On harnessing natural resources for sustainable development

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6 January 2010

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Is the Present Pace of Economic Development Sustainable? The mainstream economics has characteristically been myopic in visualizing the relationship between human beings and the ecosphere, the surrounding in which they live, work and prosper. Man thought that everything, whether animate or inanimate, exists for him and he exists only for himself. Nature is bountiful to him; moreover, nature is immutable and invulnerable. The triumph of science in the sixteenth century onwards reinforced his belief in his power and centrality. However, he always has only a scant understanding of nature. This is evident in the statement made by David Ricardo – a leading classical economist of the nineteenth century – that the powers of the soil (read natural endowments/resources) are original and indestructible. It is evident from the fact that the neoclassical production function P=f(K,L) considers production (except in agriculture) dependent only on man (labour) and man-made resources (capital) and, in addition to confusing between the stock and the flow (Georgescu-Roegen 1971; 1986), implicitly ignores the possible implications of productive activities to the natural resources. It is evident from the fact that the neoclassical economists conceptualized economics as a science that is preoccupied with satisfying the human wants and allocating resources for meeting that end. The methodology of allocation, which is largely substitutive, incremental and local, provides no scope to incorporate long run, inter-generational implications of the allocation decisions. The economic man thinks only for himself, not even for his fellow beings; not to mention those who are not around or not yet born. Furthermore, when economics is considered as an exercise in optimization, and multi-objective optimization is fraught with methodological problems, the myopia is reinforced due to technical reasons. The myopia is also reinforced by the anthropocentric nature of the mainstream economics.

If we look into the generalized system of trophic level in our ecosystem, the material resources stand at the bottom. Lest we get confused, it must be explicitly stated that the concept of 'food' may be generalized and defined not only for the living beings (organism) but for all systems that work to use the available energy and other material resources rendering them unavailable to the future use. In this sense, for example, a car 'eats' gasoline, a cement factory 'eats' limestone, a blast furnace 'eats' ore and plants 'eat' the sunlight and the chemicals in the soil. At a little higher level, plants become 'food' to many other organisms and mechanisms. The plants are food for a great variety of animals; they are also 'food' for the furniture industry.

The plants and their products, the minerals and their derivatives, energy and its sources are all 'food' for the human beings. For the survival of the human species, it is required, therefore, that the trophic chain remains functional and healthy. It may be noted that the human species signify not only the people living today, but also those who will be born in future. The need is, therefore, to think on our present activities and its implications to the trophic system of the future generation.

Ever-increasing population and ever-proliferating demand for variety and choice together with a marked preference in favor of deliberate under-utilization of resources as well as deprecation of thrift have exposed the available reserves of natural resources to the danger of depletion. The culture based on the

market economy has made the people concerned only about producing and consuming more, with their eyes closed to the indiscriminate exploitation of resources and dumping of the obnoxious byproducts into the environment.

There is now abundant scientific evidence that humanity is living unsustainably. The environment is gradually becoming more overstressed; trophic chains and various biogeochemical cycles in the nature are being interrupted; ecological services are becoming disturbed. It may be reiterated that the ecological services are necessary for sustaining life on the earth. Costanza et al. (1997) enumerate the support functions provided by the ecosystem that are necessary for life on Earth. These are: (i) gas regulation, (ii) climate regulation, (iii) disturbance regulation, (iv) water regulation and supply, (v) habitats, (vi) soil formation, (vii) nutrient cycling, (viii) waste assimilation, (ix) pollination, (x) food production, (xi) raw materials, (xii) genetic resources, and (xiii) addressing human recreational and cultural needs. Each and all of these functions of the ecosystem have been already under a great stress due to the prolonged and indiscriminate exploitation spurred by industrialization and market-based management of the economy and the society.

