A Framework for India's Water Policy

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Abstract

As India plans for an expanded economic future, its expectations are jeopardized for want of a unifying national water policy. Formulating such a policy is a daunting task. In a technological world, sustained equitable water management to meet diverse needs of all segments of society demands a coming together of the best available scientific knowledge, avowed human values of democracy and social justice, and a will to adapt governance to complex interactions between ineluctable earth processes and human society. Therefore, a rational policy on water has necessarily to start with an overarching framework that recognizes the attributes of the remarkable natural phenomenon we call water, the physical limits of India's water endowments governed by these attributes, and the imperatives of civilized adaptation of India's citizens to the constraints imposed by immutable laws of nature that govern its dynamic. Such a framework will ideally lay down certain broad principles that will guide the crafting of laws, statutes, regulations, and conventions despite the spatial and temporal variability in water occurrence around the country. This paper presents such a unifying framework by placing India's water endowments in the context of the hydrological cycle, and perspectives of legal and cultural traditions that facilitate a just adaptation of society to a sharing of common resource vital for the survival of all living things. Comprehending the nature of water and civilized living within these constraints requires a harmonious coming together of all branches of human knowledge from the sciences to the humanities. The following couplets from the Rg Veda and the Thirukkural exquisitely portray a deep appreciation of humanity's sacred relationship with water.

या आपो॑ दि॒व्या उ॒त वा॒ स्रव॑न्ति ख॒नित्रि॑मा उ॒त वा॒ याः स्व॑यं॒जाः ।
स॒मु॒द्रार्था॒ याः शुच॑यः पाव॒कास्ता आपो॑ दे॒वीरि॒ह माम॑वन्तु ॥२॥

(RgVeda, VII 49.2)

Those heavenly waters, or those that flow when dug, or even those that are self-born, flowing towards the ocean, purifying, may those waters, Goddess, protect me here.

நீர்இன்று அமையாது உலகெனின் யார்யார்க்கும்
வான்இன்று அமையாது ஒழுக்கு

(Thirkkural, 2.10)

Without water, the living earth cannot be; if so for anyone, without rain order cannot be.

Introduction[1]

This work is a contribution towards an articulation of a rational water policy for India. It is based on the following premises:

- ❏ Sustainable management of its water endowments is paramount for India's continued existence as a viable society
- ❏ Presently, water management in India is not satisfactory. As used here, management includes water quantity, water quality, and water pollution
- ❏ Sustainable water management can be accomplished based on principles derived from a fusion of scientific knowledge and human values
- ❏ Science cannot make policy, even as policy cannot work without underpinnings of objective scientific knowledge
- ❏ For safeguarding the well-being of present and future generations, science, technology, social sciences, jurisprudence, and the humanities must constructively come together to design policy for sustainable water management

The purpose of this work is to provide a rational, overarching framework to facilitate formulation of a national water policy to guide an equitable sharing of water among all segments of Indian society against the backdrop of its finite space-time availability. The desired framework must unify the country, despite the fact that availability of water, and local traditions of sharing water may vary from region to region.

If water were an infinite resource, it could be freely exploited for benefit and profit using available technologies, aided by policies that provide incentives for exploitation. Efficient extraction would then be limited only by the scope of reigning policy to nourish exploitation. In reality, however, water is both vital for life and a finite resource. Its unfettered exploitation cannot therefore be a legitimate activity for any individual or social group. Rather, these twin constraints mandate implementation of policies designed to enforce optimal use of water to benefit all segments of society. Whilst necessarily bounded by the natural regime of the water cycle on earth, and its total availability over the Indian landmass, optimal management can profit greatly from creative approaches that fuse objective scientific knowledge with constructive human sensibilities, and inclusive societal perceptions. This is the human challenge in formulating India's water policy. An overarching framework for India's water policy thus rests on the following three quintessential elements:

i) Hydrological Cycle, ***the dictating natural phenomenon***,

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[1] An outline of this work was presented before a group of scholars knowledgeable about water on August 10, 2009 at a Discussion Group sponsored by the Indian Academy of Sciences and hosted by the National Institute of Advanced Studies, Bangalore. Illuminating discussions ensued. A list of participants is given in the Appendix

ii) India's water setting, ***the reality that demands adaptation to nature***, and

iii) The science-society interface, ***the human challenge***.

This paper begins with a brief exposition of these three elements in a connected perspective, followed by a discussion of what may be done to help establish a framework to facilitate formulation of India's water policy. The paper concludes with an outline of science components essential for a sustained operation of such a unifying water policy.

The existence of water on its surface has made planet earth the extraordinary entity it is in the cosmos. For close to four billion years, life on earth has ceaselessly evolved to adapt to earth's changing regimes of water. Human aspirations for unlimited prosperity have to be moderated by this knowledge, and society must show wisdom to sensibly adapt to ambient water regime. Failure to accept this challenge timely will likely lead to unacceptable stresses on India's society.

The Three Elements

Hydrological Cycle, *the dictating natural phenomenon*

Modern science and ancient Hindu thought alike have recognized the pre-eminent place of water in the evolution of earth and life. According to the Rg Veda (X. 129.3, Max Müller, 1889), in the beginning there was water without light (*salilam apraketam*), out of which evolved an uncreated and a self-developing world. Emerging knowledge in modern science shows that water, in the form of the hydrological cycle, plays an unparalleled role in the geological as well as biological evolution of the earth.

In its essence, the hydrological cycle (Figure 1) is simple to understand, within grasp of an elementary school child. Yet, it inspires the most advanced scientific research. Central to comprehending hydrological cycle is the concept of time scale. In the atmosphere, water evaporated from land may pour down as convective rainfall in a matter of hours. At the other extreme, rainwater may descend ponderously in the earth's deep for tens of millions of years before returning to the atmosphere in volcanic eruptions. Remarkably, all time scales have relevance in continually sculpting land and influencing evolving life forms.

Structurally, the hydrological cycle may be thought to be made up of four interacting components (Figure 2); the atmosphere, surface water, soil water, and groundwater. The main characteristics of these components are briefly discussed below.

