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Abstract

This paper deals with the interface between science and economics in environmental policy making in India. It explains Nehru's concept of scientific temper and its influence in the formulation of science and technology policy and development of the science and technology system. It reviews the evolution of global environmental policy regime and the important role assigned to science to gain insights into ecological processes, to assess the nature and causes of environmental pollution and degradation, and to use scientific evidence as basis for formulation of environmental policies. Then it assesses the roles assigned to science and economics in formulation of policies relating to pollution prevention and control and management of natural resources in India. The implications of uncertainties and risks in environmental management are highlighted for public policy.

Keywords: *Environmental uncertainties and risks, natural resources management, pollution prevention and control, scientific temper, sustainable development,*

JEL Codes: *Q2, Q5,O13 and P28*

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INTRODUCTION

In the fifties and the sixties the primary objectives of science and technology policy in India were economic growth and self-reliance. From the seventies, social and environmental considerations and leadership in a few strategic sectors influenced allocation of resources for science and technology sectors. The importance of scientific evidence and the role of economics in framing optimal policies for achieving sustainable development gained momentum since the United Nations Conference on Environment and Development in 1992.

This paper aims to highlight the significant roles of science and economics for sustainable development of India. This paper proceed as follows. The next section deals with the concept of scientific temper and its influence in the formulation of science and technology policy and development of the science and technology system. The following section deals with the evolution of global environmental policy regime and the important role assigned to science to gain insights into ecological processes, to assess the nature and causes of environmental pollution and degradation, and to use scientific evidence as basis for formulation of environmental policies. It states how economics with scientific basis can contribute to formulation of sustainable development policies. Then India's environmental policy regime is dealt with. It assesses the roles assigned to science and economics in formulation of policies relating to pollution prevention and control and in management of natural resources. Then we, note some uncertainties and risks in environmental management and their implications for science policy and economic policy. The final section provides the concluding remarks.

SCIENTIFIC TEMPER AND SCIENCE AND TECHNOLOGY POLICY IN INDIA

Jawaharlal Nehru, the first Prime Minister of India, crusaded for scientific temper. The 42nd Amendment Part IV-A Article 51-A (h) in 1976 on Fundamental Duties reads: (It shall be the duty of every citizen of India) to develop the scientific temper, humanism and the spirit of inquiry and reform. Sen (2006), Economics Nobel Laureate, says scientific temper involves the application of logic and reasoning, and the avoidance of bias and preconceived notions in arriving at decisions, and becomes particularly valuable while deciding what is best for the community or the nation. According to him a group that practices the scientific temper has two characteristics – internal pluralism and external receptivity. Ramesh (2011), former Minister of Environment and Forests, says that 'the essence of Nehru's fixation on scientific temper was this—a questioning mind, pushing the limits, not getting encumbered or structured by narrow limited concerns, not afraid to be inconsistent with changing facts and circumstances but always proceeding on the basis of objective realities, not prisoner of any dogma, modern or archaic'. Thus, openness, neutrality, receptivity to changing facts and objectivity characterize the scientific temper.

The Scientific Policy Resolution of 1958 and the Technology Policy Statement of 1983 emphasize self-reliance, as also sustainable and equitable development. Science and Technology Policy of 2003 notes that 'science and technology have had unprecedented impact on economic growth and social development. Knowledge has become a source of economic might and power. This has led to increased restrictions on sharing of knowledge, to new norms of intellectual property rights, and to global trade and technology control regimes. Scientific and technological developments today also have deep ethical, legal and social implications' (Government of India, 2003). Narasimha (2008) examines

how science and technology in India have influenced and in turn been influenced by economic policy and strategic considerations.

The Science and Technology system in India consists of central government science and technology departments (Department of Atomic Energy, Department of Space, Department of Science and Technology, Department of Biotechnology, Department of Scientific and Industrial Research including Council of Scientific and Industrial Research institutions, Ministry of Earth Sciences, science research institutions funded by different ministries), state governments' science and technology departments, in-house R&D in private industry, science departments in Indian Institute of Technology, universities, and in non – government organizations.

