Role of Science and Technology in the Sustainable Development of Society: An overview

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ABSTRACT

Exponential Growth of Technology in India has played a significant role in all round development and growth of economy in our country. Sustainable development is an emerging area, because it addresses the socio economic development of every human being. India has opted for a judicious mix of indigenous and imported technology. Purchase of technology is commonly called "Technology transfer" and is generally covered by a technology transfer agreement. This work focuses on the key areas of sustainable developments and scientific contributions towards it. This write-up almost identifies the critical issues or problems associated with sustainable development. Identifying the problems and giving the necessary recommendations for solving the problems encountered. The development of any country is almost depends on the advancement in developing the technology in different fields. The revolution takes place between eighteenth and nineteenth centuries makes a world to think differently in the science and technology steam engines, textile, printing etc. Countries that take part across this industrial revolution are developed, much more than other countries because the machine occupies the work more from men. Further advancements in twentieth century in space, aircraft, computers, biotech and information technology are boost the developed nations much advanced. The new technology with young minds creates a synergy both in knowledge and resource utilization.

Keywords: *Science, Society, Sustainable Development, Economy*

I.INTRODUCTION

In today's highly interconnected world, human beings, as part of the biosphere, are considered the major force impacting our planet; therefore, the human species is facing a crucial transition period. In this uncertain stage of human history, vulnerabilities and risks are high but also are opportunities for socio–ecological changes and transformations. What is important is that global sustainability becomes the foundation of our interconnected and interdependent global economic, social and environmental systems. The reality however is that we still promote a model of development based on the premises that development is a process of structural changes that will imply a series of historic steps that developing countries have to follow in order to move from a traditional society to a more modern one in order to reach the present levels of mass consumption of developed countries. This model assumes that industrialization is the main driver of growth, and consequently the degree of development is essentially measured by levels of production and consumption, using indicators such as Gross Domestic Product (GDP) and per capita income, ignoring other relevant information such as social equity, life expectancy at birth, redistribution of wealth, access to educational and health systems, absence of violence, environmental sustainability and other indicators that measure better the improvement of living conditions and welfare of all. It is in this context that concepts such as Knowledge Economy, defined as an economy where ‘‘the generation and the exploitation of knowledge have come to play the predominant part in the creation of wealth’’ (DTI 1998), gained root and became the paradigm of most of the interventions in the field of Science, Technology and Innovation (STI). However it is clear that with the financial, energy, food and environmental crisis that the world, as a whole, is facing nowadays, a paradigm shift will have to occur, in particular in economies that are extremely vulnerable to global trends and issues such as the economies of the Least Developed Countries (LDC) and Small Islands Developing States (SIDS), in particular in Africa. It is high time to acknowledge that integrating environmental, educational and social issues into economic decisions is vital to humanity. It is time to reaffirm that economic and financial crisis cannot be solved without deeply transforming the way we consume, we produce, and we interact with our planet. Clearly, part of the problem rests in the fragmented and restricted analysis on which we base our decisions, in the predatory nature of the globalization process occurring today, and in the fact that local problems need more and more global solutions. In order to address the causes of the present crisis it is important to look at knowledge in a different way, not only as a driver for the economy but as the main driver for the empowerment of the people in the different societies. The concept of Knowledge Societies, defined as societies that have a culture of science and use knowledge to act, is therefore a better one to use when discussing STI and development, but unfortunately is still only part of the discourse and rarely integrated and used in the design of policies, programs and interventions. It is needed that alternative models for development are discussed and that they integrate concepts, such as the one on sustainable societies, concepts that supports the paradigm shift from a knowledge economy to knowledge societies. These alternative concepts of development defend that we should think in the diversity of sustainable societies, with economic and technological options that are differentiated, that are geared towards a harmonious development of the people and their relationship with the natural world, clarifying the boundaries of a new ethical behavior in the relationship between nations and its people, and placing the common good in the front of development interventions. In itself this implies that more than one development model is needed, and that nations and regions should choose models that are interlinked and interdependent and that reflect visions of the world that are locally relevant and culturally appropriate. In that sense we are talking about development models that are people-centered and inclusive; models based on local realities that take advantage of local knowledge and innovation capacities; models that start from the country’s potential to solve both local and global issues and that strives to create a culture of ingenuity, science and technology. Models that capture the complexity of our

