

Solar, earth and human capitals, and sustainable development

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The three capitals

All developmental activities are ultimately based on three types of capitals¹ which make earth habitable for human life in its present form. Broadly speaking these are solar capital, earth capital and human capital (Figure 1). The equatorial-tropical-subtropical belt receives the maximum solar energy throughout the year. This belt acts as the heat engine of the world and sets a temperature gradient from equator to poles with the associated climatic processes. Solar capital is one of the important ingredients of a deceptively simple process like photosynthesis which uses this energy into making of actual usable materials. Photosynthesis takes place in phytoplankton in sea and other water bodies and on land in plants.

The earth capital (or what may be termed as natural resources) includes resources like air, water, land, soil formation and all that is on the land and under it: e.g. forests, biodiversity, grasslands, wetlands, oceans and metallic and non-metallic minerals (including oil). Among these, wind, water, geothermal heat and biomass are potentially renewable. The earth capital includes natural

processes like detoxification, dilution, decomposition and recycling of vital chemicals like carbon, oxygen, nitrogen, phosphorus, sulphur and above all water. It also includes renewable energy of sun, wind, flowing water, geothermal heat and biomass. The earth system is not static but has been changing over periods of time. It has also the capacity of self-renewal and purification. Its biodiversity has capacity for evolution and adaptation to changing climatic conditions including natural pest and disease control.

The earth capital also has life-sustaining capacity and on account of several factors has been favourable to the origin, evolution and diversification of life ever since the first self-replicating DNA molecules arose over 3.8 billion years ago. The pinnacle of evolutionary process is the origin and evolution of *Homo sapiens*. There have been many species of microorganisms, plants and animals that have come and gone, but some have stayed on the earth ever since their origin.

Although a moot point, what if from today, sunlight does not become available to earth! Much of the life as we know will come to an end because of being directly or indirectly photosynthesis-dependent. Some forms of life may

spread: e.g. the biota found deep down on the sea floor or that exist in and around volcanoes on the bottom of the oceans where there is no sunlight.

The solar and the earth capitals constitute the most important components of the life-support system of the earth to be used by all species including human. The solar capital gets converted into goods and services through photosynthesis. The human capital resides in the human ingenuity, diversity, ethnicity, and diversified history, culture, religion and philosophy leading to varied technologies and socio-economic systems.

From the interaction between earth capital and human capital (technology) there emanates the manufactured capital. It includes manufactured goods using tools, machinery and equipment, and physical and mental capabilities and talent of human being. In this system technologists evolve technology, managers put it to use and look after the manufacture of goods, and workers do the actual work. The entrepreneurs invest monetary resources and then reap the profits. Thus economics is basically production, distribution and consumption of goods and services to satisfy people's wants and needs. Therefore, the three capitals together are the major source of all economic development that takes place on the earth (Figure 1). If used judiciously and with thought and care, these capitals can reform the face of earth to the good, the benefit and the well-being of not only human species but also of all creations.

The impact of human capital

The story of human species on earth begins with its ancestors like *Australopithecus afarensis* (3.36 millions years ago). After about 2 million years, arose the genus *Homo*: first it was *H. habilis*, then *H. erectus* and finally *H. sapiens* (400,000–150,000 years ago) which along with its genetic diversity also acquired physical, mental, social and cultural diversity^{2,3}. *H. erectus* and particularly *H. sapiens*, colonized all the continents of the world except Antarctica.

H. sapiens (or the human being) has

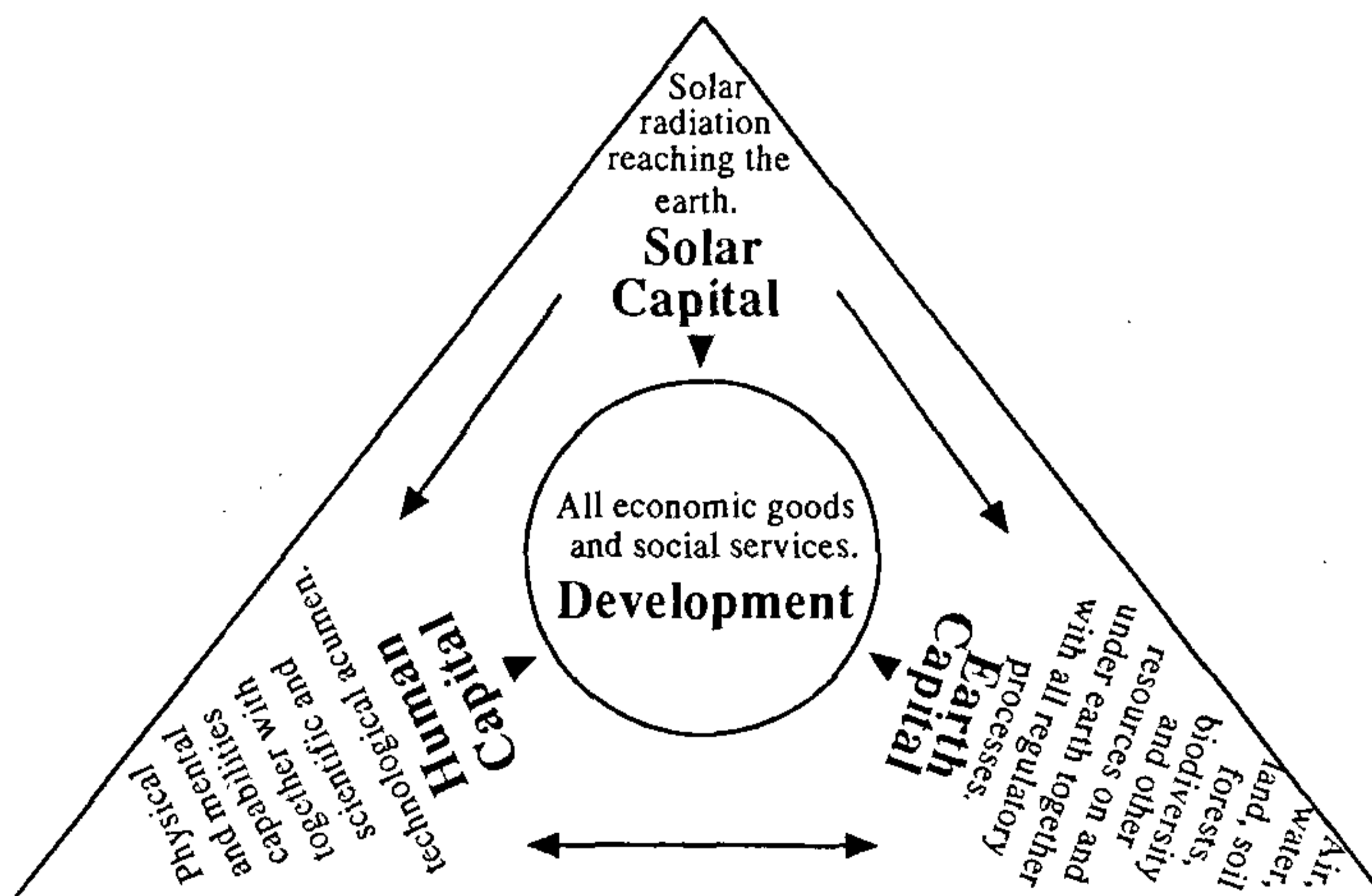


Figure 1. The three capitals for development.

been the most intelligent and a thinking animal that the earth has hosted, and has reached the present state through three types of societies as a result of three major revolutions. The first revolution was the *Stone-tool Revolution*. Here the first resource was food (plants and animals), second resource was stone which the then human being used to defend itself and also to kill its prey and do other jobs. These resources together with fire-making ability gave the then human being a distinct edge over all other animals. It not only became a thinking animal but also had an innovative mind. At this stage it was essentially a society of hunters and gatherers: men hunted and women and children gathered.

