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WATER POLICY AND SCIENCE: A PRESENTATION TO IIASA, LAXENBURG, AUSTRIA, ON 18 APRIL 2007

by

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Abstract

This paper is about the contribution that water science can make to good water policy. It sets forth some basic propositions about water policy, water science, water engineering, economics, other social sciences, ecology, and so on, and then proceeds to identify certain policy questions which would benefit from scientific inputs, such as restraining the growth of demand for water, the extent of possible augmentation of supply by local community-led rainwater-harvesting, the strengthening of the professionalism and rigour of the examination and evaluation of big projects where these are considered necessary, the regulation of the exploitation of groundwater resources, the right policy towards floods, and so on. It also queries certain current formulations such as IWRM, minimum flows, virtual water, water stress, etc. It refers briefly to two Indian projects and questions whether they are good science. In conclusion it raises the question of the implications that climate change has for water policy.

I. Introductory

I am grateful to Prof. Leen Hordijk for inviting me here and giving me the opportunity of meeting all of you. It is an honour to speak to such a distinguished audience. I am not a scientist or an engineer but a former civil servant. I have been writing about water-policy issues, and shall speak to you essentially about what water science can do for good water policy. As it happens, I had occasion to speak on a similar theme to an Inter-Academy Meeting on Water jointly convened by the three National Science Academies in India at New Delhi on 7 April 2006. My talk today draws upon my note for that meeting, as also upon parts of my book *Towards Water Wisdom: Limits, Justice, Harmony* which is currently under publication by Sage Publications. My observations spring from my primarily South Asian experience, but I hope that they will be found to have a wider relevance. As my concern today is with the contribution that science can make to good water policy, I shall not have much to say on issues that are largely political or economic, such as water markets or privatization or pricing.

II. Basic Propositions

Let me begin with seven basic propositions.

Proposition I: *Water, seemingly a simple thing and an unremarkable part of our daily lives, is in fact a highly complex and multi-dimensional substance.*

Water is many things in one, and is perceived in diverse ways by different people: as a basic life-support need; a fundamental legal right in some countries and a human right in the UN system; a Common Pool Resource (CPR) of the community; the property of the state; an economic good or `commodity' governed by market forces; an integral part of the ecological system, sustaining and being sustained by it; an inextricable part of culture and history; and a sacred resource or a divinity. These divergent perceptions give rise to divergent prescriptions: a right to be ensured and enforced by the state, treatment as `public trust', community management, state control, water markets, economic pricing, private sector participation, and so on.

Proposition II: *There is or ought to be a two-way relationship between water policy and water science.*

Water policy, at the level of national governments and at the level of inter-governmental or international organizations, is a statement (sometimes embodied in an Act or Code) of an approach to the use, management and conservation of the water resources of a country, a region or the world as a whole. It is generally concerned with issues of future requirements, availability, augmentation of availability for use, people's basic needs and rights, other (non-basic) uses and relative priorities, pricing in different uses, sharing (between uses, users, areas, countries), equity and social justice, the avoidance and/or resolution of conflicts, economy and efficiency in use, resource-conservation, sustainability and ecological soundness. It is obvious that a good water policy, whether at the national or regional or global level, must be founded on a good understanding of water, and in particular, on good water science. Water policy issues in turn may generate questions for some of which answers may have to be sought in water science.

Proposition III: *Water science is not the same thing as water-engineering.*

Water science means an understanding of the role(s) that water plays in nature and on Planet Earth. To many people, the term ‘water science’ brings to mind large dams and reservoirs and long-distance water transfers, such as Bhakra Nangal, Aswan, Hoover, Three Gorges, and so on, but these are instances of water engineering. Impressive and awe-inspiring as some of the famous engineering marvels might be, they may not always be consistent with water science as defined above. In other words, not only is water engineering not water science, it may even be bad science in some cases.

