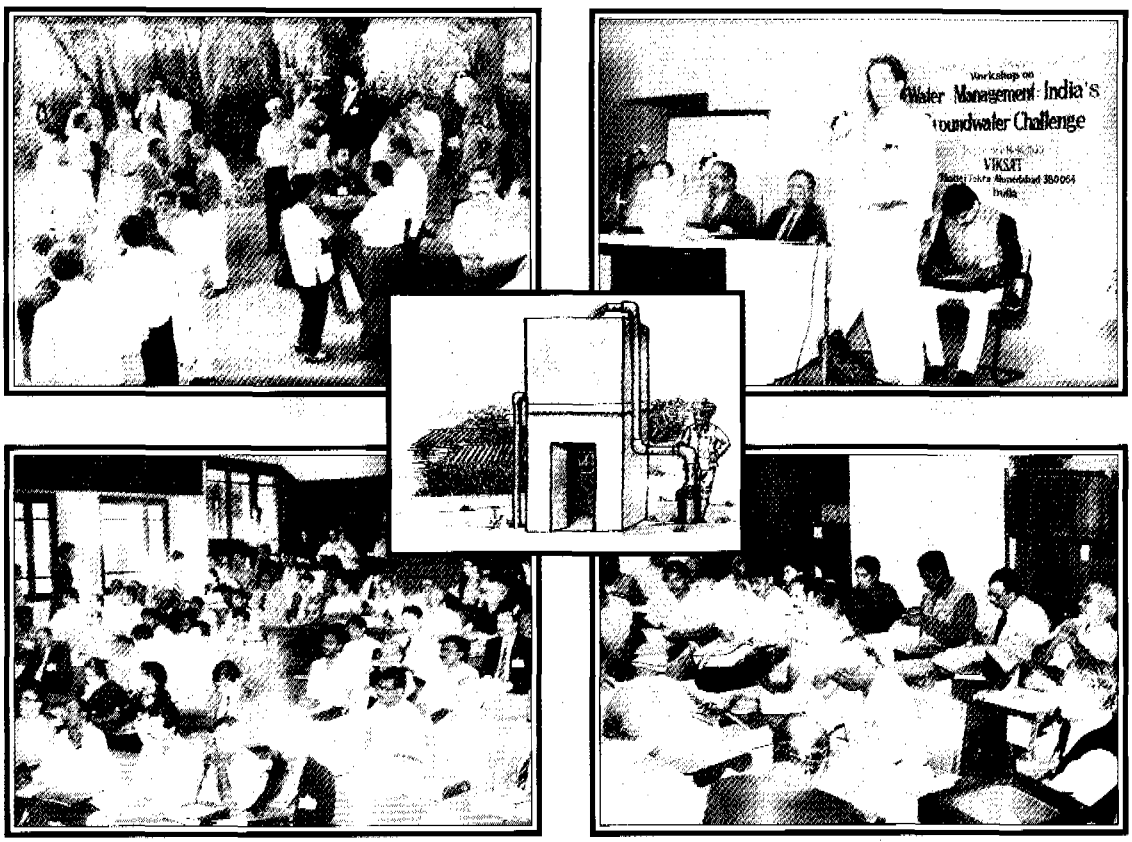
Groundwater Law: The Growing Debate



Vikram Sarabhai Centre for Development Interaction - VIKSAT
Natural Heritage Institute

822-IN98-16612

Selected Titles on Water from VIKSAT

1. **Local Water Management Initiatives: NGO Activities in Gujarat**; (Ed) Dr. Marcus Moench & M. Dinesh Kumar.(E).

2. **Proceedings of the Workshop on Water Management: India's Groundwater Challenge**; by Dr. Marcus Moench, Dr. Susan Turnquist & M. Dinesh Kumar.(E).

3. **Participatory Mapping As a Diagnostic Tool for Groundwater Studies**; by M. Dinesh Kumar, Praful J. Patel & Dr. Marcus Moench. (E).

4. ***Groundwater Management: Role of Cropping* Pattern & Irrigation Water Management**; by M. Dinesh Kumar & M.M. Chauhan. (E/G)

5. **Tube Well Turn Over: A Study of Groundwater Irrigation Organisations in Mehsana**; by M. Dinesh Kumar. (E/G).

6. **Groundwater Law: The Growing Debate**; (Ed) Marcus Moench.(E).

7. **Groundwater Management: Supply Dominated Focus of Traditional, NGO and Government Efforts;** (Ed) Dr. Marcus Moench. (E).

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10. **Groundwater Management: Future Options**; by M. Dinesh Kumar (G)

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12. **Social Reproduction Vs Economic Reproduction: A Study of Women's Role in Agriculture**; by M. Dinesh Kumar and Anjal Prakash. (E)

13 **Banking on Cooperation: A Study of Irrigation Management Institutions in Gujarat** by M. Dinesh Kumar, Shashikant Chopde & Anjal Prakash (E)

E = English G = Gujarati

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© VIKSAT November, 1998

Publisher : VIKSAT
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Design Coordination and Production : Mahendra Dadhania

ACKNOWLEDGEMENT

The workshop on "Water Management : India's Groundwater Challenge", in which most of the papers included in this monograph were initially presented, was funded by the Ford Foundation, Aga Khan Foundation and International Development Research Centre. Additional editorial assistance was provided by the Netherlands embassy.

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FOREWORD

Under India's Constitution, Water is considered a State Subject, with legislation and administration framed within the context of the State boundaries. As regards surface water, the Indian Law has given it the status of a public property, whether it is in the form of a natural flow in a river or stream or as storage impounded by a dam or a natural tank, pond or a lake.

Due to political and other reasons, the states, *de facto*, have come to exercise pre-eminent power in the matter of both surface and ground waters. At a practical level, *de jure* rights in groundwater are not very clear. Thus, the groundwater lying beneath a person's land is fully under his control. As such, he appears to have the legal and absolute right to extract the ground water in a manner he deems fit. Although a common property resource, the groundwater is virtually in the hands of those whose land contains ground water. The groundwater extraction process having thus polarised in the hands of a few, is being increasingly "commercialised".

In this fast changing scenario, coupled with changes swept in by the New Economic Policy, the underprivileged and the marginalised suffer the most.

Attempts by the Government to introduce Ground Water Bills through the states have met with stiff resistance in the past. The latest attempt in the early nineties met with some success in the sense that some states have implemented it partially. Political agendas get mixed up and the Supreme Court had to intervene last year to direct formation of a Ground Water Authority.

The papers in this publication were presented during the Workshop on **Water Management: India's Groundwater Challenge.** The papers surveyed the national and international scene in this context and provided the basis for a lively debate. The first print of this publication has gone out of stock within two years of its publication necessitating reprinting now.

We hope our publications including the present one will continue to facilitate meaningful debates leading to policy actions at various levels. Your comments and suggestions are most welcome.

Srinivas Mudrakartha
Director

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Groundwater Law: The Growing Debate

Summary

Dr. Marcus Moench

I Introduction

Numerous papers prepared for the recent workshop on **Water Management: India's Groundwater Challenge** touched on legal or regulatory issues. With overdevelopment and pollution problems threatening groundwater availability and quality in many areas, legal frameworks which enable effective management to occur are widely regarded as essential. How those frameworks should be structured is, however, the subject of substantial debate. The primary tension is between those advocating centralised regulatory structures and those who view decentralised approaches as being both more implementable and equitable. In addition, issues related to the inclusion of quality criteria and environmental rights were raised in several papers and the workshop discussions.

This volume contains the ten papers presented at the above workshop which deal most directly with legal and regulatory issues. A brief summary of key issues raised by the papers and the main conclusions that can be drawn is presented first in this preface. Papers follow in rough groupings that address similar sets of issues. The perspective of those involved in groundwater management from the governmental side is presented first in the papers by S.C. Sharma and Dr. H.Chandrashekhar. Papers by M. Srinivas and M. Moench which contain critiques of the recently proposed model bill as well as preliminary thoughts on alternatives follow. Basic conceptual issues influencing the choice of legal frameworks are addressed after this in the papers by K. Singh and S. Turnquist. Background information on the approaches followed in the United States and China is presented in the papers by G. Thomas, Z. Smith, J. Nickum & J. Turner, and F. Sheng. The monograph concludes with a research agenda on groundwater law for India prepared by C. Singh.

II Summary of Key Issues

Groundwater rights in India are currently tied to land ownership. Individual landowners have the right to construct wells in whatever manner they desire and extract as much groundwater as they can. This right structure is derived from English common law and is widely criticised in the papers prepared for the workshop. Many call for the separation of land and water rights as a prerequisite for the establishment of effective management systems (See: C. Singh, K. Singh, S.C. Sharma, S. Turnquist and H. Chandrashekhar). How rights should be defined and where they should be vested is the subject of less agreement.

It is interesting to note that authors writing on other areas, particularly the western United

States, comment on the abandonment of common law doctrine over groundwater as scarcity emerges. As Zachary Smith comments in his paper: "The common law doctrine was developed in relatively wet England and, as with common law generally, brought to the relatively wet east coast of the United states." It was then adopted in many arid western states but has since been abandoned.

Government officials such as H. Chandrashekhar and S.C. Sharma explicitly or implicitly call for water rights to be vested in the State and for the State to have full regulatory authority over use. This approach lies at the core of the Model Bill circulated by the Central Government in 1970 and again in 1992. In contrast, many of the NGO and academic researchers advocate the creation of use rights which are vested at multiple levels and enforced through less centralised mechanisms. Debates over the Model Bill with respect to the relative viability and desirability of centralised control based approaches are common in many of the papers.

In theory a wide variety of alternatives to centralised regulation could be possible. Most authors, however, suggest the need for some form of intermediate level institutional framework which is capable of reflecting both local conditions and capturing some of the wider social objectives in resource management. Turnquist, for example, proposes a "three- or even four-tiered system of quality management in India, in which the centre provides certain resources to the states, who in turn provide certain rights and resources and designate responsibilities to smaller, hydrogeologically-based groups." Similarly, Katar Singh calls for a system of correlative use rights vested in cooperatives with actual ownership of the water being held under a public trust system by the state. Overall, many of those outside government organisations argue that enforcement of any rights structure or management system requires local support and this is not possible to obtain through centralised mechanisms. Furthermore, approaches based around decentralised organisations and rights are likely to reflect local conditions to a greater extent and possibly be less subject to inequities and corruption than are fully centralised approaches. At the same time, no one argues for a fully decentralised approach where all decision making power would rest in the hands of individual rights holders.

With the exception of the paper by Chhatrapati Singh all authors concentrate human use rights. Chhatrapati argues forcefully that rights definitions should encompass environmental uses and that these rights should be held in public trust by the state. As with Chhatrapati's focus on environment, Turnquist is the only author to focus on the quality dimensions of groundwater. She argues that: "groundwater rights should include rights to groundwater of usable quality." Turnquist also makes the important point that prevention of pollution is key, once polluted it is often technically and/or economically not feasible to clean up groundwater resources. Furthermore, non-point source pollution, i.e. that stemming from the actions of widely dispersed individual users (such as individual farmers), may represent the greatest long term threat. Rights and the legal structure must be designed with these factors in mind. Overall, both the environmental role played by groundwater and the fact that water quality greatly affects the value of groundwater resources are key dimensions frequently missing from discussions of groundwater management.

A common assumption in all the papers from India is that groundwater should be managed sustainably. This is often not even recognised as an assumption. This assumption does not, however, underlie management systems in all other parts of the world. New Mexico and a variety of other states in the western U.S., as Zachary Smith documents, have opted for orderly depletion of groundwater resources with the goal of minimizing social and economic disruption.

Although many papers focus on India, several present experiences from other parts of the world.

The history and results of rights definitions in the Western U.S. are well documented by Drs. Greg Thomas and Zach Smith. In many parts of the U.S. highly decentralised approaches based solely on individual rights definitions have been followed. After examining this history Dr. Thomas concludes that "Properly designed and delineated local groundwater management institutions consistently outperform the decentralised model .... The local management option also compares favourably with a highly-centralised allocation based on a state-wide permit programme, for all criteria except that the more centralised approaches are better able to foster conjunctive use of ground and surface water. The local management option has the strong advantage of being sensitive, adaptable and responsive to local conditions and perceptions of need. It also has the virtue of depending largely upon local rather than state or national initiative to create, finance and govern the management institution and avoids the type of ponderous bureaucracy which has been the bane of too many natural resource management regimes historically."

Turner and Nickum document China's experience with rapid decentralisation of water management. The results, so far, have been mixed. Rapid decentralisation of authority has not brought about the hoped for benefits. Corruption has increased. Local management entities often lack the technical and organisational skills to carry out their responsibilities effectively. Finally, high level ministerial infighting has limited the implementation of key elements intended to create incentives for water conservation at local levels. Part of these problems may be due to the rapid and poorly planned approach taken to decentralisation. At the same time, any assumptions that decentralised approaches are automatically better than centralised ones regardless of how they are designed and implemented are clearly unfounded.

The above observations appear to have great relevance for the emerging debate in India. Debates in India tend to polarise between those advocating fully centralised control and the proponents of "local" (i.e. village or user-group) management. Given the large number of wells and history of private ownership, implementing a centralised regulatory regime appears extremely difficult. At the same time, fully decentralised approaches (based, for example, around private ownership or village level groups) are unlikely to incorporate wider social needs in the approach they take to management and often, given the size of aquifers, will not function at a scale sufficient to address physical management needs. Some form of intermediate level institutional structure that can function at the scale of an aquifer or somewhat larger administrative unit yet still retain a local legitimacy appears essential. Ultimately, effective manage-

ment may require a mix of actions at multiple levels ranging from the individual user up to the central government. In this context, Moench argues for the creation of an " enabling framework" of legislation that would allow a mix of approaches to be tried in different situations.

III Conclusions

Given the widely diverging opinions of authors and range of emerging issues, it is clear that debates over groundwater law and regulation will not be resolved rapidly. Ultimately, any legislation that is passed should create a framework for addressing emerging problems through institutional structures that are both viable (in terms of the functioning of any organisations created) and reflect social concerns for equity, environmental values and resource sustainability. The transition from the current situation toward this ultimate goal will require substantial research and experimentation.

Chhatrapati Singh provides a research agenda. According to him: "At least four different types of legal research need to be carried out to explore alternatives for appropriate groundwater legislation. First, examination is needed of the existing and possible legal regimes where private rights to groundwater can be contrasted with common property or common access rights. Second, research is required to understand situations in which water rights are separated from land rights and the possible legal alternatives and consequences of this separation. Third, understanding of legal regimes in which environmental and other multiple-use values (such as conjunctive use of groundwater with other natural resources), play significant roles is required so that appropriate elements for reflecting these values can be incorporated in any new legal structures created in India. The fourth type of research required relates to legal regimes for different hydrological or ecological situations."

To Chhatrapati's agenda must be added the issues of effective institutional structures for management implementation and ways for incorporating quality and pollution dimensions into the overall rights and regulatory framework.

Unless the institutions designed for groundwater management are socially viable (i.e. large numbers of individuals are willing to invest time in their maintenance and functioning and they have sufficient social authority to actually implement management decisions), legal frameworks will remain as paper exercises. Since little experience with groundwater management exists in the Indian context, what these institutions will ultimately look like is unknown. Substantial research and experimentation is required to identify institutional possibilities for management implementation.

Similarly, how best to incorporate quality and pollution dimensions into the groundwater rights and regulatory structure is a key area where research is required. Quality and pollution may, ultimately, be the primary factors determining effective availability for many uses (there may be lots of water underground but if it has become highly saline the effective availability is nil). Realistic institutional structures for addressing rights to water of a given quality and the problem of non-point-source pollution have yet to even be proposed.

Finally, there is the question of process. Since it is not clear what approaches to groundwater management will ultimately prove viable, proposals mandating single approaches may be counterproductive. Emerging problems require action. At the same time, flexibility is required so that experimentation and research can occur and initiate a process of institutional evolution. Legal frameworks that allow this flexibility appear desirable.

Regulation of Groundwater Development in India: Existing Provisions and Future Options

S. C. Sharma

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Groundwater development for drinking and domestic, irrigation and industrial purposes has acquired an important position in the overall water resource development programme of India. At present, it accounts for about 50% of the total irrigated area in the country. In addition, about 80% of drinking and domestic requirements and sizable portion of industrial uses are met from groundwater. Furthermore, because groundwater is widely available, forms a dependable source of supply, can be developed rapidly at relatively low cost and is under direct control of individual farmers, it has become the preferred source with all users. During the 8th Plan, an irrigation potential of about 8.5 million ha. is planned to be created from groundwater. This represents over half the total target of 15.80 million ha. of irrigation potential planned to be created from all sources during the 8th plan period.