Thanks primarily to women, imperceptibly there developed an agricultural society and then followed *Agricultural Revolution*. Soon land and water became important resources for cultivation and irrigation of crops respectively. These changes accompanied the invention of wheel, plough and domestication of crops and animals. This helped in insulation of the human being against vagaries of nature by ensuring supply of food. A fallout of the agricultural societies was that human being became a 'son of the soil' (*Bhoomiputra*). These changes took place during the last 6–10,000 years.

Around 1712 AD two things happened². Firstly, wood began to be replaced by coal as source of energy; and steam engine was invented. This was the beginning of the third revolution: the *Industrial Revolution*. This revolution is only about 285 years old but has been a 'mixed blessing' inasmuch as living standards of humans improved but quality of environment deteriorated increasingly. Progressively there was greater damage to earth with lowering of the quality of environment on account of overpopulation, soil erosion, loss of forests and biodiversity, pollution of air, water and land, global warming, ozone depletion, waste generation becoming a health hazard, etc. This led to environmental, developmental, economic and even political problems. At the root of this were the doings of just one species: the *Homo sapiens*. Thus from the biospheric point of view, the origin and association of human species with earth has been a 'mixed blessing'.

In this regard there are some important precedences. Some 6000 years ago, there

were six flourishing contemporary civilizations which fell like house-of-cards. These were: European–Mediterranean, Babylonian, Nile Valley, Indus Valley, Huang Ho and Mayan². The principal underlying reason for their fall has been disrespect for environment. Progressively the human species became the most *unnatural* species that has ever existed on the surface of earth. But the basic fact is that human being is the only species that has power of intelligence to enable to modulate environment so that it may suite her/his convenience. Thus human-kind is able to evade natural selection to a large extent through the application of science and technology in which there has been tremendous growth in knowledge. Such ingenuity led to creation of artifacts. Furthermore, a human genotype which may have congenital defects in her/his organs in the body can also evade natural selection and continue to live and, what is worst, even leave progeny. All she/he needs is enough money to buy the most modern medicaments and healthy organs to replace the defective ones. One can also change an ugly face into a beautiful one.

Human being invented or discovered drugs (e.g. antibiotics in mid-1940s) to control some of the vicious diseases. This era started with the discovery of penicillin which was hailed as a major step in disease control. Initially the results were miraculous. There was a spate of new antibiotics discovered. Soon a race began between microorganisms and the discovery of increasingly more potent and new antibiotics. The race has not ended. Today we have strains of pathogenic microorganisms which are not only drug-fast but, what is worst, *feed* on antibiotics. This is most ominous: an altogether new race has begun between humans and the tiny microorganisms.

The moral is that by the use of science and technology we are trying desperately to perpetuate human genotypes which would normally have little or even no selective value in nature. In this process human being has pitched itself against the natural laws. Secondly humans have entered in a race against harmful micro-organism, where the indications are that the battle is unequal and humans will remain pitched against these organisms perpetually. Their genetic system is simple and capable of countering what humans can do. In the long run, it is, therefore,

an unequal battle and microorganism and even insects seem to have an edge over human beings.

Interaction between earth and human capitals

Earth has been regarded as Goddess by the Greeks (The *Gaia* concept), we in India regard her as Mother – we call her Mother Earth (*Dharti Mata*)². The *Gaia* concept became popular thanks to Lovelock⁴, an outstanding atmospheric scientist. He concluded that earth is a 'homeostatic living organism' and felt that the *Gaian* concept could become a *scientifically verifiable religion*. There is, however, a difference between the two concepts. Goddess is generally put on a pedestal and one bows before her and worships her; *but* with mother we have an organic connection through an invisible but indelible and permanent umbilical cord, which lasts throughout ones life; we are her children in every sense, we seek her benevolence, we depend on her and draw sustenance from her. She also provides an abode for human race and meets all the needs. In fact this is true for all the living creatures be it plants, animals or microorganisms. Ultimately, mortal remains of all organisms return to Mother Earth. There is a subtle distinction between concepts of *Gaia* and *Mother Earth*, but both are basically reverential in character.

Responsibilities of human being

With all the knowledge human being has, it is clear that so far there is no concrete evidence of life on any other planet in our solar system except the earth. Thus earth is not only unique but is also indeed a 'miracle'. The human race has a major responsibility to save this miracle in space and time because human being has also vast knowledge and power at its command. It can peer at the earth both from outer space and also while sitting on the earth itself. The changes being made by human being may be subtle or obvious, but ultimately are fouling the earth's atmosphere, hydrosphere, lithosphere and biosphere. The subtle changes in quality of air, water and water bodies, movement of glaciers, vegetal cover, forests, deserts, soil, even individual species and biogeochemical cycles together with energy

flow, can now be constantly followed and measured. What is equally important is that such information can be transmitted within seconds to any part of the earth. Never before had human being acquired such a power for instant gathering of data, instant analysis, drawing strategy and conclusions and spreading the message, and also have the feedback in record time from village to the country as a whole. Such information can also be used to evolve a repair strategy and save our country and the region from ecological damage. It can also help to evolve a local to global overview and have an attitudinal change from exploiter/destroyer to saver/helper.

The repair strategy is essentially slower than power of disruption and destruction. It takes millennia to reach a stage of a climax forest but only a few hours to destroy such a handiwork of nature with myriad species that have made it their abode over millennia. *There is now a need to question the very role humans have played on the surface of this planet in changing the biosphere.* Such a change has been more for the worse than for the good of all other species.

The human being has spread to all the continents except Antarctica. It is now trying to colonize Antarctica but for a different purpose. Therefore, the effect of human presence on the Planet has made obvious and subtle changes in the life-support system. These are not only local but some changes have had global implications. The extravagant lifestyles of the industrial countries are no longer a concern of only those countries but also of the developing countries, the reason being that local changes add up to become global changes. There is only one earth and we are all interconnected, interrelated and interdependent.

The damage to earth is increasingly overshooting its repairing capacity. This is indeed a matter of deep concern for all humanity. Therefore, it is high time that the entire human race irrespective of cast, creed, or colour joins hands to repair the damage it has already done, or is in the process of doing. For this, there is an urgent need to evolve a code of conduct for human race, because otherwise our only abode will cease to support us. For instance, we may have drawn so-to-say a moratorium on the nuclear activity but the nuclear haves have not abandoned nuclear arsenals. The world

is unequal, not only regarding nuclear power but also the damage inflicted to the earth on several other counts (including over-use of resources).

Today we have knowledge and power to create wealth from waste; raise forests and improve their diversity or raise plantations to meet the wood needs in a matter of decades on denuded and abandoned land; conserve species; try to improve the quality of air, water and land; try to reverse pollution; harness energy from sun, wind and water; redesign crops with the knowledge of genetics, breeding and biotechnology; use microbes to do some beneficial tasks (e.g. manufacture of insulin and other products); take to use of natural products from medicinal and aromatic plants, natural oils, gums, dyes and what not, but we cannot recreate species already lost. We have controlled population of unwanted weedy species, so we also need to control our own unwanted numbers.

Thus human race has vast and myriad powers but we need courage to restrain and use these only for the good, the benefit and the well-being of our atmosphere, hydrosphere, lithosphere and biosphere of which we are an integral part. We have to be on the side of life and the living biota and the life-support system but never ever on the side that kills the 'goose that lays the golden eggs'.

The present day crisis in environment and development is actually an outward symptom of a inner crisis in our mind and spirit about the type of society we are trying to build where human numbers are outstripping increasingly the diminishing resources of the earth, whose carrying capacity is in jeopardy, we are generating waste on an unprecedented scale, and the very security and functioning of biosphere is getting impaired. Is this the type of civilization we should build?