Proposition IV: *It would be wrong to look for answers to social science issues in the realm of natural science.*

Not all the aspects of water mentioned earlier fall within the domain of science. To the extent that we are thinking of aspects and dimensions that fall outside that domain, science may not have much to say. For instance, if we ask how much freshwater is available in nature, we are asking a hydrological question, but if we ask how much water will be needed by the year 2025 we are asking a question about many things including patterns of water-use, ways of living, their alterability, and so on. It follows that water is as much a matter of social science as one of natural science.

Proposition V: *It would be wrong to look for answers to all social science issues exclusively in economics*.

Within the sphere of social sciences, water is as much a matter for the sociologist, the social anthropologist, the historian, the cultural theorist and the lawyer, as a subject for economists – though the latter tend to assume a special and over-riding importance for their discipline. We must recognize that all questions and issues cannot and must not be treated as economic ones.

Proposition VI: *Limits on our draft on natural resources, particularly water, set by ecological imperatives and the health of planet earth must not be exceeded. We cannot learn to live in harmony with our neighbours until we have learnt to live in harmony with nature.*

Proposition VII: *In addition to harmony with nature, a concern for equity and social justice must be the governing consideration in whatever we plan or do in relation to water.*

No explanatory remarks seem necessary in respect of the last two propositions.

Having stated those preliminary propositions or ‘axioms’, let me offer you a few suggestions on how science can contribute to the making of water policy.

III. Re-examining ‘Demand’

The first question on which a scientific contribution would be very valuable is: does the world face a water crisis? (I am not referring to the phenomenon of climate change. We shall come to that later.)

Given the growth of population, the pace of urbanization, and the path of economic growth on which all countries are embarked, and given the finite nature of the availability of freshwater on this planet, the proposition that the pressure on that finite resource will increase leading to a crisis in the near future seems very plausible. It may seem odd, if not perverse, to question it. However, whether there will be scarcity or a crisis will depend to a very large extent on what the `demand’ is assumed to be, and that will depend on how we use water. *`Demand’ is what we should look at first, before we even begin to think of supply-side answers. The crucial question is: how much water do we really need? Science may have something to say about this.*

Consider how future `water demand’ is projected. Making a whole range of assumptions, the requirements of water for various uses (personal, domestic, institutional, municipal, agricultural and industrial) are projected, based on current patterns of use with some adjustments for improvements and economies. In each one of these, *major* economies in water use are necessary and possible in relatively poor or ‘developing’ countries, and also in rich or ‘developed’ countries, though for different reasons. (Incidentally, I have serious reservations about the terms ‘developing’ and ‘developed’, but am obliged to follow current usage.)

In the so-called ‘developing’ or ‘third-world’ countries, the thrust would be on improvement in efficiency and minimization of waste in every use, maximizing the utility that we get out of every drop of water, keeping in mind at the same time considerations of social justice and equity. This would be partly a question of administrative, economic and social reforms (better governance, regulation, pricing, equitable distribution, and so on), but science, technology and innovation may have a role to play. Let me elaborate that a bit.

In the context of public urban and rural water supply systems, ignoring the current per capita norms, and assuming that a norm of 100 litres per capita per day (lpcd) or so is adequate for both rural and urban areas, it is clearly necessary to even out the prevailing skewed distribution. Those who are getting pitifully small supplies should get more, and those who are using too much water should be brought down to a reasonable level. This may be a question of regulation, pricing and penalties, but there may be technological aspects: *are there technical means of restraining over-use or denying supplies over a certain level?* The answer is probably 'Yes', but practical problems may need to be overcome in operationalizing that proposition.

A similar question can be asked about use in hotels, etc. Is pricing (higher rates for higher use, and penal pricing beyond a limit) the only instrument available for controlling profligate use or *is denial of supply beyond a limit technically and practically feasible*?

A related question is whether a multiple supply system can be introduced such that water for drinking and cooking, water for the garden, and water for the toilets, are kept separate.

Enormous quantities of good water are being used for the transportation of human waste. Are there effective alternatives to flushing toilets? If not, can we at least minimize the requirement of water for this use?