The Atmosphere

Although a cycle has no beginning or end, from a human perspective we may consider atmosphere to be the starting point of the water cycle. It is the source of rain and snow, as also the reservoir of water evaporated and transpired by plants (exhaled during photosynthesis). Of all the water existing on earth, atmosphere stores only about 0.001% on average at any given time. In comparison, the total annual rain falling on

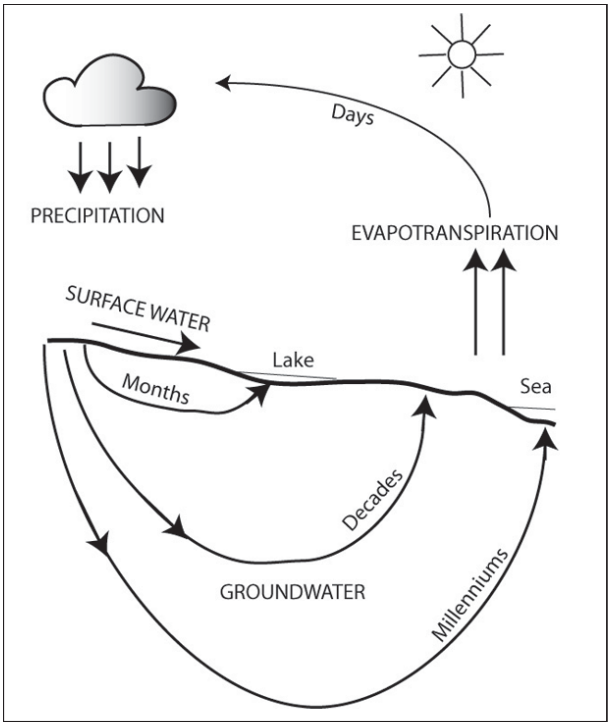

Figure 1: The hydrological cycle. Water circulation occurs at many time scales. All time scales are relevant in the geological-biological evolution of the earth

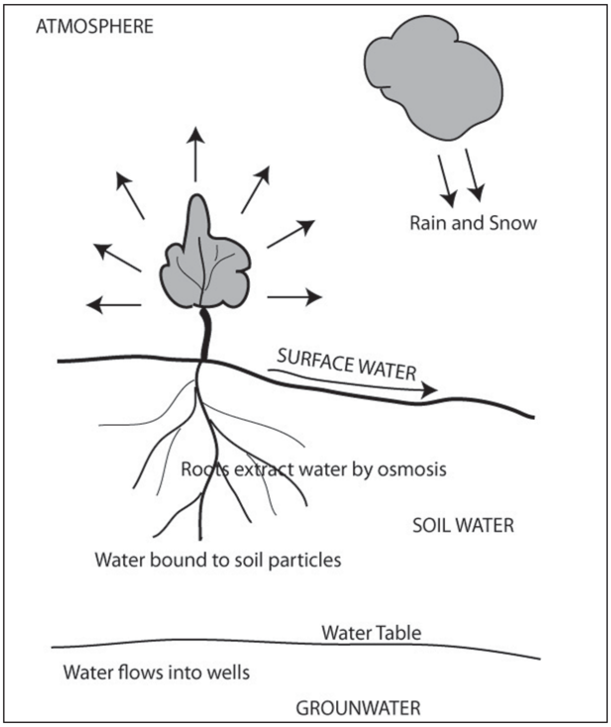

Figure 2: Four inter-connected components of hydrological cycle: atmosphere, surface water, soil water, and groundwater

earth (over land and the oceans) is some 40 times larger. Thus, water resides on an average for about 9 days (residence time) in the atmosphere, before being renewed.

The physical state of the atmosphere at any given time, and its variation in time, constitute the earth's climate. It is driven by a balance between solar radiant energy received by the earth, and that reflected and radiated back to space. Any change in the earth's solar heating caused by periodically varying sun-earth relationship, or in its radiative output caused by changing transparency of the atmosphere by greenhouse gases, forces the climate to shift to a new equilibrium, establishing new regimes of temperature, pressure, precipitation, evaporation and other atmospheric attributes. Thus, a change in climate reorders the hydrological cycle, thereby influencing physiographic variations and biological diversity. Aside from variability, climate is unpredictable. In our own times, we are witnessing unprecedented rate of global temperature rise with implications for sea level rise and changing precipitation patterns. Spectacular advances in the physical sciences and computing technology now make it possible to understand and explain climate patterns semi-quantitatively on various time scales, but the goal of precise quantitative climate prediction remains elusive.

Over the past quarter of a century, two important discoveries have come to light in climate science. First, tree-ring studies on submerged tree stumps in lakes have established that between 800 and 1,500 A.D., the Americas experienced two megadroughts, each lasting for more than a century (Stine, 1994). Second, ice-cores recovered from the Antarctic and Greenland have shown that during the past 650,000 years, the earth's climate has alternated between glacial and warmer periods approximately every 100,000 years, and that around 12,000 years ago, climatic temperatures changed by as much as 10 degrees over a period of a decade or two (Severinghaus, 1998). Evidence in support of other similar episodes is accumulating.

Surface Water

Water that flows over the land surface heading for the ocean, or that is stored in ponds, lakes, wetlands and other water bodies constitutes surface water, accounting for about 0.009% of the total water on earth. It is the principal agent of erosion, transporting sediments and nutrients to land lying along a river's path. Surface water thus constitutes the base that underlies aquatic ecosystems. Water entering into a stream from rainfall may take days to centuries before returning to the atmosphere.

Fundamental to an understanding of the surface water regime is the concept of a drainage basin (Figure 3). Every location on the earth's land surface belongs to one watershed or another. A striking feature of drainage basins is their hierarchical structure. The drainage basin of a major river is an assemblage of thousands of interconnected watersheds of various sizes. The surficial drainage pattern of a stream represents optimal energy usage, and reflects the most mechanically efficient pathways by which the stream may transport sediments downstream. Therefore, the stream mechanically resists any force that seeks to change its ambient drainage pattern, and in the process settles to a new equilibrium with the changed stresses. Through millions of years, communities of living beings have continually evolved to adapt to changes in drainage patterns. When the existing drainage pattern of a basin is disrupted, either by natural forces (volcanic eruption, earthquake) or man-made systems (dams, diversion of streams), the streams adjust themselves to changed conditions by establishing a new equilibrium. Such adjustments are potentially stressful and often fatal to existing flora and fauna.

