15. I am grateful to Dr Niranjan Joshi who informed me about options in education that a science student perceives, that I as a professional (medical) student did not. He further informed me that only by B Sc and M Sc does the student really understand that he/she has the full option *not to study*, something that is not often realized at school level. For the first time I understood that we are talking of adult options!
16. A major eye opener for me was the summer training. When everybody was getting through CSIR–UGC NET, whatever we did was good. Even if students goofed during much of the summer (many did not), it was alright. Now that performances are plummeting down, the question became more acute. What were they doing for these two months? Did it add to something? Again the truth is hard to get at over the large barriers of politeness on all fronts. One suspects that an open-ended programme without strong prior commitments is not likely to be useful.
17. When I was a medical student, my chief of surgery told me something that I never forgot. He said, 'If the patient actually lives, you can never be sure that it is because of you. If the patient dies, you can also never be sure that you did not do something worthwhile to prevent it.'
18. Practicals are often a joke since, in the absence of testable experiments, Lowry or Biuret represent the only doable practical, excepting perhaps a language course or statistics (the latter is quite acceptable to me!).
19. The traitorous feeling is only replaced by even a more horrible feeling of being an absolute liar.
20. Anil Gore mentioned to me that an education officer reporting on the status of his county (in the USA) asserted that all his wards were definitely above average!
21. In the last 12 years, I have noticed that M Phil students invariably score less than the M Sc in their so-called course work. Amazingly few publications arise from this M Phil programme. I am equally amazed by the number of theses judged outstanding by the external examiners (usually a restricted breed of obliging souls). Fortunately our Biotechnology programme has been considered interdisciplinary and students are not compelled to join for M Phil, a time-pass occupation for the transit students.
22. Incidentally this data is available for any student that passed through our hands for any year and can be had for asking.
23. Since departmental functioning is democratic, we cannot formally give our recommendation letters in this format. Actually nobody asked us this way either except universities abroad. So far we have been making do with some approximate statements while precise statements are now available.
24. The term adult choice is not restricted to what goes on between consenting adults. It is more akin to the notion of adult education. Teaching adults is characterized by the fact that these adults have a different level of social and interactive abilities, which are different from children. Therefore they have to be handled differently and oriented and motivated differently.
25. The referee adds, 'even fewer at the Ph D level'!

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COMMENTARY

Sustaining development in the developing countries

T. N. Khoshoo

Sustainable development entered in the environmental agenda in the second half of the eighties, more so when the book *Our Common Future*[1] was published in 1987 by the World Commission on Environment and Development (WCED)[1]. As of today, sustainable development is fast becoming a composite discipline and involves several major disciplines including science, technology, sociology, economics, ethics, trade and law. But defining sustainability in exact terms has proved to be difficult. This does not mean that the concept of sustainability is not relevant. One of the easiest ways to comprehend sustainability is that the rate of harvest from a renewable system must never exceed the rate of annual increment. If it remains within that limit, and, if there are no major environmental perturbations, the system can go on *ad infinitum*.

In 1992, that is five years after the publication of the above book, United Nations Conference on Environment and Development (UNCED) was held at Rio de Janerio with over 30,000 attendees. Thereafter the term sustainable development became very popular all over the world. Most people thought that these two words constituted a panacea for all the environmental ills and problems facing the earth. Considerable euphoria was generated on this account, and, during the last decade, an unusually large number of books and papers appeared on this subject. Increasingly it became clear that sustainable development was not a panacea for all the environmental ills. Furthermore, it also became fashionable to prefix eco- or green- before every word or action so as to make such expressions (and sometimes even the tasks) ecologically respectable and thereby legitimize the same even when these are basically unsustainable. Much of it was only in words and little in deed. Thus in real terms, sustainable development still remains an enigma. For instance, what is sustainable development for the resource-guzzling industrial world in its megacities, or an eskimo living in the arctic circle, or the ecosystem people in the dense tropical forests of Africa, Amazonia or Andamans, or the very small hamlets in the Himalayan or Andean highlands, or people in deserts of Sahara, or the poor fishermen living in coastal areas, etc. The question arises that for such diverse situations, are there some common principles that would make development sustainable? Regrettably, so far the concept of sustainable development has been treated more as a socio-economic and political concept. Sustainable development would need tremendous inputs from many areas including science and technology. Another dimension of the problem is that

sustainability in the ecological and economic systems has to be checked against a particular time-scale. It may vary between the life span of an individual, a species, or the earth itself.

The net result is that the concept of sustainability is becoming increasingly complex and amorphous. There is need for considerable thinking, debate, analyses and even modelling so as to define precisely the conditions and policies that help to confer sustainability in general, and in a specific ecological, socio-economic, scientific, technological and industrial situation. Reconciliation between economic and biological systems is also one of the central issues. For instance, what should be the population of human beings in a given time frame with a particular resource-base available in a particular habitat against a particular socio-economic, scientific and technological milieu? These are indeed difficult questions but need to be looked into in depth with a healthy and a positive approach. Thus the euphoria generated earlier has of late been gradually (but perceptibly) subsiding and scientists, technologists, economists, sociologists and others have begun to grapple with hard facts.