Solow's (1957) pioneering work on the measurement of contribution of technical change to economic growth stimulated extensive research on the nature and sources of total factor productivity growth. Now we know that the contribution of technical progress to economic growth comes in the following forms: (a) upward shifts in production functions lowering input-output ratios, (b) technical progress embodied in inputs, (c) discovery of new materials, new resources, processes and products and improvements in organizational efficiency, and (d) substitution of limitational inputs by new materials.

In recent years, the intellectual property regime and consequential access issue to the technologies, restrictions on technology transfers, risks associated with certain technologies like genetically modified organisms, transparency and neutrality of scientific facts and above all ethical, social and environmental dimensions of new technologies, processes and products raise many public policy issues. A new Science and Technology policy is expected to be unveiled by end of 2012.

EVOLUTION OF GLOBAL ENVIRONMENT POLICY

The United Nations Conference on the Human Environment at Stockholm from 5 to 16 June 1972 proclaims that 'Man has constantly to sum up experience and go on discovering, inventing, creating and advancing. In our time, man's capability to transform his surroundings, if used wisely, can bring to all peoples the benefits of development and the opportunity to enhance the quality of life. Wrongly or heedlessly applied, the same power can do incalculable harm to human beings and the human environment. We see around us growing evidence of man-made harm in many regions of the earth: dangerous levels of pollution in water, air, earth and living beings; major and undesirable disturbances to the ecological balance of the biosphere; destruction and depletion of irreplaceable resources; and gross deficiencies, harmful to the physical, mental and social health of man, in the man-made environment, particularly in the living and working environment', (United Nations Conference on Human Environment, 1972).

The UN Conference on Environment and Development came with Rio Declaration, a set of principles for environment and development policy, and Agenda 21, an action plan for the future. Three important principles in the Rio Declaration relating to science and economics are:

Principle 18
Science and technology, as part of their contribution to economic and social development, must be applied to the identification, avoidance and control of environmental risks and the solution of environmental problems and for the common good of mankind.

Principle16
National authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost

of pollution, with due regard to the public interest and without distorting international trade and investment.

Principle 15
In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation (United Nations Conference on Environment and Development, 1992).

Agenda 21, Chapter 35 is on the role and the use of the sciences in supporting the prudent management of the environment and development for the daily survival and future development of humanity. It notes that a 'first step towards improving the scientific basis for these strategies is a better understanding of land, oceans, atmosphere and their interlocking water, nutrient and biogeochemical cycles and energy flows which all form part of the Earth system. This is essential if a more accurate estimate is to be provided of the carrying capacity of the planet Earth and of its resilience under the many stresses placed upon it by human activities. The sciences can provide this understanding through increased research into the underlying ecological processes and through the application of modern, effective and efficient tools that are now available, such as remote-sensing devices, robotic monitoring instruments and computing and modelling capabilities' (p. 401).

Two important outcomes of the Rio Conference are the United Nations Framework Convention on Climate Change and the Convention on Biodiversity.

The World Summit on Sustainable Development 2002 in Johannesburg came with the Johannesburg Plan of Implementation. It calls for 'the integration of the three components of sustainable

development -economic development, social development and environmental protection - as interdependent and mutually reinforcing pillars. Poverty eradication, changing unsustainable patterns of production and consumption and protecting and managing the natural resource base of economic and social development are overarching objectives of, and essential requirements for, sustainable development', (The World Summit on Sustainable Development, 2002).