In contrast to surface water supplies which must be developed through man-made surface water reservoirs, groundwater occurs in natural "reservoirs" underground. In addition, unlike surface sources, pumping expenses, borne by users, are a major recurring cost associated with groundwater utilisation. Despite the additional expense of pumping, irrigation with groundwater generally works out to be less expensive than irrigation from surface flow sources. Although groundwater has many merits when compared to surface sources, the required awareness and discipline for developing this resource in a socially equitable manner has not come among the various agencies responsible for its development.

Groundwater is a replenishable resource. To avoid depletion, it has therefore to be ensured that the amount pumped does not exceed the amount annually recharged. Over-exploitation of the resource besides increasing pumping costs, can cause adverse effects on the hydrologic balance and water quality. It is, therefore, essential to take necessary safeguard measures to ensure that the balance is not disturbed and that average annual exploitation is kept within the permissible limits.

Present Status of Groundwater Development

Irrigation potential from groundwater sources has grown dramatically over the past four decades. Tables 1 & 2 give details of area brought under irrigation from various sources and the number of groundwater structures. Table 3 indicates the investments in irrigation sector.

Table 1: Cumulative Irrigation Potential Created (mha)

Year	Surface Maj & Med.	Surface Minor	Surface Total	Ground Total	Grand Total
March 1951	8.6	6.4	15.0	6.5	21.5
March 1980	25.3	8.0	33.3	22.0	55.3
March 1985	27.6	9.7	37.3	27.8	65.1
March 1990	31.5	11.2	42.7	34.9	77.6
March 1992	32.8	13.1	45.9	38.0	83.9

Table 2: Number of Groundwater Structures (000)

Year	Dugwells	Pvt. Tube Wells	Public Tube Wells	Pump sets Electric	Pumpsets Diesel
March 1951	3860	3	2.4	21	66
March 1980	7786	2132	33.3	3965	2650
March 1985	8742	3360	46.2	5733	3550
March 1990	9652	4695	71.0	8180	4300
March 1992 (Tentative)	10285	5400	75.2	9290	4530

Table 3: Investment in Irrigation Sector (Rs. Crores)

Period	Plan Expenditure, total	Major & Medium Plan	Minor Plan*	Institut. Exp. on M. I.	Total Exp. on M.I.	Total Irrig.	% Total Exp. on
1951-56	1360	380	66	Neglb.	66	446	14.8
1956-61	4672	380	142	19	161	541	29.8
1961-66	8577	581	328	115	443	1024	43.3
1966-69	6603	434	326	235	561	995	56.4
1969-74	15778	1237	513	661	1174	2411	48.7
1974-78	28811	2442	631	780	1411	3853	36.6
1978-80	22941	2056	497	490	987	3043	32.4
1980-85	109646	7531	1979	1438	3417	10948	31.2
1985-90	180000	11556	2805	3513	6318	17874	35.3
1990-91	61137	2565	832	921	1753	4318	40.6
1991-92	64698	2782	977	972	1849	4631	39.0
1992-97	434100#	22214	5977	5119	11096	33510	33.1

* About 40% of Plan expenditure and over 90% of institutional finance in the Minor Irrigation sector is estimated to be invested for groundwater development. In addition, another approximately 30% of total investment is from private sources and not included in the above figures.

Present level of groundwater development:

The replenishable groundwater resources of the country have been assessed volumetrically as 45 million hectare meters. About 30% of this is presently extracted each year. When viewed for the country as a whole, sizable potential still remains to be utilised. There are, however, certain pockets in the country where declines in the water levels have taken place during the past decade or so.

For purpose of considering groundwater development schemes for institutional financing, resource assessments have been made on block, taluka or watershed basis. Groundwater development is being regulated utilizing the concept of "stage" of groundwater development within a given administrative unit -- generally the "block". The "stage" of groundwater development is defined as the ratio between projected net annual groundwater draft (withdrawal) at year five and the portion of groundwater resource utilisable for irrigation. [1] Based on this, the blocks are categorised as "White" (Safe), "Grey" (Semi-critical) and "Dark" (Critical) areas as indicated in Table 4.

Table 4: Stage of groundwater development

(% of recharge available for irrigation extracted)	
White or safe area	Below 65%
Grey or Semi-critical area	65 to 85%
Dark or critical area	Above 85%

As of January, 1992, according to the National Bank for Agriculture and Rural Development (NABARD), the categorization of blocks with reference to the stage of development of groundwater resources was as indicated in Table 5.

Table 5: Categorization of Blocks/Talukas/Watersheds as on January, 1992.

	Total	Dark #	Dark%	Grey#	Grey%	White#	White%
1. No. of Blocks*	4568	257	6	361	8	3950	86
2. No. of Talukas (Gujarat)	183	18	10	14	7	151	83
3. No. of Watersheds (Mah.)	1481	34	2	57	4	1390	94

*Except Gujarat and Maharashtra. Gujarat has 183 (Talukas)/218 (Blocks), Maharashtra has 1481 (Watersheds)/366 (Blocks).

Need for regulating groundwater development

The need for regulating the extraction of groundwater arises from the following considerations:

1. The portion of groundwater "utilisable" for irrigation is estimated as recharge from all sources minus a 15% reservation for domestic and other uses.

a) Protection of resource against over-exploitation:

The status of groundwater development is given above. Based on available statistics, among the blocks categorised as "Dark," more than 120 have reached a stage of over-exploitation. Consequently, water level declines in these blocks have already set-in. It is therefore essential to take remedial measures in these areas to stop and, if possible, reverse the declining trends. Any delay in the implementation of remedial measures may cause land subsidence and ecological imbalance. Regulation of extraction is one of the primary measures available to arrest water level declines by keeping development within permissible limits i. e. within the limits of available resource.

b) Protection of resource against quality degradation:

Over-exploitation of the groundwater resources often results in quality degradation particularly in coastal areas and areas affected by inland salinity hazards. Groundwater pumping in such areas has to be judiciously planned based on a solid scientific understanding of the regional hydrology. Over-pumping in fresh water aquifers which are hydraulically connected to saline water bodies or saline aquifers, could cause intrusion of saline water thus permanently damaging the fresh water aquifer. This is already occurring in areas such as Mehsana District of Gujarat.

c) To ensure social equity:

In many areas, well-to-do farmers install high capacity wells. These can cause drastic falls in water levels and, in some cases, the failure of adjacent shallow tubewells. The owners of shallow wells are forced to deepen or reconstruct their structures each year if they wish to maintain access to groundwater resources. Those who can not afford to do this, lose access. To protect the interests of such users, it is essential that groundwater extraction in an area is regulated in ways that ensure both equitable distribution of access to the resource and protect supplies to meet the minimum needs of all users.

Regulation of groundwater development will also be essential to guarantee the minimum needs of those citizens who do not own land and thus do not enjoy any legal water rights.

Existing measures for regulating Groundwater Development

At present indirect administrative measures in the form of limitations on institutional financing for schemes requiring credit are the only control commonly being exercised for regulating groundwater development in India. Financial institutions generally insist on technical clearance from authorised Groundwater Departments of the concerned State before granting credit for the construction of new wells, pump set purchases, etc. The Departments evaluate groundwater availability. Spacing criteria between two groundwater structures are also prescribed by local banks availing refinancing facilities from the National Bank for Agriculture and Rural Development (NABARD).

Groundwater Development Programmes are carried out by loaning agencies (primarily banks) based on the groundwater estimated to be available for development within administrative blocks. Groundwater balance estimates are made based on the methodology approved by the State Groundwater Departments and Central Ground Water Board. Proposed groundwater development programmes are cleared subject to groundwater availability. In general, the ease with which schemes are cleared and credit granted depends on the level of development prevailing in the block under consideration. . In areas classified as "White," the scrutiny is less vigorous and programmes are approved even on the basis of groundwater availability estimates calculated using ad hoc norms. In the case of "Grey" and "Dark" areas, scrutiny is much more detailed and the agency responsible for groundwater resource assessment is required to carry out micro-level surveys and provide the data required for justifying clearance of a scheme. Where clearance is denied, credit will not be given by banks or other public sources of financing for any further groundwater development activities. In addition to limitations on credit, power connections for pumps can be denied in areas with a high stage of groundwater development or areas where groundwater is over-exploited.

Current restrictive administrative measures do not prevent affluent farmers from constructing wells in critical areas. This brings in an element of socio-economic inequity. Poor farmers requiring institutional financial assistance for well development can not obtain it and are deprived of the opportunity to construct wells. Affluent farmers with access to their own or private sources of capital can still construct high capacity wells. These may affect water availability in existing shallow wells of adjacent poor farmers.

Groundwater Rights:

Under the constitution, the right to life is fundamental and universal. Except as implicit in the fundamental right to life, there is no fundamental right of access to water. Land owners have an absolute right to the water under their land. Groundwater is a part of the dominant tenancy under the laws of the state. The right to extract water can not be transferred separately from land. Transfers to new owners are only possible if the land is transferred along with the water right. The amount of water it is legally possible to extract does not depend on the amount of land owned. Any land owner can abstract any amount of water.

The above legal framework implies that, in India, only the land owners own groundwater. As a consequence, the landless -- who constitute more than 30% of the rural farm population -- and tribals do not enjoy private ownership of groundwater or other water rights. Tribals, however, have community rights. The result of this legal provision is that any land owner may extract any quantity of water and sell it to anyone at prices he considers appropriate and can command.

The rights granted under such a legal framework are inappropriate in a socialistic society and does not suit the interests of the nation as a whole. Since the attachment of water rights to land ownership can violate the fundamental right to life, the current water rights structure

needs to be modified to ensure equitable distribution of this resource, particularly for those who do not own land.

Model Bill (1970)

The main factors behind drafting any legislation for regulating the development and exploitation of natural resources are:

i) to ensure that activities of man do not prove detrimental to nature and have deleterious effects on the environment; and

ii) to ensure sustainable availability and equitable distribution of the resource to various sectors and sections of society.

In view of the above and with the goal of regulating the development of groundwater resources in a scientific manner, a Model Bill was framed in 1970 by the Ministry of Agriculture, Government of India, under whose authority the subject of groundwater fell at that time. Under the Constitution, water is a state subject. As a result, the model bill could not be adopted directly by the Central Government. Instead, it was circulated to the States with the recommendation that it -- or a suitably modified version of it -- be adopted as legislation.

Salient features of the Model Bill were:

1) The State Governments were to acquire powers to restrict the construction of groundwater abstraction structures (including wells, borewells, tubewells etc.) by individuals or communities for all uses except that of drinking water.

2) For discharging the various functions to be acquired by the Government under the legislation, a Ground Water Authority was to be constituted by each State. The Authority was to consist of a Chairman, representatives of the concerned State Government Departments and knowledgeable persons in the field of groundwater appointed by the State Government. The Authority was to be provided with support of technical persons and other staff considered necessary for enforcing the legislation.

3) Applications for sinking wells for purposes other than domestic use were to be considered by the Ground Water Authority keeping in view the purpose for which water was to be used, the existence of other competitive users, the availability of groundwater and any other relevant factors.

4) Persons/Organisations desirous of taking up the business of sinking of wells/tubewells were to be required to register with the Ground Water Authority. The Authority was also to be vested with the power to cancel any permits, registrations or licenses issued by them.

5) Finally, the authority was to be provided with complete legal support to enforce the

various provisions of the legislation. It was also provided that the orders issued by the Authority would fall outside the purview of the Civil Courts. The Civil Courts were to be barred from granting injunctions on any decision taken by the Authority.

No state adopted the model bill. Only Gujarat framed some legislation. This excluded many of the key provisions contained in the model and has never actually been enforced in any area.

Revised Model Bill (1992)

Since the initial Model Bill was never adopted, The Ministry of Water Resources constituted a Working Group to re-examine the provisions of the 1970 draft and suggest revisions. This Working Group considered the existing provisions and expanded on them to include the following new provisions:

i) Extension of the bill to cover all uses including drinking and domestic use, and

ii) exemption of small and marginal farmers from obtaining prior permission of the Ground Water Authority for the construction of groundwater abstraction structures provided these are for their exclusive use.

The revised draft Bill has been circulated to the States for their comments and adoption in a suitable manner.

Present Status of Enactment of legislation in the States:

Maharashtra:

The Government of Maharashtra is the only state government which has enacted and implemented legislation covering the whole of the State. The State through a notification (dated the 16 August, 1993) has promulgated an Act to regulate the exploitation of groundwater for protection of public drinking water sources. The Act, "Maharashtra Act No. XXVIII of 1993," is also titled the "Maharashtra Ground Water (Regulation for Drinking Water Purposes) Act, 1993". It applies to the whole of the state and has come into force with effect from 10th September, 1993. The Act :

a) prohibits sinking of a well by any person or agency without prior permission, (except on behalf of the State government or a local authority for creation of a drinking water source) and for any purpose within 500 metres of a public water source (if both the sources are in the area of the same watershed);

b) provides that the appropriate authority (e.g. the State constituted groundwater authority) shall have the right to prohibit, restrict or regulate extraction of water from wells to suit the public interest,

c) provides that the groundwater authority can declare any area as "water scarcity area" for a period not exceeding one year when it is of the view that public drinking water sources in the area are likely to face scarcity. On declaration of an area as water scarce, construction of wells except for drinking water purposes will be prohibited,

d) prohibits sinking of wells for any purpose in over-exploited watersheds -- i. e. those where extraction of groundwater is above 85% of the estimated average annual recharge,

e) prohibits, after giving notice to its owner and opportunity of being heard, the extraction of water from an existing well in an over-exploited watershed for a period of six months from 1st February to 31 July or temporarily or permanently close or seal off such a well provided the extraction of water from such a well is likely to adversely affect a public drinking water source,

f) grants the right to enter any premises for survey and scientific studies and install any instruments or for closing or sealing off a well, stopping/removing illegal constructions, disconnecting power connections, etc. in order to enforce the provisions of this act,

g) includes a provision for compensation at the market rate to owners for the loss of the well or the loss of crops due to closure or sealing of the well,

h) provides a penalty for contravening any of the provisions of the act or obstructing any person in the discharge of his duties. The penalty, on conviction, will be imprisonment from one month to six months or fine from one thousand to five thousand or both.

Gujarat

Gujarat enacted groundwater legislation by partially amending the 'Bombay Irrigation Act' as applicable to the State. The legislation is applicable only to nine identified districts in the State. Furthermore, unlike the Model Bill, construction of all groundwater extraction structures has not been brought under the purview of legislation. Instead only construction/ deepening of wells/borewells/tubewells having depth of more than 45m has been barred.

Tamil Nadu, Andhra Pradesh and Karnataka

These States have framed draft legislation containing the full provisions suggested in the Model Bill. In no case however, has the legislation been adopted.

Madras Metro-Water Act

An act entitled the Madras Metropolitan Area - Ground Water Regulation Act, 1987 (Tamil Nadu Act 27 of 1987) was passed to protect water supplies for the city.

The Act provides for licensing the extraction, use and transport of groundwater in Chinglepattu district and registration of all existing groundwater structures in the district.

Madhya Pradesh Peya Jal Parirakshan Adhiniyam, 1986 :

The Madhya Pradesh Act provides for preservation of water in water sources and for regulation of tubewell construction in order to maintain water supplies to the public for domestic purposes and for matters ancillary thereto. Under the Act, the Collector has been given powers to declare any area as a "water scarcity area" for any period in order to maintain or increase the supply of water to the public or to ensure its equitable distribution. Digging of tubewells without permission for any purpose in water scarcity areas is prohibited under the Act. In addition, digging of tubewells in the zone of interference of any tubewell constructed or maintained by the State Government or other local authority for the purpose of domestic water supply to the public is prohibited. Contravention of the Act's provisions is punishable by imprisonment (up to two years), fines of up to two thousand rupees or both.