One year before the publication of the report *Our Common Future*, the present author[2], while presiding over the 73rd Indian Science Congress Session (1986), was among the very first to speak and write on *Environmental Priorities in India and Sustainable Development*[2]. Perhaps this was among the very first research papers to paraphrase the concept of sustainable development as applied to a large populous country like India which is reasonably rich in resources but not so rich in technology, and essentially is a country of poor people. Twelve areas of work were identified that could help to confer sustainability in this country. This publication immediately became teaching material in India and abroad. Today there are a large number of definitions of sustainable development (some think the number is over 100).

Originally the WCED[1] described sustainable development as development that ensures meeting 'the needs of the present without compromising the ability of future generations to meet their own needs'. It implies that the present generation has to impose voluntary limits on the use of resources as dictated by the present state of technology and socio-economics and the resilience of biosphere to absorb the ill-effects of human activities. As a starting point this may be a reasonably good premise.

By the time the Rio Conference was held in 1992, a good deal of literature was generated on the subject. During the subsequent five years (1992–1997), this concept was debated threadbare, and in 1997 the UN General Assembly held a special session to commemorate Rio + 5 (years). The concept of sustainable development got a big jolt on account of the stand taken by the US President himself. This was notwithstanding the fact that there is a UN Commission on Sustainable Development which reports through ECOSOC to the General Assembly of the United Nations.

The Indian scene

India is a populous, fairly resource-rich and a reasonably science and technology-rich country. Even if India exercises strict population control, its population will still keep on increasing for the foreseeable future because prospective mothers and fathers are already with us. This is true of most developing countries in Asia, Africa and Central and South America. So far priorities have been dictated by industrial countries. A time has come for reversal of roles, because the industrial countries (Northern consumers) are using resources far in excess of their requirement and the rate of renewal of the renewable resources. Furthermore, the developing countries cannot afford a situation where machines replace people. This will be counter productive. They need, what has been called labour-intensive industrialization, or, should we say, *humanization of industrialization*. There is only a very general and a casual appreciation of economic evaluation of Nature's services; therefore, there is a need to evaluate such services in social and economic terms. This alone will bring home to the developing countries the scientific, technological and economic value of ecological assets and help in their proper conservation based on S&T principles.

In general the western countries have been rather indifferent to making even modest alterations in their highly consumeristic lifestyles. They give the impression that the concept of sustainable development would be a drag on their development. On account of such indifference of industrial countries, the 1997 UN meeting on environment has been summed up in the famous equation: Rio + 5 = 0. This equation conceals little but reveals a lot. The Kyoto Conference on Climate Change held in November 1997 and General Assembly of this Global Environmental Facility (April 1998) were not materially different. This is in line with the stance taken by industrial countries in several other conferences and meetings. One only hopes that there would be a real and lasting understanding between industrial and developing countries on this account.

The concept of sustainable development can still be a rallying point at least for the developing nations. There may not be total unanimity about the exact definition of the term, but its application can become widespread. One can hazard a reasonably good guess about the basic principles underlying such development which could confer sustainability no matter which habitat or people are involved. With proper policies and programmes there is a possibility of ensuring good degree of sustainable development in developing countries which have large populations and face a science and technology crunch.

In India there is yet another dimension to the problem of sustainability. Part of India's economic strength lies in the unusually large number of villages (576,000) and the habitations around the megacities. In terms of employment, the contribution of agriculture, animal husbandry, fisheries, village level small industry, vendors, rag and trash pickers, hawkers and the like of these is significant. Actually they are small-time producers who are unrecognized for their contribution to India's economy. No one has ever ventured to calculate in fiscal terms their contribution to the economy. Taken together they make a significant economic contribution. Though these are small vocations, these constitute the largest employment sector. With marginal technical and fiscal inputs, and with improved work and working conditions, their contribution to economic sustainability can become considerable. This is also clear from the fact that each and every megacity in India is indeed a twin city: the megacity proper and the slums round it. The two are interdependent in ways more than one, but at present both

are inherently unsustainable. While it is difficult to bring sustainability to the megacities on account of its resource-guzzling nature, the slums could be improved with marginal economic inputs, appropriate housing, sanitation and medicare. This segment of India's population can no longer be ignored in any consideration regarding over-all sustainability of the country.

Due to over population, our environmental assets (land, soil, water, air, forests, biodiversity, fisheries, etc.) are indeed highly stressed on account of over-extraction, over-utilization due to demand over stripping the mean annual increment or repairing capacity of these environmental assets. This indeed is not a healthy sign.

The root cause for unsustainability

The present economic system is based on the Keynsean Model. The basic philosophy on which this model rests is clear from the words enunciated by John Maynard Keynes in 1930: '*For atleast another hundred years we must pretend to everyone that fair is foul and foul is fair; for foul is useful and fair is not. Avarice, usury and precaution must be our gods for a little longer still. For only they can lead us out of the tunnel of economic necessity and into daylight*'.