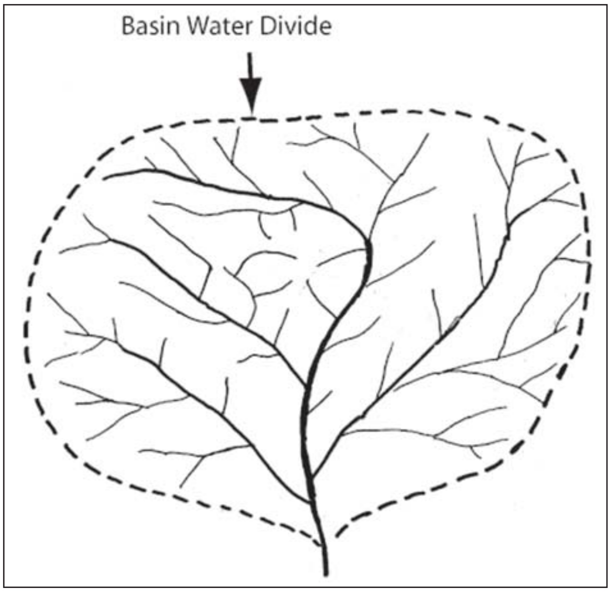

Figure 3: The notion of a drainage basin defined by a bounding water divide is fundamental to comprehending surface water

Soil Water

Among the four components of the hydrological cycle, soil water is the least understood. Soil water occurs between the land surface and the water table. Its chief characteristic is that it is bound tightly with the soil grains and cannot be extracted by wells. However, plants have evolved over time to extract soil water by osmosis. In the soil zone, water essentially moves upwards (to sustain evaporation) or downwards, to recharge groundwater. Approximately 0.005% of the earth's water resides in the soil zone. Water entering the soil zone may reside there over a period of months to centuries before returning to the atmosphere.

Until a few decades ago, the soil zone was of primary interest to agricultural scientists interested in increasing crop productivity by managing water in this zone. However, with the recognition that anthropogenic contaminants discharged on the land surface pass through the soil zone in their downward passage to groundwater, the soil zone attracts much greater attention now from environmental and ecological specialists as well as those in agriculture.

Because of the existence of capillary forces in the soil zone, soil water is difficult to manage. Yet, it is an important part of the hydrological cycle mediating critical exchanges between surface water and groundwater. Water flow in the soil zone is a complex physical process governed by competition between upward-directed evaporative forces, and downward-directed gravity. The rate of groundwater recharge is thus subject to these constraints.

Groundwater

Groundwater is water that occurs below the water table completely saturating the pore spaces of its reservoir. Compared with the other three components, groundwater is the largest reservoir, accounting for about 0.5% of all water on earth, and is amenable to extraction through wells. The residence time of water in groundwater may vary from months to millions of years. Groundwater is not readily accessible to physical observation. For this reason, it has historically been considered a mystical or occult phenomenon. However, scientific understanding of groundwater systems has steadily advanced over the past two centuries removing its shroud of mystery and making it amenable to rational, quantitative management.

The notion of groundwater circulation and the associated concept of a groundwater basin are of seminal importance to its optimal management. Groundwater circulation in a deep sedimentary basin is schematically shown in Figure 4. This situation may represent, for example, its passage from the Himalayan foothills down towards the river Ganga. On a large scale, the land slopes from the Himalayas to the Ganga plains. But locally, there are high-grounds and valleys. Water falling on high-ground moves vertically down by gravity to recharge groundwater. Within the groundwater reservoir, water initially moves laterally, and then vertically upwards to emerge at the land surface in discharge areas and return to the atmosphere via evaporation or transpiration. Below local topographical highs, groundwater travels a short distance from recharge areas before discharging in nearby depressions. These are shallow groundwater systems. But, at higher elevations, groundwater may move down to great depths, and travel great distances before discharging, to constitute deep groundwater systems. Artesian basins are good examples of such deep systems. Thus, a groundwater basin is an assemblage of many subsystems, shallow and deep, and this conceptual framework constitutes the foundation of groundwater hydrology.

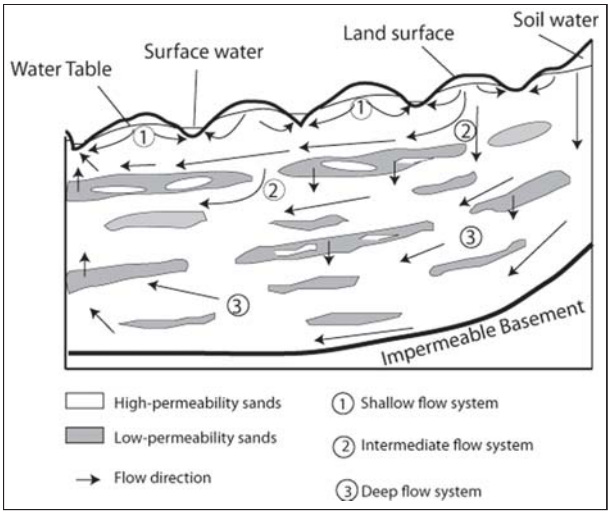

Figure 4: The concept of a groundwater basin comprising shallow, intermediate, and deep flow systems constitutes the foundation of groundwater hydrology.

Clearly, for deep flow systems to exist, geological formations must have void spaces to allow water movement to great depths. In areas underlain by hard rocks such as igneous and metamorphic rocks of peninsular India, water can circulate only in weathered and disintegrated rocks close to the land surface and in fractures that tend to close with depth. As shown in Figure 5, groundwater circulation in these areas tend to be typically shallow, closely conditioned by topography.

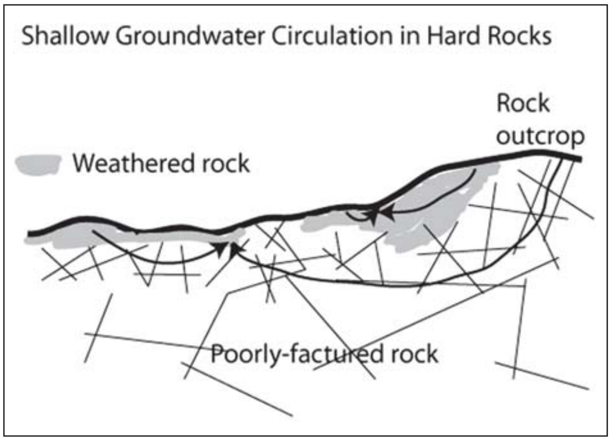

Figure 5: In hard rocks, groundwater circulation is shallow, subject to local topographical control

The groundwater flow system also governs the chemistry of rocks through which groundwater moves. In areas of recharge, groundwater tends to be rich in oxygen, mildly acidic and corrosive, and therefore being capable of dissolving many chemical elements. In recharge areas, groundwater tends to be aerobic or oxidizing. As the oxidizing aerobic water moves away from recharge areas towards areas of discharge, it reacts with rocks and minerals along the way, involving consumption of oxygen. It progressively becomes less acidic (or, more alkaline) and more anaerobic or reducing. Under these conditions, chemical elements tend to get precipitated, enriching groundwater in the most soluble chemical compounds.