Furthermore, the doings of human being are such that the biosphere functioning is being impaired increasingly due to climate change, CO₂ increase, ozone depletion, etc. In every sense we are destroying and undermining our own future. Thus human race has unleashed a situation which may fast become out-of-control and human species is likely to be affected adversely.

Earth without humans

The question arises as to what happens

to Mother Earth if by some chance the entire human race gets annihilated all of sudden, leaving behind all the artifacts (buildings, palaces, castles, roads, automobiles, aeroplanes, railways, industries, power plants, shopping arcades and all other infrastructure) that have resulted from human genius. Thereafter, what would be the scenario on the earth, say after 2 to 3 centuries.

All that was created by human being would have deteriorated. The buildings would have crumbled, all means of transport would have rusted, and all open spaces, roads, fields, agricultural land, parks, aerodromes, etc. would have been colonized by trees, shrubs and herbs and animals of sorts.

Most of the natural biodiversity including endangered species and forests would have flourished. However, all agribiodiversity crafted by human being would have perished. Such diversity is essentially unnatural (created to fulfil needs of the humans) and therefore bizarre and depends on its sustenance of human beings. Reciprocally human being depends on it for its own survival. For instance, the 3 to 4 feet tall wild form of *Brassica oleracea* (commonly called wild cabbage), still growing wild in European Mediterranean coast, will flourish, but the six different vegetables (e.g. cabbage, cauliflower, brussel's sprouts, kale, broccoli and kohlrabi) selected and literally crafted by human being over a period of time would have ceased to exist because these are bizarre and highly specialized with no selective value whatsoever in nature. In cabbage the whole plant has become a gigantic bud, cauliflower and brussel's sprouts are highly condensed but large and soft inflorescences of very minute sterile flowers, broccoli has large auxillary buds (mini cabbages), kohlrabi is a swollen, soft and leafy stem, and kale is indeed a very leafy vegetable (Figure 2).

Similarly, the ancestor of maize with only a few grains which are adequately protected (not naked like maize grain) and which can shatter, would flourish (Figure 3 a, b); perhaps so would modified teosinte whose grains were non-shattering but threshable (Figure 3 c). The cultivated maize having 'naked' grain without the hard casing of the ancestral species (Teosinte) evolved into a highly specialized type of cob specially crafted to fulfil the need for high yield. On account

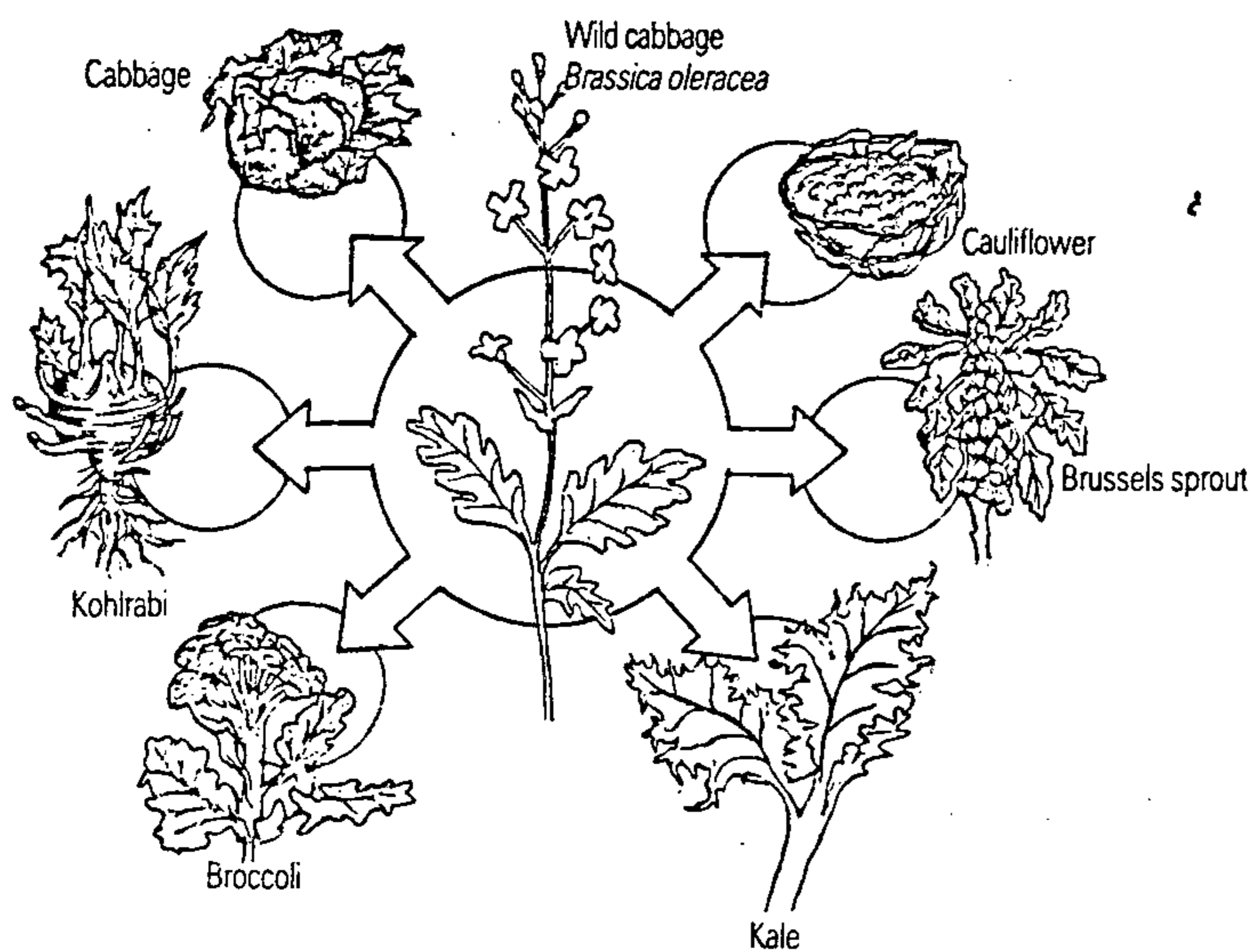


Figure 2. Wild *Brassica oleracea* and the six over-specialized cultivars developed from it by human being⁵.