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development challenges and the dynamics of the natural environment we live in. It implies that we have to embrace the values, behaviors and lifestyles required for a sustainable future and in that process strengthen two critical drivers for development: ethics and empowerment. It is about building up conviction and commitment to pursue a better development path; it is about using diversity to sustain growth. The concept of sustainable development has experienced an extraordinary rise over the past two decades and now pervades the agendas of governments, international organizations and corporations as well as the mission of educational and research programs worldwide. Although there are some earlier antecedents, these ideas had their formal appearance with the Brundtland Report, Our Common Future (1987) and the results of the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Council for Science (ICSU) World Conference on Science (1999). At the same time a list of important and influential documents were published, showing the relevance of sustainable development within the global agenda (Clark and Dickson 2003; Kates et al. 2001; NRC 1999; Parris and Kates 2003; UNCED 1992) conforming the bases for the organization of a new research and innovation paradigm. As mentioned in the State of the Planet Declaration (Planet Under Pressure 2012): ‘‘The defining challenge of our age is to safeguard Earth’s natural processes to ensure the well-being of civilization while eradicating poverty, reducing conflict over resources, and supporting human and ecosystem health.’’ This is a clear challenge to science and engineering. For it requires building scientific and technical skills and to develop the social support to apply them (Brito 2005). 2 The Role of Science, Technology and Innovation Policies 15 The international scientific community has an n important role to play in finding alternative solutions to the development challenges of today. This has implications, it means that the scientific endeavour will have to integrate the different disciplines and move from interdisciplinary to transdisciplinary, to build the knowledge needed for finding more sustainable paths for the future. It is interesting to see that sustainability science, as a new paradigm, has been applied more and more in the last decade and those large programs such as Future Earth are taking roots in the scientific community and growing. However, when we look at the distribution of research projects that have sustainability science at the core we realize that the African Continent is lagging behind, once again (Bettencourt and Kaur 2011). Therefore, if we want a planet that will continue to develop and strive towards improved living conditions for all its citizens, sustainable economic growth and environmental sustainability specific policies, programs and actions that promote the production of knowledge, technologies and innovations needed for sustainable development have to be in place everywhere in the world.

There is an increased recognition that Science, Technology and Innovation (STI) can spur inclusive and sustainable development in multiple ways. For STI to be a driver for sustainable development it is important that Development Agendas are people-centered, creating an enabling environment for the power of STI to be a harness for development. This implies that countries and regions have to develop, implement and monitor their national and regional STI policies and programs that promote knowledge production, dissemination and utilization as well as the development and appropriation of technologies that spur innovation not only at large production facilities but also at grassroots level, involving small and medium enterprises (SMEs), as part of a broader development agenda. These frameworks require that special attention is given to human capital development, a fundamental block of any sustainable development agenda, and to governance mechanisms that promote broader participation in decision making in STI related issues, in particular promoting the participation of vulnerable groups such women, youth, Small Islands Developing States (SIDS) and indigenous people. The STI policies need to be transversal, cross–cutting policies that support and build the structural pillars for sustainable development and through dialogue, engage the wide range of development stakeholders. It also explores the ways UNESCO intervenes in this strategic area for development through the design, planning, formulation, monitoring and evaluation of national and regional STI strategies and policies (including reforms), as well as thorough building the national and regional capacities in science and in public policy development, and the development of national, regional and global fora on STI and development.