Union Territory of Pondicherry and Karaikal:

Agriculture - Control and regulation of groundwater exploration in Pondicherry & Karaikal regions :

The Government of Pondicherry issued an order dated 21. 9. 1988 prohibiting within 6 km of coast the following activities if undertaken without permission:

a) Construction of new tubewells for any purpose by individuals or an agency,

b) Installation of new power connections for energizing tubewells,

c) Location of new industries needing more than 10,000 litres of potable water per day,

d) Rejuvenation of an existing irrigation or domestic tubewell except on the basis of need.

The order also mandates a minimum spacing between wells of 150 m to 200 m and bans the sinking of wells within 30 m of main irrigation canals.

Punjab

The Government of Punjab, is of the view that enactment of legislation should be deferred because it would have an impact on a very large number of small and marginal farmers. The State Government advocates steps such as cropping pattern diversification, restrictions on new electric connections in over-exploited and dark areas, introduction of sprinkler irrigation and drip irrigation and artificial recharge in order to check over-exploitation of groundwater.

In this context, it should be noted that the Model Bill seeks to protect the rights of small

and marginal farmers. Whereas affluent farmers can afford to make investments in well deepening and construction, small and marginal farmers are at a disadvantage because of the acts of their wealthy neighbours. The Model Bill, if enacted, will therefore protect the rights of small and marginal farmers by limiting the ability of larger farmers to construct wells as they wish.

Constitutional Provisions

Under the constitution, water resource regulation and development are given in the Union and State Lists as Entry 56 in List 1 and Entry 17 of List II of VII Schedule. The various relevant articles are reproduced below :

List I - Union List

56. "Regulation and development of inter-state rivers and river valleys to the extent to which such regulation and development under the control of the Union is declared by Parliament by law to be expedient in the public interest".

List II - State List

17. "Water, that is to say, water supplies, irrigation and canals, drainage and embankments, water storage and water power subject to the provisions of entry 56 of List I".

From the various provisions in the Constitution it can be seen that there is still some lack of clarity in so far as the jurisdictions of the Union and State Governments in the Water Resources Sector are concerned.

Reaction of public to the Model Bill:

The revised Model Bill was discussed in the meeting of the State Ministers for Irrigation and Water Resources in September, 1992 and was released to the press to ascertain public reactions. Comments on the Model Bill indicate that whereas by and large the bill is accepted by the critics, concern has been expressed that the legislation will lead to corruption and intimidation of the general public and is viewed as a sort of a policing measure. In this context it is important to note that even though the apprehensions may be based on the social situation in some areas, the fact that the extraction of groundwater needs to be regulated cannot be overlooked. It is therefore essential:

a) to regulate the extraction of groundwater and ensure equitable distribution;

b) to protect ecology and environment against the effects of over-exploitation of groundwater.

It is also important to recognise that the enactment and enforcement of any legislative measure carries with it the possibility that basic principles will be disregarded or that favouritism and corruption can occur. Instances in which Acts on Income Tax, Sales Tax and such other taxes are violated have come to notice. Such instances should however not deter enforcement of a measure aimed at protecting the national welfare, particularly where large numbers of people depend on a resource and unscientific extraction of the resource is likely to effect its availability and sustainability. The fear that enforcement of legislation may lead to corruption can, therefore, not be viewed as an argument against promulgation of groundwater regulation.

Possibilities of Central Legislation:

The constitutional provisions relating to water development have been outlined above. As per entry 17 in List II of VII Schedule, development of water is a State subject. The fact that the haphazard and over-exploitation of groundwater leads to deterioration in water quality -- in other words pollutes the fresh water -- could bring the subject of groundwater development under the scope of the pollution control act. The Ministry of Environment and Forests has already issued orders prohibiting the construction of wells/tubewells within 500 m of the sea coast in order to protect fresh water aquifers from sea-water intrusion.

Since demands on water resources will continue to increase for providing food and fibre to the growing population, major aquifers running across the state administrative boundaries (Transboundary aquifers) will need to be tapped. Arrangements for sharing and managing water in such aquifers are required. Whether this aspect can be covered under entry 56 of List I of VIIth Schedule or a separate provision will need to be introduced requires urgent consideration.

The need for a uniform central legislation is also justified to ensure same level of protection to all citizens. Groundwater over-exploitation can, over the long run, cause land subsidence, land ward movement of the coast line and disruption of the ecological balance. For these reasons, there seems to be a well established need for a central legislation even if it requires amending the constitution.

Since land and water are part of the same natural system, the need and possibilities to regulate the natural resources of land including forests, land and water under a single law also needs consideration.

Need for separating water rights from land rights:

In order to ensure equitable and proper distribution of groundwater, water rights need to be separated from the land rights. Right to water must be recognised as a natural right or a fundamental right under article 21 of the Constitution. Prioritisation of uses with the right to drinking water being the highest should be recognised under the law. Since groundwater and surface water are a part of the same hydrologic cycle, the two sources could also be dealt with under the same law.

Conclusion and Recommendations:

The options available for regulating groundwater extraction are :

a) Regulation by education i.e. by creating awareness among the people regarding the adverse effects of groundwater over-exploitation.

b) Regulation by administration and legislation as stated above.

Whereas the need to regulate groundwater is paramount, simultaneous actions are required to ensure availability on a sustainable basis. To achieve this, measures such as artificial recharge of groundwater, conservation through economic water use and protection from pollution will have to be taken without further loss of time.

Formulation of better Management Techniques and Legislative Control on Utilisation of Groundwater Resources in Karnataka

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ABSTRACT

Scanty and erratic distribution of rainfall and surface water characterise much of Karnataka State and agriculture, industry and even domestic sectors depend heavily on groundwater resources. As a result, overdevelopment has occurred in some groundwater dependent areas and water tables are declining leading to a critical situation. In contrast, in many canal command areas of the State, groundwater levels are continuously rising, creating water logging problems. Due to the emergence of both depletion and water logging problems, there is an urgent need to manage and conserve groundwater resources by imposing legislative controls and adopting better management techniques.

1: INTRODUCTION

In many parts of the country, fresh water is scarce and groundwater levels are declining. The demand for fresh water is increasing day by day due to increasing population, rapid urbanization, changing lifestyles and, especially, expansion of agriculture and industry. Fresh water requirements are expected to double by the turn of this century. The only way to solve this complex situation is to evolve better management techniques and strictly enforce legislative control on the utilisation of water resources.

2: LOCATION AND CLIMATE

Karnataka, one of the Southern States of India, is situated between 11° 31' and 18° 45' north latitude and 74° 12' and 78° 40' east longitude. The geographic area of the State is 1,92,000 sq.km. accounting for 5.8% of the total area of the country. It has a cultivated area of 1,25,000 sq.km, out of which about 20 percent is under irrigation.

Rainfall distribution in the State is highly variable. Nearly 80% of the total geographical area is frequently affected by drought of various intensities and magnitudes depending upon location and time of year. The annual normal rainfall is 1138 mm received over 55 rainy days. It varies from as low as 458 mm to as high as 4,029 mm. About 70% of the annual rainfall is received during south west monsoon, about 17% during north east monsoon and the remain-

ing part is received during the pre-monsoon period. More than 2/3rd of the area of the State receives an annual rainfall of about 750 mm or less. In these areas, the one good crop expected in a normal year is frequently lost due to scanty or uneven distribution of rainfall during key periods of crop growth. As a result, crop production under both rainfed and irrigated conditions is highly uncertain.

3: SURFACE WATER

Seven river basins, Krishna, Cauvery, Godavari, West flowing rivers, North Pennar, South Pennar and Palar, constitute about 1.9 lakh sq. km. of drainage area in Karnataka State.[2] It is estimated that the average annual yield of these rivers and their tributaries is about 97,352 M Cu.m (3,440 TMC), out of which only 47,735 M cu.m (1687 TMC), about 49%, is considered as economically utilisable water potential for irrigation. Up to 1992, about 22.5 lakh ha. of irrigation potential from surface water resources had been created. During the pre-independence era, the development of surface water sources for irrigation in the State was very slow and unsystematic. This eventually caused high level of dependence on groundwater for agriculture and other uses.

4: GROUNDWATER RESOURCE

Karnataka is underlain mostly by crystalline rocks. The occurrence, movement and storage of groundwater are controlled by the lithology and structure of the formations. Weathered and fractured granites, gneisses, schists, basalts laterites and limestones form the main aquifers. The thickness of the weathered zone varies from 10m to 60m . Dug wells, which are the main groundwater extraction structures, are being replaced by dug cum borewells and deep borewells. Precipitation is the main source of groundwater recharge although some takes place through induced infiltration from stream, tanks and applied irrigation water. Due to erratic rainfall and uneven distribution of surface water, the use of groundwater has increased dramatically over the last two decades. Fig.(1) shows that during 1971, 1981 and 1991, the groundwater utilisation was 200,000 ham, 300,000 ham and 600,000 ham respectively. The extent of utilisation doubled over the last decade. This was due, primarily, to the increase in number of deep bore wells and to energy subsidies (electricity for groundwater pumping is charged at a nominal rate). Table 1 shows groundwater sources and utilisation in Karnataka as on 31.12.92. It can be seen from the table that groundwater utilisation is considerably more in districts where surface water availability is less. The rate of utilisation of groundwater has reached an alarming stage in the districts of Kolar, Bangalore, Tumkur and parts of Belgaum and Bijapur, causing an abnormal drop in the water table (Fig.2). This has led to the failure of dug wells and shallow wells, scarcity of drinking water, high energy consumption, etc.

In contrast to areas where surface water supplies are limited, in all command areas of the State, groundwater levels are continuously rising (Fig.3). This has created water-logging

2. One Lakh = 100,000

problems and resulted in a reduction of agricultural production. A survey conducted in 1983 on the Tungabhadra Project Command, which was commissioned in 1953, indicates that an area of 33,000 ha was severely affected by water logging and salinity problems. The area affected by these problems is increasing at a rate of about 6,000 ha annually. Production was reported to be zero on about 20,000 ha and cultivators had been forced to abandon their lands. Water scarcity in the tail portion of surface water systems is another common problem. Tailenders generally receive too little water, too unpredictably and too late. As a result, it is desirable to support and accelerate the conjunctive use of groundwater and surface water in command areas. This will go a long way in solving the twin problems of water logging and tailend deprivation. An overview of areas affected by declining and rising water tables is given in Figure (4).

5: FUTURE WATER DEMANDS

Demand for water has begun to exceed the capacities of natural and man made systems. The most accessible and lowest cost sources of water have already been used. As demand for water for food production and urban supply increases, the availability of good quality water decreases because of urban, industrial and agricultural pollution. To overcome the shortages, the water available in the deeper aquifers is pumped out, leading to harmful effects such as declining groundwater levels, land subsidence and loss of investments in existing wells.

Before water depletion problems become acute, it is of utmost importance to act and implement administrative control measures to check further exploitation of groundwater, at least in the over-exploited areas.

6: WATER LAWS OF MUSLIM COUNTRIES

The middle east countries, cradle of Muslim religion, have for ages considered water as a national asset or public property. Any substance such as water that is rare will be valuable and the State would like to have control over it. This logic is the source of inspiration for the water laws of Muslim countries. A brief review of the laws of these countries will enable us to realize the importance and necessity of groundwater legislation.

The Prophet Mohamed, founder of the Muslim religion, with profound common sense ordained that no one will deny water for fellow beings to quench their thirst or the thirst of their animals. It is interesting to note that the Prophet brought water, in all its forms, under the purview of the religion. Important points which have been included in the Shariat follow:

i) No one can refuse surplus water without sinning against Allah and against man;
ii) Any one who gives water to a living creature will be rewarded;
iii) He who digs a well in the desert when there is pasture around the well and when there is no other water nearby cannot prevent the animals from quenching their thirst at this well.
iv) He further recognised the necessity of having sufficient spacing between two wells in

order to protect the quality and quantity of the existing well. He called it the "Harim" or forbidden area around a well. The size of harim has also been prescribed depending on local conditions.

v) In general it seems that the Prophet declared water, pasture, and fire to be public property in order to avoid hoarding and exploitation.

As time passed each country in the middle east framed its own laws. Perhaps the first codified water law was the Mejelle code framed by the Ottoman empire which comprised several of the present middle east countries. The code is amazingly comprehensive, describing the definition of water, regulation of use of water, priorities of water, water tax, etc.

After the fall of the Ottoman Empire, the constituent countries framed their own water laws based on their own historical, geographical, cultural, traditional and religious background. As the demand for water increased, the problems became more complicated. This necessitated detailed and complicated water laws to meet the changed conditions.

Turkey, Romania, Iran, Israel and many more countries have declared that groundwater is a national asset and have suitable laws backed by sufficient administrative and technical machinery to implement them.

7: WATER LAWS IN U.S.A.

Different states in America have framed policies and adopted legislative control measures to regulate the over-exploitation of groundwater.

Farmers in water scarce sections of Arizona, Arkansas, California, Colorado, Florida, Idaho, Kansas, Nebraska, New Mexico, Oklahoma and Texas have adopted new irrigation technologies to improve irrigation efficiencies and have also changed over to crops requiring less water. This has been due to the increased lift and decreasing yield of the tube wells or pumping systems. In addition to this the local governmental agencies in several states have passed laws severely restricting further irrigation development.

Florida State requires "Consumptive Use Permit" by farmers using groundwater for irrigation which regulates/restricts the quantity of water that an irrigator may use. Oklahoma and Texas states limit the number of wells by imposing a spacing requirement but do not prohibit the drilling of new wells in groundwater mining area if spacing permits. Lack of control over factors other than spacing has led to further over exploitation of groundwater. In some areas, local governmental agencies have appointed water cops in order to check the wastage of water and impose penalties for those who violate the law.

The technologies or the management guidelines as discussed above can at least be implemented in India to arrest the further over exploitation of groundwater.

8: WATER LAWS IN INDIA

Water has been considered sacred by Indians for ages. Until recently, the Indian community did not realize the value of water since supplies were relatively large, the population was smaller and the level of demand was lower. At present, however, the population and its level of demand have increased and water is scarce. There is a need for implementation of better management techniques and formulation of legislative control over water resources. There is ample historical precedence for this. Even in 400 BC, Kautilya in his Arthashastra had indicated the amount of royalty to be collected for both surface water and groundwater . This shows that even though we had relevant information regarding water management during that period, in recent history we do not have any such elaborate laws or procedures related to utilisation of groundwater.

9: NEED FOR GROUNDWATER LEGISLATION:

Even though everyone accepts the need for groundwater legislation, avenues for implementation need to be identified. Groundwater is generally considered to be private property and belongs to those under whose land it occurs. As a result, regulation for agricultural uses will be difficult. Even in urban areas, the private nature of groundwater will make regulation complex. It is common in all the metropolitan cities to see groundwater being sold from tankers. Some families are solely dependent on such a groundwater-selling business.

Given the above facts and considering the historical, religious, traditional and agricultural background of our country, a broad framework of groundwater legislation is suggested below.

10: GENERAL FRAMEWORK OF GROUNDWATER LEGISLATION

Groundwater as State Property: Groundwater should be considered as State property and state laws have to be framed for its utilisation.

Groundwater User: Any person, individual, group, or a society or one who utilises groundwater for any purpose should be defined as a groundwater user.

Registration of Groundwater Users: All groundwater users should register with the administrative groundwater authority constituted under law.

Registration of Groundwater Structures: All the existing groundwater structures should be registered and numbered in a systematic way.

Right to Use Groundwater: Users have no absolute right to use groundwater that occurs under their land. They should have to obtain a license from the groundwater authority on the quantum of water that can be extracted.

Royalty on Groundwater: Groundwater users should pay a royalty fixed by the groundwater authority. The income obtained shall be utilised for further investigation of groundwater and irrigation developmental activities.

Metering Groundwater Extraction: All the groundwater structures licensed by the groundwater authority should be metered and monthly monitoring should to be done by the authority to check the extraction as mentioned in the license. This system may be difficult to implement, but it is not impossible. It can be introduced in stages depending upon the situation and level of groundwater utilisation.

Supply of Surplus Water: Surplus water available in a particular groundwater structure should be made available to the adjacent land under cultivation at a nominal cost covering the purchase charges, depreciation charges, pumphouse, etc. This will protect the small farmer or a farmer in whose land there is no possibility of striking water.

Restriction on Groundwater Extraction: Groundwater authority should have the right to restrict groundwater utilisation if over-exploitation or pollution occurs. The authority should have the power to cancel the license if the user exceeds the limit fixed.