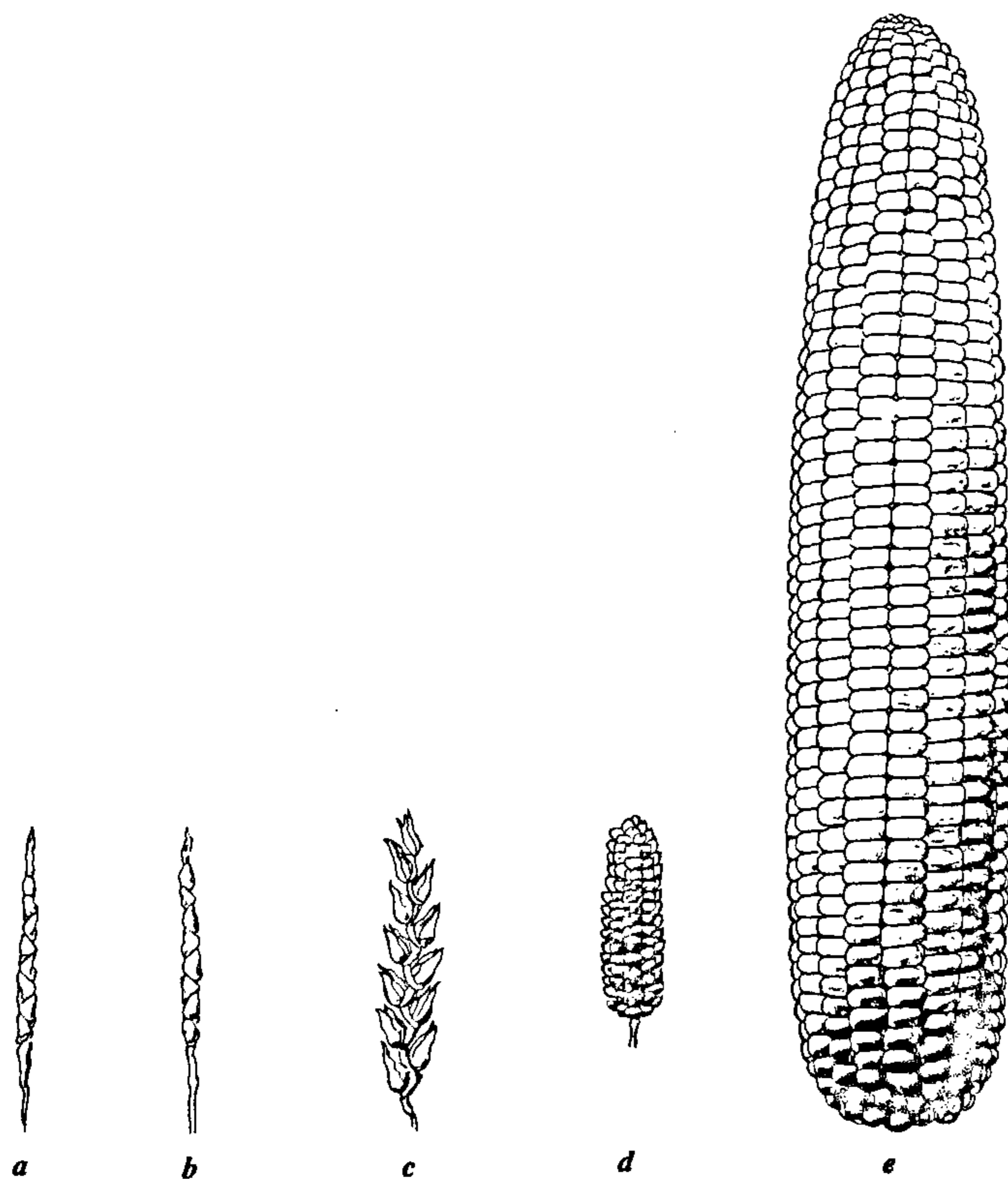


Figure 3. Stages in the evolution of cultivated maize⁵.

of this the modern corn (Figure 3 e) would become extinct particularly because seedlings would have to penetrate the leaf-like sheaths protecting a cob. Then the seedlings would be densely clustered and compete for water, soil and nutrients and fail to reach reproductive stage⁵ (Figure 3 e). Maize is so specialized that it would become extinct without human intervention, because it does not have any selective value in nature. The same is true of other crops and domesticated farm and non-farm animals (e.g. many breeds of dogs selected from the wild wolf, *Canis lupus*) selected by human being over the years.

Human ingenuity has through successive breeding and selectoral cycles tampered with reproductive processes of the agricultural plants and animals. The investment of their energy has been in reproduction leaving little for their defence and survival (see Figures 2 and 3). The story of agriculture has been that from hardly any worthwhile yield per unit of area and time in the wild progenitors, there has been investment to boost the yields in cultivars, be it, wheat, rice, maize, potato, pig, cattle, chicken, etc. For instance, in chicken the egg yield per hen per year has shot up from about 13 per year in the wild to over 300 in domestic breeds, making chicken merely egg-laying machines.

All the cultivars/domesticates are over-specialized and thus have become over-dependent on human being having been evolved only to fulfil food needs of humans. Therefore, these cannot face natural selection and exist without the intervention of human being. Associated with such transformation there have been skeletal and a number of other deformities which, like cultivated plants, make the domesticated chicken totally unfit to face natural selection.

The marine life in coastal/mangrove regions and in deep sea would improve in absence of humans because there would be no extraction of edible marine animals, sea weeds and corals. Furthermore, there would also be no dumping of pollutants and wastes in these habitats. In addition, the natural environment would have improved, e.g. quality of air, water and soil would have become much better. The reason being that the sources of present-day pollution would have ceased to exist. However, the host of non-biodegradable synthetic chemical compounds that are

alien to biosphere, but manufactured and used by human beings, would persist, unless some microorganisms begin to feed on them and degrade the same into elemental forms.

No doubt human being in its present form has become the *most unnatural species* existing on the surface of earth. This would be increasingly so in the future. All the elements that epitomize human culture and civilization (e.g. literature, art, music and all other finer things of life) would vanish in absence of human interest and creativity.

Increasingly, one gets a distinct feeling that the earth together with most other species will fare much better without humans, because humans have created a type of civilization that is leading to the destruction of the earth. We have, therefore, to change our ways if we want to be a part of the biosphere in perpetuity. We need to change our mindset regarding unlimited growth and development, jobs, consumption patterns and the politics of domination that is behind some of the unstated objectives. Furthermore, the general feeling that sustainable development can be achieved only with better technology, laws, agreements, treaties and enforcement is true only to some extent; because ultimately it is a question of ethics and morality behind resource use. There is no alternative to this change. We have to learn new values, new imperatives and move in a determined manner towards sustainable society. There is not even one action big or small taken after 1992 (United Nations Conference on Environment and Development) towards sustainability, notwithstanding the fact there is also a Commission on Sustainable Development. It is largely a business-as-usual situation.

The fundamental point is that we have to practice ethics and morality not only *vis-à-vis* humans but also for all other creatures (plants, animals and even most microorganisms). We must respect not only human life and affirm our responsibility both to our near and dear ones but towards all life and all creatures. Over-use of materials (living and non-living), in strict sense, also amounts to violence against nature as a whole.

Homo sapiens is indeed different from all other species, because it is a thinking animal: it can *recall* its past and gain from it if it wants to. Furthermore, it

can *foresee* the future. But whatever decisions emanate will have to be moral and just. Transition to sustainability must become our moral and ethical obligation to generations that will follow us. Here each one of us has a role. Each individual and her/his action is indeed critical for society, because a society is an extension of an individual. *The bottom line is that biosphere does not need us, but it is we who need biosphere for our well-being.* Therefore, there is need for serious introspection. *The 'enemy' of environment is within each one of us.* Nature is very complex, we have not understood its ways fully, we must approach it with tremendous humility, awe and respect. We must accept the fact that environment is most critical for our ecological, social, economical, ethical and even military security. These are parts of one whole and cannot be delinked.

Towards sustainable development

As is clear from Figure 1 the very foundations of all sustainable or unsustainable development rest on the use or misuse respectively of the three capitals. The agricultural development can be regarded as a major solar enterprise backed by the use of some earth capital (land and water). The industrial development involves a major use of earth capital. Both agricultural and industrial developments are backed by human capital. While earth capital is finite and limited, solar capital is indeed clean and infinite. It has yet to be used to a significant extent. This can be a major input in improving chances for sustainability.

Furthermore, human mind has been very creative. During a relatively short span of time, it has created three types of diversity: agri-biodiversity, cultural diversity and developmental diversity (Figure 4). Agribiodiversity involved picking up the right kind of grasses and other plants and animals, followed by a meticulous domestication and selection process, so much so that it has not been possible for modern human being to add any totally *new edible economic species* even when powerful tools of science and technology have been at his command. One marvels at the meticulous work done by the so-called primitive human being. Based on the interplay of the three capitals, three types of human societies have evolved in a sequential manner.

Types of human societies

From the point of view of environment and development there are three types of societies. A *Hi-Tech or Throwing Society and Economy*, a *Back-to-Nature or Subsistence Society and Economy*, and a *Sustainable Society and Economy*. The first two represent the two ends of the spectrum, while the third is indeed the 'middle path'. The Hi-Tech or Throwing Society represents what one sees today in the industrial countries. They act as though the resources of the earth are unlimited and technology can help to do anything and everything. Such a society believes that developmental considerations are most important and subordinate to environmental ones. This pattern of life is unjustifiable and is not tenable on moral, ethical, economic and environmental considerations. The Back-to-Nature or Subsistence Society is regarded as primitive even though it may be sustainable. But it denies the fruits of modernity to the poor and the needy. This is unjustifiable and this segment has to be taken out of the morass of poverty and helped to enjoy atleast some of the fruits of modernity. In fact this is their right.