Some of the issue related to Science, Society and Sustainable Development and the recommendations made thereon to solve them are discussed here:

- **Science in Transition**

In the past, our scientific methods and institutions have tended to emphasize the study of individual natural processes rather than systems, analysis more than synthesis, and understanding nature more than predicting its behaviour. And in many instances, science has focused on short-term, small-scale problems, often in mono-disciplinary mode, rather than on long-term, large-scale or integrated problems. While these approaches and perspectives have built up a considerable base of knowledge and led to a vast portfolio of useful technologies, especially in the 20th century, many of the problems now facing humankind can be solved only if we approach science more holistically. Greater effort is needed to *understand* integrated natural systems on multiple time and space scales.

Scientific findings must also be *applied at the right scales*. The impact of technological interventions on individual people, communities and the environment must also be carefully considered. To do this, science needs to become more multidisciplinary and its practitioners should continue to promote cooperation and integration between the social and natural sciences. A holistic approach also demands that science draw on the contributions of the humanities (such as history and philosophy), local knowledge systems, aboriginal wisdom, and the wide variety of cultural values.

The influence of science on people's lives is growing. While recent benefits to humanity are unparalleled in the history of the human species, in some instances the impact has been harmful or the long-term effects give causes for serious concerns. A considerable measure of public mistrust of science and fear of technology exists today. In part, this stems from the belief by some individuals and communities that they will be the ones to suffer the indirect negative consequences of technical innovations introduced to benefit only a privileged minority. The power of science to bring about change places a duty on scientists to proceed with great caution both in what they do and what they say. Scientists should reflect on the social consequences of the technological applications or dissemination of partial information of their work and explain to the public and policy makers alike the degree of scientific uncertainty or incompleteness in their findings. At the same time, though, they should not hesitate to fully exploit the predictive power of science, duly qualified, to help people cope with environmental change, especially in cases of direct threats like natural disasters or water shortages.

The current trend toward privatization in many countries is influencing the focus and practice of science. While in some instances the net result may be to increase research capacity and knowledge in selected areas, there is major concern that the trend may be undermining public-sector science, especially fundamental research and efforts to solve socially important problems of no interest to commercial enterprises. Patent protection of private intellectual property, for example, makes the job of public research more difficult. There is also concern over the social implications of private ownership and control of technology, and its effect on broad public scientific literacy, and on options for public choice.

Another major trend shaping science is globalization. The end of the Cold War, growing technology demand from emerging economies, world recognition of the interconnectedness of the planet’s biophysical systems and improved communications, especially via the Internet -- all these forces are boosting cross-border scientific cooperation and information exchange between individual researchers, institutions and governments. However, much of the expansion is occurring in just a handful of scientifically advanced countries. For science to be truly global, more effort is needed to ensure all countries, rich and poor, and a wide range of world cultures are included in collaborative research and technology transfer. This is especially important in areas like global climate change which will affect, sooner or later, all human beings. With the right policies in place, joint scientific work in critical areas such as the Arctic, for example, could serve as a model for other types of global cooperation.

A major challenge for global science is to find institutional arrangements conducive to success. The proliferation of international networks and programs, the so-called "acronym jungle", reflects a rather ad hoc approach, necessitated in part by the narrowness of purposes of established scientific institutions and the lack of strategic, integrated support by national governments in areas like global change or international aid. What is needed is the formation of true international partnerships that allow scientists in different disciplines and countries to fully support each other’s aims and share resources and management duties to mutual advantage.

Recommendations

Scientists and scientific institutions should

- promote multidisciplinary approaches to research, encourage cooperation between the social and natural sciences, and draw lessons from the humanities, local knowledge systems and aboriginal wisdom;
- encourage a holistic approach to problem solving that takes into account a realistic range of socioeconomic conditions and effects, as well as multiple time and space scales, where appropriate;
- carefully explain the implications and the inherent limitations of their research findings to the public;
- fully exploit the predictive power of science to serve social needs with candid awareness of the limitations of scientific predictions;
- promote the inclusion of scientists from resource-poor countries in international cooperative projects and maximize their access to information and technology;
- encourage the creation of science-coordination mechanisms at the highest level of the United Nations, fully involving the governments of all countries, as a way to promote integrated responses to global problems.