Protected Zone: Any area can be declared as protected zone on the grounds of over-exploitation or as a measure to check pollution.

Priorities: Priorities to use groundwater can be fixed by the State depending on local conditions. However, the first priority is to be given to drinking water.

Government's Responsibility: Government should not guarantee groundwater users either quantity or quality, nor shall it be responsible for damage caused by a lawful user to another lawful user. However, it can fix the quantum of groundwater to be extracted by each groundwater user after a proper study.

Data on each Groundwater Structure And Groundwater Usage: Every groundwater user shall furnish the geological, geophysical, hydrological, agricultural, horticultural information, etc., related to groundwater structures in his/her land to the prescribed authority.

Spacing of Wells: It is necessary to prescribe a spacing limit between wells, which will depend upon hydrogeological, physiographical and climatological conditions in order to check the interference of the wells.

Policy for Drinking Water: The authority can exercise its powers to stop the extraction of water by the borewells used for irrigation purposes inside the village limits and restrict them for drinking water purposes only.

11: WATER MANAGEMENT

Water management implies a programme of development and utilisation of available resources for beneficial use of the society. The development of water resources for beneficial use involves an integrated approach of administrators, scientists and people. Some water management techniques are briefly described below:

Water Management in Command Areas

Although we talk much about the conjunctive use of groundwater and surface water, it is nowhere implemented systematically. Conjunctive use allows flexible cropping patterns and multiple-cropping in canal commands. For a proper water management it is necessary to treat command areas as one composite unit in which ground and surface water resources should be judiciously managed to optimise benefits. It is necessary to charge uniform water rates for irrigation from both sources to serve the area in an optimal manner and to achieve maximum food production. It is also advisable to drill public tube wells especially in areas with high or rapidly rising water tables. This should aim to achieve maximum groundwater irrigation as a means to discourage canal irrigation by subsidized pricing of groundwater. In addition, as groundwater irrigation increases in the head reach and along the canals, more canal water will reach the tailend. This would achieve more extensive spread of canal waters and also improve recharge to the groundwater reservoirs in the tailend.

Better Irrigation practices

Farmers should be encouraged to adopt new technologies such as drip and sprinklers to improve irrigation efficiencies. They should also be encouraged to change over to semi-dry crops. Growing of water intensive crops in the well commands should be discouraged. In low rainfall areas with declining water tables, irrigation techniques and agricultural practices have to be adjusted carefully to achieve maximum benefits. We have to learn more from the practices in vogue in Israel where rainfall is very less but the agricultural and horticultural production is more than sufficient, making this agricultural land as an exporter of horticultural products.

ACKNOWLEDGMENTS

The author is highly grateful to Dr. G.S. Srinivasa Reddy and Shri.S.Madhukeshwar for their help in preparing the paper. Shri.R.Venkatswamy, Shri.K.N.Shivakumar, Shri.V.Sridhara are thanked for software support.

REFERENCES

1. Annaiya, G S. and Chandrashekhar, H. (1976) Legislative and Administrative Measures for better management of groundwater use. Tenth Sir.M.Visweswaraya Memorial Technical Seminar on Water Management for efficient irrigation.

2. Basappa Reddy, M., Madhukeshwar, S. and Srinivasa Reddy,G.S. (1993)"Augmentation of Water Supply and its management in the drought prone areas- Chitradurga District"Proceedings of Seminar on Water Management and water conservation techniques for Drought Prone Area, held at Mysore on 9th August 1993, P.171-178

3. Basappa Reddy M., Venugopal,T.N., Srinivasa Reddy,G.S. and Madhukeshwar, S. (1993), Groundwater Resource and methods for augmentation in the drought prone blocks of Karnataka. Proceedings of the Seminar on Water Management and Water Conservation Techniques for Drought prone Areas at Cuddapah P 110-123.

4. Copenara D.A. (1973) "Water laws in Muslim Countries"- Irrigation and Drainage paper 20/1, FAO.

5. Dhillon, G.S.(1993) "Will decline in water table lead to Hydrological drought" - Proceedings of the Fifty Eighth Annual Research and development session held at Bangalore P - 25-34.

6. Robert Chambers (1988) "Managing Canal Irrigation, Practical analysis from South Asia", Oxford and IBH Publishing Co. Pvt. Ltd.

7. Sachidananda Shankarabharathi (1963), Kautilya's Artha-shastra", Department of Literature and Culture, Government of Mysore.

8. Tushar Shah (1991) Managing Conjunctive Water use in Canal Commands Analysis for Mahi Right Bank Canal Gujarat, Future directions for Indian Irrigation research and policy issues edited by Ruth Meinzen- Dick and Mark Svendsen.

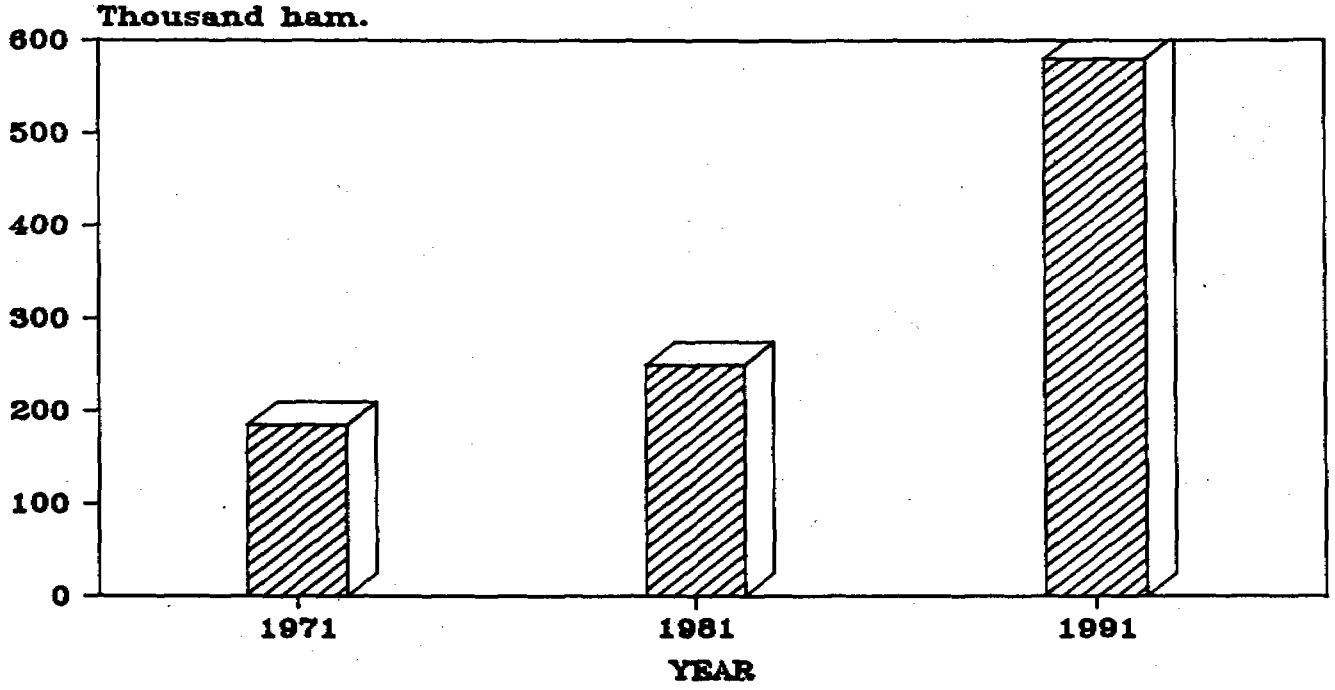
TABLE - 1

GROUNDWATER RESOURCE AND UTILISATION

Sl. No.	District	Geogaphical area (Sq.Km.)	Gross Annual Recharge (ham)	Net annual Recharge (ham)	Gross draft (ham)	Net Ground water utilisation (ham)	Percentage utilisation
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	Bangalore	8000	89963	76460	91681	64177	84
2	Belgaum	13400	118403	100642	92857	65000	65
3	Bellary	9900	86795	73776	29989	20992	28
4	Bidar	5400	51021	43368	28671	20070	46
5	Bijapur	17100	110078	93572	77741	54419	58
6	Chickmagalur	7200	76807	65287	9486	6640	10
7	Chitradurga	10900	70388	59830	48923	34246	57
8	Dakshina Kannada	8400	118911	101075	52629	36840	36
9	Dharwad	13400	124882	106150	44196	30937	29
10.	Gulbarga	16200	105485	91796	27389	19172	21
11.	Hassan	6800	77064	65505	14886	10420	16
12.	Kodagu	4100	35652	30304	2743	1920	6
13.	Kolar	8200	77712	74047	98984	69289	94
14.	Mandya	5000	74889	63741	21446	15012	24
15.	Mysore	12000	120137	102116	41363	28954	28
16.	Raichur	14000	104682	88981	29610	20727	23
17.	Shimoga	10600	158159	134435	16380	11466	9
18.	Tumkur	10600	99149	84278	79554	55688	66
19.	Uttara Kannada	10300	105315	89518	15646	10952	12

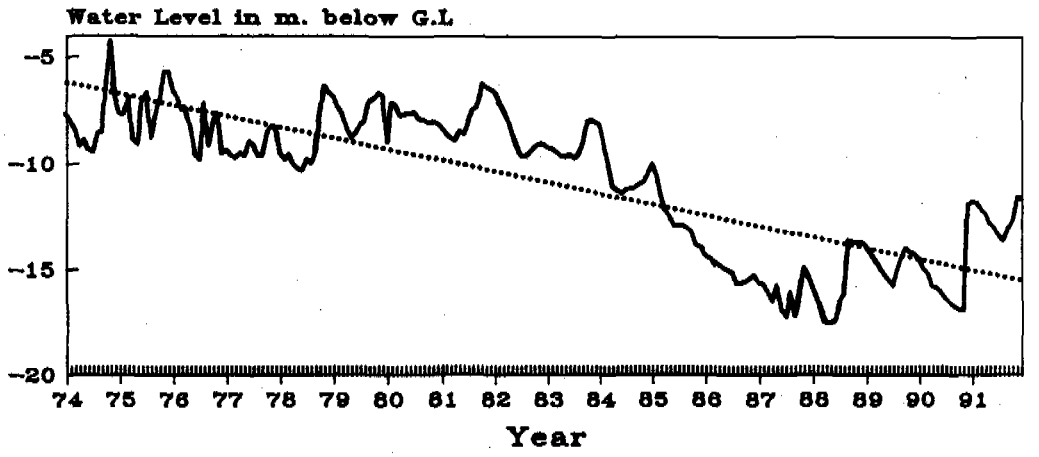
Fig.1

GROUNDWATER UTILISATION
KARNATAKA



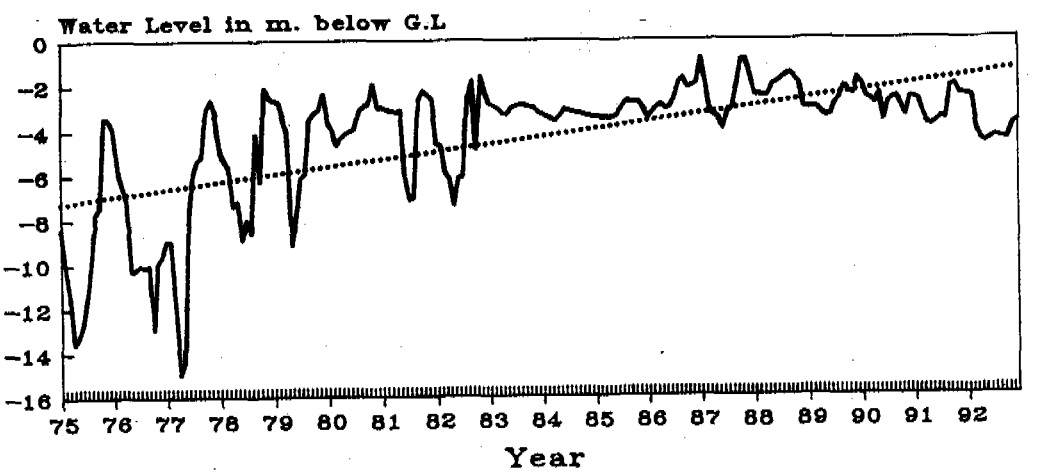
DMC

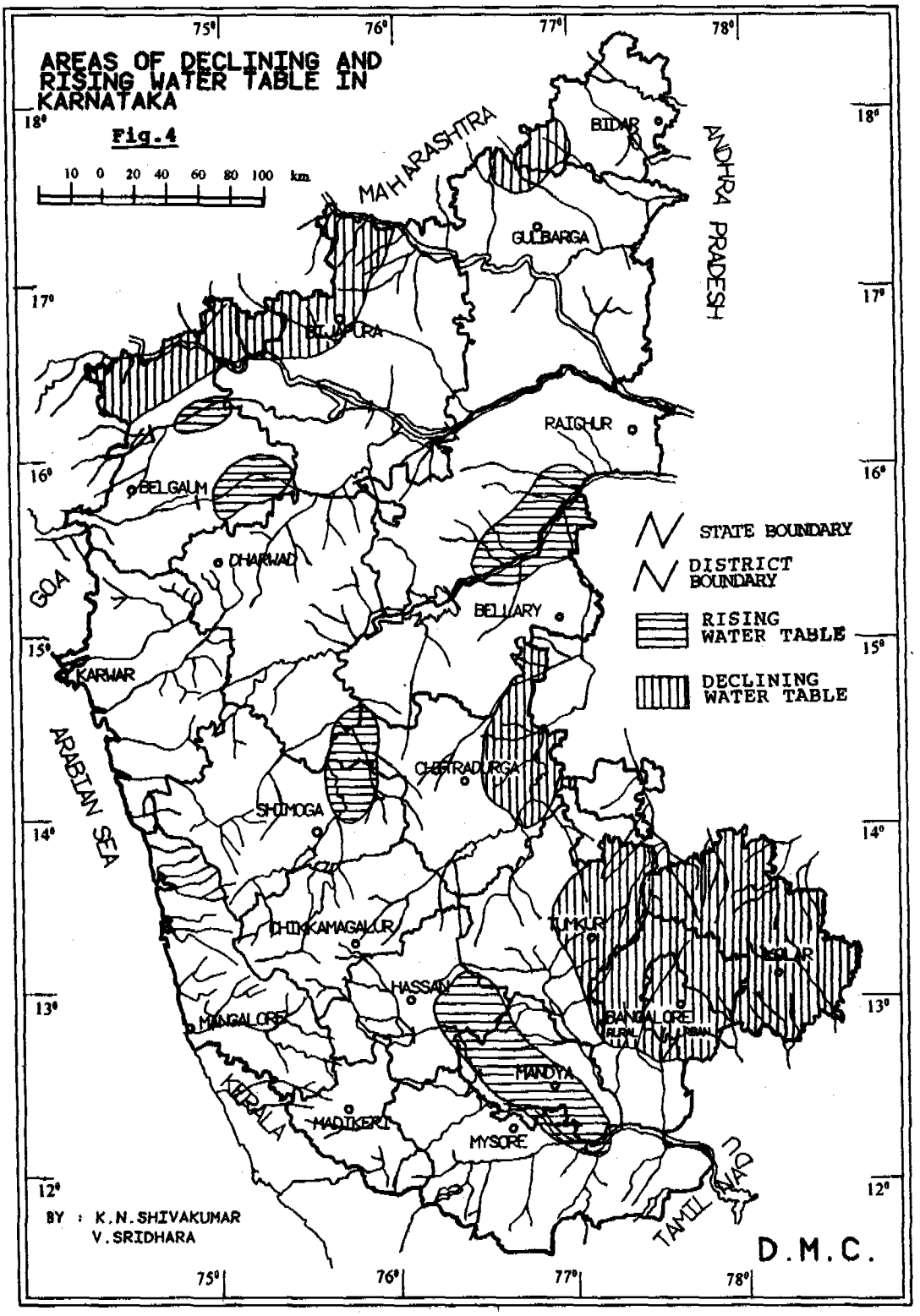
Fig.2 WATER TABLE HYDROGRAPH
HUNASANAHALLY OB. WELL, SIDLAGHATTA



DROUGHT MONITORING CELL – DARS PROJECT

Fig.3 WATER TABLE HYDROGRAPH
MALEBENNUR OB. WELL, HARIHAR TALUK




AREAS OF DECLINING AND RISING WATER TABLE IN KARNATAKA
Fig.4
10 0 20 40 60 80 100 km
75°
76°
77°
78°
18°
17°
16°
15°
14°
13°
12°
MAHARASHTRA
ANDHRA PRADESH
GOA
KERALA
TAMIL NADU
ARABIAN SEA
BIDAR
GULBARGA
BIJAPURA
RAICHUR
BELGAUM
DHARWAD
BELLARY
KARWAR
CHITRADURGA
SHIMOGA
CHIKKAMAGALUR
TUMKUR
KOLAR
HASSAN
MANGALORE
BANGALORE RURAL
BANGALORE URBAN
MANDYA
MADIKERI
MYSORE
STATE BOUNDARY
DISTRICT BOUNDARY
RISING WATER TABLE
DECLINING WATER TABLE
BY : K.N.SHIVAKUMAR
V.SRIDHARA
D.M.C.