The UN Conference on Sustainable Development (2012) has a major theme: Green Economy in the context of Sustainable Development and Poverty Eradication. Para 69(g) of the final report urges the need to promote ' the science-policy interface through inclusive, evidence-based and transparent scientific assessments, as well as access to reliable, relevant and timely data in areas related to the three dimensions of sustainable development' (United Nations Conference on Environment and Development, 2012). It also urges enhanced participation and effective engagement of civil society. Para 63 recognizes the importance of the evaluation of the range of social, environmental and economic factors and encourage, where national circumstances and conditions allow, their integration into decision-making. Para 76 (a) resolves to strengthen the institutional framework for sustainable development, which will, inter alia, promote the balanced integration of the three dimensions of sustainable development. Thus, the Rio + 20 envisages an inter-face between science and economics in balancing and integrating the three pillars – economic, social and environmental- of sustainable development based on scientific evidence and active public participation.

Thus, even though the UN summits assign a prominent role to science-based environmental policy, they recognize the important role of economic analysis in internalizing environmental costs in producers and consumers decisions, designing economic instruments for pollution control, economic valuation of natural resources and evaluation of trade –offs among the three pillars of sustainable development.

INDIA'S ENVIRONMENTAL POLICY REGIME

The UN Conference on Human Environment in 1972 exerted a major influence on environmental policy in India. The government set up a National Committee on Environmental Planning and Coordination in 1972. The 42nd Constitution Amendment Act 1976, Article 48A (Directive Principles) states that 'the state shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country'. Article 51 A (g) (Fundamental Duties) aims 'to protect and improve the natural environment including forests, lakes, rivers, wild life and to have compassion for living creatures'. The UN Conference on Environment and Development in 1992 and its Agenda 21 influenced pollution prevention and control and natural resource management policies.

(a) Pollution Prevention and Control

Environmental legislations such as the Water (Prevention and Control of Pollution) Act 1974, the Air (Prevention and Control of Pollution) Act 1981, the Environment (Protection) Act 1986, the Public Liability Insurance Act 1991 and the National Environmental Tribunal Act 1995 were enacted. All environmental laws come under criminal laws. The Water Act paved the way for the establishment of Central and State Pollution Control Boards.

The Central Pollution Control Board adopts the standards and control regime. It prescribes minimum national standards based on comprehensive industry studies undertaken by technical institutions. There are three types of standards: concentration-based, equipment – based, and load-based. The State Governments and the State Pollution Control Boards can prescribe tighter standards taking into consideration the assimilative capacity of the local environments. In the command and control regime, compliance is generally poor.

The poor enforcement of the regulations is due to lack of sufficient staffs and inadequate monitoring capabilities with the Pollution Control Boards, penalties unrelated to the compliance costs, and also political interferences. This resulted in many judicial interventions under the banner of public interest litigation for the enforcement of the right to clean air and water (See Sankar, 1999).

The Policy Statement for Abatement of Pollution, issued by the Ministry of Environment and Forests in February 1992 admits that 'the state of the environment continues to deteriorate' and favours 'a mix of instruments in the form of legislation and regulation, educational programmes and information campaigns'. It recommends the "polluter pays" principle, involvement of the public in decision making and new approaches for considering market choices 'to give industries and consumers clear signals about the cost of using environment and natural resources' (Government of India, 1992). For a brief review of the initiatives taken by the Ministry of Environment and Forests for pollution control by using market signals, see Chelliah, et. al., (2007).

National Environment Policy, 2006, notes that 'although criminal sanctions, if successful, may create a deterrent impact, in reality they are rarely fruitful for a number of reasons'. On the other hand, giving unfettered powers to enforcement authorities may lead to rent-seeking. It says that 'civil law, on the other hand, offers flexibility, and its sanctions can be more effectively tailored to particular situations. The evidentiary burdens of civil proceedings are less daunting than those of criminal law. It also allows for preventive policing through orders and injunctions' (Government of India, 2006).