In agriculture, we need to *minimize the wasteful use of water and maximize what we get out of each drop of water* (i.e., maximizing water-productivity and not merely land-productivity). This would involve the study of water conveyance, crop water requirements, cropping patterns, irrigation techniques, yields, and so on.

In industry, similarly, the requirement of water per unit of output (for cooling and for process) needs to be drastically reduced, waste minimized and the same water used over and over again, with a minimal allocation of make-up water to cover unavoidable losses.

These are not high-science questions. Some would involve minor engineering, some would be a matter of technological improvements and innovations, and some may call for high science. All of them would require a concerted effort in which social sciences would need to play a part.

In the 'developed' countries, assuming that the levels of equity and efficiency are much higher than in developing countries, 'water demand' is nevertheless unconscionably high for other reasons, namely, the pursuit of consumption-oriented lifestyles. Improvements in efficiency and equity may still be called for, but the growth of demand can be significantly restrained in these countries only by bringing about changes in ideas of 'development' and ways of living. In the effort to persuade people that civilized living is possible without the consumption levels of today, Science and Technology may have a useful contribution to make.

IV. Augmenting Availability

However carefully we manage demand and prevent it from getting out of hand, some augmentation of availability may be necessary. There are only three means of augmenting the availability of water for use: (i) big projects (dams, reservoirs, canals), (ii) drilling for groundwater and (iii) local rainwater-harvesting and micro-watershed development. All three can provide benefits, but all three have their impacts and consequences. Leaving groundwater for later discussion, let us consider the other two.

I have been advocating primacy to community-led local water-harvesting, recourse to big projects being limited to those cases where they are the only option or the best of available options. I shall not enter into that debate here. Leaving that aside, it is clear enough that a massive push needs to be given to local, community-led initiatives for the augmentation and conservation of water. That is part of official policy in India now. Even internationally, there is much interest in rainwater-harvesting. However, mainstream opinion continues to regard this as a minor, secondary or supplementary component of national or global water planning. The question therefore arises as to how much water-augmentation can be achieved through this route, and how significant a part of water-planning this can become. Let me explore this briefly.

The `availability' of surface water is generally measured through river-flows at terminal points. However, what is available in nature is rainfall and not just river-flows; and available water becomes `usable' not merely by being stored in large reservoirs behind dams but also through capture in local water-harvesting structures (whether for direct use or for re-charging groundwater aquifers). Clearly, some of the rain that falls will go underground, some will evaporate, and some will be retained in atmosphere or soil, and so there will necessarily be a gap between precipitation and river-flows. Illustratively, let me give some Indian figures: there is an annual precipitation of 4000 BCM over the Indian landmass, and the 'availability' figure, as measured at the terminal points of the river systems, is 1953 BCM. As you can see, the gap is large. Given that gap, it seems possible to hypothesize that we can capture a part of the rain that falls as an additionality to the availability figure mentioned above.

Professors Kanchan Chopra and Biswanath Goldar of the Institute of Economic Growth, Delhi, have estimated the possible `additional run-off capture' as 140 BCM. That number may be questionable, but *prima facie* it seems that this route can be a significant and not necessarily minor component of our water planning.

However, any interception of rainwater in the upper catchment may affect the run-off. There may be a reduction of run-off in villages lower down; on the other hand, in some areas there could also be a rise in the groundwater table. If there is a serious reduction in run-off, river-flows may be affected, in which case the local augmentation of availability may be partly offset by a reduction in the flows measured on the river-systems.

Having regard to the above, it is clear that *research (both conceptual and empirical) is needed on the potential for local augmentation through rainwater-harvesting without adverse impacts on areas lower down, and the extent to which that augmentation would be truly an additionality to river-flows*.

