~stress~~ mental & physical stress that is the inevitable result of promoting a deficit technology & economy. (Gok P. Restoration of Nature)

Do we have the courage & conviction to bring about this radical change in our higher education?