Under civil liability pollution charges and taxes can be proportional to the extent of violations, but their introduction requires amendments to the pollution control laws to permit taxes on emissions and wastes. As taxes on polluting inputs and outputs can be introduced

under the prevailing pollution control regime and as the administrative capacity exists for levying and collecting the taxes with the tax authorities in India, the Ministry of Environment and Forests asked Madras School of Economics to recommend eco taxes for consideration by the government. Chelliah, et. al., (2007) recommended coal cess based on its ash and moisture content, tax concessions for environment friendly substitutes for chlorine, phosphates, chemical fertilizers and pesticides, and policies for pollution reduction in automobiles, plastics and lead acid batteries disposal. In the 2010-11 Union Budget, a cess on coal at the rate of Rs 50 per tone was introduced. Tax differentiation, tax exemptions, concessional taxes, and lower taxes for certain environment-friendly goods were announced in the 2011-12 Union Budget.

At present, the government relies largely on tax concessions and subsidies e.g., rebates on customs and excise duties, accelerated depreciation allowances, and capital and interest subsidies for pollution abatement and use of environment-friendly/ climate-friendly substitutes. Other economic instruments like bank guarantees for compliance with pollution control legislations, deposit refund systems, green rating, and preference for environment-friendly products in public procurement are being encouraged.

Tradable pollution permits provide incentives for the polluting units to internalize environmental costs in their decision making. They satisfy environmental effectiveness criterion as well as dynamic efficiency. Their introduction requires political acceptance of the idea, creation of large market for trading and administrative capacity for measurement and monitoring of pollution. Government of India (2010b), in the Discussion Paper on Emission trading, says India needs robust and innovative regulations that leverage technology and harness markets to ensure compliance in a cost-effective manner. Another reason for introducing pollution control based on aggregate emissions is that, in the present regulation concentrated on enforcing source-specific standards,

there is no link between ambient and source standards in terms of the volume of polluting activities. If the permits are auctioned, there is a new source of revenue to the government. For successful implementation four important areas are: setting the cap, allocating permits (grand fathering or auctioning), monitoring and compliance. The 'Perform, Achieve and Trade' initiative of Bureau of Energy Efficiency for achieving energy savings in large industrial units is a market-based instrument.

Environmental policy reform based on sound science and public participation can internalize environmental costs in decision making and influence peoples' behavior to improve environmental quality. Introduction of pollution charges, taxes and cesses, creation of markets for emission trading, and penalties for non-compliance at rates higher than the compliance costs will also generate new financial resources for environmental management As India is becoming a globalised market economy, and it is a member of World Trade Organization and many multilateral environmental agreements India can achieve sustainable development goals by using market-based instruments.

There is a need for promotion of environmentally sound technologies. Agenda 21, Chapter 34, says 'environmentally sound technologies protect the environment, are less polluting, use (all) resources at a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than the technologies for which they were substitutes'. It says these are 'not just individual technologies, but total systems which include know-how, procedures, goods and services, and equipment as well as organizational and managerial procedures'.

In most developing countries including India, micro, small and medium enterprises account for nearly half of the industrial output and more than half of the share in employment. Environmental management is difficult in this sector because these units are dispersed and there is no

information base on the emissions and wastes. In view of the social benefits like decentralized development and employment generation especially for weaker sections, sustainable development of these units require special efforts for transfer of environmentally sound technologies to these units. While industry –specific and location-specific scientific research is necessary for identification of the technologies appropriate to the industries, social cost benefit analysis of transfer of environmentally sound technologies in terms of net economic , social and environmental benefits would be useful for framing policy instruments for sustainable development of these industries. See Central Pollution Control Board (2011) for status of the existing technologies and potential for adoption of clean technologies.

Integration of the three pillars of sustainable development in public policies in a balanced measure is a difficult exercise. It necessitates the evaluation of costs and benefits of designing and implementing alternative policies, based on national circumstances and policies, in terms of the three pillars. For example, pursuit of economic efficiency and environmental effectiveness goals requires that all prices reflect their social (private and environmental) costs. But social goals such as poverty eradication and ensuring access to clean energy to poor at affordable prices necessitate provision of food and energy at affordable prices to the poor, which means setting the prices below their social costs and government bearing the subsidy burden. Social benefit cost analysis can contribute to evaluation of the policy trade- offs , determining the extent of and phasing out of the subsidies, and better targeting of the subsidies to the poor by using unique identification cards.

