A Comparative Study of Groundwater Institutions in the Western United States, France and Peninsular India for Sustainable and Equitable Resource Use –Some lessons for India[1]

N. Nagaraj, PhD

Professor, Department of Agricultural Economics, University of Agricultural Sciences,

GKVK, Bangalore-560065, E-mail: nagarajnareppa@yahoo.com

Ph: 080-23637002 (O) 9880004823 ©

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Abstract

In India, the rights in groundwater belong to the landowner as groundwater is attached with land. Since land ownership is a prerequisite to ownership of groundwater, it is difficult to assign “open access” nature to groundwater resource. Though landowners own groundwater *de jure*, this right is limited by huge investment necessary to tap the groundwater, which makes only restricted access to those who have adequate resources to invest. In western US, the issues of groundwater depletion are being effectively addressed through institutional policy instruments with local control. According to water code, all water within the state is the property of the state, but the right to use may be acquired by appropriation in the manner provided by law. These include formation of natural resource districts with varying responsibilities over groundwater issues, creation of an enabling framework specifying user rights, correlative rights to a reasonable use, issue of permits for extraction, allocating quotas and declaration of moratorium on new wells in critical/over exploited areas.

In France, there has been a modest success in dealing with groundwater overexploitation in the Beauce area through the involvement of user groups in the decision making process of Basin Committee. The approaches such as the participation of user groups in the decision making process, the creation of Basin Committees, the imposition of regulatory measures such as issuing of the permits and submission of feasibility reports to drill the wells, the dissemination of vital technical information pertaining to resource use and status, have yielded some degree of success in French context, suggesting to replication of some of these approaches to Indian context.

Keywords: Basin committee, correlative rights, groundwater depletion, natural resource districts, permits, property rights, quotas, reasonable use and user rights

A Comparative Study of Groundwater Institutions in the Western United States, France and Peninsular India for Sustainable and Equitable Resource Use –Some lessons for India

The first part of this study aimed at institutional perspective of groundwater management in dealing with overdraft problems in India and western US. A great deal of management problems relating to groundwater overdraft and use are emerging in both India as well as in western US.

Approaches towards prudent water use

The Dublin principles and the Integrated Water Resources Management have indicated that water should be treated as an economic good. By hypothesis, overexploitation of groundwater resources in the hardrock areas can be checked by following these principles. In addition inefficiency in the use of water resources can be minimized and environmental problems such as salinity and alkalinity can be under check. Groundwater resource in hardrock area is exhibiting signs of over draft indicating rapid decline in the water table threatening groundwater-based agriculture (Nagaraj and Chandrakanth 1995). Surface irrigation is also subjected to greater vulnerability due to frequent failure of monsoons. While market based and institutional approaches which call for pricing surface water and groundwater and groundwater regulation for instance, are a political economy question, the technological solutions like the appropriate crop pattern, land use and efficient use of water through irrigation technologies, are entirely in the domain of farmers

Legal status of groundwater in India:

The legal status of groundwater is not clear in India. The Easement Act of 1882, recognized customary community rights in surface water based on long use and allowed private usufructuary rights in groundwater by viewing it as an easement, inseparably connected to land. The general rights structure is governed by English common law of absolute ownership (to owners of overlying land) and the resource is legally unbounded (Singh 1990). The rights in groundwater belong to the landowner as groundwater is like a chattel attached to the land property. There is no limitation on the volume of groundwater extraction by a landowner. This has created unequal distribution due to the unlimited power for withdrawal of ground water by the land. Many experts and policy makers have been emphasizing the need for appropriate water rights system for

regulating groundwater extraction and use particularly at the individual level. For instance, both the Model groundwater (control and regulation) Bill of 1970, as that of 1992, formulated by the center, and circulated among the states, for their possible enactment, have proposed some kind of groundwater permits and licensing system. (GOI, 1972 and 1992). Since water is a state subject, the groundwater laws are to be enacted by the states. Unfortunately, no state has enacted any groundwater legislation so far barring Gujarath. The 1976, National Commission on Agriculture suggested criteria to be used for specifying individual rights in groundwater on a physical and quantitative basis, but also in identifying the administrative frame work necessary for their enforcement. This is very similar to that of correlative rights system prevalent in Western US.

Property rights to Groundwater:

In India, groundwater development is under the private ownership regime. The legal status in terms of de jure rights is not transparent. Groundwater is attached like a chattel to the land, without any limits on extraction. Thus only the landowner can own the groundwater right implying that the landless does not have any stake in the resource. This clearly reflects the inequity as far as groundwater access is concerned. The table 1 summarises the existing property rights structure relating to irrigation wells in India. Since land ownership is a prerequisite to ownership of groundwater, it is difficult to assign "open access" nature to groundwater resource (Singh 1993). Whether groundwater is a open access resource or private property resource is still a mute point. Though landowners own groundwater *de jure,* this right is limited by huge investment necessary to tap the groundwater, which makes only restricted access to those who have adequate resources to invest. Under these circumstances the groundwater rights are obscure. Ciriacy-Wantrup (1969), indicates that groundwater is fugitive resource, since definite property rights belong only to those who are in possession ie., who gets there fastest with mostest.