❖ Economics versus Sustainable Development

Science today seems caught in a cross-fire between two opposing world views. On the one hand, science is a major tool of the ideology currently driving the world economy, namely that of the free market system, continual growth and the pursuit of personal wealth. On the other hand, science is increasingly being called on to produce knowledge and technology that promote environmentally sustainable, people-oriented development and long-term management of resources.

The world economy continues to rely heavily on cheap oil, a non-renewable resource and major contributor of greenhouse gases. Fossil fuels - oil, coal, natural gas - will continue to power world industry for several decades. The fact that they will do so despite the availability of technically feasible alternative "green" energy technologies, brings the dilemma into sharp relief. Examples of the conflict between current economic forces and the need for sustainable development can be found in many other domains as well. The imposition of structural adjustment policies by international financial institutions, for example, has forced some countries to reorient agricultural research and production to focus on cash crops that generate foreign currency rather than food crops for local consumption. In some cases, such policies have put food security and the continued production of the land in jeopardy, created enormous personal hardship for citizens, and led to social unrest.

Free trade arrangements, too, may pose a threat to some of the underlying components of sustainable development, affecting biodiversity, community self-reliance, and local knowledge systems. In some cases, the elimination of trade barriers between countries has led farmers to abandon the cultivation of traditional crop varieties that were well adapted to local conditions and tastes, in favour of imported varieties that may respond better to newly expanded markets.

Deregulation and privatization are two trends aimed at improving commercial competitiveness, and stimulating economic growth. Yet in some sectors such as energy production and food it is becoming clear that these trends cannot be reconciled with the requirement imposed by sustainable development that hidden environmental and social costs of economic production — that is, costs bourne by present or future society but not normally reflected in prices of goods and services like energy, be taken into account.

In the past, developments in the energy field have had more to do with the protection of vested economic interests than with concern for the public good or environmental conservation. The prospect of that approach being perpetuated is a major concern for the future of energy science, since fossil fuels are a finite resource and a major contributor of greenhouse gases, and research or energy alternatives is handicapped.

Recommendations

- Policy makers must accept that, for certain key areas like energy development, decisions must not be based only on political expediency — such as the prospect of short-term economic benefits and job creation. To do so denigrates the role of forward-thinking research and development (R&D) and undermines long-term social development. Rather, what is needed is a vision of the world that looks "seven generations" ahead, in the manner of the holistic philosophies of North American aboriginal people.
- Public debate on the dangers of "consumptive" lifestyles typical of the industrialized countries, needs to be reactivated. If everyone on the planet lived as many North Americans do, we would need the resources of "seven Planet Earths". As this is clearly impossible, the implications of inevitable major changes soon to come should be openly discussed at all levels of society.
- Scientists need to cultivate a new vision of science — one that promotes the development of sustainable "closed" systems of production and consumption, which are compatible with the recycling behaviour and equilibrium of natural systems.
- Agencies that provide research grants should be broader in their terms of reference and more neutral and flexible so that scientists are not continually pushed to find short-term solutions when long-term ones are needed. In some countries, the allocation of research funds is controlled by small powerful groups who engage in favouritism for their own personal gain or prestige. Governments should ensure that systems for evaluating and funding project proposals are fair, objective, and transparent.

❖ Science Policy and Ethics

Scientific advances are never, in themselves, a guarantee of social benefit. Technology has to be treated as a servant of society, not a master. Increasing commercial productivity, while at the same time necessary, unemployment and poverty is not a socially acceptable solution. Science must be fully integrated with broad societal needs, but this tenet is not yet fully accepted. One reason for public mistrust of science is that ordinary people feel they will sometimes end up being the ones to suffer the costs of technological innovation. It was suggested repeatedly at the North American meeting that the time has come to introduce an international code of ethical conduct for scientists to ensure that science is directed for the public good.