Along the path of groundwater, the composition of minerals and rocks at any position is thus governed by the acidity and the oxidation state of local groundwater, profoundly affecting the distribution of soils, microbial communities, and ecosystems in the overlying drainage basin.

The connected water System

A fact of major importance that emerges from the foregoing is that surface water, soilwater, and groundwater are all inextricably linked, and constitute a single resource, replenished every year by the excess of rainfall over evapotranspiration (Figure 6).

Additionally, the surface and sub-surface water systems are linked to the atmosphere, at various scales in space and time. In upland areas and foothills, streams recharge groundwater. They also dump coarse sand and gravel materials along the foothills, making these sites ideally suited for artificial recharge. Downstream in the flood plains, the reverse happens and groundwater discharge sustains base flow in streams. Thus, surface water and groundwater are intimately linked. From a human perspective, they, along with the intervening soil water, constitute a single unified resource.

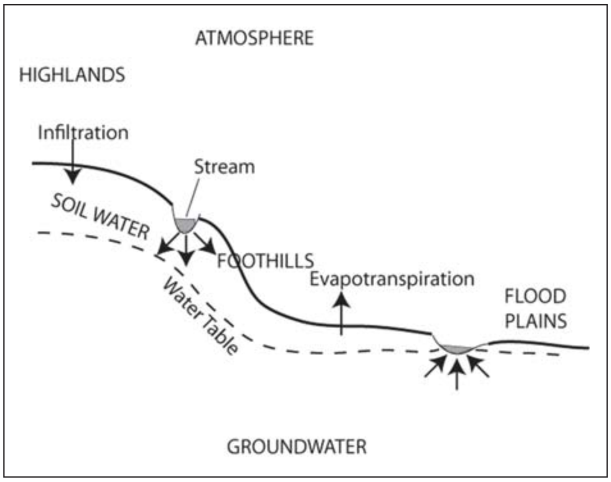

Figure 6: Linkages among components of the hydrological cycle. Over highlands and foot hills, streams recharge groundwater. In lowlands and flood plains perennial streams are sustained by groundwater discharge

Erosional and Nutrient Cycles

Closely linked to, and functioning within the hydrological cycle are erosional and nutrient cycles. Rainwater falling at higher elevations expends its potential energy by breaking down rocks, transporting the sediments downstream, and depositing them at lower elevations. Over geological time, sediments deposited at lower elevations sink deep, are metamorphosed, and eventually thrown up into mountains through orogenic (mountain-building) processes. As it happens, plants and animals along a river course have evolved to adapt to the texture and the chemical composition of sediments. Consequently, alteration of the physical or chemical nature of sediments along a river course seriously impacts habitats of existing flora and fauna.

Chemical elements, notably carbon, nitrogen, phosphorus, and sulfur, are nutrients in as much as they constitute the building blocks of biomass. Just as water, the total quantity of these elements in the earth is finite. Because water is an universal solvent, nutrients too get circulated through the hydrological cycle. For example, it has been estimated that carbon in the atmosphere gets recycled every three years.

In combination with the hydrological cycle, erosional and nutrient cycles together constitute the earth's vital cycles.

A Global Water Budget

Worldwide hydrological knowledge suggests that of the total rain falling on the earth, there is an excess of evaporation over precipitation over the oceans. The reverse is the case over the continents. It is assumed that the evaporation excess over the oceans is balanced by the net precipitation over land. On a global, continental scale, it has been estimated that annual return of water to the atmosphere through evaporation and transpiration constitutes about 65% of rainfall (Brutsaert, 2005). Referred to as consumptive use, this water is unavailable for human use. Of the 35% of the total rainfall staying on land, a reasonable estimate assigns about 25% to surface water, and the rest as groundwater recharge. These figures provide a broad estimate of annual water availability.

It is clear that all water needed for human use must be obtained by diverting surface water flows or groundwater flows. All water, including those in major reservoirs that can sustain society through drought years, are derived from rain. However, only a portion of the 35% left over after evapotranspiration can be practically diverted for human use due to technological limitations as well as the imperatives to avoid destruction of ecosystems.

India's Water Setting: *the reality that demands adaptation to nature*

India occupies an area of 3.28 million sq. kms., extending from 8°N latitude in the tropics to the more temperate climatic zones at about 30°N. Its varied physiography and geology, in consort with the hydrological cycle endows India with a unique and complex water setting. India's water input from the atmosphere is governed by the south-west (summer) and the north-east (winter) monsoons (Figure 7). Average annual precipitation is widely variable from about 300 mm in the state of Rajasthan to over 3,000 mm in Meghalaya, Arunachal Prdeah, and Kerala, with a national average of 1,170 mm (Ministry of Water Resources, 1999). Characteristically, monsoon rains occur intensely over short periods of time, resulting in rapid surface water runoff.

For a broad comprehension of the nation's water resource environment, it is convenient to divide India into three hydrological provinces: the Himalayan mountain belt, the adjacent Indus-Ganga-Brahmaputra plains, and peninsular India (Figure 8). The distinctive hydrological features of each of these zones are as follows.

The Himalayan Mountain Belt

This arcuate, rugged mountain belt, extending from Kashmir to Mizoram, comprises metamorphosed sedimentary formations and igneous rocks vulnerable to erosion by the rapidly flowing streams. Annual rainfall increases from less than 1,000 mm in the west to over 3,000 mm in the east. The Himalayan Belt constitutes the source of sediments that fill the Ganga-Brahmaputra Basin, and are eventually destined for the Bay of Bengal. The Himalayan foothills host the transitional belt of Terai-Bhabhar with its own very distinct ecosystems.

The Himalayan Belt makes up about18% of India's land area, and supports about 6% of its population.