The United Nations *Millennium Ecosystem Assessment Synthesis Report* (MEASR) reveals that people now are transforming ecosystems throughout the world at a faster and more extensive pace than any other time in human history. Of particular significance: 60 percent (15 out of 24) of the ecosystems examined by the authors (of the Report) are being used unsustainably; the changes being made to these ecosystems are increasing the likelihood of "nonlinear" changes (e.g., the emergence of diseases); and poor people are disproportionately being impacted by the harmful effects of ecosystem degradation (Sawyer, 2006). To quote from MEASR (pp. 56-75):

> "*The structure of the world's ecosystems changed more rapidly in the second half of the twentieth century than at any time in recorded human history, and virtually all of Earth's ecosystems have now been significantly transformed through human actions. The most significant change in the structure of ecosystems has been the transformation of approximately one quarter (24%) of Earth's terrestrial surface to cultivated systems… More land was converted to cropland since 1945 than in the eighteenth and nineteenth centuries combined… Between 1960 and 2000, reservoir storage capacity quadrupled…; as a result, the amount of water stored behind large dams is estimated to be three to six times the amount held by natural river channels (this excludes natural lakes)… In countries for which sufficient multiyear data are available (encompassing more than half of the present-day mangrove area), approximately 35% of mangroves were lost in the last two decades… Roughly 20% of the world's coral reefs were lost and an additional 20% degraded in the last several decades of the twentieth century… The ecosystems and biomes that have been most significantly altered globally by human activity include marine and freshwater ecosystems, temperate broadleaf forests, temperate grasslands, Mediterranean forests, and tropical dry forests… Globally, the rate of conversion of ecosystems has begun to slow largely due to reductions in the rate of expansion of cultivated land, and in some regions (particularly in temperate zones) ecosystems are returning to conditions and species compositions similar to their pre-conversion states. Yet rates of ecosystem conversion remain high or are increasing for specific ecosystems and regions… Ecosystem processes, including water, nitrogen, carbon, and phosphorus cycling, changed more rapidly in the second half of the twentieth century than at any time in recorded human history… The distribution of species on Earth is becoming more homogenous. By homogenous, we mean that the differences between the set of species at one location on the planet and the set at another location are, on average, diminishing. The natural process of*

> *evolution, and particularly the combination of natural barriers to migration and local adaptation of species, led to significant differences in the types of species in ecosystems in different regions. But these regional differences in the planet's biota are now being diminished... Across a range of taxonomic groups, either the population size or range or both of the majority of species is currently declining… Between 10% and 30% of mammal, bird, and amphibian species are currently threatened with extinction… Over the past few hundred years, humans have increased the species extinction rate by as much as 1,000 times background rates typical over the planet's history… Genetic diversity has declined globally, particularly among cultivated species… Human use of all ecosystem services is growing rapidly. Approximately 60% (15 out of 24) of the ecosystem services evaluated in this assessment (including 70% of regulating and cultural services) are being degraded or used unsustainably.*"

Sawyer (2006) notes that a recent study in the journal *Science conducted by Worm et al.* concludes that "*marine biodiversity loss is increasingly impairing the ocean's capacity to provide food, maintain water quality, and recover from perturbations*" (Worm et al., 2006, p. 787). If overharvesting trends continue, the study's authors report, all taxa of fish currently harvested may collapse by 2048. He also notes that in 1998, scientists in Antarctica drilled the deepest ice core ever recorded and found that carbon dioxide and methane levels are higher now than they have ever been in the past 420,000 years (Petit et al., 1999). This increase in greenhouse gases is transforming ecological arrangements by changing Earth's climate: increasing the planet's temperature, melting glaciers and ice sheets, altering weather patterns (e.g., increasing the frequency and severity of hurricanes), and changing the composition of local plants and animals (Flannery, 2005). These observations, and many others not produced here, make it amply clear that our relationship with the ecosystem has become unstable and the pace of our development is unsustainable.

It may also be noted that the very concept and movement of sustainable development is not without criticism. Anderson (2002) suggests that the real purpose of sustainable development is to contain and limit economic development in developing countries, and in so doing control population growth. It is suggested that this is the reason the main focus of most programs is still on low-income agriculture (Wikipedia: Sustainable Development). Veon, a businesswoman and international reporter, who covered 64 global meetings on sustainable development, posits that:

> "*Sustainable development has continued to evolve as that of protecting the world's resources while its true agenda is to control the world's resources. It should be noted that Agenda 21 sets up the global infrastructure needed to manage, count, and control all of the world's assets.*", Veon (2004).