V. Big 'Water Resource Development' Projects

In the case of big projects, the adverse impacts and consequences (environmental, social, human) are by now fairly well-known. I need not state them in detail here. The accepted answers to that problem are: Environmental Impact Assessment (EIA) studies and Cost-Benefit Analyses (CBA) leading to an investment decision. There are serious problems with both EIAs and CBAs but they are partly methodological and partly institutional. EIAs have to be made truly professional, objective and independent. CBAs are limited and may have to be enlarged into Multi-Criteria Analyses, but even so, they may still have to be supplemented by qualitative (i.e., non-quantitative) considerations; and the entire exercise has to be rigorous even where quantification is not possible. *I am not going into these important matters in detail because they are not necessarily questions of science. However, as we proceed beyond `environmental impacts' to `ecological economics' (or ecological concerns in a broader sense transcending economics), science may have valuable contributions to make.*

May I also draw your attention to the extensive conceptual and methodological discussions on CBAs that took place at a Conference convened by Yale University in 1999?

VI. Some Current Formulations

At this stage I propose to refer to certain concepts and formulations that have gained currency in the international water circuit. These are: IWRM, Drainage Basin Management, Minimum or Ecological Flows, Virtual Water and Water Stress. I mention them to this audience because they are not just concepts but prescriptions and have considerable influence on the making of water policy at national and global levels. This seems to me a matter for concern because they have a scientific ring but are in fact highly problematic.

(a) `Integrated Water Resource Management', `Drainage Basin Management':

The phrase `Integrated Water Resource Management' or IWRM has come into extensive use in recent years, particularly in the Global Water partnership (GWP) and World Water Council (WWC) circles and at the World Water Forums. The related term `Drainage Basin Management' is now established usage in Stockholm. These terms may seem unexceptionable, and they do represent advances on earlier thinking, but they continue to carry with them some limitations arising from the sources of their origin. That origin can be traced back to the earlier preoccupation with the planning of big projects and the dominance of engineering in that planning. The influence of the old ways of thinking has not wholly disappeared. While more dimensions have been added, there has been no radical departure. It seems to me that IWRM does not represent true inter-disciplinarity. Further, the terms `IWRM' and `Basin Planning' carry within themselves the seeds of centralization and gigantism, and they fail to incorporate adequately the elements of decentralized, local, community-led planning and management, and of traditional knowledge and wisdom.

Similarly, while the expression `drainage basin' is a technical term with a precise meaning, it is a very limited perception of one aspect of a river. To think of a river as a drain may be technically correct, but it is a reductionist view. How can anyone trained to think of a river primarily as a drain even begin to understand the multi-dimensional roles of the major rivers in the economic and social lives, cultures and civilizations of the countries concerned?

The terms `IWRM' or `drainage basin management' may have their uses, so long as we understand their limitations. Besides, there is the problem of reconciling and harmonizing two seemingly divergent approaches: on the one hand, the 'basin planning' approach which has a bias towards centralization, gigantism, high technology and bureaucratization; and on the other, local rainwater-harvesting and micro-watershed development, which is small-scale, decentralized, community-led, informal, and ‘low-tech’.

(b) `Minimum flows’ or `environmental flows’ or ‘ecological flows’

These terms are much in currency now, but let us begin with a brief reflection on how they emerged. Not very long ago, the `use’ of the waters of a river meant their abstraction from the river, or their diversion through canals; `in-stream’ uses were not (or not adequately) recognized; and water flowing to the sea was generally regarded as `wasted’. The approach was to `harness’ river waters through dams, barrages or other structures to the extent technically feasible. The stress was on maximizing `use’ as defined above, and this implied that flows downstream of the structures would be reduced. In some instances rivers dried up and failed to reach the sea. In course of time, the realization began to dawn that this was not necessarily a good thing, and that the reduction of flows could have various adverse consequences. During the same period, environmental concerns were growing and gaining depth and strength. As a result, the idea that a river must not be totally dried up and that some flow must be maintained emerged and gathered strength. That was the origin of the term `minimum flows’. Later, the better-sounding terms `environmental flows’ and `ecological flows’ came into use. However, wrong ways of thinking lie hidden behind these phrases.