Sustainable society

Can one hazard a guess about the shape of a sustainable society in a country like India? Basically it has to be a healthy blend of environmental, developmental and economic imperatives. The underlying rationale has to be that ecosystems, agro-ecosystems and industrial economic systems have to be conserved and used in

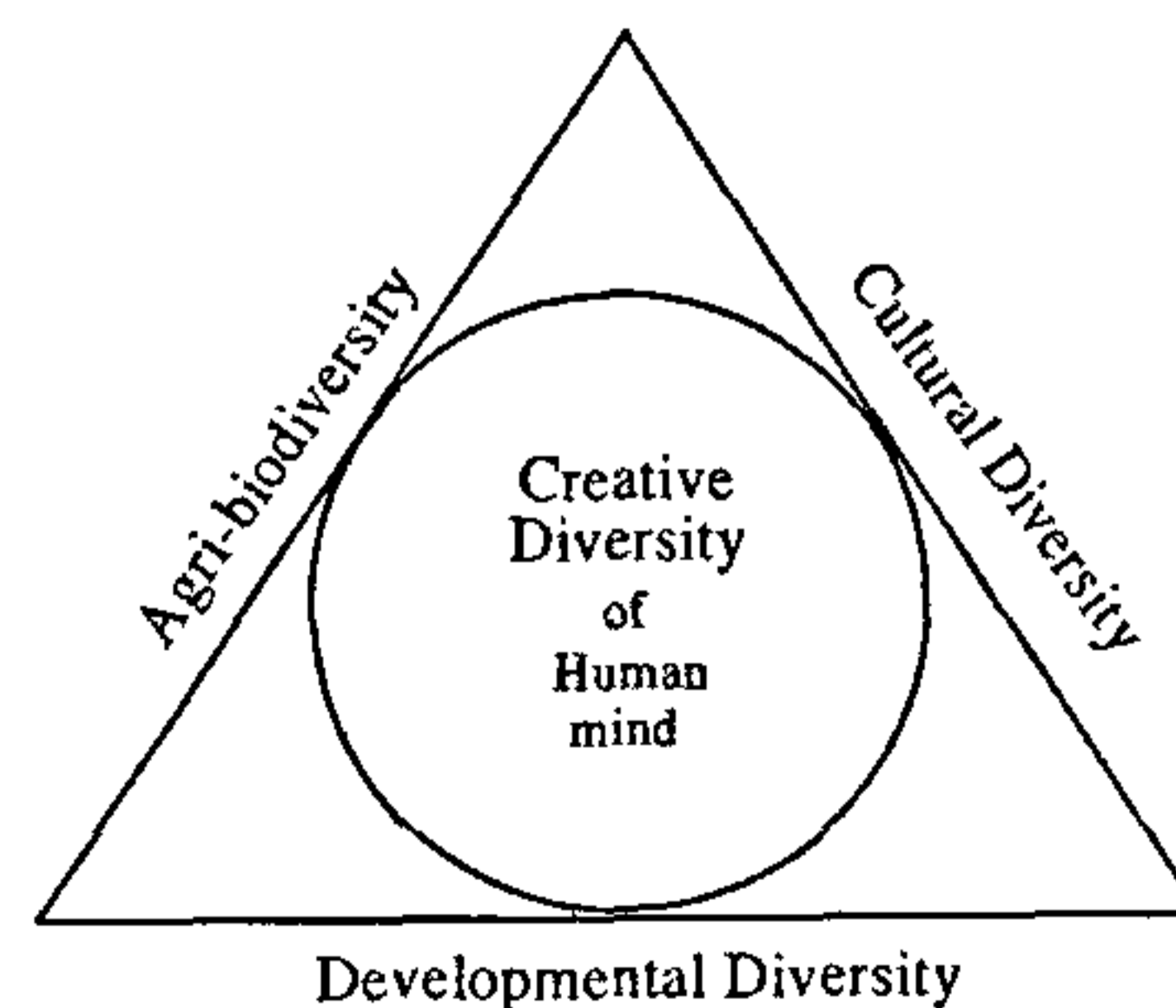


Figure 4. Creative diversity of human mind.

a sustainable manner. Furthermore, economic growth has not to be at the expense of ecological assets. The sustainable society has to aim at working in *partnership* with nature and conserve resources and energy, reduce waste, and avoid degradation of renewable resources. It must produce goods that are easy to recycle, reuse and repair after use. Sustainable economy aims at maintenance at a constant and sustainable level of both the number of people and quantity of goods. These should be in line with the carrying capacity of the concerned systems: ecosystems, agro-ecosystems or industrial economic systems. The basic needs of the people are met without any serious detriment to environment. *Need not greed, and comfort not luxury, should be the guiding principles.*

The method of growing food and raising livestock has to be based on soil and water conservation, bio-fertilizers, biological control of pests and minimal use of non-renewable energy. There is needed extensive use of relevant biotechnology under sustainable society. Under this path of development, people must believe that resources of earth have to be protected and sustained not only for human being, but also for other species. *The approach to manage and sustain resources of earth is not centered around human being but around the entire life-support system.*

Sustainable society and economy is based on a firm belief that earth is finite in area both for colonization of species and utilization of resources, but human numbers keep on growing. It follows from this that there cannot be infinite and unlimited growth and development with finite and limited resources that earth has. Furthermore, the increasing population growth and production and consumption of goods and services, stress and strain the natural processes and renewability so as to maintain the life-support system (air, water, soil, flora and fauna) in a healthy state. It is, therefore, essential that environmental degradation and depletion of resources is prevented by working *with* nature. The aim is to reduce unnecessary use and waste of resources (including energy) and not cause permanent extinction of species.

A sustainable society would largely be a solar/photosynthetic/biomass society where solar energy and solar hydrogen together with whole range of renewables are used and aims at not wasting resources

unnecessarily and avoid interference with other species. The idea is to reduce short term gains that have long term environmental and economic costs.

A sustainable society would insist that the national accounting system should take into account both the economic growth rate and the rate of ecological resource degradation and rehabilitation. The two together will give a correct picture of the state of the country's economy. This would ensure that the economic growth is not at the expense of ecological assets. Although India has rather a rich resource base, the majority of the people are essentially poor. The sustainable group must have faith in science and technology as a powerful instrument of social and economic change and must advocate the use of technology relevant to a particular situation with emphasis on local self-reliance. As indicated above, we need to believe in recycling and reusing materials and advocate adoption of all the technologies that help to conserve the life-support system of the planet without affecting its regenerability. This would lead to rational use of resources with minimum waste. The guiding principle is to satisfy the need and not greed of the people, ensure comfort not luxury, and above all bring about equity with social justice. Unlike the Hi-tech Society, which basically in its present form works *against* nature, the Back-to-Nature Society works *in* nature, and the Sustainable Developmental Society would work *with* nature.

The attitudinal difference between eco-fundamentalists and sustainable developmentalists can be seen from the fact that the former talk of *ecocide*, *ecodisaster* and *eco-catastrophe*, while the latter, taking note of the former, talk and plan through *ecotactics*, *ecotechnology* and *ecodevelopment*. Their roles could be complementary to one another—the former use shock tactics to arouse interest, while the latter do something positive on the ground.

The twin goals of sustainable developmentalists are: restoration of the past ecological damage, and insulation of the country from the damage as a consequence of future development. The latter must entail minimum risk to environment. They recognize the fact that there is no form of development with zero-risk. To accomplish both restorative and preventive strategies, they advocate the use of

science and technology in an abundant measure.