Natural Endowments, Resources and Technology: Although the two words, 'endowments' and 'resources' are often used together and to many they mean the same, there is a need to give them two different meanings. It is pertinent to begin this discussion by asking a few questions. Was petroleum among the 'resources', in today's sense, before the internal combustion engine was invented? It is known that some 4000 years ago, or even before that, asphalt was used in the construction of the walls and towers of Babylon; there were oil pits near Ardericca (near Babylon), and a pitch spring on Zacynthus. Great quantities of it were found on the banks of the river Issus, one of the tributaries of the Euphrates. Ancient Persian tablets indicate the medicinal and lighting uses of petroleum in the upper levels of their society (Wikipedia: Petroleum). However, unlike these days, there was no great need of exploration, extraction, refining and transportation of the petroleum (or its ore). But petroleum is now

important. The reserves of petroleum as a crude oil existed since the unaccountable millennia in the past. It was and even now its reserves are the natural endowment, the free and generous gift of nature. But the invention of the internal combustion engine and the technology to make the crude oil suitable to be fed into these engines are largely responsible to make the resources of it and its reservoirs, and in turn to make it the determinant of the dynamics of the world economy, politics and technology.

Were the uranium ores the 'resources' (in today's sense) before the fission research was conducted during the 1930's and the technology to exploit the unique nuclear properties of uranium was invented a little later? Of course, the use of uranium in its natural oxide form is known for over two millennia, when it was used to add a yellow color to ceramic glazes. Since the late Middle Ages, pitchblende was extracted from the Habsburg silver mines in Joachimsthal, Bohemia (now Jáchymov in the Czech Republic) and was used as a coloring agent in the local glassmaking industry (Wikipedia: Uranium). However, uranium as the central material for nuclear weapons and nuclear power plants is the result of the last century's research. After this research only the metal became important scientifically, politically and economically.

Were the inert and the noble gases not present in the air before they were identified and extracted in sufficient quantities and could these natural endowments be transformed into resources until the technologies of their industrial extraction and their useful applications were invented? However, now they are very useful as cryogenic refrigerants, superconducting magnets, gas chromatography, halogen lamps, neon lights, high precision imaging, microlithography and micro-fabrication essentially needed for integrated circuit manufacture as well as for laser surgery, laser angioplasty and eye surgery.

So far we discussed regarding the natural endowments and their conversion to resources due to technological development. But is it not the same for the manmade things? Boolean algebra, although invented in the middle of the nineteenth century was languishing for about a hundred years before it could be used for designing computers. Discovery of the genetic laws of nature led to development of high-yielding plants that can support larger population per acre of land. Development of wireless communication will save enormous resources earlier needed for making wires. Gradually we are moving towards the paperless economy. Manmade fibers have reduced the need for natural fibers and the resources needed for their production. Use of appropriate technologies for generating power (nuclear, solar, hydel and wind power) may reduce pressure on the organic and conventional sources of power. And this list is too long to be enumerated in details.

What is the lesson that we have learned from this narrative? Technological development can transform natural endowments into resources. It can also redistribute the pressure on different types of resources without affecting the scope of meeting the demand for various goods. Technological development may increase efficiency (output/input ratio), reduce wastage and thus ameliorate the pressure on the resources that we have at our disposal.

Wastage and its Cultural Determinants: Wastage is one of the major reasons of draining out resources for no good. Today, worldwide, the market-system of managing the economy and the society is prevalent, and it is gaining further strength through the process of globalization. It shapes a particular type of culture, the habits of mind, which determine the action of the people. The ever-increasing scope of choice for meeting the wanton demands and defining development and welfare (of the mankind) in terms of the magnitude of such a scope of choice, a subconscious social appreciation and approval of wasteful use of resources, ever-widening positional economy (Hirsch, 1978), lax attitude to judge the appropriateness of human efforts and the allocation of resources on such endeavors are all culture-

bound. Even the proclivity to invent and contribution to development of technology and its adoption are culture-bound. Veblen has demonstrated how the dominant culture, the culture that suits best to the temperaments and the means at the disposal of the leisure class, is the culture that promotes, supports, applauds and prizes wastage of resources. Of late it has been evident in the revealed preference of technical manpower (engineers) to joining management, banks and administrative professions rather than in the professions where they could be more productive. Veblen has also shown how the market-based economic systems may be antithetical to efficiency leading to wastage of resources. To quote Veblen (1921, p. 63),

> "*The experience of the past few years teaches that the usual management of industry by business methods has become highly inefficient and wasteful, and the indications are many and obvious that any businesslike control of production and distribution is bound to run more and more consistently at cross purposes with the community's livelihood, the farther the industrial arts advance and the wider the industrial system extends.*"

Veblen (1921, pp. 8-9) argues:

> "*The mechanical industry of the new order is inordinately productive. So the rate and volume of output have to be regulated with a view to what the traffic will bear — that is to say, what will yield the largest net return in terms of price to the business men who manage the country's industrial system. Otherwise there will be "overproduction," business depression, and consequent hard times all around. Overproduction means production in excess of what the market will carry off at a sufficiently profitable price. So it appears that the continued prosperity of the country from day to day hangs on a "conscientious withdrawal of efficiency" by the business men who control the country's industrial output. They control it all for their own use, of course, and their own use means always a profitable price. In any community that is organized on the price system, with investment and business enterprise, habitual unemployment of the available industrial plant and workmen, in whole or in part, appears to be the indispensable condition without which tolerable conditions of life cannot be maintained. That is to say, in no such community can the industrial system be allowed to work at full capacity for any appreciable interval of time, on pain of business stagnation and consequent privation for all classes and conditions of men. The requirements of profitable business will not tolerate it. So the rate and volume of output must be adjusted to the needs of the market, not to the working capacity of the available resources, equipment and man power, nor to the community's need of consumable goods.*"

The same motives of the business men also determine whether the scientific inventions, the innovations, the achievements made by the research and development and the like are shelved or partially/fully harnessed to enhance or thwart efficiency and productivity. The societal value system has a marked preference for administration, accounting and financial management. To quote Veblen (1921, p. 21) once again,

> "*This sustained advance in productive capacity, due to the continued advance in technology and in population, has also had another notable consequence. According to the Liberal principles of the eighteenth century any legally defensible receipt of income is a sure sign of productive work done. Seen in the light of this assumption, the visibly increasing productive capacity of the industrial system has enabled all men of a liberal and commercial mind not only to credit the businesslike captains of industry with having created this productive capacity, but*

> *also to overlook all that the same captains of industry have been doing in the ordinary course of business to hold productive industry in check. And it happens that all this time things have been moving in such a direction and have now gone so far that it is today quite an open question whether the businesslike management of the captains is not more occupied with checking industry than with increasing its productive capacity.*"

The International Council of Science (ICS) explicitly recognizes the role of culture in development and application of science and technology (especially to support sustainable development) but laments the scant research done in this sphere. "*The challenge of effectively harnessing STI [Science, Technology and Innovation] for SD [Sustainable Development] requires linking the universal aspirations of science to the diverse realities of social life embedded in different cultural contexts. Culture and values define our goals, frame our attitudes, and provide standards against which the behaviour of individuals and societies can be judged… however, relatively little is known about the long term global trends in values, attitudes, and behaviours that will both help or hinder a sustainability transition. There are a number of isolated studies which attempt to show how integrated conservation and development projects have, over the medium term, assisted in changing local attitudes and behaviour, but global data on sustainability values, attitudes and behaviour, however, do not exist.*" (ICS, 2005, pp. 18-19).

The Signs of Transition to the Post-Industrial Society: If we look into the trends of development in the last few decades, we observe the signs of the arrival of what Bell (1973) called the "Post-Industrial Society", although these signs are more vivid in the developed/industrialized societies and rather pallid and only apparent (partly misleading too) in the less developed/industrialized societies. Bell predicted that by the end of the 20th century, the US, Japan and Western Europe would reach the post-industrial stage. This "post-industrial" stage would be characterized (Wikipedia: Sociocultural Evolution) by:

- domination of the service sector (administration, banking, trade, transport, healthcare, education, science, mass media, culture) over the traditional industrial sector (manufacturing industries, which have surpassed the more traditional, agricultural and mining sector after the 19th-century Industrial Revolution);
- growing importance of information technologies;
- increased role of long-term planning, modelling future trends;
- domination of technocracy and pragmatism over traditional ethics and ideologies;
- increasing importance and use of technology and intellect;
- changes in the traditional hierarchy of social classes, with highly educated specialists and scientists overtaking the traditional bourgeois;

As Florida (2002) has shown, *the* U.S. society may now be classified into four main occupational groups: agricultural, working, service and creative classes. The creative class is engaged in complex problem solving that involves a great deal of independent judgment and requires high levels of education. This class includes a super-creative core of people in science and technology, and in arts and humanities, creating new ideas, new technology and/or new creative content. *This creative class* comprises about 30% of the workforce including the 12% super creative core.