In the first place, expressions such as `environmental flows’ or `water for nature’ carry the implication that in allocating water for various purposes, an allocation must be made for `environmental’ purposes or for `nature’. This is to turn things upside down. We *receive* water from nature; we cannot presume to *allocate* water to nature. Water itself is a part of nature, and sound ecological balance will determine the continued availability of water. Ecology, then, is prior to all water-uses, and it is absurd to make an *allocation* of water for ecology. Ecological considerations may impose *restraints* on the various uses of water, and on the draft that we make on nature: ecology itself cannot be treated as being among the competing recipients of allocations of water. Instead, ecological imperatives must guide our water-use.

Secondly, while the idea of a `minimum flow’ or `environmental flow’ in streams and rivers is welcome in so far as some flow is better than no flow, this does not imply any major change in thinking: abstraction and diversion continue to be the norm, with a slight limitation by way of `minimum’ or `environmental’ flows. There is a danger here: the notion of a *minimum flow* seems to sanction by implication that of *maximum abstraction.* `Minimum flow', intended to be the floor, may well become the ceiling: people may feel that so long as they have left that much water in the river, they are entitled to divert the rest. Rivers must flow, and we should be wary of interfering with the natural flows. What we need is not *minimum flows,* but *minimum interference with natural flows*. What is needed is not the grudging maintenance of a small flow (`minimum'): we must ensure that the flow continues at *desirable* levels.

What are *desirable* levels of flows? Flows are needed for maintaining the river regime, making it possible for the river to purify itself, sustaining aquatic life and vegetation, recharging groundwater, supporting livelihoods, facilitating navigation, preserving estuarine conditions, preventing the incursion of salinity, and enabling the river to play its role in the cultural and spiritual lives of the people. These multiple and diverse functions and purposes are not fully captured by phrases such as `ecological flow', `environmental flow', and so on. We have to go beyond these. Reversing present thinking, we must learn to regard natural flows as the norm and abstraction or diversion as the departure from nature, to be resorted to minimally and with care.

It might be argued that the idea of `natural flows' is problematic, but that is not so. One does not have to go back to pre-historic or pre-agricultural times. It is true that with human settlements on the banks of rivers and the beginnings of irrigated agriculture river waters began to get used, but the flows were not substantially affected until human *intervention* in the rivers through structures of some kind for the diversion or storage of waters began to take place. If we define `natural flows' as flows as they were prior to such interventions, the concept is not an obscure or difficult one.

(c) <u>`Virtual Water':</u>

The terms `virtual water' and `virtual water trade' are relatively recent but seem now to be well established. A water-abundant country can grow and export things such as rice or wheat or fruit and vegetables needing much water to produce, and a water-deficient country can import them. This is taken as equivalent to exporting / importing water. It is argued that developing countries that face growing pressure on their water resources need not use their water to grow such water-demanding produce, but could import their requirements from water-rich countries (thus virtually importing water).

Many would argue that a distinction needs to be drawn here between imports of staple food and imports of other things such as fruits and vegetables, and that a vulnerable dependence on food imports is not desirable. Opinion is divided on that issue, with some arguing that we can export whatever we can and import whatever we need (including food), and others stressing the importance of a degree of self-reliance in food. Leaving that aside, it seems to me that there is an element of obfuscation in the concept of `virtual water trade'.

Every import or export can be re-described as something else. Exports of rice and wheat can be treated as exports of water (among other things); exports of aluminium can be regarded as exports of electric power; exports of iron and steel originate in iron ore and can be regarded as exports of the soil of the country; and so on. This can serve the purpose of drawing our attention to the implications of certain kinds of trade. For instance, a water-stressed country or area within a country can be cautioned against producing, say, rice for markets outside its borders. However, in international conferences and forums the concept of virtual water trade tends often to be used as one more means of persuasion directed at developing countries, extolling the virtues of markets and imports as against domestic production. We need to be wary of this insidious theory.

`Water Stress'

The term `water stress' is widely and loosely used. We often come across statements to the effect that the per capita availability of water resources in a particular country is declining, and that it is fast becoming a water-stressed country. There is a bit of confusion here that needs to be cleared up.