The most formidable task before a Sustainable Society is to achieve, in actual practice, sustainable development that will alleviate the condition of the teeming millions of India who have to be brought out of the present day morass of poverty, penury, want, illiteracy, disease and joblessness through the application of location-specific science and technology. It must firmly believe that our teeming millions in villages (including tribals and adivasis) are entitled to the fruits of modernity without affecting the resource base adversely. It is not ethical to keep them out of the mainstream of national development and advocate, as some eco-fundamentalists do, a Back-to-nature approach.

Panchayat Raj (governance through local Village Councils) shorn of its populist and political overtones, can be one major instrument of the much-needed socio-economic change at the grass roots for India's teeming millions. However, what we need is the right mix of development and environment to enable people to produce, protect and sustain resources so as to raise their quality of life. It would also generate employment and halt migration from villages to cities. The fundamental question is what pattern of development needs to be followed. The answer is simple; it has to be the bio-intensive form of development because foundations of our village society are biological: agriculture, animal husbandry, forestry and fisheries. These are all biomass-based vocations. Furthermore, there has to be intensification and diversification of biomass production, processing and utilization. To ensure this would involve sophisticated science and technology including biotechnology. Furthermore, biomass production has not to be monsoon-dependent. Such a positive approach alone will help rural people to insulate themselves against future ecological and economic shocks, which otherwise would make them 'ecological refugees'.

For the success of bio-intensive pattern of development at the grassroots, two measures are very necessary. Firstly, land use planning and land-tenure, which though somewhat intractable issues, have to be solved in favour of people particularly the weaker sections. Secondly, our per capita land holding is very small,

and with population increase it would become still smaller. We have, therefore, to get more and more biomass from less and less land. This is possible by involving environmentally clean science and technology, particularly genetics, breeding, pharmaceutical sciences and biotechnology, and advocating use of not only high-yielding varieties but also biofertilizer and bioinsecticides in order to make biomass production sustainable and continuing to maintain the tilth and health of soil.

Our very life and existence and economic system depend on solar, earth and human capitals. The technology to use the earth capital is generated by the human capital. We have also to respect not only human life but affirm our responsibility towards all life.

Thinking must become systematic, holistic and futuristic. We must anticipate consequences of first, second and even third order, and must redesign our behaviour towards people, government and business, and above all towards our atmosphere, hydrosphere, lithosphere and biosphere. These should not be abused and over-used because these alone will help to evolve sustainable societies.

Models of development

Broadly speaking, there are two models of development for India (Figure 5). The top-down Nehruvian model of development involves industrial development in which mostly non-renewable resources (including energy) are used. Generally, such development everywhere has been oblivious of the destruction of natural resources, which represent wealth in their own right. The prime indicator of this development is the increase in Gross National Product. This is essentially a human-made macro-economic indicator, which neither reflects the extent and nature of human well-being, nor the damage done to the environment.

The bottom-up Gandhian model is basically aimed at building self-reliance and self-respect in a villager, and poverty alleviation of region's teeming millions who are steeped in penury. Village is a socio-economic and cultural unit and not a geographic unit. This model involves enhanced biomass production, processing, and utilization. A large section of our society has to be served by this model which depends on renewable resources

(both man-made and natural). The model is largely fuelled by solar energy (photosynthesis). The indicator to be used for estimating growth of such a model has to be the increase in the Gross National Resource Product, which should be sustainable and should cause the least or manageable amount of ecological damage to the production base. The basic principles (local self-reliance and equity with social justice) of the Gandhian model of development must become applicable to all situations from ecosystem to industrial societies. However, the top-down model of industrial development is relevant primarily to the industrial economic sector. This model needs refinement and has to be made sustainable.

The Gandhian model leads to decentralized economic planning and to an economy of permanence⁶ while in a top-down model of industrial development there is the danger that the rich become richer, and poor poorer. Success will be measured not by homogeneity but by a heterogeneous situation, but by recognizing diverse societies in which unity is appropriately blended with tradition, and where man-made development does not become destructive of the natural capital. Both models have their constituencies. Thus, following a pragmatic path, there is need for a synthesis of the bottom-up (Gandhian) and the top-down (Nehruvian) models. Herein lies the salvation of this country.

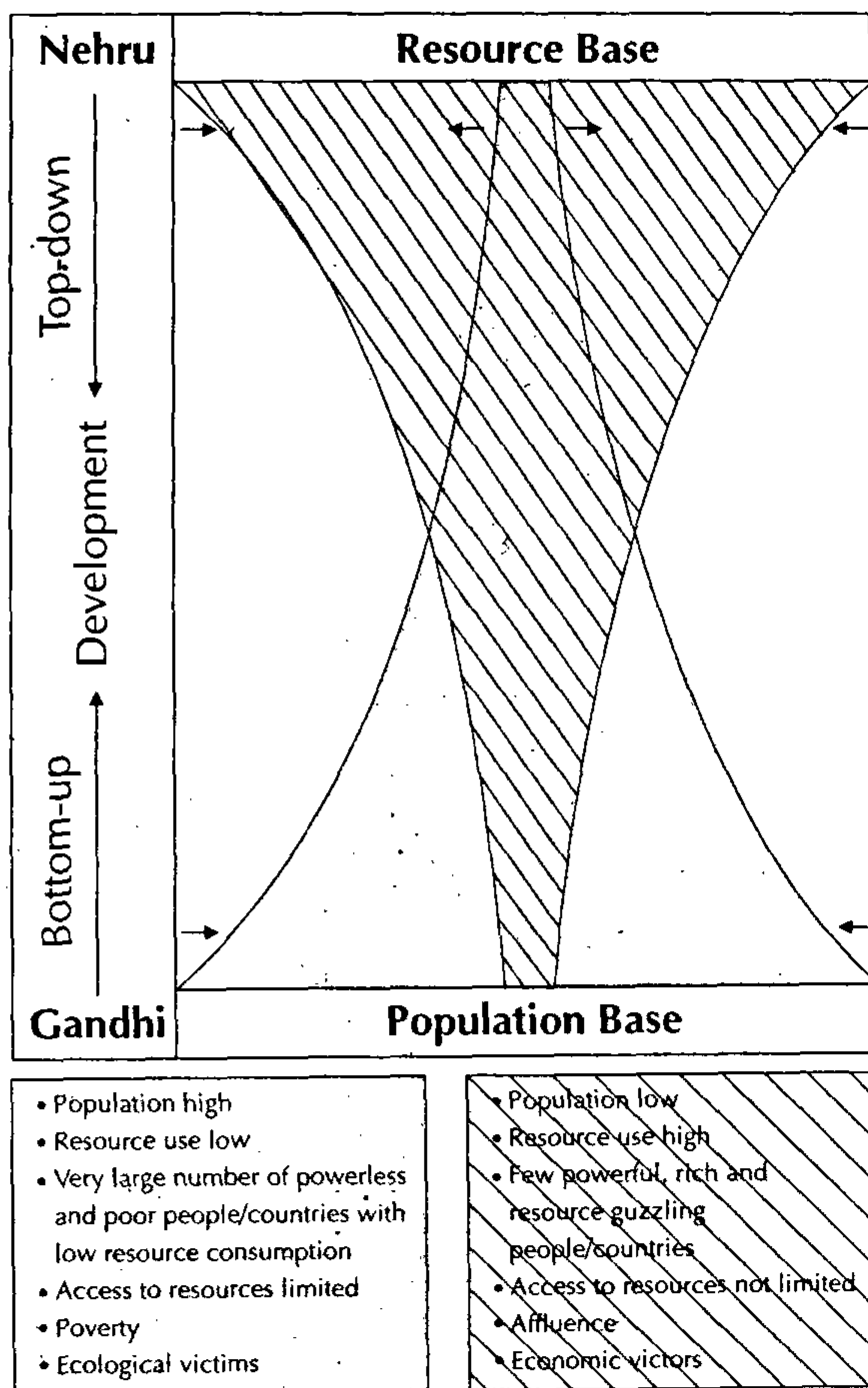


Figure 5. Relationship between population and resource use in developing and industrial countries.