A Critique of the Proposed Groundwater Bill

M. Srinivas

ABSTRACT

The government is rightly thinking of bringing out a groundwater bill in response to the imbalances we have caused in the hydrologic cycle due to heavy mindless withdrawals from the replenishable groundwater resource. Two approaches are possible to addressing groundwater problems: legislation and voluntary. The proposed bill focuses heavily on the first approach with little support for the second. Although the bill contains many useful and conceptually good elements, avenues for NGO and community involvement are lacking. These and other aspects of the proposed bill are discussed. A general debate is recommended for focusing attention on the seriousness of the issue and bringing awareness among the people.

Introduction

Conservation-minded people must have always felt bad at the way most of us tend to waste precious natural resources. This includes water, the precious commodity, which is mostly in short supply in India. Seeing taps just left open in hotels throughout the day must be a common experience for most of us; all the same, in many cases the taps are just non-functional. The other extreme is the water used for irrigation. As almost all the states have only a fixed small amount to be paid as per the rating of the pumpset for electric consumption, farmers tend to run their pumpsets often round-the-clock. Whether it is groundwater or surface source, one must agree that there is a general tendency towards disproportionate use of the precious resource.

The Hydrologic Cycle

The water availability for our consumption comes from one phase of nature's hydrologic cycle. When we keep on withdrawing from our bank account without bothering to deposit adequately, we are bound to go bankrupt sooner or later irrespective of the size of the initial funds. The imbalances we have caused in the hydrologic cycle due to heavy mindless withdrawals from the replenishable groundwater resource, coupled with shrinking rain water harvesting structures, have today resulted in a situation wherein the government is rightly thinking of bringing forth a bill for legislation on groundwater.

In order to make the bill workable, there are various issues which the government policy makers should take into serious consideration. This article attempts to identify a few.

Need for Circulation of the Bill

There are always two ways of ensuring abidance of any rule: one is by legislation and the

other is voluntary. The latter is always preferred to make life simpler. Once having understood the importance of the issue, any right-thinking person would tend to cooperate rather than oppose by taking the issue to courts and entering into time-drawing tactics. Hence, I would strongly recommend a general debate through various media for the dual purpose of focusing attention on the seriousness of the issues, and also bringing awareness among the people.

Voluntary agencies or the so-called Non-Governmental Agencies could play a vital role in this regard. These agencies are no doubt closer to the people and the ordinary man, compared to the government, and hence are able to feel their pulse. The feedback that can be obtained from the voluntary agencies would be extremely helpful in moulding public opinion, all of which would ultimately lead to successful implementation of the bill. Simply bringing in legislation without creating awareness or having a general debate would result in the legislation remaining incomplete.

Title of the Bill

The title reads : A Bill to regulate and control the development of Groundwater. To my mind development is always positive, which makes it meaningless to "regulate and control the development". The bill essentially refers to and deals with extraction of groundwater and does not refer to any development of groundwater which should normally include not just the one activity of extraction but all the activities that go with it. To name a few, the recharge measures, construction and maintenance of all the structures that aid in recharge, extraction etc., contribute to the development of groundwater. Hence the word "development" should be replaced with "extraction".

Small and Marginal Farmers

Section 2 (g) defines the term "Well". The definition rightly provides exemption to Central and State government agencies or representatives thereof for sinking wells for the purpose of scientific investigation, exploration, development or management work. This also further applies to the wells provided for the small and marginal farmers.

On the aspect of small and marginal farmer, one can cite how even rich farmers, in numerous instances, have managed to get a "small and marginal farmer" certificate for availing of various subsidies provided by the government. One case in point is the National Biogas Programme where a large share of the biogas plans have been cornered by the farmers above the `small and marginal' category. In fact, the deserving small and marginal farmer often feels helpless and the subsidies very often do not reach him.

What checks do we build-in to prevent this? This needs a lot of thought, and requires evolving a foolproof method of certifying a farmer under this category, as against the existing system.

Groundwater Authority

Section 3 envisages establishment of a Groundwater Authority. Though this is a well-intentioned proposition, there is always a danger of this too joining the list of several authorities across the country, which remain on paper, or at most do more disservice rather than service. The crucial factor, therefore, is the composition of the Groundwater Authority.

As mentioned in the draft bill, the Chairman would be an appointee of the State Government/Union Territory, while the members would be representatives of the various Departments concerned with survey, exploration, development or protection of groundwater. There is also a provision for appointment of "such members who, in the opinion of the Government have special knowledge or practical experiences in matters relating to groundwater."

One finds nothing innovative in the composition of this authority. In order to make the authority really effective, I strongly suggest that, given the sensitivity of the subject, there should be a 50:50 composition of the government and non-governmental bodies. In the selection of the non-governmental representatives, organisations with a proven track record in the concerned issue should be invited to the board. Such NGOs have more of a mandate to ventilate the felt-thoughts and needs of the people. Distinguished individuals who have been struggling for the cause would add value to the board.

Notified Areas

Conceptually this is quite good. Especially since there are several large pockets in our country where the groundwater position is really alarming. For instance, in Coimbatore district, the water level is as deep as 75 - 100 meters below ground level. One can find huge dug wells as deep as 100 meters! Being a highly industrialized area, borewells are often drilled to a depth of 250 meters.

The concept of notified areas reminds me of politicians and other influential persons managing to get their districts declared as "drought-affected", obviously for additional funds, subsidies and other advantages that flow on from this. In this case, their efforts will be towards getting the areas de-notified. Since the stakes would be large when industries, factories or big farmers are involved, I foresee a tricky situation. What built-in mechanisms are we thinking of for avoiding these sorts of undesirable situations?

Power on Permits

Section 8 deals with the power to be vested in the Groundwater Authority for altering, amending or varying the terms of the permit. That is, it can stipulate the amount of water that can be extracted, and implicitly, the rating of the pumpset that can be fitted etc., based upon technical reasons. There is scope, however, for the users to present their case in full.

In order to decide upon the terms of the permit, there needs to be good technical support in terms of data on the aquifers, their characteristics etc., throughout the country. I am afraid we do not have such an exhaustive information base. Determination of aquifer characteristics that help arrive at an optimal pumping rate and the time duration of pumping especially in hard rock areas is still at the research stage. In this context what are the norms that the Groundwater Authority would arrive at, in the absence of reliable exhaustive scientific data? In all fairness, this has all the potential to become a matter of litigation especially when the stakes are so high.

Water Litigants

In developing a case for litigation, there is a great possibility of an entirely new breed of practicing geologists, geophysicists and other water-related practitioners becoming consultants in order to provide meat for the cases. Given the state of the art, there would be a greater number of cases registered than discharged.

Section 7 permits status quo ante during the pendency of the case either with the Groundwater Authority or a higher court. Given the speed with which the cases are disposed of in the courts of our country, and the current backlog, one would be justifiably skeptical of anything tangible coming out of it. While this may prove to be a boon for those who can afford to go to court, the small and marginal farmers certainly would not be able to do so, even though they have the right. In the meanwhile, notified areas might become de-notified with the advent of a good monsoon, the cases having served their intended limited purpose for the benefit of the litigants. There will thus be the usual pattern of the reaping of fruits for the haves, in these types of situations.

In this context, one is reminded of the various state pollution control boards and the efforts of the state governments over the years towards coaxing the pollution-causing industries to contain or treat their pollutants before disposal. Nothing much has come out of this so far, though vast stretches of fertile agricultural land, drinking water sources, and groundwater have all been rendered useless. North Arcot district in Tamil Nadu with hundreds of tanneries disposing of their effluents to ultimately reach river Palar is just one example.

Lack of Systematic Data Acquisition

Drilling data is precious information which helps in deciphering the aquifers and their aerial extent. It also helps in understanding the occurrence and movement of groundwater, apart from helping us in quantifying the groundwater availability.

Though there are hundreds of drilling rigs and millions of bore wells drilled during the last two decades, there is dismally poor collection and maintenance of drilling records. The few exceptions are perhaps the CGWB, a few government agencies, and some in the voluntary sector.

The present situation underlines the need for initiating efforts to ensure proper collection and maintenance of drilling records by the government and non-government or private drillers, rather than thinking of them only in terms of providing permits or licenses for doing their job. Such an effort would help the Groundwater Authority to discharge its mandate more meaningfully, at least in the future, if not immediately.

Yet Another Avenue for Corruption

This is the biggest evil that needs to be checked. The moment we have permits and things like that, the scope for corruption is large. Let's not shy away from recognizing this fact. The effort, therefore, should be to build inherent checks.

It is imperative that transparency should constitute a core element in the functioning of the Groundwater Authority. The presence of committed individuals and organisations from both governmental and non-governmental institutions, apart from distinguished individuals on the board, should serve as a worthwhile check.

Last Word

Last but not the least, let's take this business of groundwater legislation seriously. Let there be as much debate as possible. It is common knowledge today that it is the concept of an integrated approach that helps restore the fragile ecosystems, of which groundwater forms a strong component. It is interesting to note that external aid agencies like the World Bank, International Funding for Agricultural Development etc., are all insisting on the participation of the community, which has long been the common approach of many voluntary agencies in India. Belatedly the government of India has recognised the work of such agencies, and as a result there is a trend towards increased partnership in the process of social development.

In keeping with this spirit, we look forward to the Groundwater Bill not as something thrust from the above, but more as something that evolves for the ultimate benefit of the small and marginal farmer.

Approaches To Groundwater Management: To Control or Enable?

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ABSTRACT

This paper analyses proposals for groundwater regulation currently being circulated in India and discusses alternative approaches designed to enable the initiation of locally based management systems.

Appropriate roles for the state and local organisations in natural resource management have been the source of debate both in India and internationally. Often, states attempt to address emerging natural resource problems via centralised control mechanisms. This approach is frequently ineffective and negates the interest local populations have in developing solutions to problems that affect them before all others. A basic philosophical premise underlying this paper is that local initiative represents a wellspring capable of generating innovative and implementable management solutions to many emerging problems. While local efforts are unlikely to generate solutions to all -- or possibly the majority -- of problems, frameworks are needed that enable local responses to emerge wherever the initiative exists.

The first section of this paper provides a general introduction to emerging groundwater problems in India and the range of issues bearing on their solution. This is followed by a section focused on current attempts to develop groundwater legislation -- in specific the model bill circulated by the Central Government. Implementation issues and the "fit" between emerging trends in water management and the structures proposed in draft legislation are examined. The third section of the paper discusses legislative and legal rights frameworks that enable multiple approaches to resource management to emerge depending on local conditions. Institutional structures in the U.S. that enable local action are discussed first. This is followed by a more comprehensive presentation of enabling approaches potentially relevant to the Indian context. Conclusions are summarised in the final section.

I Introduction

Groundwater is probably India's most valuable and perhaps its most vulnerable water resource. According to some reports: "groundwater irrigation already accounts for 75-80% of the value of irrigated production in India." (Daines & Pawar, 1987, p. 5). Roughly 35 million hectares (Mha) can be irrigated from groundwater -- a figure which exceeds the 33 Mha of irrigation potential created through all major and medium irrigation works (Saksena, 1989; Dhawan, 1990a). Beyond irrigation, groundwater is the major source of drinking water for numerous cities and rural communities and serves as the main source of clean water for industry as well.

Long viewed as an unlimited "renewable" resource, threats to groundwater supplies are becoming increasingly evident. In Gujarat, for example, official estimates indicate that groundwater extraction is approaching total recharge in 36 taluks and exceeds it in a further 24 (GOG 1992).[3] Water tables throughout northern portions of the state have been falling (High Level Committee, 1991, GOG, 1992). Similar problems are well documented in parts of Rajasthan, Punjab, Tamil Nadu and Karnataka and may even be occurring in some sections of the huge aquifer underlying the Gangetic basin (Bandara, 1977; Pant, 1987; Bandyopadhyay, 1987, 1989; Sims, 1988; Dhawan, 1990b; Krupanidhi, 1987; Rai & Phaliwal, 1988; Reddy *et al*, 1992).

Dropping water tables are not the only concern, quality issues are also growing. Salinity, fluorides, nitrates and the presence of pathogenic organisms are major concerns in many sections of Gujarat (Phadtare, 1988). Roughly 65% of Haryana state is underlain by saline groundwater and fresh water pockets are heavily tapped (Gangwar & Panghal, 1989). Saline intrusion affects the groundwater under many coastal cities.

Little is now being done to address emerging groundwater problems and calls for more effective management are common (Sinha & Sharma, 1987; Ghosh & Phadtare, 1990b; Chakravarthy, 1990; Saksena, 1989). A model bill for regulating groundwater use was circulated as early as 1971 and an updated version was again distributed in 1992. Draft bills have been presented in the legislatures of several states including Tamil Nadu and Karnataka but have never been enacted. So far only Gujarat has actually passed any groundwater legislation.

All groundwater legislation so far proposed takes a highly regulatory approach. This is evident, for example, in the title of the recently circulated "Model Bill to Regulate and Control the Development of Groundwater" (GOI, 1992). The following section discusses the model groundwater bill in detail. The main provisions contained in the bill are discussed first. These are then examined in relation to some of the issues facing the development of effective management systems.

3. Greater than 65% of available recharge in the first 36 Taluks is extracted.

II The Model Bill

The Ministry of Water Resources, Government of India, circulated a "Model Bill to Regulate and Control the Development of Groundwater" to the states in September 1992. This model bill, like the others that preceded it, has no actual regulatory significance. Under the Indian Constitution, water is a state subject over which the Central government has little direct authority. The model is, however, important for what it reveals of the Central Government's thinking (and that of many of the nation's top water specialists) on the best approach to addressing emerging groundwater concerns. This thinking has potentially great influence both for the guide it provides and because of the Central Government's leverage over funding flows.

A) Provisions

The model bill has the following 24 sections:

1. Short Title, Extent and Commencement
2. Definitions
3. Establishment of a Ground Water Authority
4. Staff of the Ground Water Authority
5. Powers to Notify Areas for Control and Regulation of Groundwater Development
6. Grant of Permit to Extract and Use Groundwater in the Notified Area
7. Registration of Existing Users in Notified Areas
8. Power to Alter, Amend or Vary the Terms of the Permit
9. Prohibition of Carrying on the Business of Sinking Wells in Notified Area
10. Grant of License for Sinking of Wells
11. Cancellation of Permit/Certificate of Registration or License
12. Powers of the Groundwater Authority
13. Restriction on Publication of Information and Returns
14. Service of Orders, Etc.
15. Delegation of Powers and Duties
16. Members and Employees of the Groundwater Authority to be Public Servants. Central Act 45 of 1860.
17. Protection Against Action Taken in Good Faith
18. Cognizance and Trial of Offences
19. Offences and Penalties
20. Compounding of Offences
21. Offences by Companies
22. Appeals
23. Bar of Jurisdiction by Civil Courts
24. Power to Make Rules.

The bill's primary substance starts in Section 3. This section enables the state government to establish a groundwater "Authority" and appoint its chairman and members. Although the chair's background is not defined, the members are to be "representative of the Departments as

are concerned with survey, exploration, development or protection of groundwater" and others "who in the opinion of the Government have special knowledge or practical experience in matters relating to groundwater" (GOI, 1992, Section 3). The bill also enables each state to appoint, as "public servants" under the Central Act 40 of 1860, "such number of technical and other staff as it may consider necessary." (Sections 4 & 16). Combined, these provisions enable states to create bureaucracies for controlling groundwater use and extraction which are under direct control of the state governments.