Scientists in their daily work are sometimes isolated from mainstream society, making it difficult for them to be clearly aware of public needs. Conversely, policy makers, in need of sometimes urgent advice on technical matters, sometimes urgent, may be unaware of the scientific expertise residing under their very noses. Society has much to gain by the proactive involvement of scientists in policy making.

Medical biotechnology is a leading-edge area of science in which the pace of progress is perhaps faster than society's capacity to deal with the ethical and social implications. Genetic research, while offering major benefits for disease diagnosis and treatment, also poses serious questions about the nature and sanctity of human life and the protection of human rights. The possibility that genetic technology could be commandeered by powerful groups to pursue goals in their own interests but which may be socially destructive or discriminatory is not to be considered lightly. It is an issue of particular importance to disabled persons. Greater dialogue between scientists, policy makers and the public, especially those groups disproportionately affected by technological developments, is clearly needed.

A major concern is that recent advances in health sciences will lead to the "genetification of medicine", that is, a trend toward understanding and explaining human beings and human health largely in terms of genes and their interactions. A worry here is that the role of environmental and social factors will increasingly receive insufficient attention, leading to a one-dimensional view of diseases and disabilities.

A further ethical issue for science is what has been referred to as the "commodification" of basic human needs such as food, shelter, clothing, fuel and health services. In many countries, many of these items have traditionally been supplied through non-monetary social support structures, often family-based. As cash economies and government welfare programmes increasingly treat these necessities of life simply as commodities to be bought and sold, there is a serious risk that technological innovations, stimulated by scientists working within a commercial framework, will be exploited mainly by well-to-do minorities, with little or no benefit to the poor. The potential of science to improve human social conditions in non-material ways needs much more attention.

Recommendations

The gaining of scientific knowledge must not be assumed to lead automatically to direct commercial policy exploitation of that knowledge. Often the knowledge is of greatest benefit if it increases public understanding and awareness. Scientists cannot always control the application of their findings. However, they have a responsibility to engage in public dialogue about the implications of scientific findings and to help distinguish between socially beneficial and socially harmful applications.

- Action is needed at the international level to protect the human species from human-induced genetic alteration and to ensure that technological applications in the fields of human genetics are ethically and socially sound. Review committees at the institutional and national levels, such as those that examine and appraise research projects, can help focus attention on key ethical and safety issues. However, stronger and higher-level mechanisms for decision-making and enforcement in this area of science are also needed. UNESCO has an important role to play in this regard.
- Scientists should be more proactive in policy making. This could be done by promoting, among governments around the world, the concept of "science/policy contracts". These agreements would recognize the value of scientific advice, but also make clear that such advice is but one ingredient in decision-making and not necessarily the overriding one. Such contracts should set clear performance standards by which the inputs of scientists can be evaluated.
- The world scientific community should consider adopting an international code of ethical conduct for scientists, similar to the Hippocratic Oath taken by physicians. This code would apply a similar principle of measurability to scientific behaviour that scientists so cherish in their day-to-day pursuit of knowledge.
- (In a commentary subsequent to the workshop, one participant suggested that the Engineer’s Pledge, which undoubtedly has influenced the ethical conduct of professional engineers in several countries, could also be a model for principles of conduct of science in general, adapted to express consideration for all of humankind, ecological integrity, and long-term consequences).

❖ Integrating Issues - Science and Society

Advances in science and its resulting technologies, such as global communication, satellite images of Earth, together with the popular fascination with dinosaurs etc., have irrevocably expanded the space and time scales with which people at many levels of society now view their world. Science is largely responsible for a growing public awareness that people share the planet with all other living creatures, that the environment which supports all life is subject to change, and that human activities are presently changing this environment and threaten to change it seriously. In the past two centuries, science has been used mainly as a tool for economic expansion and military power for the wealthier segments of the human race. It is now clear that the current consumption of natural resources and increasing stresses on the regional and local environment cannot continue indefinitely without breakdown of the natural support systems that make present civilizations possible. Science, which helped to bring about this situation, now has an over-riding responsibility to help societies make a transition from an obsession with growth to achievement of a dynamically stable and sustainable ecological and economic system. In this transition, an alliance between modern technical science and the holistic wisdom from indigenous societies and philosophers from all cultures can be very important.