Although similar statistics (as we find in Florida's elaboration) may be presented for the less developed counties also, it is doubtful that such a class really functions and could be considered as creative in such countries. In less developed countries the creative core is much smaller in quantity and much inferior in quality. The research work being carried out in various universities and dedicated (specific) research institutions are much geared to ostentation or 'display' by means of annual reports, research project

reports and statistical juggleries of various sorts to justify the existence of the institutions and the languishing 'intelligentsia' hanging around and their unproductive utilization of scarce economic resources. The hope of less developed countries, therefore, lies in the benefits of being the latecomers as well as trickling down of knowledge and technologies in the wake of globalization.

Are We Actually Serious about the Dwindling Sustainability of the Pace of Development? To give a couple of simple examples, especially in the Indian context, let us consider the use of ball pens, so popular these days, that we hardly find anyone writing with a fountain pen that used a nib and ink. The fountain pen technology was environment-friendly, but the ball pen technology results into throwing of billions of used, plastic-made and hardly degradable, ink cartridges into the environment. Ball pen refills are not refills in any true sense. Use of cars in preference to the public modes of transport and the policies of government and financial institutions raise doubts on our seriousness to consider sustainability as a real issue. Although wind and solar power generation may be technically feasible, much has not been done to popularize the related technologies. Recycling of wastages is rather a matter of academic discussion. Mines are being harnessed most uneconomically and in a wasteful manner with all their serious implications to the economy, the society and the environment (Tripathi et al. 2005; Shankar et al. 1993). Policies of regeneration of forest resources and medicinal plants are implemented with a conspicuously relaxed attitude. The alternative/traditional medical system, such as Ayurvedic (one may consult the Ayurvedic Nighantu for details), Unani, Tibbi and Homoeopathic (one may look into the Indian materia medica and pharmacopoeia), recognize a large number of plants (and animal products) that have well-documented and well-tested curative powers. These resources are at present exploited without any plan and consideration for their conservation, replenishment and cultivation. Presently many of them have become rare and are gradually approaching to extinction. However, the Government and the researchers are oblivious and busy at concentrating on only a few of them. The research in the West determines the value of the medicinal plants in the East. Even collection of relevant data and information, which the Government Departments and the Agencies ought to have collected, is limited to the purpose of annual reports and hardly cater to any scientific investigation or policy-making, and, therefore, a research work on evaluation or policy formulation has to rely on scanty data and a basketful of assumptions (Barik and Mishra, 2008). New sectors, such as the tourism industry, are looked upon as a source of income to the state, but the harmful effects of tourist visits on the environment at the tourist sites are grossly undermined.

Due to such a casual concern, little could be done in the past to manage natural resources for sustainable development. In its Report of the Working Group on Natural Resources Management - Eleventh Five Year Plan, the Govt. of India (2007) admits: *"During the last three decades, despite considerable emphasis on conservation, natural resources degradation in the country has accelerated. Over exploitation of ground water across the country has resulted in increasing number of dark blocks every year. Improper use of surface water is resulting into water logging and salinity in soil to such an extent that it is nullifying the creation of additional area under irrigation. Unbalanced use and at times excessive dependence on chemical fertilizers (particularly urea), is deteriorating the chemical, physical and biological properties of soil. Mining of soil nutrients and depletion of soil organic matter is resulting into soil fatigue, which is affecting the growth in agriculture productivity. Degradation of perennial bio-mass in common land / forest department land continues to increase in spite of significant efforts under joint forest management. This is leading to enhancement of flash flood during rainy season, reduction in base flow during post rainy season as well as over all shortage of food and fodder. … The technology fatigue, soil fatigue, declining fertilizer response rate, depleting water resources, irrigation potential and capital stock and agro-climatic aberrations are identified as the key factors behind the deceleration in*

agriculture growth. The agriculture economy is seriously affected by the unsustainable use and degradation of the natural resources. (Ch. VIII: p.91)

This attitude is not only limited to India or the less developed nations. Gillespie (2001), studying the situation of economic growth, markets, trade, debt, aids, peace and sovereignty in the developed nations concludes that notwithstanding the emergence of the concept of sustainable development, the conventional paradigm of development remains largely intact. This implies that "without serious consideration of a number of underlying concerns, all the rhetoric pertaining to social and environmental sustainability may come to nothing".