Table: 1. Nature of Property Rights for Irrigation Structures in India.

Type of well	Rights Structure	State Rights
Wells (private)	Absolute ownership	No rights
Wells (public)	Customary rights of groups/communities	State has power to regulate
Bore-wells (private)	Absolute unlimited rights to extract water beneath his land	No right to own/regulate
Bore-wells (public)	Usufruct right granted	State has power to regulate

Source: Singh, 1993

The Ministry of Water Resources for the government of India mooted the groundwater (control and regulation) Bill during 1970 and revalidated it in 1992 to regulate and control the development of groundwater. This was circulated to all the states with an advice to enact it with necessary modifications since water is a state issue (Singh, 1993).

Institutional Management in Western US:

Each state in the western US, has its own selection of groundwater laws and regulations. Beneficial and reasonable use concepts are one of the main legal boundary conditions on water rights. Under the beneficial use concept, individual own water use rights as long as use is accepted as "beneficial". Reasonable use concepts further limits rights to overlying users unless injury to other overlying owners can be avoided. In addition to this, "public trust" concept being used in western US as a non-legislative approach to initiating water management. The basic idea is that water is a public good, held in the trust for the welfare of the population (Moench 1991).

In western US, the issues of groundwater depletion are being effectively addressed through institutional policy instruments with local control. According to water code, all water within the state is the property of the state, but the right to use may be acquired by appropriation in the manner provided by law. These include formation of natural resource districts with varying responsibilities over groundwater issues, creation of an enabling framework specifying user rights, correlative rights to a reasonable use, issue of permits for extraction, allocating quotas and declaration of moratorium on new wells in critical/over exploited areas. These regulations enabled to set an upper boundary for extraction of groundwater and made groundwater legally scarce. This has had a profound impact on use pattern and conservation of groundwater

in the region. In India, lack of effective groundwater institutions at local level to deal with emerging problems in groundwater development and use has resulted in intergenerational, inter-temporal and inter-spatial misallocation and severe overdraft.

Groundwater Management approaches in Western United States-A case of Upper Republican Natural Resource District in Nebraska

According to water code, all water within the state is the property of the state, but the right to use may be acquired by appropriation in the manner provided by law. States and local governments have traditionally managed groundwater in Western United States. In some states the management systems have been established by state governments and regulated at the state level. In some other states the management has been delegated to local institutions such as a water management or Natural Resource District (Smith 1993). As a result of this local orientation, groundwater management systems have been developed in a unique and different way to address an array of issues pertaining to groundwater management. Compared to other western states of US, Nebraska is heavily dependent on groundwater. About 90 % of the total water withdrawn annually is being used for irrigation. Over-drafting has been a serious problem in many parts of Nebraska besides quality degradation. In some parts of the state water levels decline of up to 50 ft have been reported (Smith, 1993).

Need for regulation

Historically, in many regions of Nebraska groundwater pumping has been faster than it is recharged leading to overdraft. This has several environmental consequences in the region such as increased well depth, drilling of more wells, increased extraction cost and reduced flow in to the streams. Recognizing that continued depletion of groundwater threatens prosperity and quality of life, the Nebraska State legislature created a framework to manage the groundwater resource in 1972. This legal framework enabled to establish Natural Resource Districts (NRDs) which are unique to Nebraska with local leadership responsibilities for protecting groundwater from overuse and pollution.

The Upper Republic Natural Resource District (URNRD) is one out of the 23 districts in Nebraska where the groundwater depletion problem was unabated. The district is solely dependent on groundwater for agriculture and other activities. All uses other than irrigation represented only one percent of the total groundwater uses in the

district as evident from the table give below. In the District around 517,000 acre-feet of groundwater were abstracted from the aquifers and used in 1998. Nearly 99 % of this annual total water withdrawn were used for irrigation

Table: 2 Groundwater use pattern in URNRD for the year 1997-98

Type of use	Acre feet used	Percentage of total
Irrigation	512,000	98.91
Domestic/Municipal/Rural villages	3,795	0.73
Livestock	1663	0.32
Industry and Golf	202	0.04
Total	517,660	100

The groundwater irrigation development in the study region has witnessed 3 distinct pattern of growth. From1940s to 1960s well irrigation was accompanied by flood and sprinkler method of irrigation. In the 1970's there was a spurt in the number of wells with widespread use of centre pivots. This spurred unregulated withdrawal of groundwater in the district. Since1980s there has been regulation of well irrigation through the local control of Natural Resource District. Currently there are 3200 registered irrigation wells in the district irrigating around 430,000 acres.

Management Structure

There are three distinct stakeholders influencing the groundwater management decisions in the State of Nebraska. At first level, the State in general, provides a legal and policy framework. At the second level, the legislature has enacted local control groups in order to effectively manage the groundwater resources by establishing Natural Resource Districts. Finally at the primary level the users are involved in the management.