There is now a need to rethink about the Keynesean economics, and blend ecological and economic objectives into a mutually supportive and an integrated system. This is possible when we calculate the *real* economic value of our natural resources. For instance, what is the value of components of the biosphere like fresh air, clean water against dirty and polluted air and water, fertile vs degraded land, forested vs deforested areas, or what is the scientific and economic value of our rich biodiversity, etc. Most environmental organizations do not take up work on such innovative and relevant topics. There is a strong case for an annual National Ecological Survey and National Ecological Budget along with the National Economic Survey and National Economic Budget. The two have to be mutually reinforcing. Ultimately we need a methodology to calculate in realistic economic terms, both eco-decline and eco-regeneration. The two go hand in hand. This is only possible if we know how to cost natural resources realistically. We have today only a vague and a casual appreciation of Nature's services which now need to be costed realistically. It is here that considerable amount of S&T and economics would be involved. This will bring home to less developed countries (LDCs) the value of their assets and build a climate for sound resource conservation based on sound S&T and economic principles. It is here that studies like the one undertaken by TERI[3] have become most relevant. Such studies would need periodic updating not only by TERI but also by several other organizations dealing with individual subject areas.

The present economic system has evolved on a mistaken notion that natural resources are abundant, population is still not so high and ecosystem regenerability is higher than degradability. In addition, it is also due to the lack of a strong S&T base in developing countries. It is now abundantly clear that none of the foregoing assumptions is true and now one has to seriously ponder about it. The root cause for all these ills is the rising population and lack of S&T infrastructure in the developing world and over-consumption and wrong use of S&T in the industrial world.

The ground reality

Roughly 38% of the people in India live below the poverty line. They destroy the environment on account of their needs, while the rich destroy environment out of greed. To bring the former out of the present morass of poverty is one of the most important scientific, technological, economic and environmental challenges facing the country. For instance, firewood is still the only or the most important energy source in most, if not all, villages and even among poor sections in the mega-cities of India. Media always show head-loads of firewood and fodder collected from near-by forests and carried by women, but never cycle-loads of firewood (little pieces of stray wood and fallen branches from trees) carried by poor men working in posh localities in the cities. Both these are common sights. This is so notwithstanding the fact that we have in this country all conceivable energy systems ranging from burning of cowdung/firewood/trash to atomic power with everything in between. The poor in the villages still have to sweat and toil for food, fodder, fuel and water. This is particularly true for village women who have to toil to make their ends meet with the added burden of acting as child-bearing machines. This is a reality, even though India has made good deal of progress in development during the last 50 years. The problems of the poor have not attracted the attention of the scientific and technological community in India except in the agricultural sector. This is indeed most regrettable.

In agriculture, India has made spectacular progress through the Green Revolution. Here was an area where commitment of the political system was total when it said that in India *agriculture cannot wait*. Our agricultural scientists and technologists rose to the occasion. However, the tempo has not been kept up, and today there are signs of a *browning of the green revolution*. Given the wherewithal and the commitment of the agricultural scientific community, it should be possible to have a successful Second Agricultural Revolution. It is within their competence and comprehension. Agricultural diversification, application of relevant S&T including biotechnology and small-scale industry are the answer to elimination of the abject poverty in the villages. People need economic, social and technical support and facilities for credit and linkages with market. This would help marginal farmers and even landless labour.

The welfare of villages with development based on ecological and economic principles and gender equality together with access to education, health care, livelihoods, credit and decision-making are critical to the success of such eco-development. This would make women, who constitute 50% of the workforce, self-reliant by offering opportunities for education, better skills, livelihood security, right to make decisions (including the number of children they need to have), generate microenterprises and have access to credit at the local level. They can then play an important role in alleviating poverty.

The local communities have to be adequately strengthened and empowered economically and socially. This would bring people into the mainstream of development. This applies particularly to the rural women. Not only their quality of life but

also their access to resources have to be improved. It can happen only when they participate in decision-making through Panchayati Raj.

Any government, howsoever strong and efficient, cannot do everything by itself. Sustainable development in India can be a reality only when proper linkages are built to sustain such development on a participatory basis and decentralized governance. The overwhelming number of villages in India cannot be governed, managed or served from Delhi or even from the state capitals. Centralization has not paid dividends as is clear from 50 years of experience. Communities have to come forward to take up the challenge. Wherever decentralization has taken place in India[4–6], the results have been remarkable, because participatory management rests on decentralized governance, increased access to resources on a fairly equitable basis and generation of employment. Benefits in such cases have been reasonably equitable regardless of the social and economic status of the concerned community members. The net result has been that livelihood security of the rural communities has increased.

Communities have to come forward to take up such challenges. Decentralized governance has been the sheet anchor of such development. Any civil society has to guarantee a better future with long term security of its people. Therefore, in a developing country, sustainable development must generate economic and social growth that is equitable with no or manageable effect on environment. It must also lead to empowerment of people. Such growth and development will widen the range of choices and opportunities for the people. Use of Panchayati Raj institutions must, therefore, be encouraged.

What will confer sustainability?

There is an urgent need to work out the carrying capacity of different systems in terms of growth of population, resource availability and use, and the technology used. These systems vary from the natural ecosystems where ecosystem people live, to agricultural systems (from subsistence to sustainable ones) and to a variety of industrial economic systems, and from rural and small scale, to urban and large scale industry. The idea is to help developing countries to reach the goal of sustainability, a concept which at present is still eluding them.

For bringing sustainability in the poverty-stricken villages of Bihar, MP, Rajasthan and eastern UP (the so-called *BIMARU* states) and Orissa, there are no reliable studies. Also, we hardly know the way we can bring even a reasonable amount of sustainability in industrial areas in the developing world let alone in the industrial countries. Most global environmental problems of the world actually emanate from the industrial countries. The latter have been over-taken by techno-optimists who care less and even advocate getting resources from other celestial bodies. Notwithstanding the inquisitiveness of the human mind, the situation prevailing today shows little attachment to Mother Earth atleast in the industrial countries who exploiting the earth of its resources are now trying to reach other planets in our solar system. Even with all the uncertainties the concept of sustainability is still most useful to both the developing and industrial countries.