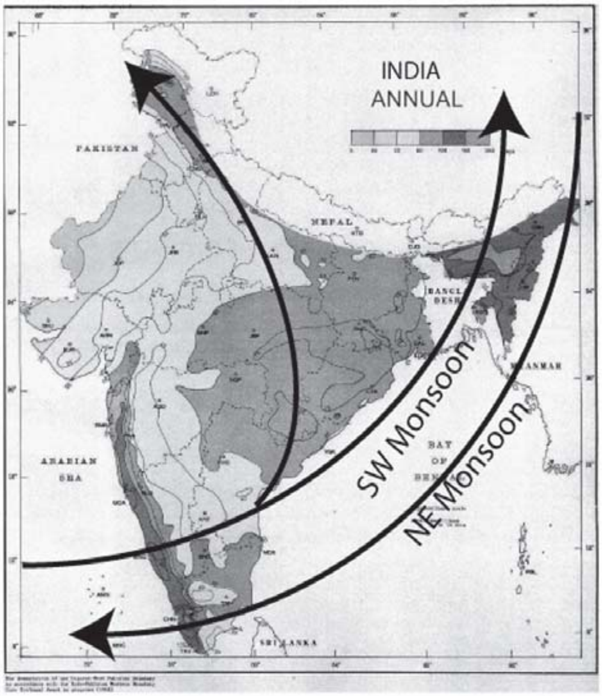

Figure 7: India receives its annual input of water from the coupled systems of southwest (summer) and north-east (winter) monsoons

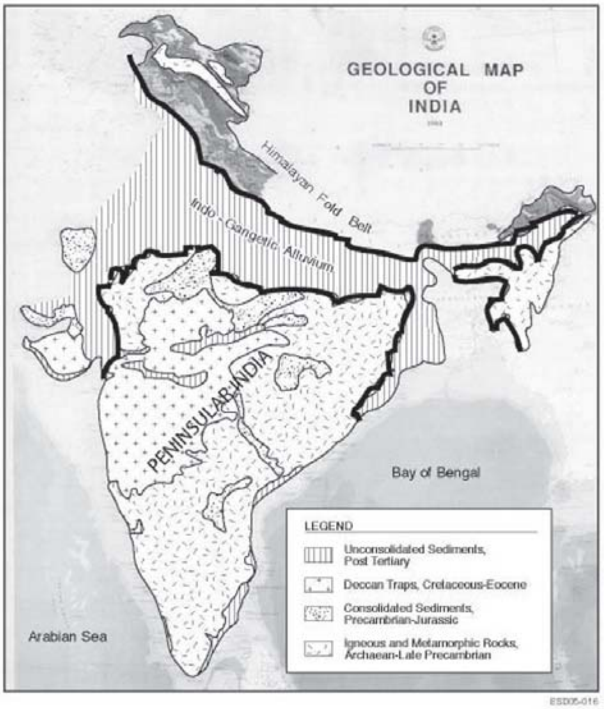

Figure 8: India's three hydrological provinces, each with distinct characteristics: Himalayan mountain belt, Indus-Ganga-Brahmaputra plains, and Peninsular India

Indus-Ganga-Brahmaputra Plains

Bounded on the north by the Himalayas and on the south by the peninsular plateau, the Indus-Ganga-Brahmaputra plains stretch from the Rajasthan desert to the swamps of the Sunderbans at the head of Bay of Bengal. Annual rainfall varies from less than 100 mm. in western Rajasthan to over 2,000 mm. in West Bengal.

The gently sloping plains with fertile soils have been a cradle of irrigated agriculture and human habitation for millennia. Drilling for oil in independent India has revealed the existence of productive aquifers to considerable depths. Both because of the perennial snow-fed streams that nourish the Indus-Ganga-Brahmaputra plains, and because of the porous sediments that aid deep groundwater circulation, these plains are the most richly endowed with water among the three hydrological provinces.

The Indus-Ganga-Brahmaputra plains occupy about 32% of India's area, and support 48% of the population.

Peninsular India

Extending from the Vindhya-Satpura mountains on the north to Kanya Kumari on the Indian Ocean, Peninsular India is an easterly sloping plateau, with a steep escarpment and a narrow coastal strip adjoining the Arabian Sea on the west. The coastal strip, which confronts the path of the south-west monsoon, receives annual precipitation in excess of 2,000 mm. The easterly slopes of the plateau lie in a rain-shadow region receiving noticeably less rainfall. Because of tropical to sub-tropical climate and lush vegetation, Peninsular India experiences relatively high evapotranspiration rates. Peninsular India is drained mostly by easterly-flowing rivers, except for the Narmada and Tapati which flow west.

Peninsular India is geologically a very old landmass, mostly underlain by igneous and metamorphic rocks, and old, compacted sedimentary rocks. Often referred to as hard rocks, these geological formations provide very little void space for water to permeate and be stored. Groundwater occurs in disintegrated, weathered rocks and in fissures that tend to close with depth. Unlike the sedimentary formations of the Ganga Plains, groundwater circulation in hard rocks is shallow and controlled by local topography. Groundwater storage is limited and is vulnerable to seasonal climatic changes. Sedimentary formations ranging in age from over 100 million years (Jurassic) to recent are known in interior patches, and along coastal strips of Peninsular India. Compared to the rest of Peninsular India, these formations offer enhanced groundwater potential.

The semi-arid climatic conditions of Peninsular India have historically motivated the harnessing of rainwater through ingenious water diversion structures and storage reservoirs. Collectively, these structures represent impressive works of hydraulic engineering cumulated over centuries. Reportedly, the total number of such reservoirs in Andhra Pradesh, Karnataka, and Tamil Nadu exceeds 125,000 (Agarwal and Narain, 1997). Fed by local rainfall, and supported by groundwater inflows, these tanks have historically served their purpose. With widespread operation of deep-well pumps over the past decades extracting much of groundwater that would otherwise have contributed to these reservoirs, there is reason to believe that the functional environment of these water storage structures may have been severely altered.

Although water quality is not a major problem over much of Peninsular India, mention must be made of large tracts of black-soil areas in Maharashtra, Karnataka, Andhra Pradesh, and Tamil Nadu that degrade water quality, often unsuitable for drinking. Peninsular India occupies about 50% of India's land area, and about 45% of the population.

India's water budget

Since all human water needs must be met from whatever falls as precipitation, and since annual rainfall renewability is finite and subject to uncertainty, it is instructive to examine India's water budget that compares average annual rain input with average annual water use. The primary goal of this exercise is to examine if India's water demands are well within annual renewability, or if demand exceeds renewable supply. In the latter case, water conservation and management become crucial.

Over the past few years, researchers have (Gupta and Deshpande 2004, Kumar and Sharma 2005, and Garg and Hassan, 2007) looked at India's water budget using basic information provided by the Ministry of Water Resources (1999). The middle column in Table 1 presents a water budget based on this approach. As seen, the total average annual precipitation is 3,840 cubic kms., of which 1,869 cubic kms. (48.7%) is stated to be surface runoff, and 432 cubic kms. (11.3%) as groundwater recharge, constituting a total of 2,301 cubic kms.(60%). By implication, the remaining 1,539 cubic kms. (40%) goes back to the atmosphere as evapotranspiration. Of the 2,301 cubic kms. remaining on land, Gupta and Deshpande (2004) estimate that 1,123 cubic kms. (48.8%) can be diverted for human use. The estimated present water use of 634 cubic kms. is notably smaller than the utilizable 1,123 cubic kms. Accordingly, Planning Commission (2007) has concluded that India's water demand will not exceed supply for another few decades.