In order to conserve, protect, develop and manage the natural resources of the state of Nebraska, the legislation established 24 Natural Resource districts in the state based on the approximate hydrological boundaries of the recognised river basins. The state has given districts a variety of regulatory tools to deal with the problems of groundwater depletion, contamination and user conflicts. The Upper Republican Natural Resource District (URNRD) in Nebraska State is the frontrunner to initiate a

variety of controls with local efforts to manage the groundwater resource in the Ogallala region. The URNRD encompasses Dundy, Perkins and Chase Counties began operations since July 1972. Kansas bound the URNRD on the west by Colorado and on the south.

Board

The Board of Directors comprised of 11 members that governs the Upper Republic Natural Resource District. All eligible electors of the district landowners may vote for the election of the Board members at general elections. The election takes place once in four years. The district is divided into ten sub-districts and one Board member is elected from each sub-district and one member at large is elected. Thus locally elected Board of Directors governs the districts and the management comprising the full-time professional faculty runs day to day functions. The Board is an autonomous body responsible for establishing district policies/ programs/ rules and regulations and adopting the necessary budget, in order to fulfil the responsibilities of the district as authorised and required by law. Property tax is the chief source of revenue to the board. A majority of the voting members of the Board shall constitute a quorum and the concurrence of a majority of the Directors present at any regular or special meeting at which such quorum is present shall constitute the official action of the entire Board.

The rules and regulations are approved and enforced by irrigators, with the support of the majority of the local users. The Board has forum to represent the user grievances and suggestions. In case of conflicts the aggrieved person can challenge the board decision and he can appeal for reviewing the decision within 30 days. If he is not satisfied with the decision he can approach the court for redressal. Further the information and other records are open to the public. Thus there is an element of transparency in the administration. The system is based on democratic principles and there is some degree of local control over the management system. This joint management approach enables various stakeholders to participate in the planning and decision-making process in a democratic way and therefore would legitimate the actions of the board. The URNRD long-term goal is to manage aquifers in the district by balancing groundwater withdrawals with recharge and protecting natural water quality.

Institutional framework for groundwater management

Prior to 1975, Nebraska groundwater law was governed by reasonable use doctrine. According to this rule landowners are entitled to appropriate as much water as can be put to reasonable and beneficial use on their overlying land. The Nebraska Supreme Court also stated that in the event of inadequate groundwater supply, each user is entitled to a reasonable proportion of the whole groundwater supply. Thus Nebraska follows "Nebraska Rule of reasonable use". It is a blend of American and California rule of correlative rights. By1975, this common law framework was slightly amended by legislation. Further, the State has prioritized the uses of groundwater considering domestic as the highest preference followed by agriculture, manufacturing and industries. Thus, the concepts of reasonable and beneficial use formed legal boundaries on water rights for users.

The advent of high capacity pumps and center pivot irrigation system enabled to expand irrigation by unrestricted pumping of groundwater creating irrigation boom during 1970s. This irrigation boom ignited further spurt in the development of well irrigation creating an imbalance between discharge and recharge leading to fall in water levels in the aquifers. In response to drastic fall in groundwater levels in several regions of the state, the Nebraska Unicameral enacted the Groundwater Management Act in 1975. This law granted a wide range of powers and basic responsibilities to the local natural resource management districts to control the groundwater development. Unlike other local resource districts in the region, Nebraska's NRD's are quite unique in a way they are multipurpose democratic local institutions having a local control over wide range of natural resource management issues. The responsibilities include: soil and water conservation, rural water supply, flood and soil erosion control, recreation, wildlife habitat management and forestry and range management. In order to address the groundwater overdraft problems, the Natural Resource Districts were granted authority to alter the rules and regulations governing use and access to groundwater. In this endeavour the NRD should take approval from the state department of water resources for exercising the rules and regulations and to create a groundwater control area. Thus the NRD's play a key role in state groundwater policy formulation and implementation. Within a designated control area the GWMA provides the NRD's board discretionary options and powers to regulate groundwater development and use. In this endeavour the board has formulated several management approaches to deal with groundwater management problems. These include access and allocation rules, regulatory measures and economic instruments.

Access and allocation rules

1) Well licensing and permits: All wells with pumping capacity over 50 gpm in the district require a permit, a meter and an allocation. Thus the free access has been restricted by licensing and permit system.

2) Allocation procedure: Each certified acre within an irrigated tract is granted an allocation of 14.5 acre- inch annually. Thus for a 5 year period the total allocation would be 72 acre inches i.e., (14.5" x 5 = 72"+ carryover from previous period). This allocation of 72" is designated as basic allocation. Groundwater users extracting less than the total basic allocation together with unused could be carry-forward to subsequent allocation period without limitation.

3) Irrigated acres and tracts: Requires Board approval and certification of irrigated acres to which allocations of groundwater can be applied and reporting of total irrigated acres. There is also a limit on certified acres to 130 per well, for new wells in the critical townships.

4) Pooling of groundwater: Board allows for pooling of groundwater allocation across tracts to enable irrigators to annually adjust amount of water applied on individual tracts subject to the condition that the overall allocation is not exceeded as stipulated in the pooling contract. Further, satellite pivots are allowed (transfer of allocated groundwater from one tract to another) for which the allocation is granted but prohibits an increase in the total allocation resulting from the transfer.