Once the Groundwater Authority has been formed, the model bill provides for the notification of specific areas by the state where the "Groundwater Authority is of opinion that it is necessary or expedient in the public interest to control and/or regulate the extraction or use or both of groundwater in any form in any area" (section 5). Within notified areas anyone wishing to sink a well (with the exception of small and marginal farmers) is required to obtain a permit from the Authority. According to the wording in the model bill: "If the Groundwater Authority is satisfied that it shall not be against public interest to do so, it *may* grant, subject to such conditions and restrictions as may be specified, a permit authorising the extraction and use of the water." (Section 6(3), emphasis added). Existing users are also required to apply for a certificate registering their uses of groundwater with the Authority within ninety days following notification of the area.[4] This application must contain details on the water source, extraction mechanism, quantities extracted, water uses, period of extraction, area served (if irrigation) and service details in addition to volumes extracted (if drinking or municipal supply). As with the grant of permits for new wells, the Authority "*may* grant, subject to such conditions and restrictions as may be specified, a certificate of registration authorising the continued use of the water." (Section 7(3), emphasis added). In making its decision on both new wells and existing uses, the Authority is required to consider: "(a) the purpose or purposes for which water is being used; (b) the existence of other competitive users; (c) the availability of water; (d) any other fact relevant thereto." (Sections 6&7(5)). Until the permit decision has been made, existing users are entitled to continue extraction as before notification. Once a permit or registration certificate has been issued, the Authority: "may, for technical reasons, alter, amend or vary the terms ... with a view to limit the use of water either permanently or temporarily." (Section 8). The Authority is also empowered to cancel permits and registration certificates on the basis of (a) fraud or misrepresentation in obtaining it; (b) failure to comply with conditions or breaking other provisions of the act; or (c) the emergence of a situation which "warrants limiting of the use or extraction of groundwater." (Section 11).

In order to carry out its duties under the proposed act, the Groundwater Authority is given wide ranging powers to enter, inspect, require data collection (including the installation of water measuring devices), serve notices, seize mechanical equipment, destroy any "hydraulic work," search ("with such assistance... as it considers necessary") and "exercise such other powers as may be necessary for carrying out the purposes of this Act." (Section 12). The act explicitly states that the "power conferred by this section includes the power to break open the

4. The ninety day restriction may be waived if the Authority is "satisfied that the user was prevented by sufficient cause from filling the application in time." (Section 7).

door or any premises where sinking, extraction and the use of groundwater may be going on" provided that anyone inside has refused to open the door (Section 12(2)). It also states that the Code of Criminal Procedure 1973 (2 of 1974) applies to all searches and seizures (Section 12(3)).

The model bill provides extensive insulation from judicial interference for both actions taken under the act and the individuals involved. Section 17 states that: "no prosecution, suit or other legal proceeding shall be instituted against the Government or the Groundwater Authority or any other officer of the Government or any member or other employees of the Groundwater Authority for anything done or intended to be done in good faith under this Act, or the rules made thereunder." Section 22 provides that: "no civil court shall have jurisdiction in respect of any matter which the state government or the Groundwater Authority is empowered by this Act to determine and no injunction shall be granted by any court or any other authority in respect of any action taken or to be taken in pursuance of any powers conferred by or under this Act." In addition to protecting the Government and its officers, the model bill explicitly excludes prosecution for offenses under the act to be initiated without the written consent of the Groundwater Authority (Section 18). The net effect of these provisions is to remove the standing of anyone outside the Authority to appeal to the courts.

Finally, as punishment for contravening any aspect of the act, the model bill provides for fines and prison terms. First offenses under the act are punishable by fines of up to 500 rupees. Second and subsequent offenses carry prison terms of up to six months and/or 1000 rupees fine. In addition, there is a fine of 50 rupees per day for breaking the provisions of Sections 6 & 9 (new uses & well drilling).

Overall, the proposed Model bill, if passed, would set up a regulatory system, insulated from local involvement, where power is concentrated at the state level and formally wielded by the technical bureaucracy.

B) Issues

A wide variety of issues are inherent in the structure proposed by the model bill. How the bill could be implemented is uncertain. If it were implemented, the implications for community participation, equity in access to groundwater resources, integrated approaches to water management, efficient water use, and the ability to evolve flexible approaches which are responsive to local conditions would be great. Furthermore, the approach would not resolve basic conflicts between emerging problems and the poorly defined nature of groundwater rights.

The fact that a wide variety of issues exist in the Model bill does not imply that groundwater legislation is unneeded. Nor does it imply that centrally controlled regulatory structures are inappropriate under all circumstances. Legislation is essential. Regulation by the state may also be required for addressing specific problems or issues. State regulation is, however,

probably not the optimum approach to dealing with the wide range of groundwater issues now emerging in many areas.

1) Implementation

As currently structured, passing the groundwater bill in the state assemblies and then implementing its provisions would face major hurdles. The experiences of states where legislation has been proposed are illustrative. Only Gujarat and Maharashtra have passed any legislation bearing on groundwater. In Gujarat the legislation, an amendment to the Bombay Irrigation act, defines terms, and allocates power to regulate and license tubewell construction, control groundwater use, prevent waste, and make regulations (Sinha & Sharma, 1987, p. 12). Although passed in 1976, it was only formally brought into force for certain areas of Gujarat in 1988 (Jacob, 1989, p.3). According to local officials, actual implementation has never occurred. The recent Maharashtra legislation only deals with the protection of drinking water sources. It was signed by the Governor on August 10, 1993 so there is little experience regarding it's effectiveness. In addition to Gujarat and Maharashtra, at least two other states, Tamil Nadu and Karnataka have recently considered legislation (Government of Karnataka, 1987; Government of Tamil Nadu, 1990). The acts considered by these states were similar in their basic approach to the model bill but tended to provide a higher level of punishment for violations. The Karnataka act, for example, provided for up to two years imprisonment for contravening any provision except well registration. Tamil Nadu's act authorised electricity supplies to be cut off for any violation. This electricity cut-off provision was also suggested for Karnataka by the central government in 1987.[5] Neither of these acts were passed, much less implemented.

The fact that states have been unable to pass or enforce groundwater legislation is indicative of two basic problems: 1) the sensitivity of the state attempting to regulate what, for landowners, is essentially an open access resource; and 2) the lack of effective mechanisms for implementation.

Under English Common Law, the basic legal structure throughout India, extraction of percolating waters with no limit on quantity is the right of every landowner (Sinha & Sharma, 1987, p. 10; Jacob, 1989, p. 2). This right is, in theory, limited by the Easement Act and Irrigation laws which "proclaim the absolute rights of government in all natural water" (Singh, 1990, p. 50). The presence of the government's claims has not, however, altered the view of virtually every well owner that they have an ultimate right to use the water in their well in any manner or quantity they please. As a result, proposals for government regulation of wells and their use are highly sensitive. Official statistics indicated that nationwide the number of diesel and electrical pump sets was 12,581,000 in 1990 (Dadlani, 1990, p. 12). Governmental efforts have resulted in the completion of roughly 9.5 million dugwells, 4.7 million shallow tubewells over the 1st through 7th plan periods (GOI, 1991, Tables 31&32). Well owners are one of the

5. Letter from the Secretary in the Ministry of Water Resources to the Chief Secretary, Government of Karnataka, dated August 24, 1987.

most wealthy and, as a result, probably one of the most politically influential rural groups. Legislation that threatens what they see as their interests is bound to face substantial opposition.

The lack of effective mechanisms for implementation is an equally large stumbling block for the proposed regulations. The physical issues inherent in policing a large number of wells located on private lands are huge. The history of rural electricity rate collection is illustrative. In most states, electricity boards shifted from metering to charges based on pump horsepower due, in large part, to tampering with the meters and an inability to collect charges.[6] Electricity Boards theoretically have the authority to cut off connections for non-payment of dues. In practice this is difficult to do when large percentages of the rural population are not paying and maintaining food production is a prime goal of the state. Even if a connection is cut off, farmers are adept at reattaching their lines illegally. If the state is unable to meter electricity and collect charges, it is difficult to see how it would be any better at metering water from privately controlled wells or regulating its use. The case of surface irrigation systems is also illustrative. Canals, gates, relatively strong organisations and established legislation should provide a greater inherent capacity for centralised control of surface systems than is present in the groundwater case. Despite this regulation has proved problematic. Often "system managers ... have no effective power to enforce the rules or the penalties for violating those rules" (Vaidyanathan, 1991, p. 19).

Problems with implementation are likely to be compounded by the approach taken in the Model Bill. If the bill were implemented, many well owners would probably view it as an attempt by the state to take control over their personal resources. This approach is likely to set up an antagonistic "us-them" situation. Overall, as B.D. Dhawan comments on the groundwater regulations passed in Gujarat: "there is little hope for effective implementation of such laws which are inherently difficult to enforce in the Indian conditions of small land holdings, inadequate administrative set-up in the countryside, and eroded state of ethics." (Dhawan, 1989, p.9). Without active participation or, at an absolute minimum, passive cooperation of the local population, no attempt to regulate water use from private wells on individual farms is likely to work.

2) Participation

Throughout India, there is a growing focus on "people's participation" in the management of natural resources. Examples of this range from the widespread initiation of Joint Forest Management projects to the current experimentation with turn-over of irrigation systems (or system components) to local communities for management (Poffenberger, 1990; Malhotra & Poffenberger, 1989; Shah, J.V. 1993; Vermillion, 1991). Non-government organisations have long worked with local communities to enhance their natural resource management capabilities. Current experiments often involve collaborations between state governments and major donors such as the World Bank.[7]

6. Based on discussions with Electricity Board officials in Gujarat, Tamil Nadu and Karnataka in 1991-1992.
7. The World Bank is, for example, supporting irrigation turn-over activities in Maharashtra and Gujarat.

The above efforts still have a long way to go. In the water case, irrigation system turn-over to local communities is only in the experimental phase -- long-term results are not yet in. Excluding a few scattered instances, possibilities for community management of groundwater resources remain theoretical. In many areas communities have developed organisations for managing groundwater extraction -- actual management of the resource to control depletion is, at best, rare.

Despite the lack of experience with managing groundwater resources on a large scale through local "participatory" organisations, the overall tendency in current water resource management thinking is towards greater participation. As Vaidyanathan comments in the case of surface irrigation: "A management system with full user participation and control requires a radical departure from present arrangements. Although it will take time to accomplish, such a system should be the ultimate goal." (Vaidyanathan, 1991, p. 19) Although there is intense debate between those who favour Vaidyanathan's position and those who are more skeptical of local management capabilities, legislative structures need to provide avenues for participation and local management. Unless this is done, there is little possibility for tapping and testing the well of local initiative that could generate management solutions to many emerging problems.

As currently written, the Model Groundwater bill would greatly limit participation by users in management of the resource. The proposed "Groundwater Authorities" would, as defined under section 3 of the model bill, be dominated by officers from technical departments appointed by the state. There is no provision for user representation in the Authorities. Notification of areas is also controlled by the state and the Groundwater Authorities under Section 5. There is no provision for user involvement in defining the areas to be notified. Decision making power over the creation of new wells and how water from old wells is used is also allocated to the Authorities under Sections 6,7,8 & 11. Users are, in fact, explicitly excluded from direct power to influence management decisions by Section 18 which excludes prosecution for offenses under the act without written consent of the Authorities and by Section 22 which excludes actions taken under the act from civil court jurisdiction. In sum, the Model Bill does not envision user participation in management decision making and seeks to limit the scope for user interference as far as possible. This runs directly counter to the widespread efforts to increase user involvement in the management of natural resources in India and worldwide.

The lack of scope for user involvement limits the ability of the state to take advantage of local concerns and initiatives. Numerous examples exist of communities and non-government organisations initiating actions to address local groundwater problems. In Maharashtra, the Panni Panchayat experiments have received substantial publicity (Sathi, 1989). In Gujarat, MAHITI, AKRSP, SVRTI, VIKSAT and the Mehsana District Dairy Cooperative are all directly involved in efforts to help rural communities manage their groundwater resources.[8] Similar efforts are occurring in numerous other states. While none of these efforts represents a

8. VIKSAT, AKRSP, MAHITI, and SVRTI are all non-Government organisations working in the field of rural development and natural resource management.

full response to emerging groundwater problems, on a local basis they have achieved far more than has been achieved through the past twenty years of attempts to pass groundwater legislation.

3) Equity

Aside from the lack of mechanisms for tapping local initiative, significant equity concerns would emerge if the Model Bill were enacted and implemented. Regulatory structures the world over are rarely equitable. In the Western U.S. water laws and regulations have been regularly criticised for tending to favour current users over others. In India, regulations are easily bypassed by those for whom wealth and status provide access to high level officials and the political structure. As a result, despite the provisions for small and marginal farmers, limitations on groundwater use or well drilling would tend to disproportionately limit access for less wealthy sections of society. Provisions for the protection of small and marginal farmers could even increase inequity. In many cases the wealthy are able to have themselves classified as "small" or "marginal" and thus gain a substantial share of the benefits from regulatory exemptions or subsidies intended to assist the poor. Even if applied equitably, the structure of penalties for breaking provisions of the act is inherently inequitable. The 500 rupees fine authorised under Section 19 of the Model Bill is insignificant for a large farmer or business owner but may represent several months earnings for a small farmer. Furthermore, since the size of the fine is not explicitly tied to the magnitude of the violation, a small farmer could, theoretically, face the same penalty for unauthorised irrigation of 1 hectare as a large farmer would face for unauthorised irrigation of 100 hectares.

The equity concerns discussed above, which are admittedly common in any regulatory approach, are compounded by the concentration of power advocated by the Model Bill. In it, regulatory powers and sole authority to hear appeals are concentrated within the Groundwater Authorities. There is no independent forum of appeal for those who's interests are not represented within the Authorities. Furthermore, groundwater authority members are unlikely to represent all sections of society. Under the Bill, members of the Groundwater Authorities are to be appointed by the government. Representatives from government technical organisations are the only group specifically indicated for membership on the Authorities (Section 3). These individuals are likely to represent wealthy, well-educated, sections of society. As a result, the potential for inequitable application of regulations is great.

4) Integrated Water Management

In a sense, one of the greatest issues in the Model Bill is the way in which it represents a continuation of the fragmented approach to water management prevalent throughout India. The organisational structure of water management in India is highly fragmented. Irrigation, rural drinking water, industrial water supply, municipal water supply, pollution control, and groundwater are generally under completely independent agencies. In addition, other Departments (such as Agriculture, Forestry and Rural Development) control programmes influencing

water resources. Government departments often compete with each other and departmental loyalty is highly emphasised among employees. As a result, despite frequent formal attempts to encourage cooperation, effective coordination between departments is rare.

The formation of Groundwater Authorities proposed under the Model Bill appears to extend this fragmentation by setting up another, independent, government organisation with responsibility for a small fraction of the larger water management needs. As proposed, the Authority would only have power to influence extraction and, potentially, use of groundwater. It would have no authority to influence groundwater supply either by initiating recharge activities on its own or by coordinating the actions of other agencies who's activities influence recharge. It would also have no power to regulate the range of activities that influence groundwater quality. Industrial pollution, seepage from municipal sewers and agricultural return flows may be as important as the amount of groundwater extracted in determining effective groundwater availability. Water which is too polluted for a given use is unavailable. Approaches to groundwater management that do not encompass quality are partial at best.

Overall, the Model Bill would probably exacerbate rather than reduce fragmentation issues. Given the competition which typically exists between departments, provisions for representation of the different technical organisations on the Groundwater Authority (Section 3) are unlikely to result in coordinated approaches to addressing groundwater problems. Furthermore, with authority only over extraction and use, the two major vectors of supply and quality are likely to be ignored.

5) Market Mechanisms

Beyond fragmentation, the Model Bill is very limited in the approach it takes to controlling groundwater extraction and use. It focuses solely on developing administrative control mechanisms for regulating groundwater use directly and misses the potential management opportunities represented by water markets and indirect economic levers.