`Water stress' is a term that we owe to Prof. Malin Falkenmark, and it is now an established concept. The degree of stress is measured with reference to the annual per capita availability of water resources in a country or region (AWR). An AWR of 1700 m^3 means that only occasional and local stress may be experienced; an AWR of less than 1000 m^3 indicates a condition of stress; and one of 500 m^3 or less means a serious constraint and a threat to life. What we are measuring here is the quantum of water resources available to a country divided by the population. On the other hand, the basic water requirement per person or BWR is the quantity of water that a human being needs to meet his or her daily needs for drinking, cooking, bathing and sanitation. Peter Gleick has estimated this as 50 litres (Gleick 1996). That works out to 18.25 m^3 per person per annum. If we consider that a low estimate and double or triple it, it still comes to no more than 36.5 or 54.75 m^3.

Why then should a per capita availability of 1000 m^3 mean that a country is water-stressed in Falkenmark's terms? The answer is that in addition to our direct and personal water needs, we also need food, consumer goods and various industrial products, energy, and so on, and water goes into their production. It follows that the totality of our water needs goes well beyond BWR in Gleick's sense. That is what Falkenmark's AWR norm measures. If the water available to a person falls below say 150 lpcd or 54.75 m^3, that person, as a human being, will be in a state of stress. If the country as a whole has an annual water resource availability of less than 1700 m^3 Falkenmark argues that the country will be approaching a state of stress. The `stress' of the country in this sense is not the same thing as an individual's stress in the absence of water. In the latter case, we are referring to a pathological state, whereas in the former `stress' is a metaphor for a difficult situation. This distinction is not always kept in mind in the discussions. (It is of course true that with a very low AWR level, a country may find it difficult to meet the people's minimum needs for a reasonable quality of life, and that at that level the country's economic stress may actually translate into physical stress for the people.)

In some cases, a country that is not well endowed with natural resources may manage to meet a wide range of its requirements quite satisfactorily through imports. We may hold different views on how dependent we should be on imports for meeting essential requirements (this was referred to earlier in the discussion of `virtual water'), but that is an economic or political point. What the `water stress' theory implicitly assumes is that a country needs a WR endowment adequate to support a level of domestic production of goods and services, and that a country better endowed with water resources than another would be better placed both politically and economically than the latter. It seems clear that the water stress theory does not accept the proposition that the stress can be eliminated entirely through trade. It will be seen that there is a conflict between the `virtual water trade' theory and the Falkenmark concept of `water stress'.

I have gone into these five formulations at some length because I felt that a gathering of scientists would be interested in the conceptual issues involved in these debates, and would like to promote clear thinking on them.

VII. Groundwater

Turning to groundwater, the reckless extraction of this precious resource in many parts of the world (India, China, the USA, etc) and the resulting rapid depletion of aquifers, as also their pollution and contamination, have caused alarm and dismay in recent times. There is general agreement that the use of this resource has to be urgently brought under control and stringently regulated, but there are many difficulties in the way of regulation. I shall not go into this matter in detail here, because the issues involved are essentially administrative, legal, social, political and economic. *Major reforms are needed but science may not play a significant role in them. However, there are certain questions in respect of which scientific inputs may be needed, particularly in India and China: for instance, developing a fuller knowledge of aquifers, their nature, their boundaries, and their relationship to river basins; determining the extent to which groundwater flows find direct outlet to the sea without joining surface waters; developing technical means of limiting extraction to safe limits; understanding the factors behind the incidence of fluoride, arsenic, etc, in groundwater and finding answers to those problems; and so on.*

VIII. Floods

Turning now to floods, the initial response to flood damage was to try to \`control' floods through structural means such as dams or embankments. Over the years, serious doubts have emerged about the efficacy of such flood-control measures. There is a growing recognition that what we must learn to do is not so much to \`control' floods as to cope with them when they occur and minimize damage, partly through \`flood-plain zoning' (i.e., regulation of settlement and activity in the natural flood plains of rivers) and partly through \`disaster-preparedness'. However, that view is not universal; the notion of \`flood control' continues to hold sway over people's minds, and to influence official thinking. *Much of what needs to be done lies in the area of administration, law, economics, and so on, but science may have something to say on (a) the basic question of the feasibility of controlling floods and diverting flood* *waters and the role that such measures can play in the management of floods and minimization of damage, and (b) timely flood-forecasting and information systems*.