The above allocative volumetric management approach has set limits on the volume of groundwater withdrawals by each user. Further, per acre allocation of 14.5 inches provides a user the right to pump a maximum of 72-acre inches of water over a period of 5 years. There are no restrictions regarding the allocation of this quota by the user when, how and how much to be used. If the allotted quota is negative at the end of the 5^{th} year, then for the ensuing 5 year period the irrigator/s will not be eligible to get any allotment.

The district also provided options to the users on how to meet the extraction limits through a system of carry-forward and pooling provisions. The pooling system allows the well owners to combine all allocations from different wells as long as the aggregate allocation does not exceed the sum of the individual wells. The advantage of this system is that the irrigator can apply water to the crops on different scales such as 12" 13" 16" so on based on soil type still meeting the average of 14.5" of annual allocation.

The estimated consumptive requirement of water for crops in the district is around 25". Out of this 11-12" is met through rainfall and remaining is through groundwater. Hence, based on the consumptive use norm an allocation of 14-acre inches has been arrived.

Table: 3. Water allocated and actual use pattern in URNRD

County	1988-92	1993-97
Allocated (ac. inches)/yr.	14.5	14.5
Dundy:		
Av. Actual use (ac. inches)	12.6 (13)	12.2 (16)
Perkins:		
Av. Actual use (ac. inches)	10.3 (29)	9 (38)
Chase:		
Av. actual use (ac. inches)	12.5 (14)	10.4 (28)

Note: The figures in the parentheses indicate percentage reduction from the allotted quota.

As evident from the table: 3, the actual use between two periods has been less than the allocated water. Another interesting feature is that the average actual use has been reducing between 2 periods. This clearly indicates that irrigators are managing the water more efficiently through improved irrigation technology.

In the study area the land values are directly related to the amount of water conserved out of the allocated quota. Thus, the conservation of groundwater has a profound effect on land values in the region.

Regulatory measures

1) Spacing requirements: The Board has set minimum well spacing requirements for all new wells drilled in the district. Well spacing requirements have been accepted as a regulatory norm in the district. These regulatory norms have been established basically to prevent direct well interference problems while pumping rather than restricting the access to the resource. Under Nebraska State law the isolation distance from well to well be 600 ft. In critical Townships the spacing requirement is 5,280 ft except those wells used strictly for domestic, livestock or monitoring purpose. Further any irrigation well drilled after June 1981, in the control area the spacing must be at least 1,320 ft from any stock or domestic well not belonging to the groundwater user. In critical area for replacement well in lieu of an abandoned

well which is located within 1,320 ft shall be drilled within 150 ft of the abandoned well it replaces.

2) Flowmeters: All existing wells for the purpose of irrigation, commercial livestock, municipal and industrial use with a capacity of more than 50 gpm shall have an approved flow-meters installed before April 1980. And the annual water use is reported to the district. This would facilitate for the management to know the actual total volume of water abstracted on each well.

3) Critical Townships: Under the current rules, townships are designated critical if the average 3 year groundwater level decline exceeds 0.25 % of the saturated thickness of the aquifer. Once designated critical, the township must remain so designated for a period of 5 years. At the end of 5-year period, the township is either removed from the critical designation or re-designated as critical depending on the change in the saturated thickness of the aquifer. Currently there are 42 critical townships in the district out of 84. This clearly indicates that 50 % of the townships are in critical area.
4) Supplemental irrigation wells: The management prohibited supplemental irrigation wells. After 1990 no permit was approved for any supplemental wells.
5) Water quality: Board has established water quality criteria and monitoring and remediation procedures. In this regard the URNRD entered into a co-operative agreement with the U.S. Geological Survey to conduct groundwater quality survey. The focus of this survey is to establish a scientifically sound baseline on quality of the groundwater in the district.
6) Moratorium: In response to increased pressures to drill new wells in the district the board approved moratorium on well permits and new groundwater allocation in critical areas of the district since Feb 1997. This is the first of its kind to impose the moratorium in the state of Nebraska. This will expire in the month of August 1999. Again continuation or removal of this issue has to be discussed in the Board.
7) Variances: The Board may grant variances from the strict application of rules or regulations upon good cause is shown.
8) Adjudication: Provides for formal adjudicatory hearings detail general enforcement provisions for carrying out the rules and regulations of the district and specifies conditions for cease and desist orders. Any groundwater user aggrieved by the Board action may request for a formal adjudication hearing. Any groundwater user

found to be violative of these rules and regulations may be required to cease and desist withdrawing groundwater until such time the compliance is met.