For making sustainable development a reality under varied environmental conditions, deep thinking is needed about what will confer sustainability under a particular scientific, technological, social, economic and cultural milieu. As we go along, these studies can be increasingly refined and perfected. Obviously sustainable development is a function of a whole constellation of factors. As pointed out above, in 1986 the present author thought sustainability in India can be conferred by bringing an understanding of about 12 issues[2], but today with better understanding and a wider perspective, the list has to be expanded to many interconnected, inter-related and interdependent issues. The list may expand further or even contract with better understanding about the complexity regarding paraphrasing of sustainable development in specific scientific, technological, economic and social terms. We therefore need critical studies on the following issues which are grouped under five heads for convenience:

Sustainable management and utilization of natural resources

Stabilization and control of human population growth; integrated land-use management; conservation of water resources including its rational use; sustainable forestry for long-range ecological security and meeting rural, urban and industrial wood needs from plantations, and helping in ecological revival/restoration; conservation and utilization of biodiversity and its linkages with cultural, economic, ethical and social diversities; sustainable agriculture, horticulture, animal husbandry and fisheries; protection of coastline and conservation of biowealth in the extended economic zone (EEZ); integrated and sustainable energy systems and augmentation of research, development and demonstration in solar and bioenergy systems with particular reference to rural areas; ecologically compatible housing and slum improvement; control of pollution of air, water (fresh and marine) and of land; waste and residue minimization (including hazardous wastes), and recycling of wastes so as to make industry environment-friendly; and sustainable development of island communities.

Improving health and access to resources for weaker sections and women

Primary health care in rural areas; updating health services and evolving strategies against disease-causing drug-fast microbes and the AIDS epidemic; strengthening ecological, social and economic security of women and weaker sections of the society; free access to fertility control measures particularly to women from the weaker sections of society and harnessing women's power; and sustainable livelihoods for the poor.

Economic and ecological efficiency and security

Proper economic valuation of natural resources; transition from ecologically insensitive to ecologically sensitive economy, and dovetailing economic, ecological and social goals; reducing and then eliminating poverty by strengthening ecological, social and economic security; environmental costing of projects; building environmental accounting system(s) by making ecology and economy mutually supportive; strengthening ecological security at the national and regional levels; environmentally sustainable trade development; and generating employment and sustainable livelihoods.

Making technologies ecofriendly

Transition from eco-unfriendly and consumptive, to eco-friendly and conservation

technologies including eco-labelling of products; strengthening micro-enterprises; improving environmental information technologies including collection and dissemination of data; environmental education and awareness; environmental rating of projects; environment-friendly biotechnology; regional cooperation in environment; and strengthening scientific and technological bases of sustainable development.

Participatory management

Decentralizing governance by appropriately blending top-down and bottom-up development patterns; encouraging participatory management; and periodic updating of legal support.

This is only an illustrative list of concerns which need to be updated and refined before taken up for implementation. By and large most of the foregoing issues are common to most developing countries because these countries are reasonably rich in resources but poor in technology. This group of countries need to take a hard look at abundant local technical knowledge and mini-local enterprises because many of these can confer sustainability at the local level, which would enliven this segment of the society. This would involve the use of S&T, sociology, economics, ethics, law and other cognate subjects. It may be pointed out that each developing country will need to work out indepth its own pattern of sustainable development in relation to its social, cultural, economic and religious milieu and availability of resources and the level of technology. For instance, what is true for USA may not be true for India because the former is about three times larger in area[7], with 3.5 times less population[8]. USA is technologically a very advanced country, but is it doing enough to achieve sustainability?

Techno-optimists in USA have advocated that resources can be obtained even from neighbouring planets. Accordingly, the country is now racing to colonize Moon and Mars. It is not doing this only for scientific, technological and intellectual reasons but there appears to be a long-range covert agenda: once the resources of the earth are depleted, perhaps they would get the same from moon and/or mars. Hence USA is involved in geological prospecting (including water) of these celestial bodies. Furthermore, this programme also appears to be aimed at containing possible threat to USA from any country which may oppose it. It is, therefore, a deep-seated economic, industrial and military agenda with a guaranteed long-range investment from the US Government. This idea is to ensure flow of resources which in turn will ensure a particular life style which is basically unsustainable. Thus this exercise is not only an exercise of scientific exploration but also an exercise to control resources that may be available in the celestial bodies nearest to the earth. History is repeating itself; only some five hundred years ago, Irish and other Europeans set out to colonize and subjugate indigenous peoples of the Americas, Africa, Australia, New Zealand and parts of Asia including India. No doubt they were enterprising people and wanted to explore new pastures. The reason was that the British Isles and Europe were over-populated and diseases were rampant.

On the other hand, the pursuit for sustainability by a developing country like India is going to be straightforward: for providing reasonably good livable conditions to its teeming millions. Indians have nowhere else to go. In fact there are no uncolonized areas left on earth that are habitable. India has to ensure in perpetuity food, housing, energy, clothing, medi-care, education, vocations, etc. for its people. India also needs to chalk out a realistic agenda for sustainable growth and development. Therefore, the foregoing list of items that are critical for sustainable development of a developing country, need to be understood in depth and steps taken to translate these into action.