(b) Natural Resources Management

The Botanical Survey of India for carrying out taxonomic and floristic studies in wild plant reserves was established in 1890. It is responsible for exploration, inventorying and documentation of phytodiversity,

identification of threshold species, survey and documentation of traditional knowledge and development of national database of Indian plants. The Zoological Survey of India, established in 1916, has a mandate to survey, collection, documentation and ex situ conservation of wild animal diversity of the country. India has institutions for forest survey, conservation and management of mangroves and coral reefs, national river conservation, and regeneration and eco development. India has 4.92 per cent of its geographical area under protected areas. The protected areas include 102 national parks, 516 wildlife sanctuaries, 49 conservation reserves and 4 community reserves.

India has been successful in using satellite technology for forecasting weather, flood and tropical cyclones, disaster management, and agro meteorological advisory services. Remote sensing technology is being used for wasteland mapping, biodiversity characterization at landscape level, forest cover mapping, and coastal zone mapping. For an assessment of the costs and benefits of using geosynchronous and remote sensing satellites services in various applications, see Sankar (2007).

The Planning Commission-National Natural Resources Management System, constituted in 1983, is an apex body and has members from various central government departments which deals with natural resources and environment. For geospatial application and decision support system in meteorological and oceanographic studies, water information system, earth observation system, rainfed agricultural crop system, forest protection, biodiversity conservation and flood hazard mapping, see Government of India (2012). Interface between the scientists and social scientists needs to be strengthened.

The dominant theme of National Environment Policy 2006 is that while conservation of environmental resources is necessary to secure livelihoods and well-being of all, the most secure basis for conservation is

to ensure that people dependent on particular resources obtain better livelihoods from the fact of conservation, than from degradation of the resources. The 12th Plan Working Group report on Ecosystems, Restoration, Biodiversity on Sustainable Livelihoods notes that deficit in governance is the most significant challenge before the society (Government of India, 2011). The Forest Rights Act is yet to be implemented fully. Clear definition of forest rights and enforcement is necessary for sustainable management of forest resources. Livelihood support through non- timber forest products can be enhanced by strengthening the supply chain and providing minimum support price, wherever feasible. There is also a need to synergize joint forest management, rural employment guarantee scheme and eco-restoration programmes to promote sustainable management of natural resources. The access and benefit sharing regime of the Convention on Biodiversity must reward suitably the custodians of traditional knowledge and biological resources.

As for ecosystem services, markets exist only for certain provisioning services and most of these markets are imperfect. Most ecosystem services have use values and non-use values. Valuation of ecosystem services is necessary to incorporate their values in public and private decision making. Payments for ecosystem services, wherever feasible, must be attempted. We must realize that most ecosystem services have become scarce and their conservation and sustainable use enhance the well being of society, particularly the poor. Community - based self- governing organizations may be promoted for managing common pool resources such as village commons, watersheds, and wetlands related to the provisions of common property resources.

In February 2011, the Ministry of Environment and Forests has initiated a major new programme-The Economics of Ecosystems and Biodiversity (TEEB) study- of valuing its natural capital and ecosystem services in terms of economic value. The expected outputs of TEEB are: a

survey of biodiversity and ecosystem services coming from various biomes to the socio-economic groups that benefit from them, particularly in terms of livelihoods, health, food, water and energy; a framework of what and how to value natural resources in India; mapping ecosystem services and their values; calculating Environmental Adjusted State Domestic Product from changes in forests, freshwater, agricultural land and carbon sequestration; calculating Green Domestic Product and Green State Domestic Product and GDP of Rural and Forest Dependant Poor.