Narasimhan (2008a) pursued a different reasoning to check the above water budget for consistency. He found world-wide estimates of evapotranspiration for different regions to vary from 60 to 90%, with an estimated 67.5% for India (Jain et. al, 2007). Assuming a value of 65%, he calculated the amount lost to the atmosphere by evapotranspiration to be 2,500 cubic kms., leaving 1,340 cubic kms. to account for surface water and groundwater. If we assume that after allowing for ecological flows, 48.8% of this may be diverted for human use, the water so utilizable amounts to 654 cubic kms. Comparing this with the current use of 634 cubic kms., one may conclude that India's water supply and demand figures are so close that the Planning Commission (2007)'s optimistic view of India's water future may be ill-founded and complacent. Even as this is being written, Rodell et al. (2009), and Kerr (2009) report substantial rates of non-renewable groundwater depletion over a broad belt extending from Rajasthan and Punjab on the west to Bihar and West Bengal on the east.

Current status of water in India

Water and its availability are major causes of concern among all segments of India's society. Linking of rivers, rain-harvesting, artificial recharge, and desalinization are actively advanced as solutions to water problems. Viewed against the backdrop of the hydrological cycle, all these remedies have potential to alleviate water problems in limited ways. However, there are no simple or easy solutions for the challenges that confront water management on a national scale. From a science perspective, the inevitable conclusion is that India's economic future will be in jeopardy without a evidence-based water policy. The reality of India's water setting is that water availability is finite, subject to uncertainty in time. Bound by these constraints, water has to be shared among all segments of society, with the needs of future generations in mind. Under the circumstances, demand has to adapt to constraints imposed on the resource by Nature.

Water and Society, *the human challenge*

Given our present understanding of the specificities and finiteness of the global and

Table 1: India's Water Budget (All volumes in cubic kms.)

	Estimates based on Ministry of Water Resources[1]	Estimates based on world-wide comparison[2]
Annual Rainfall	3,840	3,840
Evapotranspiration	3840 - (1,869 + 432) = 1,539 (40%)	2,500 (65%) World-wide comparison
Surface run-off	1,869 (48.7%)	Not used in estimate
Groundwater Recharge	432 (11.3%)	Not used in estimate
Available water	2,301 (60%)	1,340 (35%)
Utilizable water	1,123 (48.8%) Gupta and Deshpande, Curr. Sci., 2004	654 (48.8% of 1,340)
Current water use	634	634
Remarks	Current use (634) well below 1,123	Current use (634) close to 654

[1] Ministry of Water resources, 2002; Planning Comm. 2007 [2] Narasimhan, 2008a

regional water regimes, it is perhaps incontestable that a workable water policy has to be guided by the best available science knowledge. However, since science cannot make water policy on its own, the only way for it to contribute effectively to policy formulation is by developing a harmonious blend of Knowledge and Values. If so, can one identify commonalities to make this happen? A surprisingly positive answer to this question emerges from the history of Roman Law.

Jus Civile and *Jus Gentium*

Until the sixth century A.D. in Europe, law was primarily concerned with private property. During that century Roman jurists who codified law at the direction of Emperor Justinian of Byzantium, made a bold departure from tradition. Inspired by Greek philosophy of reason, they divided property into private property and public property (*res communes*). The latter was regarded as belonging to people and governed by *jus gentium* (law of all peoples) whilst private property was governed by *jus civile* (Narasimhan, 2008b). Applying *jus gentium* to contemporary understanding of nature, they decreed that water, air, the sea, and the sea coast belonged to all people. This view has, over the centuries, been referred to as the doctrine of public trust, and has endured to form the basis for water and natural resources law in Spain, France, Holland, and Britain. It became part of the American Constitution through the Northwest Ordinance of 1787. More recently, it has been written into South Africa's Constitution. In the spirit of *jus gentium*, the Water Framework Directive of the European Union requires all its 27 member nations to formulate water policy to conform to a single unifying philosophy (European Commission, 2000).

Legal Status of Water in India

Before addressing current legal status of water in India, two observations in Kautilya's Arthaśāstra. pertaining to water ownership deserve mention (Kangle, 1988, p. 172-174). First, privately owned irrigation tanks were recognized, although irrigation was primarily looked upon as a State activity. However, ownership of a tank was lost if it was not used for five years, except in times of distress. This revocable-ownership notion recalls to mind water rights concept in the western states of the U. S. where water rights are constrained by continuous use of water granted under the rights. Second, the concept *utakabhanga* governed levy on water. A water tax was levied even when the water works belonged to the owner of the field. It is interesting that this concept implies State ownership of water. However, it is not clear if state represented the monarch or the people. If the latter, public trust would be implied.

In India's Constitution, water is a state subject (Iyer, 2007) with the Federal Government's role being limited to inter-state water issues. The Indian constitution does not make any explicit statement about a citizen's right to this vital resource. India's Supreme Court has recognized this right as part of the right to life generally, and supported the public trust doctrine by invoking Article 21 which assures life and personal liberty to all citizens. And the physical nature of water and its specific attributes find no consideration in the formulation of India's water policy. Currently there are many water laws in India (Iyer, 2009), but, water issues are essentially approached in response to emerging crises, resolving rights and settling disputes. Sadly, no rational science-based framework is available to reconcile the ambitious goals of economic prosperity, and competitive claims for this increasingly scarce resource by different segments of society. Clearly, social adaptation to nature, and a national water policy that facilitates such an adaptation, would continue to remain elusive in the absence of such a unifying framework.

What may be Done

A consensus appears to exist among many that India's water situation has to be addressed with great urgency. Two views exist on how this may be done. One advocates a campaign of active public awareness, arguing that the powers in government will act only in response to public pressure. The other view envisions a Constitutional recognition of water rights and water science as a basis for formulating water laws, statutes, and regulations that will provide a basic structure to predicate judicious and equitable actions to the nation as a whole. Clearly, in critical situations drastic measures have to be taken. In this sense, there is merit in supporting a campaign of public awareness. The shortcoming of this approach is that water is a complex natural phenomenon with science as well as human dimensions that need to be harmonized towards constructive management. It is not possible to achieve the required harmony in a public wareness campaign. Recognizing this, we adopt the second approach, the Constitutional path.

Although used locally, water unifies the entire nation. Water policy, therefore, has to include the germ capable of yielding a consistent set of alternative approaches to address issues at many interconnected levels. It cannot be left to any particular governance, local, regional, state, or national. Even as watersheds in a drainage basin are interconnected at various hierarchical levels, so also water management would need to be linked at various levels of governance. Water policy must reflect participation of an informed citizenry that comprehends the imperatives of a just sharing of a finite resource, and the obligation to safeguard its integrity. Democratic rights must be balanced by responsibility to the community at large.