There is a need to prepare state-of-the-art papers, on the various areas listed above. This has to be done keeping in view the escalation in population. This task needs to be undertaken by organizations (government and non-government) which are conversant with the ground realities and adopt by-and-large a bottom-up approach. Some very good but isolated reports, such as the one by TERI[3] and the other on water by CSE[9] have been already prepared. These reports are indeed interesting and very important.

The approach has to be realistic but incisive. A lesson has to be learnt from what were acclaimed as great success stories of the economic development in South Korea and other Asian economic tigers (except Japan). These have now begun to show their covert unsustainable social and economic faces. Perhaps the story of Indonesia is an example of *what not to do*. The root cause is mankind disregard for natural resources and economy. In this regard the recent forest fires in Mexico and Indonesia are only symptoms of ecological and economic crises. These resulted in loss of virgin forests, and hot winds and smoke covered even the parts of the adjoining countries. Initially these were the result of unsustainable slash and burn by Indonesians and Mexicans themselves and then nature's wrath stepped in.

Opening a developing country's economy is good, as long as it follows a well thought out long-range policy, and avoids short-term populist measures. Our feet must be firmly on the ground all the time. Economic development is indeed a highly professional area and hard-headed economists and sociologists have to pool their intellectual resources to chart out a long-range path irrespective of which political party is in power. *Sustainability in development (like policies on defence and foreign policy) has to be an all party agenda, no matter which party is in power.* A parallel exercise is needed for environmental threats facing the country taking advantage of our strengths while guarding against some inherent weaknesses. All these issues are basically national, therefore, above politics.

While no one would like to mix politics with sustainable development, it is but certain that at some stage politics will enter in its working. Developing countries have to be careful regarding their co-operation with industrial countries because now it is no longer necessary to *actually* subjugate a country militarily as was necessary earlier. All that is needed is a covert economic agenda. Therefore, a developing country has to be clever enough to foresee and understand the after effects of such an agenda and guard against it. It is the small print of the agreements that has to be looked into very carefully. In this regard lessons have to be learnt from SE Asia.

Green technology

There is now worldwide thinking that more importance should be given to con-

servation technologies rather than consumptive ones. Clear criteria are needed for declaring a technology green. Equally important is the question of the carrying capacity of natural and habitats restored through eco-development.

The only answer to politics of development is self-sufficiency, self-reliance, complementarity and sustainable development: where a country's resources are put to sustainable use with the help of technology relevant to the situation.

From a unit of resource we should be able to get:

- maximum usable product;
- with minimum use of energy and cost of production;
- generation of minimum pollution;
- minimum cost of depollution;
- inflict minimal damage to environment during manufacture, transport and end-use;
- generate minimum waste; and
- use packaging with short life.

Development should not involve:

- use of threatened/endangered species from threatened habitats;
- cause cruelty to animals and destruction of flora and fauna, or;
- affect other countries particularly developing ones which are essentially poor and fragile; and
- not endanger health of the user and the biosphere at large.

To achieve this would involve abundant use of relevant high quality S&T. Finally, there is the ethical dimension of sustainable development which cannot be ignored. In this regard the shining example before us is that of Gandhiji[4–6]. His role and relevance has increased because he has been a path-finder for India and the world at large. A combination of ecological security, economic security, equity and social justice are going to be the bed rocks of the future technology. Therefore, scientists and technologist have to leave their ivory tower approach and add the foregoing dimensions to their work.

Major leaps will be needed for enhancing productivity of food with no or manageable damage to environment including land and soil. The same applies to health services, materials, transport, energy and information technology. Even in forestry a major jump is needed to attain sustainability. Here basic orientation has to change from mere management of natural forests and harvesting mean annual increment, to *designer plantations* with high yield per unit of area and per unit of time. No longer can we afford to continue to over-extract wood from natural forests in perpetuity. A forestry revolution is needed most urgently where we leave natural forests only for long range ecological security and get all our wood from man-made plantations as we do in agriculture. Such a transition took place in agriculture long ago. Human race no longer depends on naturally growing plants and wild animals for its food and other needs. This change was associated with the human race entering an agricultural society from a hunter and gatherer one. In view of the escalating population, there is need for a quantum jump in agricultural production per unit area/time because no new areas are available for cultivation. There is a need for a Second Green Revolution which will have to be highly productive minus pollution and labour displacement and depend on biofertilizers and biopesticides that are non-polluting to land, water and air. Biotechnology will have to be used for enhancing production and productivity and storage.

There is thus an urgent need for high inputs of S&T to make Green Revolution-II and Forestry Revolution-I a reality. The goal has to be designer agriculture for enhanced food production and designer forest plantations for meeting the needs of firewood, timber, veneer, pulp and paper, etc.

Technologies that do not pollute land, water, and air and help in processing and storage will have to be developed. Special attention will have to be paid to human health. Disease control will have to be attempted on a very wide front and include drug-fast bacteria, AIDS epidemic/heart diseases and hypertension, etc. These will need special attention. India will need medicaments involving both high and low technologies in a proper mix because we have both disease of affluence and of poverty. Technology whether in agriculture, forestry or industry has not to be labour-displacing but reasonably labour-intensive.