Market interventions

Market interventions particularly electricity and water pricing are considered to be the strong economic levers that promote adoption of efficient irrigation technologies. However efficient technologies may not ensure the protection of the resource unless there is quantity regulation as farmers continue to expand irrigation as long as it is profitable. The extent of government support for farmers in subsidizing fuel and electricity, credit for well drilling and also support price for the product is virtually absent. Hence the market forces are also playing an important role in irrigation development and use. Unlike in India energy is not subsidized for irrigation pump-sets. Hence the energy cost is most important component influencing the amount of water to be applied. Based on the case studies in the district the energy expenditure alone accounted for 17 % of the total cost per acre. The share of irrigation expenditure in the total cost is around 40 % per acre. Thus the pricing of energy and quantity restriction on the use of groundwater strongly propelled to go for irrigation efficient technologies such as center pivots. The demand for center pivots is also swelling over the years, mainly because of water scarcity, shortage of labor to irrigate and high prices of energy. Nevertheless the center pivot irrigation system has a distinct advantage over other systems. It promoted scale economies and made very easy to manage moisture, nutrients and weed control on the farms with this system of irrigation. The efficiency in water applied is more than 85 %. Thus it served as a comprehensive crop and water management tool for the irrigators operating giant farms ranging from 1000 to 1500 acres. Thus the management approaches followed have two fold impacts. The 1st notable positive effect is stabilization of water table over the years. And the 2nd impact is in terms of increasing irrigation cost to the user by way of huge investments on irrigation equipment. The regulatory institutional framework enabled to create groundwater legally scarce and thus accomplished the objective of sustainability.

Discernible impacts of regulations:

It is clear that most of the rules and regulations primarily targeted to deal with demand management by setting limits on the upper bound for the extraction of groundwater resource. Hence, there has been a remarkable change in the water extraction and use pattern in the regulation regime. As evident from the table 4, there

has been decline in the quantity extracted, despite gradual increase in the area irrigated. The per acre water applied has also been dipped from 15 acre inches to 10.5 acre inches. The water level decline in the aquifers also reduced after 1985. The main contributing factors for this change include the local control in terms of allocation and regulation rules, use of more efficient irrigation technologies and improved farm management practices. Thus there is a discernible effect on water savings leading to conservation. Further, the legal framework has defined the user right boundaries hence; free rider problem has been reduced considerably. Further these regulations induced farmers to shift to better water management practices. However there are many anticipated benefits to the users due to regulations. The land values are increasing in the area, as the selling price of land varies directly with the amount of water conserved out of the allotted quota. The rental/lease value of land is also appreciating with the conservation of water. The actual draw down of the aquifer has been reduced for the past 5 years and water table has been stabilised. The URNRD is one of the most innovative institutional governance structure for taking collective decisions and actions on behalf of water users by developing a combination of management approaches addressing the most pressing issues of groundwater overexploitation in the region**.**

Table: 4 discernible impacts of groundwater regulations in URNRD

Year	Water extracted and applied (ac.ft)	Area irrigated (in acres)	Average use per acre	Yield per acre (bushels**)**	Water used per bushel of corn
1975-80 (Average)	520,000	419,920	14.86	-	-
1988-92 (Average)	436,000	442,000	11.8	151	0.08
1993-97 (Average)	398,000	455,000	10.5	200	0.05

Percentage change from:			
1980-92	-16.0	+5.2	-20.0
1992-97	-9.0	+3.0	-11.0
Overall change	-23.0	+8.3	-29.0

Table: 5 Temporal and spatial decline in groundwater level below land surface in the observation wells in the study area (ft)

County	1975	1985	1997	Difference between 1975-85	Difference between 1985-97
Dundy	**86**	**102**	**116**	**-16**	**-14**
Perkins	**165**	**172**	**176**	**-7**	**-4**
Chase	**75**	**90**	**95**	**-15**	**-5**

Source: Upper Republican Natural Resource District Information Packet, Feb 9, 1999.

Some of the key components responsible for the success of URNRD programs are outlined as below:

The legal and physical boundaries of the groundwater resource are generally delineated based on hydrological rather than on political lines. This has facilitated more ease for effective management. Establishment of an enabling framework that is responsive to the local conditions and water management needs of the community formed a hallmark of URNRD. The enabling framework comprised modification in property rights for groundwater use, definition of user rights on volumetric basis, permits and water metering system and allocation of quota has been largely responsible to limit the extraction rates and curtailed the excessive pumping of groundwater. Further the board has forum for conflict resolution in case of any disputes. The management approaches have been perceived as fair and worthy because local users

had developed them collectively hence adaptable to the local situation as the problem is localized in nature. Thus the process of control and command has been replaced by collective and coalesced action locally. The rules evolved and crafted collectively by the board are transparent enabling for the development of the groundwater management system. In the region according to the survey of the board 90 % of the farmers supported the moratorium on new wells. This clearly implies their collective concern for the appreciation of the problem. The measure of moratorium on new wells has reduced further pressure on groundwater. Added to the institutional factors, the two important technological components enabled for better management are; shift in irrigation technologies from flood to center pivots and access and availability of technical information relating to water tables, extraction and recharge rate of groundwater.

French Model of Water Management

The French Water Law of 1962 and 1992 delineates the principles of water Management. The striking feature of the 1964 Water Act is the creation of Water Agencies and Basin committees. The water Law of 1992, insists on the uniqueness of water resources and imposes measuring devices. In France, water belongs to the "*patrimonie commun de la nation*" (common heritage of the nation, public trust) and the state is custodian of the resource **(Montginoul and Rieu, 1996)**. According to water laws, water is considered to be a resource, as a milieu and as an environmental good to be shared among the different users including nature itself. The water management aims at protecting the overall resource, improving the reliability of supply and promoting water conservation.