SCIENTIFIC UNCERTAINTIES, ENVIRONMENTAL RISKS AND PUBLIC POLICY

Science can play an important role in identifying potential environmental hazards and highlighting planetary boundaries so that humanity can operate safely. The strong scientific evidence for depletion of ozone layer resulted in the Montreal Protocol on Ozone Depleting Substances (ODS) and the small number of ODS producers and availability of substitutes for ODS facilitated successful implementation of the Protocol.

In the case of climate change, the Intergovernmental Panel on Climate change in its Fourth Assessment Report alerted that 'warming of the climate system is unequivocal, as is evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level' (Intergovernmental Panel on Climate Change, 2007). However, the prospects of reaching a global agreement on containing green house gas emissions appear to be dim now.

There are uncertainties regarding estimates of cumulative and current greenhouse gas emissions, likelihood of the increase in global warming and the economic and social impacts. IPCC Working Group reports recognize the nature and sources of uncertainty because they

consider materials from many disciplines which use diverse approaches; qualitative uncertainty is characterized by providing a relative sense of the quality of evidence and the degree of agreement among the reviewers; and where uncertainty is assessed using statistical evidence and expert judgments, then the reports indicate the likelihood ranges e.g., 90 per cent intervals. There are many climate sceptics.

From an economic perspective, the following issues arise. First, climate change is an extreme event and may be a catastrophe. Hence, the expected utility analysis may be inappropriate; safety –first approach is more appropriate. Second, as studies by Nordhaus, Stern and many others reveal that the policy decision whether to act now or later depends crucially on the choice of the discount rate in the calculation of the net present values. Third, as Weitzman (2009) has shown, the conventional cost benefit analysis breaks down because of the cascading effects of uncertainties- from estimates of greenhouse gas emissions to the ultimate impact on per capita consumption. Fourth, global warming is a global public bad and we need international cooperation to reach a binding agreement on emission reductions and sharing of the mitigation and adaptation costs. In view of the large uncertainties and the need for preventing irreversible damages/ catastrophes, precautionary approach is desirable.

India came with a National Action Plan on Climate Change in 2008.The eight national missions are: National Solar Mission, National Mission for Increased Energy Efficiency, National Mission on Sustainable Habitat, National Water mission, National Mission for Sustaining the Himalayan Ecosystem, National Mission for a Green India, National Mission for Sustainable Agriculture and National Mission for Strategic Knowledge for Climate Change. The technical document spells out the technological options available, co-benefits, R&D collaboration, technology transfer, regulatory options and capacity building needs

(Government of India, 2008). India is able to provide greenhouse gas inventory information. It has set up a climate modeling forum.

Commercialisation of Bt brinjal in India generated a heated debate on the reliability of scientific information, impact on the farmers' access to the seeds, potential adverse effects on the traditional varieties, and also the need. Presenting a detailed note on the debate, Jairam Ramesh, then Minister of Environment and Forests, says: when there is no clear consensus within the scientific community itself, when there is so much opposition from the state governments, when responsible civil society organisations and eminent scientists have raised many serious questions that have not been answered satisfactorily, when the public sentiment is negative and when Bt-brinjal will be the very first genetically-modified vegetable to be introduced anywhere in the world and when there is no over-riding urgency to introduce it here, it is my duty to adopt a cautious, precautionary principle-based approach and impose a moratorium on the release of Bt-brinjal, till such time independent scientific studies establish, to the satisfaction of both the public and professionals, the safety of the product from the point of view of its long-term impact on human health and environment, including the rich genetic wealth existing in brinjal in our country (Government of India, 2010a).