The energy scene in India is indeed very complex, we have most forms of energy in use. With enhanced affluence there is going to be enhanced energy demand. We need to update, refine and enhance production of all forms of energy from low-tech (firewood and biomass burning) to high-tech atomic energy, and everything in between.

Lastly, there is yet another dimension to green-technology. When one buys firewood, fish, medicinal herbs or water (all these are collected almost free from nature), we *only* pay for the cost of collection and delivery of these natural materials. Methods need to be evolved to calculate their intrinsic value so that we know the real cost of the natural materials. Thus it is not enough to have green technology but it has to be accompanied by green pricing, green economics and green-marketing.

Importance of individual action

One cannot minimize the importance of an individual in bringing about change towards sustainability. As individuals, we must think about our role and goal and the fact that in the ultimate analysis it is we as individuals who have to take decisions, and solve the problems of the environment. The reason is that a community, a nation and the world at large, are, in the ultimate analysis, an extension of an individual. A sustainable community can spring from interdependence between well-informed individuals. Thus sustainable lifestyles of the individuals can lead to sustainable communities, to sustainable nations and then to a sustainable world. Similarly, key to the solution of global environmental problems lies in local action[10].

An individual is the starting point of environmental degradation. If an individual believes in need and not greed, and in comfort and not in luxury, and ponders about what is *enough* for a comfortable lifestyle, most of the problems would be solved. We have reports of influential individuals owning 3000 pairs of shoes or over 700 sarees and what not. Regrettably, both these cases are from developing countries. What example do such individuals set for the society at large. Is it justifiable? One of the major root causes is undue thirst for resources which is particularly characteristic of the industrial world and the rich in the developing world. One can understand undue thirst for knowledge but not for resources.

Keeping the foregoing in mind, one can bring about sustainability in poor

families in our *BIMARU* states and Orissa but equally important, if not more important, is to find ways to take to sustainability in the life of resource-guzzling persons in the metropolitan cities in the developing countries and industrial world at large. Here each individual requires huge amounts of materials and generates equally large amount of wastes. Major environmental problems are created during collection of raw materials, manufacture of finished goods and finally during their utilization and generation and disposal of wastes.

The most critical input for bringing about sustainability in a gamut of social, economic and cultural situations is *education*. The important point is that today an average human being in the developing world is in socio-economic shackles, and follows value system(s) which leads to unsustainability. There is need to bring about a new value system that leads to sustainable development. The critical input for this change is also education, which gives us knowledge, information, understanding and above all stresses ethics and morality.

If one follows the history of human species, there have been two distinct but over-lapping phases. The species began as having *reverence towards nature*. At that stage humans looked at nature with awe and respect, something that they did not understand. Then, they began to, understand nature, there came a phase of *subjugation of nature* which led to all manner of deforestation, ecodegradation and pollution and rampant abuse of natural resources. This has been the phase when humans got the erroneous feeling of being all powerful, and looked *down* upon nature for being exploited with vengeance. Today the world is in the latter phase! However, of late there is the beginning of a phase where many voices are heard about *reintegration or a coalition with nature*. This change is the result of a phase in history when technology was used to the detriment of nature and ultimately to the detriment of the human race itself. The reason is that everything on earth is interconnected, interrelated and interdependent. Our salvation lies in not approaching nature with arrogance but with humility and respect. Most biological scientists are of this view, because they have an inkling of the intricacies of and fascination for the web of life. This is what scriptures of most religions teach. S&T need to be used for the good and the well-being of the earth and all its inhabitants.

Towards a *sarvodaya* (or a sustainable) society

The socio-economic situation in real life is indeed very complex. For convenience, we may consider four broad situations, two of which are unsustainable and the remaining two are sustainable (Table 1). Between and within each of these two extreme categories, there are many intergrading situations. One of the two extremes of unsustainability is found among the hunter–gatherers (lower left) who live in very harsh, fragile and unstable ecosystems such as the Sahara desert. These people are essentially nomads with hardly any worthwhile assets. Here climatic conditions are very harsh and resource base is very poor, there is dire need and abject poverty. They follow local wildlife for their sustenance. Technology used to capture or kill the wildlife is very primitive, e.g. stone tools, bows and arrows or traps. They make some use of fire. The other end of the unsustainable spectrum (upper left) is seen in the industrial societies of the world particularly in their metropolitan cities. Even in the latter (e.g. New York), the situation is uneven. Resources are abundant in opulent sections while for people living in poorer sections of the city, resources are scarce. In the former, there is the vulgar show of wealth and abuse of resources. They are rich in technology, which, by and large, is misused for the so-called welfare of the rich. This is true of most industrial countries and megacities of those developing countries which have followed purely an industrial route to development. Between these two extremes of unsustainable development there are many intergrading types. The two