The potential use of economic levers and water markets to achieve management objectives is a major trend in current water management thinking. Recent reviews of India's irrigation sector are highly critical of energy and water price policies that encourage inefficient use (World Bank, 1991). Economic levers -- prices, taxes, subsidies, and market structure regulation -- are increasingly viewed as key to achieving water management objectives. Direct attempts at control via regulation are increasingly recognised as drawing on only one of a range of management options available. Water markets may also be key. Research in India documents the access water markets can provide to individuals or groups lacking the capital to construct wells of their own (Shah & Raju, 1987; Shah, 1989a,b,c). In other parts of the world, water markets are increasingly being used as mechanisms for efficiently redistributing water to the highest value uses -- particularly during times of scarcity (Moench, 1991). Attempts to influence groundwater use via shifting the agricultural market structure via, for

example, the provision of marketing facilities for low water use crops and limitations on these facilities for high water use crops, are also being discussed in India.[9]

By taking an approach that seeks to regulate groundwater use and extraction directly, the Model Bill does not encourage the use of market mechanisms. Furthermore, while no specific features of the bill appear to be fundamentally incompatible with the development of water markets, the institutional momentum created could be. Once a structure designed primarily for centralised regulation is in place, the tendency will be to respond to groundwater problems by attempting to place further controls on use. Market based approaches would, in contrast, suggest a flexible administrative structure designed to facilitate private transactions shifting water to the higher value-lower volume uses. Regulatory powers would still be needed to address social and environmental externalities but they would come into play primarily in cases where less direct management efforts were clearly failing.

6) Responsiveness & Flexibility

The approach created by the Model Bill would probably be inflexible and unresponsive to local conditions. As currently conceived, the Groundwater Authorities would make management decisions based on the deliberations of their members at the state level. Being from government organisations, the members would be accustomed to dealing with management issues within standard administrative boundaries -- the panchayats, blocks and districts. These units are often fundamentally inappropriate for water management (Moench, 1992a,b). Groundwater problems vary greatly both in their nature and scale. Some could be addressed by actions influencing a single micro-watershed. Others require management over large areas containing tens or hundreds of villages and incorporating large municipal areas. Effective management probably requires approaches based around natural units -- the watershed or aquifer.

Physical variability is not the only issue. Social conditions also vary. In most instances, regulation under acts such as that proposed by the Model Bill tends to follow a "blueprint" with similar sets of controls being implemented in each area. Specific management approaches may, however, find local support in some areas while not in others. With no avenues for participation of water users, information on the degree of local support is likely to come primarily in negative ways -- by local resistance to implementation actions. The lack of avenues for local involvement is also a missed opportunity. In many areas, non-government organisations and communities are actively involved in groundwater management. The model bill provides no scope for the utilisation of local management capacity in those areas where it already exists.

In sum, as proposed the system is not designed to flexibly respond to the variety of local conditions, both physical and social, that are likely to determine the success of management actions.

9. Workshops held at VIKSAT, February 18, 1993 and May 17, 1993.

7) Rights issues

A final concern in the approach taken by the Model bill is its lack of cognizance of water rights issues. The bill flows from the authority of individual states over water resources under the Indian Constitution. Constitutionally water is a state subject. In addition, the Easement Act and Irrigation laws "proclaim the absolute rights of government in all natural water." (Singh, 1990, p. 50). The view of water as a "state" resource is in direct conflict with the position of groundwater under English common law as a chattel to land. The proposed bill would strengthen the state's formal claim over groundwater but would do little to practically enforce that claim. This could strengthen the view, already all too often encountered among users, that water problems are the "state's problems," not those of the users, and that the state should solve those problems.

Emerging groundwater problems will, at some point, force consideration of water rights issues (Bhatia, 1992). Already, agricultural users are in direct competition with drinking water supply schemes in some areas (KON, GOI & GWSSB, 1992). The national water policy gives first priority to drinking water but there is no legal way of enforcing this. Rights other than the simple link between land and access to the underlying groundwater are gradually being defined on the *de facto* basis of capture and administrative reallocation. The Model Bill, if enacted, would simply perpetuate this process of *de facto* changes in right structures rather than examining the underlying issues and addressing them in an internally consistent manner.

Lack of a clear rights structure inhibits management. On one level, the historical link between land ownership and a fundamental "right" to extracting groundwater forms an entrenched position for opposing the state's regulatory attempts. On another level, lack of clear water rights is likely to limit the development of management approaches based around markets (clear use rights are required for transfers to occur). It also weakens the ability of less well off sections of society to protect their access to or interest in groundwater resources. The basic "right" of individuals to water as a requirement for survival goes unrecognised.

III Principles toward a new Structure

The broad range of issues pointed out in India's model groundwater legislation are common in attempts to address the degradation of natural resources. Alternatives to greater control by the state are rarely implemented. As each new problem arises it either goes unattended or another regulation is promulgated to deal with it. The tremendous diversity of problems and situations leads either to a maze of regulation attempting to address ever more micro levels of detail or to a situation where regulations designed from afar are applied in contexts where they have little if any meaning. Detailed regulations are unlikely to be implementable and have the range of issues discussed above. Less detailed regulations will not address the highly location specific nature of most groundwater problems and management options. Frameworks seeking to encourage and enable the evolution of local management systems may represent a way out of this basic contradiction.

A) Enabling Concepts

Legislation to provide a framework for addressing emerging groundwater problems is essential in India. The framework created may need, however, to act as a flexible superstructure which enables the flexible development of a range of management approaches suited to local situations rather than attempting to directly control uses. The creation of such frameworks is the fundamental component of the "enabling approach" this paper argues for.

An enabling approach deserves consideration for several reasons. First, both the physical characteristics of emerging problems and the social management context vary greatly at a local scale. Given this variation, neither uniform management approaches nor uniform organisational structures are likely to be effective. As Arya & Haque comment: "the appropriateness of an organisation would vary from region to region and therefore, each such organisation has to be developed keeping in view the local needs and responsiveness of the farmers." (Arya & Haque, 1989, p. 4). Second, as the preceding quote and my comments on the Model Bill indicate, implementation of any management system requires local support. Support tends to come where local communities are directly involved in the development of management systems. Since it is extremely unlikely that a uniform structure will find support in widely differing communities, the legislative superstructure must be capable of accommodating the variation that will accompany true participation. Third, given this variation, the superstructure needs effective mechanisms for coordination so that ultimately water problems are addressed in an integrated manner. Finally, fourth, an enabling structure will allow society and the state to tap into whatever local initiative exists to deal with emerging environmental problems. The current Model Bill provides no avenue through which this initiative or the skills and knowledge existing in local communities can be focused on emerging problems.

The role of legislation and law as enabling frameworks underpinning the evolution of management systems rather than as attempts to create unified regulatory structures is not widely discussed. I know of no case where legislation and legal structures have been explicitly designed to encourage the emergence of diverse natural resource management systems intended to address local conditions. This role is, however, implicit in the way laws and legislation are often used in U.S. water management debates. As a result, the U.S. case provides insight into how an enabling approach might be framed.

1) The Western U.S. Case

Legislation and law in the Western U.S. are, in many ways, not utilised to specify "solutions" to management problems but more to create frameworks within which interest groups can negotiate and implement management actions (Moench, 1991). The enabling framework that has emerged in the U.S. has four primary components: 1) a rights structure; 2) independent negotiating forums; 3) recognised and common organisational formats for management; and 4) a strong governmental role in data collection and dissemination. The nature of each of these components varies greatly from state to state and sometimes even within states. The

discussion below attempts to capture some of the key elements of potential relevance for the Indian context -- it is far from comprehensive.

a) Rights

The legal structure of water rights is a key feature in any enabling framework. How water rights are defined often determines the objectives of water management, the range of factors taken into consideration and who has standing to participate in management debates. The structure of water rights varies greatly between regions in the U.S. Although it is beyond the scope of this paper to examine this variation in detail, several elements seem important.

Expressions of Social Interest

Groundwater use rights in the U.S. are often linked with land ownership as they are in India. In some areas, these rights are modified by **beneficial use**, **reasonable use** and **correlative right** concepts. The beneficial use concept, where it applies, limits uses to those society defines as "beneficial." In practice this has included almost any non-malicious use. Reasonable use concepts limit individual rights a bit further by restricting rights of capture to overlying uses unless injury to other overlying owners can be avoided.[10] *Correlative* rights represent an effort to extend reasonable use concepts and specify them in detail. They have three components: "(1) overlying owners are entitled to no more than their fair and just proportion for on-site uses; (2) as between transporters out of the basin, first in time is first in right; and (3) overlying users have priority over transporters" (Goldfarb, 1989, p. 45).

The modifications in simple capture rights represented by beneficial use, reasonable use, or correlative rights concepts represent substantial steps toward enabling the initiation of management. Where rights of capture are unmodified, overlying landowners have a right to use as much groundwater as they wish. This effectively limits the standing of other landowners or non-land-owning portions of the population to influence groundwater use or extraction. By limiting groundwater extraction rights to "beneficial" uses, an avenue is opened for arguments against uses that do not meet goals defined by the wider society rather than just the individual landowner. While, in the U.S. context, "beneficial" uses have been very broadly defined to include virtually any use except for maintenance of instream flows, the term itself is subjective and could be dependent on context. The term "beneficial" potentially creates a mechanism to limit private rights in ways that account for a variety of social concerns relating to how the water under question is used.

Reasonable use concepts extend social limitations on rights of capture beyond issues in how the water is used. It is no longer just a question of whether the use in question is "beneficial" but whether extraction for use away from overlying lands impinges on others use rights.

10. Reasonable use-rights are similar to (and derived from) the concept of *riparian* rights which applies to surface waters in many areas. *Riparian* rights allocate uses to lands bordering watercourses within a single basin. In principle, they entitle each riparian owner to "a stream flow through his land in its natural condition, not materially retarded, diminished, or polluted by others" (Goldfarb, 1989, p. 22).

Standing is, thus, created for society to intervene not just in how water is used but, if extraction for use away from overlying lands is causing damage, in how much individuals can extract. Finally, correlative rights, by limiting landowners extraction to a "fair and just proportion" of the available resource, create a foundation for social allocation of the available resource between competing users. This creates standing for an overall evaluation of the resource and the development of management plans even if damage has not already occurred.

The case of Texas provides a practical example of how such legal limitations on rights can be useful in enabling the initiation of management. In Texas, a prohibition against "waste" forms the primary restriction on use. This enables local individuals and/or the local groundwater districts to initiate legal action against those who are unwilling to conserve (Moench, 1991). Waste is a subjective concept. It depends on both water availability and use patterns. A low cost, but inefficient water application technology could be seen as "beneficial" and "reasonable" where there is no shortage, but as "waste" when the resource is limited. As water has become scarce, the flexible definition of "waste" enables individuals and water management districts (local quasi-governmental administrative authorities) to encourage continued adoption of ever more efficient water use technologies and management practices. Legal action in Texas to enforce anti-waste provisions is rare. The threat of -- and potential costs associated with -- legal action do, however, provide an incentive for individuals to cooperate with conservation goals.

Beyond limitations on capture contained in how private rights are defined lies the concept of **public trust**. This concept could serve as a key component in an enabling approach. In the U.S., public "ownership" of water finds partial legal expression in the *Public Trust Doctrine* (PTD). This doctrine was founded initially under English common law in the King's sovereign power over navigable waters. The central idea underlying it is that the state holds particularly valuable public uses in trust for its citizens. As Bird states:

> The rationale for claims of right coming from PTD is that certain natural resources are so intrinsically valuable to the public that they cannot be owned by any person. Those resources are considered to be gifts of nature that ought to be preserved for the whole of the populace; their peculiarly public nature makes their adaptation to private use inappropriate. (Bird, 1986, p. 66-67)

Since uses are held in trust, "the state can not wholly alienate such uses, and private users cannot obtain vested rights ... that are paramount to public uses" (Walston, 1989, p. 585). Because public uses are held in trust and cannot be alienated, no compensation is required when "private" rights must be reduced in order to preserve public uses.

Public trust concepts have never been explicitly extended to the groundwater context. Concepts of inalienable public rights to water resources do, however, underlie most state regulatory and management attempts in the U.S. Similar concepts could serve as a foundation enabling action by a wide range of organisations in India if they are articulated in ways that

provide standing for NGOs and communities as well as government entities to participate in groundwater debates.

Overall, rights definitions that are qualified using concepts based on social goals can enable the participation of many groups in the management debate by giving them specific standing. At present, land owners can drill where they wish and pump as much as they wish. Attaching beneficial use, reasonable use, correlative or public trust limitations on their right to do this is, in effect, a statement that others in addition to overlying land owners have legitimate interests with respect to groundwater and that these interests must be taken into account. This lays a conceptual foundation that enables interventions to protect both individual and wider social interests.

Transferability

Transferability of water rights has become a central point in the U.S. groundwater management debate. In the western U.S., markets are viewed by many as the most efficient mechanism for reallocating water to meet both short- and long-term needs (Sax, Abrams & Thompson 1991). During droughts, the presence of a water market can allow short-term water transfers to high value uses, such as drinking, while at the same time compensating those from whom water is transferred. Similarly, the presence of a market in which basic water rights can change hands enables new uses to emerge while protecting old users from a sudden -- and often uncompensated -- administrative reallocation of a basic resource on which they depend. Despite these potential advantages, water transfers often have major side effects. In many areas, water availability is heavily dependent on return flows or seepage from other uses. If primary users are able to transfer water, third parties dependent on the return flows often lose. Third-party effects of transfers can extend beyond the immediate body of right holders. Major transfers of water out of basins or regions are often perceived as undermining the local socio-economic base (Macdonnell & Howe, 1986; Checchio, 1988; Shupe, 1988; Nunn & Ingram, 1988; Oggins & Ingram, 1990; Woodard,1990). This has become known as the "area-of-origin" problem. When water is transferred out of a region, the economic activity it supported can go with it. Similarly, many environmental values -- from the maintenance of stable water tables to wetlands -- can be affected if water transfers become common.

Overall, water rights must be defined in a transferable manner if markets are to play a major role in water management. At the same time, transfer rights must be defined carefully if third parties are to be protected. All states in the Western U.S now follow a "no injury" rule with regard to water transfers (Sax, Abrams & Thompson, 1991). This often results in extensive regulation of transfers which increases transaction costs greatly. To meet both efficiency and wider social goals through market mechanisms necessitates the definition of water use-rights in ways that are transferable and yet minimise the transaction costs and third-party effects of transfers (Emel, 1987).

b) Negotiating Forums

Translating standing and the presence of social limitations on private rights into the power to initiate or modify management practices requires a forum for the rights to be exercised and enforced. In the U.S., the court system provides the ultimate forum for dispute resolution. Some states, such as Colorado, even have special water courts that deal with a range of specific water rights issues (Sax, Abrams & Thompson, 1991). Courts are, however, not the only forum through which rights disputes are resolved. In many cases, the presence of rights and the threat of long, expensive, legal processes are sufficient to force interest groups to reach agreements through negotiation or arbitration. Negotiated management agreements representing compromises between a wide variety of local or regional interests often result. These negotiated solutions frequently lead to divisions of management authority so that various interest groups have a continuing say over management decisions.(Water Strategist, 1990; Shupe, 1986). This approach enables the gradual evolution of management systems that reflect local conditions and are flexible in the face of change.

c) Districts

In the U.S., special "districts" with quasi-governmental status are the most common form of water management organisation. Many of these are primarily concerned with irrigation. Despite the single name, irrigation districts are far from uniform. They often have a specific array of structural features, powers and functions matching the desires of their local constituents. As a result, the irrigation district "model" provides a good example of an approach that enables the development of management organisations closely tuned to the local context.

Despite the widely varying nature of districts, certain structural features are common to most. Sax, Abrams and Thompson (1991) have outlined these well. According to them:

> "To form an irrigation district, a majority of landowners within the boundaries of the proposed district must normally petition local officials. Most states then investigate and report on the adequacy of the proposed district's water supply, although typically the report is purely advisory. A formation election is finally held, at which a majority of the proposed district's residents - in some states, two-thirds or more of the residents - must approve the idea."

> "Once organised, the district can appropriate water, construct reservoirs, canals, and other irrigation works, and distribute water for a fee to the district's residents. Most districts also have the authority to engage in related functions such as the production and sale of hydroelectric power. Districts moreover enjoy a number of uniquely governmental powers including the power to (1) assess (i.e. tax) property within the district, (2) condemn property (including water rights), and (3) issue bonds the interest of which, under current tax laws, is exempt from federal income taxes. Because irrigation districts are technically subdivisions of the state, they are also exempt from state property tax."