Rockström et. al., (2009) report that 'anthropogenic pressures on the Earth System have reached a scale where abrupt global environmental change can no longer be excluded'. They propose a new approach to global sustainability in which they define planetary boundaries within which we expect that humanity can operate safely. According to them transgressing one or more planetary boundaries may be deleterious or even catastrophic due to the risk of crossing thresholds that will trigger non-linear, abrupt environmental change within continental- to planetary-scale systems. The identified nine planetary boundaries are: (1) climate change, (2) ocean acidification, (3)

stratospheric ozone, (4) biogeochemical nitrogen (N) cycle and phosphorus (P) cycle, (5) global freshwater use,(6) land system change (7) the rate at which biological diversity is losing ,(8) chemical pollution, and (9) atmospheric aerosol loading. Drawing upon current scientific understanding, they propose quantifications for the first seven of them. They say that humanity has already transgressed the planetary boundaries for climate change, rate of biodiversity loss, and changes to the global nitrogen cycle.

Pereira and Funtowicz (2009) discuss the changing role of science in policy making in the context of scientific uncertainty in a plurality of value systems in problems like climate change, nuclear energy, and genetically modified organisms and urge the need to change the ways in which science-based knowledge used to foster, support, or legitimize policy making. When scientific knowledge is imperfect, environmental consequences are in the nature of catastrophes and decisions are urgent, precautionary approach is needed.

In this context, it is useful to keep in mind Knight's distinction between risk and uncertainty. Risk is the situation where the relevant probabilities of different states are known or can be estimated. Uncertainty exists when the relevant probabilities do not exist either because past statistical data do not capture extreme events or abrupt changes as in the case of climate change, or the scientific evidence is insufficient as in the case of new technologies like GMOs. Scientific research may contribute to risk/ uncertainty reduction. But attitudes towards risks and uncertainties depend on individual, social and cultural characteristics of the affected individuals and their capacities to deal with them. Stakeholders' engagement from the agenda setting stage to the implementation stage is necessary to address different dimensions of the risks and to evolve appropriate mitigation and adaptation strategies. The traditional knowledge of the ecosystem dwellers in coping with the past

ecosystem changes and their strategies must be taken into consideration in policy formation.

World Bank (2010) notes that earthquakes, droughts, floods and storms are natural hazards but the unnatural disasters are deaths and damages that result from human acts of omission and commission. The report says that prevention is possible and examines what it takes to do this cost-effectively. While science helps in understanding causes, sources and impacts of natural hazards, and also in forecasting droughts, floods and storms and developing disaster management system, social sciences have roles in communication of the risks, in deciding policies for prevention or at least minimization of damages and evolving location-specific adaptation strategies.

CONCLUDING REMARKS

Even though India has the scientific and technical capability for science-based policy making on environmental issues, its potential for fruitful policy applications is yet to be realized. Very often economists and other social scientists are not associated with scientists and policy makers on decisions relating to pollution control and natural resources management. There exists ample scope for multidisciplinary research among scientists, economists and other social scientists on environmental issues, but there are barriers for such an interface because of the "silo" mentality among researchers in different disciplines, perceived high opportunity costs of learning relevant natural sciences by social scientists, and lack of institutional structures for motivating and incentivising researchers to work on important environmental problems in a multidisciplinary framework in a mission mode.

Another drawback in the Indian system is that most of the budgetary allocations are spent on generation of data/ information with fewer resources available for dissemination of data and their applications

for policy-oriented research. Greater involvement of social scientists and various stakeholders at the stage of planning R&D/ surveys/ technology choice will enable policy makers to understand economic, social and cultural dimensions of proposed policy changes, to anticipate behavioural responses of the affected people, and to ensure smooth implementation of policies.

The interface between science and economics is necessary for developing the information base and methodologies for pollution prevention and control and sustainable management of natural resources. The policy oriented joint research will enhance India's capacity in articulating her concerns in international environmental negotiations, in conducting sustainability assessments of contemplated policy changes, and in formulating domestic policies , based on national circumstances and policy priorities, by assessing the trade-offs in integrating and balancing the three pillars of sustainable development.

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