Table 1. Relationship between societal patterns and eco-developmental concerns

Unsustainable development	Sustainable development
Industrial societies Metropolitan cities	Sustainable (sarvodaya) societies!
• Resources abundant or obtained from less developed countries at nominal price	• At present largely an utopia
• Rich in technology which is more often misused	• Resources sufficient
• Resource-guzzling countries/people	• Essentially biomass-based (renewables) society using low pollution causing modern technology
• Resources abused and pollution generated during manufacture	• Technology appropriate to the situation
• Vulgar show of wealth	• Need and comfort
• Greed and luxury	• No vulgar show of wealth
• Welfare of the rich	• Blending fruits of modernity with tradition
• No real respect for nature	• Respect for nature
• Economic 'victors'	• Welfare of the weakest (antodaya) leading to welfare of all (sarvodaya)
• Economy of impermanence.	• Aiming at economy of permanence
Hunter–gatherer societies Harsh ecosystems e.g. deserts (Sahara); people mostly nomads	Hunter–gatherer societies Stable ecosystems: Ecosystem people (e.g. Andaman and Nicobar Islands; Amazonia)
• Resource base very poor	• Original inhabitants
• Access to resources limited	• Superstitious
• Very primitive technology used	• Indigenous age-old technologies
• Dire need	• Hardly any exposure to modernity
• No exposure to modernity	• Nature's (non-monetary) economy: Barter system
• Abject poverty and powerlessness	• Need but not greed
• Prevailing superstition	• Respect for nature
• No worthwhile economy	• Economy of permanence
• Ecological victims	

corners are assetless people with abject poverty on the one side, and extremely rich on the other.

In the sustainable group (Table 1) one of the two extremes is constituted by the hunter–gatherers (lower right) living in stable ecosystems. They are the *ecosystem people* like the original inhabitants of Andaman and Nicobar or many places in the Central and South Americas. Left to themselves, they have sustainable lifestyles because resources are abundant. There is no monetary economy *per se* but nature's economy prevails. They barter goods and services. There is need but no greed. Their technologies are primitive, but their lifestyle is sustainable.

Some of the best examples of sustainable development are seen in the indigenous societies behind which is the time-tested robust common sense and local technical knowledge. Taking advantage of such knowledge, one could hazard a guess for sustainable society or what Gandhiji called *sarvodaya society*. The success of such a society depends upon inputs of science and relevant technology, and micro-enterprises based on local technical knowledge. These would give succor and bring them out of the morass of poverty and penury and transform the village communities.

At the other end of the sustainable group (upper right) would be a society where resources are sufficient, there is respect for nature, they believe in need and comfort but not in greed and luxury; they make good use of technology relevant to a situation. Their aim is to have welfare of the weakest (*antodaya*) which in the ultimate sense leads to welfare of all (*sarvodaya*). This is why one could call these as *sarvodaya* or sustainable societies. The basic philosophy is to live and let live, and through frugality (i.e. more from less) and fraternity (getting in association with others) achieve sustainability. Herein lies the future of humankind. Such would be the societies of the future. Today these may exist in bits and pieces but not in sufficient numbers and certainly not on large scale. There are several individual attempts in this direction like the work of Chandi Prashad Bhatt in Gopeshwar, R. P. Misra in Sukhomajari (Haryana) and Chakriya Vikas Pramali (Bihar), Anna Sahib Hazare in Raligan Siddi and A. T. Ariyaratne in Sri Lanka. Such attempts are being made in other places as well. Table 1 summarizes the broad characteristics and the relationships between the four societal patterns and their developmental concerns.

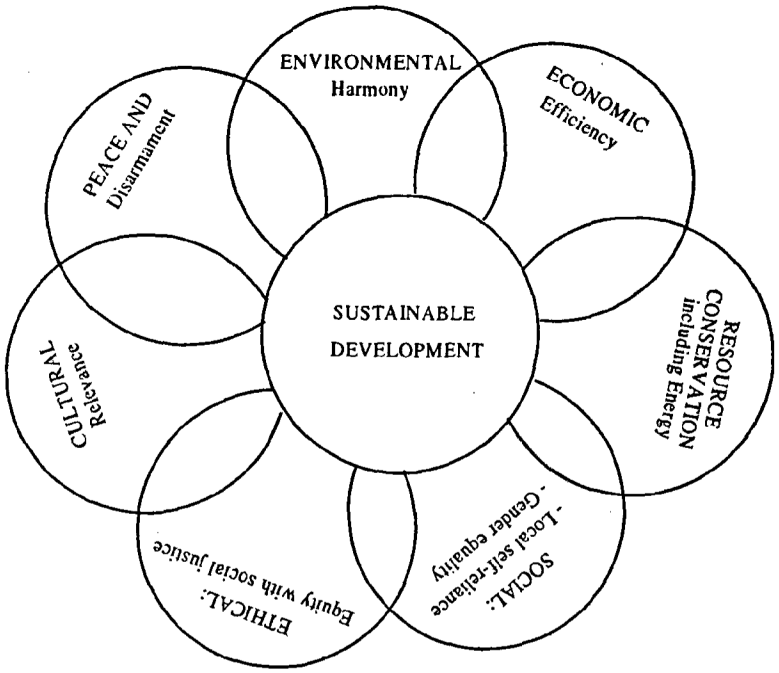

Figure 1. Major dimensions of sustainable development.

Gandhian development

Notwithstanding the fact that Gandhiji earned India freedom with little bloodshed and became a Mahatma (a great soul) in his own life time; there is a growing opinion that the 20th century did not understand him. For some he was irrelevant and that he talked and believed in what was out-moded socially, economically and technologically. However, now there are many (all over the world) who believe that he was born atleast a century ahead of his time. With his forethought and vision, he was actually a man of the 21st century.