What can be done to Ensure Sustainable Development? Bringing human use of natural resources within sustainable limits will require a major collective effort. Ways of living more sustainably can take many forms from reorganizing living conditions (e.g., eco-villages, eco-municipalities and sustainable cities), reappraising economic sectors (permaculture, green building, sustainable agriculture), or work practices (sustainable architecture), using science to develop new technologies (green technologies, renewable energy), to adjustments in individual lifestyles, etc (Wikipedia: Sustainable Development). However, such changes require concerted efforts, and not the lip service and the rhetoric. There is a need to sensitize the people, especially the supposed and potential 'creative core', to direct their efforts to a serious thinking and action to change our present preoccupation with an unsustainable development towards sustainable development. The International Council for Science (2005) explicitly highlights the role sustainable-development-oriented education. To quote ICS (2005, p. 23):

> "*… with respect to the goals of SD [Sustainable Development], it is also necessary to encourage and develop innovative new approaches to education and training. Educational curricula at all levels, but particularly in higher education, should be reexamined from a sustainability viewpoint. Educational and training efforts should encourage linkages between natural and social science disciplines, development studies, and applied technology and engineering fields (although at the same time, this must be balanced against an ongoing need for strong grounding in the basic disciplines of science and engineering).*"

CTA (2005) stresses the need to conserve and harness bio-diversity to ensure sustainable development. The Convention on Biological Diversity (CBD Secretariat, 2005; CBD Secretariat at http://www.cbd.int/secretariat) defines 'biological diversity' or biodiversity as ' *the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems*'. As it is well known now, the stability of ecosystems is directly related to biological diversity. "*Biodiversity underpins sustainable development and is essential for food security, maintaining forest productivity and environmental protection and for developing new products. It plays an important role in the agricultural sector as a source of food and food products, genetic material for agricultural product improvement, bio-control agents including bioactive compounds and botanical pesticides and in several other industries as raw material for production of timber related products, textiles and pharmaceuticals and nutraceuticals, and contributes to ecosystem balance including maintenance of soil fertility.*" (CTA, 2005). The loss of species and the destruction of habitats and ecosystems reduce this diversity, and in turn undermine the ability to withstand or to recover from severe disturbances. Therefore, conservation, preservation and a planned harnessing of bio-diversity is essential to sustainable development. For formulating an appropriate policy to this end it needs a

multidisciplinary approach. It needs expertise in a wide range of areas including taxonomy, ecological engineering, chemistry, biochemistry, pharmacology and advanced biotechnology. Building the scientific expertise is of extreme importance to support the type of coordinated research programs that are needed to achieve maximum benefits from biodiversity and contribute to wealth and job creation and improved health. It is exactly here that we need the contribution of the 'creative core' and an effective governance of research activities.

The Economic Commission for Africa (ECA) elaborates how technologies can be harnessed to ensure sustainable development. Research work and harnessing of the resultant knowledge to use biotechnology is one of the key instruments. "*Biotechnology offers rich opportunities to increase agricultural productivity and address current food shortages ... It accelerates plant and animal breeding efforts. It offers solutions to previously intractable problems.* [We] *need to develop appropriate national policies and identify key national priorities for biotechnology, bearing in mind the potential biological risks and the needs of poor people who rely on agriculture for their livelihoods. And the international community needs to loosen the arrangements for access to proprietary technology - enabling developing countries to provide poor farmers with improved seeds while protecting them from inappropriate restrictions on propagating their crops. … Governments should involve diverse stakeholders in the development of national biotechnology policies, strategies, and plans. And they should encourage full and candid discussions on biotechnology, aimed at determining how best to address problems while building achievements. Biotechnology policy should take into account national development policies, private sector interests, market opportunities, and mechanisms and links for the diffusion of technology*.", ECA (2002, p. 118). The ECA also highlights the use of 'red biotechnology' in health programs for sustainable development. Red biotechnology is a cluster of scientific techniques applied to the medical field that include genetic engineering, genomics, and pharmacogenics. Red biotechnology uses substances naturally produced in the human body, such as proteins and enzymes, to fight infections and diseases, or substances in plant and animal cells to produce medicines for human use (Europabio, 2001). Its application in medicine, diagnostics, gene therapy and making suitable vaccines are enormous (ECA, pp. 132-133). Once again, the role of the 'creative core' is central to development and providing of right direction to the use of 'red biotechnology'.