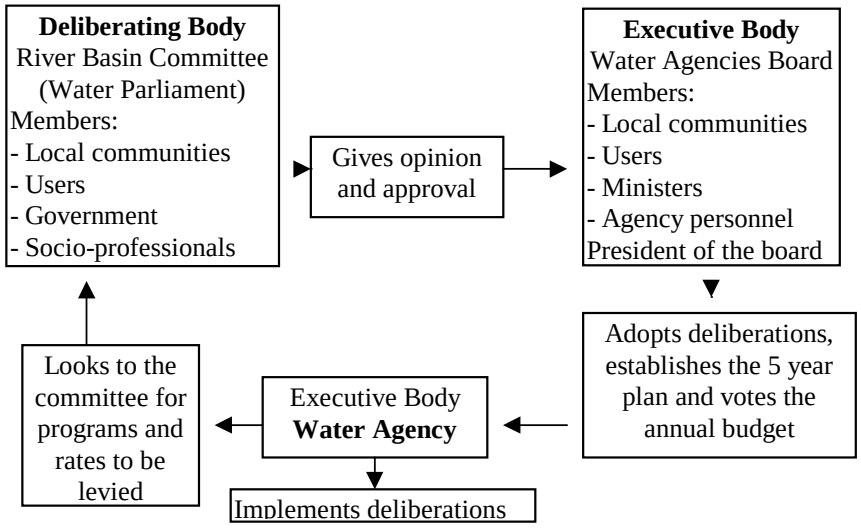
After consulting regional, county and local councils, it elaborates and adopts a Master plan for water development and management (SDAGE), which fixes for each basin the fundamental trends for a balanced quantitative and qualitative, water management.

Basin committee and Water Agencies

Various actors at different levels (Fig. 1) handle the water management in a participatory way. The entire French territory is divided into 6 major catchment areas. Each major water catchment has a river Basin Committee and a corresponding executing authority called the Water Agency (Agence de l'Eau). Indeed, the Basin

Committee is a water parliament, because its representation and powers reflect regional rather than central government control. The Water Agency plays a co-ordinating role in bringing together all the concerned interest groups in the basin. In order to deal with the present and future water related problems the stakeholders (local communities, farmers, industries, fisheries environmental protection and irrigation), government and socio-professionals meet in this committee. The interests of concerned parties are represented with different points of view debated and fair policies of water management are decided in trying to satisfy the needs of those most directly concerned. Water Agencies are both government owned corporations and public services (non-profit organisation), whose only obligation is balancing the budget through mopping up resources from water users. The Agency has financial autonomy but without enforcement powers. Each river Basin Committee appoints representatives to the Water Agencies Board, executive branch of the River Basin Committee. The Water Agency implements the deliberations of the Basin Committee. The Prefect – the government representative in each French Département, like Collector in Indian Districts – is the head of the Basin Committee. He manages and co-ordinates the state's policy concerning the issues of permits to draw water, pricing, discharge of effluents and water law enforcement. In times of extreme scarcity, the Prefect can also decide all the uses of water. The Committee is responsible for applying “user pay” and “polluters should pay” principles through the use of economic instruments such as taxes, levies and subsidies.

Fig. 1. Water Management in France



The process of price formulation for different users and uses is the task of the water committee of the Water Agency. Outside the limits of irrigation companies, the Water Agencies manage the water needs of other sectors. The agency in each basin prepares a five-year master plan and computes the price structure for different users, in order to defray the supply cost of the water. The cost includes the pollution tax and the resource tax. The pollution tax reflects the cost of treatment of the water to remove the pollutants, while the resource tax reflects the cost of infrastructure. The water committee of the Water Agency proposes the pricing details to the Basin Committee for consideration. The water parliament decides how much to pay for each category of the user and after thorough discussion, there is negotiation and lobbying in the Committee. If there are any disagreements or conflicts pertaining to allocation of water for different uses or water pricing, they will be resolved by mutual discussion and negotiation in the water parliament. The income derived from the users is re-deployed to the economic circuit in the form of aid to communities, industries and agricultural operations willing to invest in improved water purification and development.

The above-discussed structural and functional framework clearly indicates the principle of participatory approach. There is a collective endeavour in the management of water resources wherein the stakeholders in the resource are integrated in the decision making process, so that each actor is able to make known his own point of view. Another interesting aspect is the complementary role of the Water Agency as a mediator, to initiate dialogue, collate and negotiate with the different users, in order to satisfy the needs of each, subject to the constraints and the legitimate political actions.