When independence (*swaraj*) began to become a reality, Gandhiji was asked as to what pattern of development India would follow. At that point of time for a British Colony, such as India, the only model was the British Model. Gandhiji said: *'it took Britian the resources of half the planet to achieve this prosperity. How many planets will a country like India require!'* It is indeed a prophetic statement. He insisted on individual commitment because he felt *swaraj* (self-rule) does not mean independence from all restraints. It means we take from the earth what we *actually* need and no more. He stressed *non-violence* which means not to *exploit* anything including biosphere. Furthermore, one should not venture to take more than what one needs. His thinking is contained in his very famous quote which has gone into the annals of environmental literature: *'The earth provides enough to satisfy everyman's need but not for everyman's greed.'* Obviously he felt that nature produces enough for our legitimate needs and comfort, but not for our greed, luxury and vulgar show of wealth. Such a mad rush for materialism is not only irreligious but also a criminal act against nature and humanity and all creations at large. It is unsustainable and a pernicious disease. It is untenable scientifically and technologically in the long run.

Gandhiji gave the world an acid test for sustainable development in order to help the poor who are indeed the weakest link in the socio-economic chain. His famous 'talisman' was: *'whenever you are in doubt or when the self becomes too much with you, apply the following test: Recall the face of the poorest and weakest man you may have seen and ask yourself if the step you contemplate is going to be of any use to him. Will he gain anything by it? Will it restore him to a control over his own life and destiny? In other words, will it lead to Swaraj (self-rule) for the hungry and spiritually starving millions? Then you will find your doubts and your self melting away.'*

If humanity would follow Gandhiji, there would be no poverty but there would also be no stinking-rich people. His life was a life of sacrifice. In material sense he was the poorest Indian but, in what he gave to the country and the world at large, he was indeed the biggest benefactor of the 20th century. His was a life of sacrifice, charity and penance (*yajna, dhana* and *tapas*). Unfortunately, 20th century has seen more tormentors than benefactors like Gandhiji.

In view of the foregoing discussion, sustainable development under conditions of a developing country should be people-centred and must lead to: environmental harmony; economic efficiency; resource (including energy) conservation; local self-reliance; gender equality; equity with social justice; cultural relevance; and peace and disarmament (Figure 1).

It should enable solving problems at the local level which will ultimately have impact at the national, regional and even global levels. It must aim at sensible, credible and implementable environmentalism and not eco-fundamentalism. The biggest challenge is concretizing sustainable development and translating it into *actual* action points so as to be in line with our social, economic, cultural, religious and ethical diversity. To make such development a reality, would involve considerable amount of relevant S&T and inputs from economics, social sciences, ethics, law, etc. The academies and non-government institutions dealing with science, technology, education, social sciences, economics, law and ethics need to take up such studies and prepare status papers for the benefit of the Government. Finally, such sectoral reports need to be integrated into one connected whole, to ensure the creation of credible and implementable options that are relevant to the prevailing situation in India. We need to set our own house in order in the first place. Only then can we confront the northern consumers who use resources far in excess of the renewal rate. Environment in general and sustainable development in particular have to be on our national agenda, but these have to be above politics like the foreign policy, defence, agriculture and economy.

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SCIENTIFIC CORRESPONDENCE

Antifungal and insect-repellent activities of essential oil of turmeric (*Curcuma longa* L.)

The future of agriculture will be the age of biopesticides and biofertilizers. Though many of the oils and plant extracts possess fungitoxic and insect-repellent properties, they are less exploited in a big way[1–6]. The potential of neem tree as a source for formulating biopesticides has already been established. Turmeric (*Curcuma longa* L.) being an export-oriented spice crop is much valued for the yellow pigment, curcuminoids, and also contains high percentage of essential oil, which is a byproduct of the curcumin industry. Mainly essential oils of plants are used by the perfume industry for making cosmetics and other products. But essential oil of turmeric finds little demand in the perfume industry and it is used as fuel in boilers as it is a waste in the process of curcumin extraction. A study was carried out to find the antifungal and insect-repellent activities of essential oil of turmeric on six species of fungi and the cardamom aphid. Essential oil extracted from the dried rhizomes of turmeric having sp. gr. 0.93 is used for the present study.

Antifungal activity of essential oil against *Colletotrichum gloeosporioides, Sphaceloma cardamomi, Pestalotia palmarum, Rhizoctonia solani, Aspergillus* sp. and *Fusarium* sp. was evaluated *in-vitro* by poisoned food technique using potato dextrose agar (PDA) medium[7]. Requisite quantity of oil was incorporated to get the desired concentration of 1, 2, 3, 4 and 5%. Oil-free medium served as control. Wetting agent (4–5 drops) was also added to each concentration to get dissolution. The poisoned and sterilized PDA medium was poured into 90 mm sterile petri plates and allowed to solidify. These were inoculated with a 4 mm actively growing mycelial disc and incubated at 24 ± 1°C. Average colony diameter was measured at 2, 4, 6, 8 and 10 days after inoculation. After 8 days of inoculation, petri plates were taken out from the incubator and kept under light. The per cent reduction in radial growth over the control was calculated and analysed after transforming per cent values to angular values.

The insect-repellent activity of the oil was tested at 0.1, 0.5 and 1.0% concentrations in water (v/v). A small quantity of wetting agent was added for easy disso-