Accordingly, the profound role water plays in the sustenance of all living things by virtue of its remarkable physical, chemical, and biological attributes merits articulation in India's Constitution through appropriate parliamentary action. Drawing inspiration from *jus gentium*, and noting that public trust is part of the Constitution of many countries, water may be recognized in India's Constitution in a manner consistent with India's cultural and philosophical traditions. Narasimhan (2009) discusses how this difficult task may be approached.

India's self-governance rests on the Preamble to the Constitution which embraces values of justice, liberty, equality, and fraternity. Authorized by the Preamble, the Constitution provides the framework for governance. In India's tripartite system, the Legislature enacts laws, and indicates to the executive and the judiciary how these laws may be implemented and interpreted. Based on legislative policy, the executive translates the laws into rules. In this scheme, laws and policies are subject to judicial review to validate conformity with the values of the Constitution.

In a union such as India, policies and rules have to be formulated to guide water management within different States (intra-state management) of the Union, and among different states (inter-state management), giving consideration to existing and historical water use practices and local cultural traditions. Considering India's breadth and diversity, it is necessary that the legal framework enables a uniform application of management principles throughout the country.

Historically, Constitutions of democracies such as those of the United States and India have focused attention on "rights" of the people. This focus reflects the peoples' yearning to rid themselves of oppressive rulers. Nevertheless, the close of the twentieth century has witnessed a shifting of focus from inter-human relationships to the relationship between humans and Nature. Rather unexpectedly, Nature is found to demand responsibility from humans. It is remarkable that this responsibility constitutes the essence of public trust as conceived by Roman scholars more than a millennium before us.

Establishing a constitutional mandate, based on which a body of the law could be developed, is a task to be undertaken by legal experts. Recognizing this, what follows is an exploration of what a constitutional mandate may look like, and the important principles that may have to be considered in developing the body of water law.

Constitutional Mandate

Given,

- that the functioning of the hydrological cycle, the nutrient cycle, and the erosional cycle are subject to immutable physical laws, as also solar energy that drives the hydrological cycle, and these lie beyond human control,

- that these life-sustaining cycles incessantly striving to attain equilibrium, are delicately interlinked, and respond in complex ways to forces that affect their state

- that humans, with their extraordinary technological capabilities have now begun to disrupt these delicate linkages on a large scale, destabilizing the habitats and environments of subsistent living communities, including humans, and

- that water is vital for the sustenance of humans and all living things,

all waters within the nation's boundaries are deemed to be owned by the people, and the Government holds these waters in trust on their behalf, and is responsible for managing water judiciously and equitably for all citizens

Principles governing water policy

1. Atmospheric water, surface water, soil water, and groundwater constitute a single interconnected resource. Management of such an interconnected resource is best achieved with drainage basins and groundwater basins as units of management. These basins may often cut across administrative boundaries.

2. Water shall be put to beneficial use, without waste. Water-use privilege is a usufruct, mandating that the resource itself may not be damaged in the act of usage. Preserving the integrity of the resource is a sacred obligation to safeguard this inheritance for future generations.

3. Government has a fiduciary responsibility to protect, manage, allocate, and distribute water which it holds in trust for the people.

4. Every citizen has a right to safe and clean water for drinking and hygiene. In water allocation, safe drinking water and water for hygiene shall have highest priority.

5. Allocation of water for industrial, agricultural, and other economic need shall be based on thoughtful prioritization, constrained by making adequate supplies of water available for maintaining the environmental health of ecological systems.

6. Because water resource systems are inherently subject to change with time,

wateruse privilege cannot be granted in perpetuity.

7. Historical water-use privileges of indigenous peoples to maintain their traditional lifestyles shall be respected.

8. The rights of those citizens who are unable to speak for themselves in the legal and political process must be protected.

9. Institutions necessary for continued generation of scientific data to monitor and analyze the evolving behaviour of critical water sub-systems shall be established and funded, vested with the responsibility of data interpretation.to enable timely detection of adverse developments and unacceptable consequences of human action.

10. The highly complex task of introducing modernized law and institutions must be based on coordinated short-term and long-term objectives to minimize undue disruption of normal life.

Caveats

There are two reasons for the lack of a coherent national water policy for India. The first is that at the time of India's independence, our scientific awareness of the water phenomenon was not as developed as it is today. Water was taken for granted as an abundant renewable resource. The second is the enormous complexity associated with formulating a rational water policy that may unify the nation as a whole. A substantial literature exists on the difficulties that confront India's water management (e.g. Iyer, 2007; Verghese, 1990). If only the task had been easy, a water policy for India would already exist.

Perhaps the most important factor that stands in the way of a coherent national water policy is attitudinal: both of society and of government. Serious awareness of the critical role of water, the environment, ecosystems, and human habitat has emerged only over the past half a century. The technological west, home of many new developments, finds itself mired in the various unintended by-products of its marvelous technological achievements: pollution, destruction of habitats, endangerment of species, and global climate change. Therefore, a lack of awareness of India's critical water situation among a large segment of India's citizens is not surprising. However, this serious want can be addressed through dedicated public education at all levels, from the lay person through children in schools to institutions of higher learning and research.

The attitude of the government towards water as a resource merits consideration. In preindependence India, the ruling British government functioned under the premise that the State owned water, and that it had the authority to manage water as it deemed fit, without feeling obliged to involve the people in the process. This approach was contrary to principles of public trust to which England was committed for its own governance. Clearly, the resources of a colony were treated on a different footing from those of the rulers. A debate exists as to whether this mind-set continues in independent India (Singh, 1985, 1992). The central question to resolve is whether, in a democracy, the State's ownership of water is synonymous with people's ownership of it , or whether the State and People are different.

According to the doctrine of public trust, people own water without formal title, and the State holds water in trust for the people with fiduciary responsibilities. On the other hand, the Colonial mind-set was that the State, representing the Crown, had the authority to decide what was in the best interest of its subjects. According to Sankaran (2009), much of the discussions on sharing of Constitutional powers in India have devoted attention to sharing of powers among governmental organs, rather than sharing of power between the government and the people at large. If this indeed is so, the matter should be addressed at a Constitutional level. There is incontrovertible scientific evidence that water in general, and water in India in particular, has to be managed for common benefit, with participation by an informed citizenry capable of balancing rights with responsibilities.