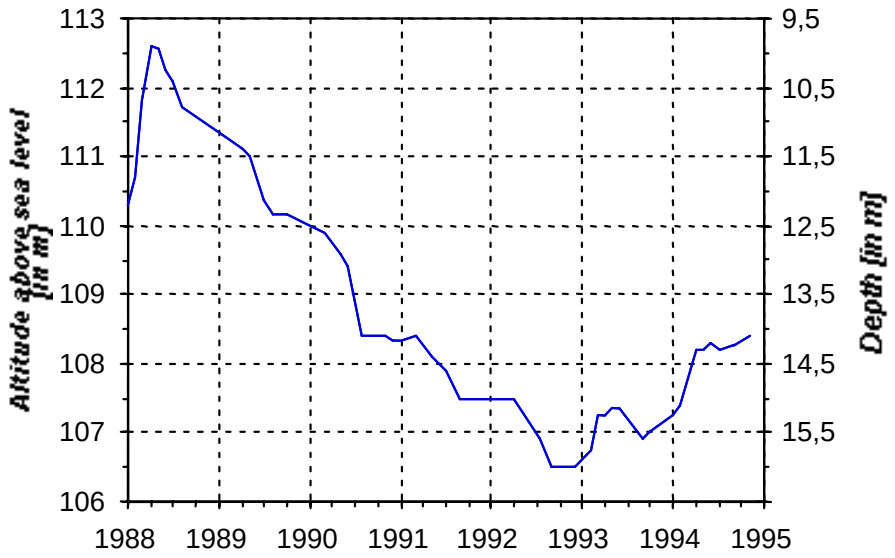
The growing problem of groundwater over-exploitation

During the past two decades, In the Loire-Brittany basin of the Beauce groundwater development has been on a massive scale leading to intensive pressure on the aquifers. In fact, the farmers were threatened by a water crisis in 1976, 1986, 1994, and 1996, on account of droughts (Dubois, 1997). Ever since 1976, the critical problems pertaining to groundwater are the depletion of aquifers and the pollution of water with nitrates, due to intensive application of chemical fertilisers and herbicides.

From the perspective of farmers, the quality aspects of water are completely diluted, but depletion problems are paramount.

As evident from the figure 2, there has been depletion of the groundwater table to the tune of 6 meters since the 1980's. The emerging environmental aftermath of this effect has been the drying up of the river Conie, in the area. In one of the studies by Loire-Brittany Water Agency similar scenario have been reported (Dubois, 1997). Due to draw down of the aquifer the surface flow from the surrounding streams has also been hampered, because the flow of many rivers and springs depends partially on water emanating from aquifers. Groundwater depletion is one of the factors contributing to the drying up of several major European marsh areas (Burrill Anne, 1998).

Fig. 2 Variation of the Aquifer level in the Beauce Region



The yearly withdrawals from the aquifer was around 300-400 million cubic meters, whereas the total estimated recharge of the basin was 266-333 million cubic meters, leading to a negative balance. For every cubic meter of water recharged, the extraction is more than one cubic meter resulting an imbalance between recharge and discharge. Thus, the withdrawals of water exceed the natural rate of recuperation over time, reflecting a clear sign of overdraft that is tending towards unsustainability. So the situation is not in the purview of safe yield principle of a basin, warranting that the resource use is not socially and environmentally desirable. Although at the macro level water scarcity has been manifested (figure 3), the local level shows that the impact is

less discernible since this has not been reflected in sharp increasing extraction cost. This is due to the fact that the irrigators have installed huge capacity pumps ranging from 80 hp to 125 hp depending on the depth of the bore-well, which can adjust the additional depth. Nevertheless, mining of groundwater beyond natural rate of recharge would lead to negative externalities in the longrun.

Measures based on water table status over a period of time

When there is market failure addressing the problems of groundwater overexploitation and environmental protection use of a combination of economic instruments and regulatory measures are required to correct the distortions. The economic levers include appropriate pricing of water and rationing the resource in terms of fixing quotas and extending the incentives and subsidies. The regulatory approaches include issuing permits for extraction, monitoring and enforcing, imposing penalties and sanctions on offenders and putting restrictions on wasteful use of water and overdraft. In France, the three distinct actors concerning the management of water include:

1) the Water Agencies (which applies economic instruments as per the norms of Basin Committee);
2) the State in general (which acts as a regulatory authority through the Basin Committee), in terms of issuing permits, discharge of aqueous effluents and fixing quotas as and when situation warrant);
3) local users at the micro level (user groups). The water users association active participation is equally essential to deal with the open access problems such as groundwater. Further, they should have an access to information concerning the dynamics of the resource in order to understand the gravity of the problem.

In Beauce, the severity of drought has necessitated some institutional changes and has enabled the users to come to a common agreement in order to resolve the crisis and to allocate the scarce water more prudently on a regional scale. Before the commencement of the irrigation season, the irrigators and the concerned authorities in the basin meet together. It is quite interesting to know how the association of pumpers with the concerned authorities meet together, know the status of the aquifers, debate the issues, come to a consensus, vote and then design a rule for implementation. The backdrop for this is provided in the table 6.