The two models are depicted diagrammatically in Figure 5. In one model a small percentage of population uses an unusually large amount of resources. Globally this is also true of a small number of powerful industrial countries guzzling resources far out of proportion. The other model results in a large percentage of the population using a small amount of resources, as is true of a large number of populous (but rather powerless) developing countries. Equalization between the two models can only be possible by shrinking the use of resources in the first group, while enhancing resources use and controlling population growth in the second group (Figure 5). At present, both these are only pious wishes because, for instance, the USA has about 5 to 6 per cent of the population of the world, but is guzzling about one-third of the world's non-renewable resources. From the resource-consumption point of view, its population actually constitutes over 20 per cent of the world's population. On the other hand, India has 16 per cent of the world's population, but from the point of view of actual resource-consumption, it represents less than 4 per cent of the population of the world⁷. The present situation neither reflects any form of equity nor social justice, and is indeed inherently unsustainable. It needs urgent attention, for otherwise it carries in it the germ of future confrontation between developing and industrial countries. *The advice from the latter to the former regarding controlling their population will carry conviction only when industrial countries give demonstrable proof of reducing their resource consumption².*

The best option for our region with its very large rural population is *bio-industrial development*, rather than pure industrial development. The bedrock of such development is sustainable production, processing and utilization of biomass (to meet the needs of the unusually large rural sector), together with a commensurate amount of pure industrial development. Furthermore, the GNP needs to be recalculated on the basis of depreciation or appreciation in land and soil, forests, water, biodiversity, fisheries, extent of climate change and ozone layer depletion, and so on. These calculations must also include specific indicators of human development and well-being. This is where India in the course of time, can

blaze a new trail by appropriately blending economics and ecology into one connected whole. Herein lies the future of India in fostering pluralism and not singularism. This is both a challenge and an opportunity for our country.

It is clear that India cannot be against industrialism *per se* but it has to have industrialism minus its negative impacts, for example, labour displacement and exploitation and environmental degradation. The important characteristics of the two models are summarized in Table 1.

Today, a major challenge as also an opportunity before the country is how soon can we move towards sustainability. In India, if we go the way we have been so far, centuries will continue to co-exist in future. We will continue to have a subsistence India of a large number of poor and dispossessed toilers and plodders who live in medieval times, and an affluent India of a small number of people who are jet-set and wealthy who may be poised to enter the twenty-first century with a bang. How soon we take even the preliminary steps to bridge the vast gap between the large powerless subsistence and the small powerful affluent India, will determine whether we can make it to a sustainable society where we have environmental harmony; conservation of natural resources (including

energy); economic efficiency; local self-reliance; gender equality; equity with social justice; ecological, social and economic security; sustainable consumptive ethic with cultural relevance; and peace and disarmament: the dream of Mahatma Gandhi^{7,8}.

The governments in the developing countries, for that matter even in the industrial countries, have yet to evolve sensible, credible and implementable agenda for ensuring sustainable ecological and economic growth, development and security. We need a comprehensive ecological and economic code about responsibility of an individual (because a society is actually an extension of individuals), society at large and country as a whole, and, to the extent possible, even of the South Asian Region. We also need to evolve a regional approach to the global issues which has become very important on account of our shared history, culture, religion, philosophy and above all fostered by our guardian, a healthy Himalaya, without which India would have been altogether different, may be a desert.

Tasks ahead

Economy-ecology nexus

There is a close connection between

Table 1. The two models of development

Bottom-up Gandhian model	Top-down Nehruvian model
Intensification and diversification of agriculture, animal husbandry and forestry, i.e. biomass production, processing and utilization, i.e. <i>renewable resources</i>	Intensification and diversification of industrial development using mostly <i>non-renewable resources</i>
Photosynthetic/solar model: use of solar and biomass energy and some non-renewable energy	Man-made industrial economic system: Use of non-renewable resources and energy. (This model should not be accepted without environment impact assessments and environmental management plans.)
Labour-intensive	Labour displacing
Caters to over 76% of population	Covers hardly 10% people
Poverty alleviation at subsistence level	Gap between rich and poor widening: rich becoming richer, poor poorer
Governance at village level through Panchayat (village council): Bottom-up approach	Governance centralized: top-down approach
Economy of permanence: Sustainable	Economy of impermanence: Unsustainable
Rural development	Industrial development
A creative synthesis of the two models is needed for achieving sustainable bio-industrial growth and development	

Source: Khoshoo⁷.

economy and ecology. The former emanates from the ecological assets (the earth capital) with the help of technology (the human capital). Economy and ecology are intimately interrelated, interconnected and interdependent. India presents to the Parliament an annual *Economic Survey*, and then a week later announces an *Economic Budget*. It is high time that we also present an *Annual Ecological Survey* of the country followed by an *Ecological Budget* with ecological deficit in the form of pollution and ecodegradation of water, air and soil, deforestation, etc. Following preventive and restorative strategies, we can wipe out ecological deficit, and have an ecological surplus in the form of clean air, water, soil and the increase in forest cover, sustainable agriculture, etc. We have to make ecology and economics as two sides of the same coin in real terms. Ecological and economic security are mutually reinforcing.

The major task facing the country is to set right the big environmental deficit created by past ecological damage, and to ensure manageable or no ecological damage from future economic development. *The most important point underlying sustainability is that we must live on the income (in the form of annual increment) from our life-support system and not on the capital.* With proper management it is possible to enhance the income. The idea is to evolve a portfolio of restorative and preventive environmental, social and economic strategies based on hard core science and technology. Examples of these are Ganga Action Plan, Wasteland Development⁹.

Ecotechnology

Equally important is the realization that the future development is going to be through the use of ecotechnologies. In fact enlightened industrialists in Japan and Germany are increasingly switching over to such technologies on account of the realization that *there is going to be far more money in conservation technologies than in consumptive technologies.*

Urgent tasks

The most important tasks needing urgent attention are: population stabilization; land-use planning in our land hungry country; water conservation; sustainable agriculture, horticulture animal husbandry

and fisheries; conservation and sustainable utilization of natural forests and raising large scale man-made plantations in order to save our natural forests; conservation and sustainable utilization of biodiversity; ecologically compatible housing particularly slum improvement; control of pollution of air, water and soil; non-polluting renewable energy systems; minimization, recycling and utilization of wastes; green technologies; control of AIDS epidemic; environmental education and training leading to environmental ethics; periodic updating of environmental laws; blending ecological and economic imperatives; and ethical and moral dimensions of resource use.