IX. Waste Water

Practically every drop of water provided for any kind of use will return to plague us as waste of one kind or another - domestic and municipal sewage, agricultural waste-water or industrial effluent. Thus, the greater the supply of water, the greater the generation of waste and the larger the problem of disposal. This is an additional reason for extreme economy in water-use and the avoidance of a ready resort to supply-side projects. Further, the more waste-water of any kind we generate, the greater the danger of pollution or contamination of fresh water, and therefore of a reduction in the available supply of usable water. This calls for a two-pronged attack. First, the generation of waste has to be minimized in every use. Secondly, waste has to be recognized a source of water, and as much water as possible has to be recovered from it for use (some kinds of uses).

I am merely drawing attention to these matters without elaboration because there is a vast literature on them. These are largely matters of investments, technology and management, but the sheer magnitude of the problems may warrant the exploration of possible innovative contributions by science.

IX. Two Indian Proposals

I should like to make a brief reference to two projects or proposals currently under much discussion in India, because they are regarded by some as examples of the application of Science and Technology or S&T to the finding of answers to the country's present and future problems: the first is a massive project for the Inter-Linking of Rivers (ILR), and the second is a proposal for meeting a part of the water needs of peninsular India through the desalination of sea-water.

The ILR Project

Two main justifications are offered for the `inter-linking of rivers'.

(i) The first is that it is an answer to the occurrence of floods in some parts of the country and drought in other parts; that the project will transfer water from the former areas to the latter, providing some relief from floods to the former areas and making more water available to the latter.

(ii) The second is that some river basins are `surplus' in water while others are `deficit', and that the project will transfer water from the former to the latter.

These are two distinct propositions giving rise to different sets of questions, but we may take a combination of these propositions as the rationale of the project. There is a divergence of views on the project in India. While many have welcomed the project as the answer to the country's future needs and problems, some have expressed a whole range of serious doubts about it. The supporters of the project claim that it will moderate floods, provide water to thirsty areas, make a significant addition to irrigated area, help in the greening of India, create millions of jobs, provide a substantial net generation of hydro-electric power, and so on. The critics question each one of these claims, and say that the project will have serious environmental, social and human impacts and consequences; that a favourable balance between these costs and the benefits arising from the project cannot be presumed but must be established link by link; that the insertion of such an enormous project demanding massive financial resources into the National Plan will thoroughly distort the planning process, and take time, energy and resources away from other necessary activities; that alternative ways of meeting the country's future needs are available; and that the project is not needed at all. I do not propose to go into the details of the Project here. In this forum, I am concerned only with the question whether the ILR Project is good science. My firm view is that it is not. I have written about this extensively, and can share those writings with those who are interested.

Desalination Proposals

For some time now, there has been talk of meeting a part of the water needs of coastal areas – mainly in Tamil Nadu - through *the de-salination of sea-water*. The idea seems to be catching on. There are two issues here. First, is this needed at all? Given the average rainfall of 1000 mm or more in the State, it seems to me that the needs of the State can be adequately met through rivers, groundwater and rainwater-harvesting. There seems to be no case for recourse to desalination of sea-water in TN. The second and more important issue is the following: is it possible to recover freshwater from the sea without generating large quantities of waste water, and can that warm concentrated brine be disposed of without inflicting considerable damage on marine flora and fauna, and without affecting the livelihoods of fishing communities? I have been told that new technology is available that avoids the brine problem. That sounds like magic to me. I seek enlightenment from science.

X. Climate Change

This not a subject on which I need to say much to this distinguished audience. It appears that there is a growing consensus among scientists that climate change is already upon us, and that the changes may be more rapid and far-reaching than imagined earlier. However, there is not much clarity as yet on the implications these changes have for water policy. I merely flag the issue for discussion.

Thank you.