Table 6. Background for Organising User Groups and Participatory Action to Manage Aquifers

Context	Crisis	Meeting	Method of management
Since 1976, there has been exponential growth in the development of groundwater irrigation	Water table has steeply decreased in drought years hence, high social pressure.	Between - Administration (Prefet head of the Basin Committee) - Irrigators - Pisciculturists - Tourism representatives - Other professionals.	- Definition of threshold level of water table - Putting restrictions for extraction on a daily fixed time - Fixing quotas of 80 mm of water per hectare, irrespective of the crop during drought

There are 9 observation wells in this area monitored by BRGM (Geological and Mining Research Bureau), an organisation that manages the national data pertaining to groundwater. The average level of water in the wells is a barometer reflecting the status of water table. Every irrigated farmer has access to reliable technical information about the aquifer. Before the irrigation season, normally during spring, the representatives of the irrigator association and the authorities meet and assess the trend of aquifers. Basically, the aim of this meeting is to facilitate discussion, to propose the macro level management of water table, and to limit the pumping in consultation with users. All the users effectively participate in the discussion, negotiate and know each user's view and constraints. After discussion, the collective decision is a rule and a final decree, which is implemented by the Prefect. Once the rule is voted, it is implemented.

Policy lessons for Peninsular India

Most of the western US states the special Natural Resource Districts are the most common institutional arrangement to deal with a wide spectrum of issues relating to water management. The Nebraska's case provides a classic example of local control over the resource to deal with overdraft issues as well as efficient allocation and use, tuned to the local needs and context of the people.

In order to replicate the Nebraska model to the peninsular India, institutional reforms mainly in the sphere of legal issues and the formation of user groups are required. The legal framework has to be clearly defined in terms of modification in property rights from absolute doctrine of prior appropriation to reasonable use as in the case of Nebraska. Further, physical and hydrological boundaries of the resource have to be delineated on a basin or aquifer level.

Currently, the scale of management relating to water resources is highly sectorized and disorganized. The government organizations such as State and Central Ground Water Board are the formal institutions dealing mainly with the technical issues of groundwater at macro level without any executive powers. Further these institutions do not reflect the local needs and aspirations, as many issues of groundwater are regional or local in nature. Since water is a state subject most laws should be passed at the state level. The model groundwater bill of 1992 has not yet been implemented in any state. The bill in its present form establishes a command and control system for groundwater regulation (Moench, 1998). This bill has been highly criticized, as it has not included local user's representation. In the light of this, the Natural Resource District model, a joint management approach with active people participation could be a promising solution to the Indian context. This could be developed at the regional or a cluster of village's level based on aquifer or watershed, where there is acute overdraft problem. The criteria to delineate a hydrological boundary for management should be flexible reflecting the local nature of problem. The district can initiate a variety of programs and controls for recharge and discharge and other regulatory measures such as spacing norms, control of new wells and regulation of water intensive crops. Elected board of directors through which the interests of all stakeholders can be voiced could govern these organizations. The board should have an overall body comprising of all the users and an executive body ratified by the committee of the farmers. The NABARD can explore the possibility of funding seed money for establishment of such NRD institutions initially. Later on they can generate their own source of revenue through licensing, well permit fees, share amount and other taxes. The members should be required to buy the shares in the groundwater district based on the irrigation command as stipulated by the district.

Designation of critically overexploited fragile areas as done in the case of Nebraska is very important for regulating further overexploitation. In these areas there is a need for regulation of bore-well drilling in terms of declaring a moratorium till the water tables are improved. Management can set allocation quota in overexploited areas for every 5 years based on crop water requirement using most efficient irrigation techniques. The limits should be based on the minimum area or share basis, which ensures reasonable income to the farm family to lead a decent life. Farmers who extract only a part of their quota could carry forward remaining amount to the next period or he can sell it to other needy users. This promotes water markets and efficient allocation of

the scarce resource. Those who exhaust their quota before the allotted period would forfeit their rights and this way the farmers are refrained from using more within a short span of time instead of spreading the use of their quota over the time horizon. This obviously promotes the use of efficient irrigation technologies and leads to conservation.

The regulatory and allocative management approaches based on permits and metering, spacing of wells has been widely used in Nebraska. These approaches need accurate data pertaining to stock of resource, flow, and recharge and discharge rates. Further the logistical costs associated with this approach is colossal since there are large number of well owners involved over space, so these measures could be restricted to those in dark areas where there is no scope for further expansion of well irrigation. The districts can also regulate the new wells, spacing of wells and well drilling agencies by issuing permits. For all unauthorized wells without permit system power supply can be stopped penalties imposed.

The real cost of extraction of groundwater has been increasing over time and this has serious equity implications for small farmers hence the special programs aimed at improving equity needs to be designed to support small farmers. Further supply of electricity may be made available on a preferential basis to these farmers who venture in-group investments.

In France, there has been a modest success in dealing with groundwater overexploitation in the Beauce area through the involvement of user groups in the decision making process of Basin Committee. The prevailing institutional arrangement, comprised of regulatory and economic instruments, to stall this problem is not effective in Indian context. However, the approaches such as the participation of user groups in the decision making process, the creation of Basin Committees, the imposition of regulatory measures such as issuing of the permits and submission of feasibility reports to drill the wells, the dissemination of vital technical information pertaining to resource use and status, have yielded some degree of success in French context, suggesting to replication of some of these approaches to Indian context.

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