Attitudinal change

Finally, there has to be a major change in the attitude of the human race from purely techno(logical)-economical consciousness to a broader perspective of eco(logical)-economical consciousness¹⁰, of which technology is one of the components. The important characteristics of the new environmental thinking are that it must become holistic, qualitative, spiritual, reverential, evolutionary and participatory. Herein lies the salvation of human being notwithstanding the fact that it may

soon acquire the capability to clone itself, even so it must remember that *death is a reality.*

Role of human being

The foregoing tasks are more or less attainable, but human race has to take decisions about its future role. It is a part of the overall system which ranges from her/himself to universe in successively expanding horizons¹¹ (Figure 6). This may look to be beyond one's comprehension, but it imposes an implicit responsibility on human beings. Three things stand out from this diagram. Firstly, there is a continuum from one's own self to the universe. Secondly, there is a progressive dwarfening of the human being. Someone has put this idea differently: collect all the sand grains on the surface of earth, these will give some idea of the number of celestial bodies floating in the universe. Take just one of the sand grains, that would be our Mother Earth. Imagine one's own self standing on this grain: one among billions of people and countless other organisms (plants, animals and micro-organisms) living on the earth. Obviously, one feels humbled and miniaturized beyond recognition. Lastly, the fundamental point is that human being

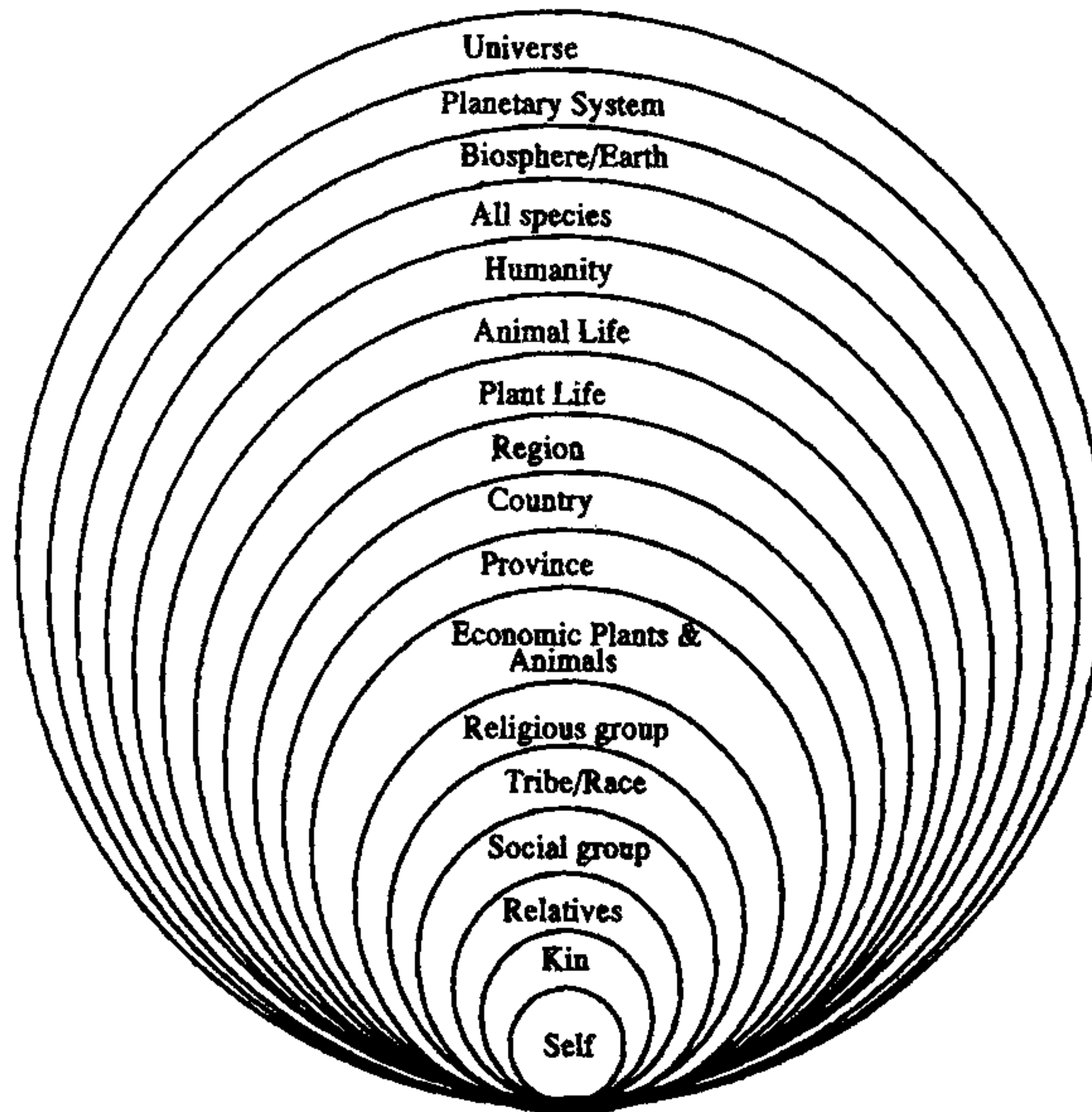


Figure 6. Place of human being in the universe. Modified from Noss¹¹.

must realize that it is not a co-creator. No doubt it is a species gifted to think, recollect and foresee, and added to this is the power of science and technology. This power must not be misused and abused. Therefore, human being must become a responsible species: scriptures talk of such a responsibility.

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ACKNOWLEDGEMENTS. I am grateful to Professors K. S. Bawa and P. Balaram for their valuable suggestions. The paper represents contribution number 56 of a research programme in Conservation of Biodiversity and Environment jointly coordinated by TERI and University of Massachusetts at Boston. The programme is supported by Mac Arthur Foundation.

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SCIENTIFIC CORRESPONDENCE

Declining semen quality in Bangaloreans: A preliminary report

The antifertility effects of environmental pollutants have been known since Roman times when the lead content of drinking vessels was suspected to be the cause of declining populations in the upper classes¹. A recent study in China has shown that exposure to low levels of lead causes an impairment of male fertility as evidenced by low volume of the ejaculate, low sperm concentrations and increase in incidence of nonviable spermatozoa². Sperm counts in Parisians declines at a yearly rate of 2.1% in contrast to Frenchmen living in Toulouse who did not show any change^{3,4}. The major difference between these two studies is that Toulouse is a rural area of France with a low population as well as car density and industrial pollution as compared with Paris. A drop in total sperm count has been reported in Greater Athens where there is an increase in air pollution⁵. More extensive studies carried out in Europe and the USA have shown that the human sperm concentrations as well as the incidence of morphologically normal and motile spermatozoa are progressively declining over the last few decades⁶⁻¹⁰. This decline has been attributed to air pollutants especially the xenoestrogens^{11,12}.

The purpose of this retrospective (1992 to 1996) study was to determine whether

there was any marked change in semen quality in the 1625 men who had come for semen analysis to Hope Infertility Clinic, Bangalore. Semen data, viz. volume, sperm concentration and percentage of motile and morphologically normal spermatozoa, during these five years was correlated with changes for the same period in air pollution indices, viz. suspended particulate matter (SPM), sulphur dioxide and lead content. SPM refers to solid and semi solid material found in the atmosphere which are less than 0.1 µm in size. SPM is a complex mixture of soot, ashes, dirt, soil, dust, pollens, molds and other carbon-based particles and acid aerosols. Particulate pollution comes from wood burning, car exhaust, mining, construction activity, plants, changes in humidity and diesel emissions.

All semen analyses were carried out in the same laboratory using methods described in the WHO Manual¹³. Data was categorized as: azoospermia (ab-

sence of sperms); oligospermia (sperm concentration < 20 million/ml); asthenospermia (> 50% of sperms nonmotile) and teratospermia (> 50% of sperms were morphologically abnormal) and tabulated year-wise.

The average values of the major air pollutants: SPM, sulphur dioxide and lead for Bangalore were obtained from the Central and State Pollution Control Boards for the years 1992 to 1996 (Table 1).

The data was analysed using a Microsoft Excel software package. The mean volume of semen and the mean concentration of sperms in 1992 and 1996 was compared using the Student's *t* test. The relationship between the semen volume, sperm concentration and the average values of the air pollutants was measured by determining the correlation coefficient between the two variables.

Mean semen volume and mean sperm concentrations were significantly

Table 1. Mean semen volumes, sperm concentrations, incidence of oligospermia and SPM values in 1992 and 1996

Year	Semen volume (ml)	Sperm concentration (millions per ml)	Oligospermia (%)	SPM (µg/m ³)
1992 (n = 410)	3.5	69 + 2.97	25	141
1996 (n = 118)	3.0	43 + 3.67	35	245