The ICS (2005, p.20) observes that "*most countries distinguish between R&D policies that focus on the generation of new knowledge, and industrial policies that focus on building and manufacturing capabilities. Convergence of these two approaches could foster the expanded use of existing technologies, while also building a foundation for long term R&D efforts. This requires paying particular attention to technologies that have broad applications and profound implications for long-term economic transformation*". This observation encompasses not only new technology (such as bio-technology and nanotechnology) but also the traditional industrial technology.

Urbanization, industrialization and economic development have grown rather collinearly in the last few centuries. Each one receives a positive feedback from the other to assume an ever-accelerating growth. This collinearity has made sustainable development more vulnerable. In India, for example, urban development (genuine urbanization and urban accretion together) is facing acute problems leading to inefficiency as well as long-run un-tenability. It is needed that the policies on urban development should look into some key questions raised by the International Council for Science (ICS, p. 21). These are: (i) what new institutional and governance structures are needed to deal with sustainability problems on the scale of a city-cluster? (ii) What technological developments are needed (for instance, in the sectors

of housing, transport, production of industrial goods) to enhance the sustainability of these urban complexes? (iii) How do the values and norms of urban residents affect their willingness to accept institutional and technological innovations, as well as their personal lifestyle choices and consumption patterns? (iv) What are the key environmental, social, economic factors that affect the vulnerability and resilience of different populations and ecosystems within these urban clusters? Since the problems of urban development are country specific, the approach to urban policies for sustainable development will have to be specific to the urban clusters in their own purview.

So far we have looked towards the 'creative core' to help in harnessing resources for sustainable development. However, the roles of other stakeholders are no less important. For example, the United Nations Development Programme (UNDP) draws heavily on the cooperation of non-Governmental agencies and volunteer network. The UNDP is connected to the volunteer sector through its Nations Volunteers programme (UNV). The UNV aims to assist environment practitioners within UNDP (and elsewhere) to draw on this resource systematically. As a globally networked organization, UNDP mobilizes volunteer-involving organizations such as NGOs, civil society organizations, community organizations, etc. In this regard, the role of national governments is to facilitate, and keenly monitor and evaluate, the functioning and contributions of such organizations. However, unless the political will is strong, proper governance of the functioning of NGOs, civil society organizations, community organizations is not an easy task. In India, for example, the role of government in monitoring and evaluation is quite lax, due to which real effects are scanty. In its Report of the Working Group on Natural Resources Management - Eleventh Five Year Plan, the Govt. of India (2007, p. 92) admits: "…the participatory approach is still not institutionalized over a wide area especially in the Government funded programmes in spite of evidence of its success (on a limited scale).

In the XI Plan, the Govt. of India formulates an encouraging approach to development and management of natural resources. It has two components, namely, (i) development of natural resources and (ii) management of natural resources. The part 1 of this component consists of five sub-components, namely, (i) large scale development of land, water and perennial biomass, (ii) treatment of problem soils, (iii) plantation of horticulture crops, (iv) limited development of rainfed farming systems through trials and demonstrations, (v) development of need based infrastructure, and (vi) establishing support systems for livestock. Likewise the part 2 of this component consists of five sub-components, namely, (i) formal allocation of users' right over CPR [common property resources], (ii) collection of user charges for CPR, (iii) repair and maintenance of assets in CPR, (iv) sustainable use of natural resources, and (v) preparation of Strategic Plan for development of rainfed farming systems in the entire project area. (Govt. of India, 2007; p.94). The effective implementation and success of this approach is yet to be seen.

To conclude, sustainable development – the entire philosophy and approach to it – requires changes in institutions, more specifically the habits of thought and action, to opt for and adopt the new paradigm of development, to change the taste and liking regarding consumption, to think of social priorities and obligation vis-à-vis the personal ones and so on. Attitudinal changes, the alteration of the world view and the habits of thought, are only possible by a proper and holistic educational planning and an efficient governance of the academia, the government departments and the law-making and law-protecting framework of our society. We have highlighted the role of the 'creative core' and good governance, but the intelligentsia, especially in the less developed nations where social consciousness is dominated by the myopic personal agenda, will not be effective unless the monitoring of the entire program of development is efficient. The people must, therefore, come forward. But, while social consciousness is weak and dormant, this requirement pushes us into the vicious circle. This vicious circle is the real trap and obstacle to sustainable development.

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