In the coming century, the rate of change of natural and human conditions and issues can be expected to continue to accelerate. Scientists have an increasing obligation to become involved with policy-makers and the public in finding and implementing solutions or means of adaptation to issues that are both local and world-wide, such as reconciling the present competitive profit motive with the common good; providing for contributions from and benefits to marginalized elements of society and minority cultures; justifying current expenditures to prevent costs or damages to future generations; rewarding collective rather than individual efforts. The role of science in society and governance has never been more important.

It can be summed up from the above discussed issues and recommendations to solve them that different sections of society especially scientists and policy-makers should promote a set of principles that underpin the crucial role of science for sustainable development, namely:

Principle 1: Recognize science as a universal public good Science is universal and scientific knowledge in its pure form is a global public good: “a mathematical theorem is as ‘true’ in Russia as it is in the United States, in Africa as it is in Australia”. Science in itself is a way of crossing national, cultural and mental borders. It thus helps lay the foundation for a sustainable world. For science to live up to its full potential, open and equal access to scientific data and knowledge is vital.

Principle 2: Acknowledge basic science as a principal requirement for innovation Applied sciences and basic sciences are equally important for sustainable development and should not be played out against each other; they are two sides of the same coin. While curiosity-driven research may not be immediately utilized, it is indispensable for scientific innovation. In order to advance fundamental knowledge about the world, basic science requires a productive environment, which makes national, regional and international long-term investments necessary.

Principle 3: Enhance diversity in science for sustainable development unleashing the full potentials of science for sustainable development requires promoting gender equity in science. Only by building on the entire spectrum of society, capitalizing on all talents, including women and underrepresented groups such as ethnic, racial and religious minorities, science can contribute to solving the greatest challenges of the future and building a sustainable world. Enhancing diversity in science also includes strengthening the scientific institutions in the South. In addition, providing equal participation and representation from the whole world in science will enhance democratic practices. All research must be conducted with integrity.

Principle 4: Strengthen science education Science possesses a strong educational component. Science literacy provides the basis for solutions to everyday problems, generally, in uncontroversial ways. Access to and investments in science education and capacity-building in science at all levels need to be strengthened, especially where the appreciation of the benefits of science and the resources for sciences are less developed. Scholarships for scientific programs should be made available in each country.

Principle 5: Raise investments in science Raising investments in science will contribute to economic development and scientific progress. Building up and expanding scientific infrastructure, i.e. schools, colleges and universities as well as centers of excellence for frontier science, will further support science education and scientific research. The international community should therefore aim at establishing minimum national target investments and according increasement mechanisms for STI. A balanced allocation of especially public resources in basic and applied science in line with respective national priorities is advisable to achieving sustainable growth and the implementation of the SDGs. In the long-term, special allotments for basic science will help break the cycle of dependency of low- and middle-income countries on scientific solutions from high-income countries.

Principle 6: Promote an integrated scientific approach Building a sustainable world requires overcoming disciplinary boundaries. Inter-, trans- and multidisciplinary cooperation, both with regard to basic and applied science, can contribute to developing an integrated scientific approach. It should be based on a broad understanding of science, which covers the whole range of disciplines from natural sciences to engineering to social sciences and the humanities, and address the social, economic and environmental dimensions of sustainable development. In this respect, international cooperation among National Academies of Sciences needs to be expanded and intergovernmental research organizations, which play an important role in ensuring sustainability, need to be strengthened. To make the most of the transformational power of science, the diversity of knowledge systems within academia and society, including indigenous and local knowledge, must be respected.

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