A related issue concerns the public availability of water data. Stream flow data in India are treated as classified information (Garg and Hassan, 2007). This is presumably because information pertaining to water is treated as vital for national security, and that releasing water information may jeopardize national interests. The issue of data access pertains more generally to geographical data, and was addressed in a special meeting of the Indian Academy of Sciences held in Bangalore in July, 1999 (Narasimha and Shetye, 1999) Here, concerns about national security have to be balanced against the rights of the citizen to have access to basic information about resources vital for day-to-day sustenance, and the rights of scholars to conduct research in an open atmosphere. Transparency in sharing information is essential for an open society. This observation does not negate the need for secrecy on account of national security under special circumstances.

Science Components

Since the focus of the present work is a coming together of science and policy, it is pertinent to reflect on the science related components that are relevant to a rational water policy framework for India.

❏ Short-term and long-term goals
❏ Science infrastructure, man-power, institutions
❏ Education, public, schools, higher education
❏ Libraries and archives

India's contemporary water situation is one of crisis management. A complex set of circumstances have led to uncontrolled water use abetted by unregulated development. Serious desire to achieve long-term sustainable management is challenged by near-term crises. The greatest challenge to India's best talents is to find an approach that may blend short-term remedies with desired long-term solutions.

Since independence, India has focused heavily on technology and commerce towards betterment of the human condition. There have been admirable successes. Yet, as the technological west has learned, successes have come at substantial cost, and even alarming impacts on the nation's water resources. Evolving understanding of earth systems indicates an imperative for directing serious attention to developing knowledge, skills, man-power, and institutions that will facilitate knowledge-based management of the nation's precious water resources.

For sustained management of earth systems, there are two fundamental needs. One is a network of dedicated monitoring systems. The other is an infrastructure for storing, interpreting, and timely dissemination of data for public information and research. It is important to note that the user, from a farmer to the municipality or the industry, has very little motivation for investing and maintaining monitoring systems. These systems have to be established and maintained by public funding. Ideally, they will also be research institutions of excellence. Time is now for India to provide incentives for its young people to devote serious attention to adapting to a finite earth.

Ultimately, India's sustainable and civilized economic future rests on education in the broadest sense. The success of democracy in a finite earth rests on the shoulder of the enlightened citizen, motivated to balance rights with responsibilities. Education about water in particular, and earth in general, has to be continuing at levels from the lay public, through schools and colleges to institutions of higher learning. It is worth mentioning here that in many states of the United States (e.g. Arizona, California, Colorado, and Montana) there are privately endowed institutions dedicated to public water education through pamphlets, journals, excursions, and public lectures.

Finally, water information of various kinds (books, reports, pamphlets) need to be archived and preserved for the future. Specialized libraries and archives have an important role to play in India's water future. One example is the Water Resources Center Archives of the University of California, housed at the Berkeley campus. Established in 1958 under a special Act of California State legislature, the mission of the Archives is to collect, preserve and provide access to historical and contemporary waterrelated materials that support instructional and research programs, and the needs of the people.

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APPENDIX

NIAS-IAS* Discussion Group on "Framework for India's Water Policy"

NIAS, Bangalore, August 10, 2009

List of Participants			
No.	**Name**	**Affiliation**	**Field of knowledge**
1	Ahuja, Dr Dilip.	Natl. Inst. Of Adv. Studies, Bangalore	Science and Technology policy
2	Badigar, Mr. Shrinivas	Ashoka Trust for Res. in Ecol.and Env., B'lore	Water institutions
3	Das, Mr. S.	Dir. (Retd.) Central Groundwater Board	Groundwater hydrology
4	Gaur, Prof. Vinod	Ind. Inst. Astrophys.	Earth Sciences; earthquakes
5	Goswami, Dr. Prashant	C-MMACS, Bangalore	Meteorology, Monsoons
6	Iyer, Prof. Ramaswamy R.	Centre for Policy Res., New Delhi	Water policy, law, water sharing
7	Jain, Prof. Sharad	Civil Eng., IIT, Roorkee Hydrology,	Water Resources
8	Kumar, Prof. Mohan	Civil Eng., IISc, Bangalore	Groundwater hydrology
9	Lingaraju, Dr. Y	Global Acad. of Tech., Bangalore	Remote sensing
10	Madhukar, Mr. Ashok	Afro-Asian Dev. Consortium, New Delhi	Development consultant
11	Mohan, Prof. Shanta	NIAS, Bangalore	Gender issues and governance
12	Narasimha, Prof. Roddam,	JNCASR, Bangalore,	Science, Society, Philosophy
13	Narasimhan, Prof. T. N.	Univ. Calif., Berkeley	Hydrogeology, public trust
14	Pani, Prof. Narendra	Social sciences, NIAS, Bangalore	Gandhian method and policy
15	Perumal, Dr. A.	GWPSAS, Bangalore	Groundwater, water resources
16	Prakash, Dr. V.S.	Karnataka DMC, Bangalore	Hydrology, water management
17	Ramakrishnan, Prof. T.V.	Banares Hindu Univ., Indian Acad. Sci	Science, Society, Philosophy9
18	Ramamurthy, Dr.	Director designate, NIAS, Bangalore	Science and Technology
19	Ramashesha, Mr. C. S.	Member (Retd.) Central Groundwater Board	Groundwater hydrology
20	Rao, Prof. K. Kesava	Chemical Eng., IISc, Bangalore	Water treatment
21	Sawker, Mr. R. H.	Geol. Scociety of India, Banglore	Groundwater hydrology
22	Sekhar, Prof. Muddu	Civil Engineering, IISc	Groundwater hydrology
23	Singh, Mr. Chiranjeev, IAS	Adminstrator, Karnataka Govt.	Water resources, electric power
24	Sitaram, Prof. Alladi	Ind. Statistical Inst., Bangalore	Mathematical statistics
25	Sreekantan, Prof. B.V.	NIAS, Bangalore	Science, Philosophy
26	Vaidyanadhan, Prof. R.	Emeritus, Geology, Andhra University, Waltair	Geomorphology, rivers
27	Vasavi, Prof. A. R.	Social Sci., NIAS, Bangalore	Agrarian anthropology
28	Venugopal, Prof. V.	COAS, IISc., Bangalore	Stochastic hydrology, rainfall
29	Verghese, Prof. B. G.	Centre for Policy Research, New Delhi	Journalism, water and society
30	Yagnik, Dr. K. S.	CMMACS, Bangalore	Fluid mechanics

* NIAS: National Institute of Advanced Studies, Bangalore; IAS: Indian Academy of * Sciences, Bangalore