> "Districts are governed by their boards of directors, the members of which are generally elected by the districts landowners." (Sax, Abrams & Thompson, 1991, p. 628)

Not all districts or district like management entities are formed by votes of the populace. The Arizona Groundwater Management Act (one of the most comprehensive regulatory pieces of legislation dealing with groundwater in the Western U.S.) enables the designation of "Active Management Areas" (AMA) -- effectively management districts. This is done in three ways: 1) legislation; 2) designation by the Director of the Department of Water Resources; and 3) by petition and vote of the local residents (Sax, Abrams & Thompson, 1991). By identifying different avenues for AMA formation, the act enables the formation of management entities to be initiated either by individuals at the grass root level or by the legislative and administrative branches of government.

In addition to similar methods of formation and a common array of quasi-governmental features, irrigation districts generally have rules for water distribution that allow discretion during periods of shortage and often enable reallocation as changing needs require (Sax, Abrams & Thompson, 1991, p. 629). In some cases, they also provide regulatory structures that allow water trading through market processes. District enabling legislation also often attempts definition of the individuals and groups with standing to participate in and/or initiate management debates. These might be landowners or the residents of a proposed area.

Data Collection & Dissemination

Data are a fundamental currency for management. Without information on groundwater resource characteristics and use patterns it is often impossible to detect emerging problems and certainly difficult to devise appropriate management solutions. In India, groundwater data are generally viewed as the private domain of Government agencies. Their distribution is often restricted due to political sensitivity and the general proprietary approach followed by Government agencies to anything they can control (Singh, 1983; Dhawan, 1990b). While the availability of groundwater data in the U.S. is far from perfect, both the state agencies and U.S. Geological Survey produce large amounts of data. Dissemination of this data to interested parties is generally unrestricted.

Access to information for all parties is often a key factor in the evolution of management agreements. A common understanding of physical relationships and the probable effects of different management actions provides a basis for negotiating agreements. As Baker and Romm point out: "Until the benefits of cooperation can be quantified for each party, it is not feasible to expect a user or user group to invest resources in the cooperative effort." (Baker and Romm, 1990, p.6) This leads them to view technical inputs such as hydrologic models as neutral "negotiating texts" that enable different interest groups to reach common agreements on management needs and appropriate actions.

2) Potential Applications in India

Although the experiences with groundwater management in the U.S. can not be transferred directly to the different environmental, socioeconomic and cultural context of India, key elements may be relevant.

The role of rights definitions as key factors determining the ability of different interests to have a say in water management seems fundamental. Although the importance of formal rights definitions is often discounted in the Indian context, perceptions of rights do play major roles. As Walter Coward found in a study of khul systems: "rules actually are useful in structuring the broad relationships among the various groups and individuals with a claim to water..." (Coward, 1990, p. 83). In this case, the right structure formed a basis for determining maintenance responsibilities as well as water allocation. In my field work, individuals often express the conflicting views that they "have no right to influence how an individual uses water from his well" but do have a "right to protest actions that damage their wells or the resource in general." Legal rights definitions that strengthen the second of these perceptions would support a community's ability to challenge individual uses and, thus, could enable the initiation of community based management actions.

The issue of rights definitions in India seems important from another perspective. Water transfers are common. In Gujarat, most surface irrigation projects are now linked to municipal supplies.[11] Well fields developed to supply drinking water to 200+ km. long pipeline projects are in direct competition with surrounding agricultural users (KON, 1992). In some coastal areas, farmers affected by saline intrusion are purchasing land inland and piping groundwater out to their fields (Bromley, 1989). These transfers are occurring on an *ad hoc* basis with potentially large impacts on users. In some cases, farmers are losing access to the basic resource required for productive agriculture. In other cases, agricultural users undermine drinking water projects designed to meet the survival needs of communities. In the absence of a rights structure that addresses transfer issues, existing users have no claim to compensation if a resource essential for their physical or economic survival is captured by others. If rights structures that allow water transfers and account for third party impacts can be designed then water markets could address both transfer needs and provide a source of compensation to those who's access to water is reduced. While rights issues are complex, they seem central to addressing emerging groundwater problems in India.

The existence of an independent dispute resolution forum also seems to be fundamental to enabling the development of local management approaches. Rights have little meaning unless they are to some extent enforceable. Furthermore, if dispute resolution authority is held by an organisation directly involved in groundwater use or management, the potential for biased decisions increases. This is likely to undermine the willingness of different interest groups to cooperate with management decisions. Since, in the Indian context, state enforcement of management decisions affecting groundwater use appears impossible, the cooperation of local

11. Discussions with S.C. Sharma, Chief Hydrologist, GWRDC

communities seems essential. Independent, impartial forums through which the range of actors can negotiate thus seem central to the development of effective management systems. Provisions such as those in Section 23 of the Model Bill that ban the involvement of the civil courts run counter to this need. While civil court system functioning in India is problematic, some independent forum seems essential.

While rights and forums for expressing them are important, they are unlikely to have much impact unless information on resource condition is generally available. Individuals in India are generally well aware of falling water tables or declines in water quality on a very local scale. Overall understanding of resource dynamics is, however, often limited. Given the general level of education and technological availability, engineering approaches involving hydrologic models may be of limited use for local communities in India. Some common understanding of emerging problems is, however, essential as a basis for agreement on management needs. As part of an enabling framework state and Central Government organisations in India could play a role similar to that played by the Geological Survey and state technical organisations in the U.S. as major sources of technical information for all interested parties.

Finally, the presence of recognised institutional forms for management would seem central to any basic enabling framework for India. The "district" model is an example of this in the U.S. case.[12] Although the nature of districts varies greatly, the basic model represents a recognised and accepted form of management organisation with: (1) a range of quasi-governmental powers the organisation can draw on; (2) financing mechanisms for organisation support; (3) mechanisms for organisation creation; and (4) a means for specifying the range of activities an organisation can take on.

No institutional form similar to the district exists for natural resource management in India. Village cooperatives are often formed to manage natural resources on a very local basis. Major problems have, however, been encountered with this form of organisation. Natural resource management often is not an income generating activity. Cooperatives also do not typically have the quasi-governmental powers either for fund raising or for enforcing management decisions that are commonly associated with the U.S. districts. As a result, natural resource management cooperatives are often ineffective.

3) The Net Result

The combination of rights definitions, dispute resolution forums, data availability and the "district" model that underlies management institution development in the U.S. does not represent a comprehensive framework enabling appropriate management responses to emerging problems. Many workers might, in fact, disagree that any groundwater management framework exists at all. It is, as David Getches (1984) comments a "fragmented system." Although

12. Mutual irrigation companies (owned by their stockholders) are also a common water management organisation in the U.S. There is no requirement for management to occur only through one type of organisation -- multiple forms could have advantages.

the legal and legislative superstructure contains many concepts and provisions that enable the development of local management systems, the net result does little to insure that local approaches coalesce into rational management responses at higher levels. Fragmentation reflects a long history of uncoordinated local decisions. It does not reflect the outcome of a coordinated effort to create an overall system designed with the specific purpose of enabling the evolution of locally responsive management approaches.

I am unaware of any attempt to define the key components required for a a more comprehensive enabling approach. The following section represents a very preliminary and admittedly partial attempt to do this.

B) An Enabling Framework

A range of components seem important for creating a framework that would enable the evolution of management approaches and institutions that are both responsive to local conditions and result in an integrated approach to water management needs at a higher level. These components include, but are not limited to, those I have outlined above that appear to be important in the U.S. case. They consist of:

- Rights structure that voice social limitations on private uses, recognise the standing of individuals and local organisations and yet allow for water transfers;
- Neutral negotiating and dispute resolution fora;
- Mechanisms for initiating the process of management area formation;
- Recognised management organisations with access to a clearly defined set of powers and financing;
- Structures for information generation and dissemination;
- Mechanisms for coordination.

1) Rights & Standing

Clear definition of basic rights and the standing of individuals or organisations to protect those rights is essential for the development of management systems.[13] In addition, where scarcity is an issue, rights are likely to come in conflict. Some mechanism for ranking rights is therefore essential.

As previously noted, concepts such as beneficial use, reasonable use, correlative rights and public trust provide for the expression of interests beyond those of the individual in how

13. including compensation for "takings", the right to drinking water as taking precedence over the right to extract groundwater from overlying lands.

water resources are used. In India, the national water policy ranks water use priorities with drinking needs first, followed, respectively by agriculture and industry. While this policy does not have the force of law, it represents a ranking of social objectives that place basic survival needs over other uses. Individual rights to pump groundwater from below their land are still unchallenged.

An overall water rights approach that defines individual rights clearly and transferably yet put limits on them through a combination of: 1) public trust, correlative rights, beneficial use and reasonable use concepts and 2) a ranking social objectives (as the national water policy does) could lay the foundation for negotiating water management approaches that represent the interests of both individuals and the wider society.

Defining rights on a volumetric basis (as many states in the U.S. attempt to do) would be extremely difficult under Indian conditions. An alternative would be to continue to define rights on the basis of capture but limit them to uses that are beneficial (not wasteful) and reasonable (not infringing on the rights of other individuals or the society). Social interests could be protected through a Public Trust approach. "Public Trust" rights might include: 1) the right of succeeding generations to a basic groundwater resource system undiminished in quantity or quality and 2) the right of populations to sufficient water to meet survival needs. It is important to note that, in addition to narrow protection of public interests, careful definition of "public trust" rights could provide a foundation for integrated water management.

For the rights foundation to be effective, individuals and organisations would need recognised standing to defend their rights or the rights of those they represent. In India, water is constitutionally a state subject. State governments and bureaucracies generally seek to minimise the ability of individuals, local communities and other organisations to intervene in water management debates or activities. This leads to centralised approaches which are unresponsive to local needs, conditions, or perspectives. As a result, a clear definition of standing for individuals, communities and NGOs to participate in water management debates seems essential to the basic enabling framework.

2) Dispute Resolution Forum

The need for an impartial and independent dispute resolution forum as a basic element enabling local management has already been discussed in detail. It is important to recognise, however, that an appropriate forum could do more than just enable management. By providing an avenue through which a variety of local interests can express their needs and concerns, the forum could go a long way toward addressing equity issues.

As previously noted, in the U.S. the courts usually provide the ultimate dispute resolution forum. Other forums -- independent arbitration services, local water courts, or elected boards representing the full range of water interests -- could potentially be appropriate in the Indian context. No single forum may be appropriate in all situations. Major procedural delays and

corruption are acknowledged to limit the viability of using the civil court system for resolving water management disputes. As a result, a general enabling framework might provide for the formation of local dispute resolution forums of a type negotiated by all interest groups within an area proposed for management. This could be done under the auspices of a permanent state level forum.

3) Management Area Formation Mechanism

The presence of a rights structure and dispute resolution forum would create one avenue for the identification of areas where management is needed. Disputes would, presumably, arise in sites where emerging resource problems have significant impact on use values. The process of negotiating a solution would then lead to identification of problem area and the creation of some management solution intended to address the problems. This approach is, however, limited. In many areas where the overdevelopment of groundwater is occurring disputes do not immediately arise. Long-term declines in the water table may not, for example, generate disputes because they don't necessarily influence the amount of water individual well owners are able to extract. Declines may, however, indicate unsustainable extraction patterns that would result in long-term damage to the basic resource. As a result, reliance on disputes as the sole mechanism for initiating water management debates is unsatisfactory.

An enabling framework could create several avenues in addition to the emergence of disputes for initiating the process of management area identification. Process triggers could be based on a set of physical or environmental indicators and/or on the interest of local users in initiating management.

The previously noted case of Arizona provides alternatives to dispute initiated formation. There, management area formation can be initiated by a petition and vote of local residents, the state Department of Water Resources (DWR), or by the legislature. Where residents recognise and wish to take action on an emerging groundwater problem they can file a petition for a management area to be formed. This petition is then voted on by people in the proposed area. If the petition is approved, the process of area formation goes forward. Where local residents are not coming forward, the Director of the DWR is authorised to initiate management area formation by showing "that active management practices are required to preserve groundwater for future needs, or that the current withdrawals are causing subsidence or diminution in groundwater storage capacity, or that degradation of groundwater quality is occurring." (Sax, Abrams & Thompson, 1991, p. 497).

Overall, an enabling framework should probably seek to identify a variety of avenues for management area formation. In some cases, local residents may display a strong concern over emerging problems. Where this concern exists, avenues that enable initiation through local action are likely to encourage support for both the organisation that emerges and for any management system it develops. In other cases, local groups may not be interested in initiating management and the state needs to retain the option, where specific problems are clearly emerging, for initiating action to protect larger social interests.

Finally, in addition to identifying avenues for management area formation, any enabling framework needs to ensure that proposed areas will form effective management units. Administrative and political boundaries often do not match hydrologic boundaries. Ensuring that management areas are defined in ways that reflect the underlying hydrologic system is essential if emerging problems are to be addressed effectively. Reviews of the hydrologic viability of proposed management areas should be an integral part of the formation process.

4) Management Organisations & Their Powers

Management cannot occur in the absence of organisations with recognised authority and powers for influencing resource use. The organisations also must be self-sustaining. To do this their structure and powers must be compatible both with the range of functions they are expected to take on and with the modes of organisation their initiators are comfortable with. They must also have clear source of financing to support their activities and staff.

Organisation Types

Since needs and functions will vary greatly from site to site, any framework intended to enabling locally appropriate management structures needs to identify a range of acceptable organisations for groundwater management. No single organisational format is likely to match the range of conditions present in all local situations. Potentially appropriate organisational types include: (1) quasi-governmental "districts"; (2) cooperatives; (3) companies, partnerships, utilities and other "private" institutions; (4) trusts, and (5) government agency.

The organisational format most appropriate in any given situation is likely to depend heavily on management needs and community interest. Where, for example, protection of a specific area is required to meet the drinking needs of an individual community or provide a drought reserve, trusts with management powers to protect these needs could be the most appropriate institutional format. Where water distribution is the issue and potential for income generation through the provision of services exists, cooperatives or private organisations could be applicable. A "district" approach might appropriate in more complex situations where income generation possibilities are limited and large-scale, integrated, management activities are necessary. Finally, management through government agencies could be essential where scale of local disputes constrain the ability of local groups to negotiate effective approaches. Overall, legislation seeking to enable the evolution of management institutions suited to local conditions should provide formal recognition for a variety of organisational structures.

Beyond the question of organisation structure lie the questions of financing and management powers.

Financing

Organisations do not last unless they have clear sources of revenue. Either the services an organisation provides must be capable of generating income or it must be capable of raising

funds through other means. As previously noted, in the U.S. districts have taxation powers. Many of them also generate income through sale of hydroelectric power or water fees. Government funding is also provided in some cases. In India, community contributions are widely viewed as critical to the effectiveness and sustainability of local resource management efforts. Unless individuals contribute directly to the management organisation, there is little sense of local ownership or of responsibility to cooperate with management efforts. As a result, financing mechanisms should probably depend on local sources of revenue as far as possible.

Powers

In addition to financing, access to authority -- recognised powers -- is essential for management to occur. The types of power appropriate to allocate to an organisation will depend both on organisation type and management needs. They are likely to vary greatly. In some cases, relatively non controversial powers -- the authority to raise funds for construction of recharge structures, education, technology diffusion, etc. -- may be sufficient. In other cases, effective management may require the development of permitting systems, extensive monitoring, well and extraction regulation, and water reallocation mechanisms.

An enabling framework will probably need to contain recognised set of powers potentially useful for groundwater management and mechanisms for different organisation types to draw on those powers. One approach might be to define the range of activities different organisation types are likely to undertake and define the range of powers they may need accordingly. Actual authority to use specific powers could be enabled via inclusion in the organization's bylaws. This approach might, for example, result in a hierarchical power structure where private and cooperative organisations have the authority to distribute water within specific service areas, trusts can limit use within a region to protect specific interests, and districts have the authority to develop overall management plans and promulgate regulations to enforce them. Another approach might be to develop a "smorgasbord" of potentially useful powers and then create mechanisms for different organisations to gain the authority to utilise specific ones. As the degree to which powers could restrict individual or group use rights increases, stronger mechanisms are required to ensure that the powers are actually needed and equitably applied. The approach could, for example, contain general authorisation for any organisation to undertake educational or other non-invasive activities. Licensing, permitting, extraction regulation, authority to encourage or regulate water markets, and other powers having a strong potential to limit individual uses might require approval by the local population (via a vote) or authorisation based on clear demonstrations of need through the independent dispute resolution forum. Finally, rather than identifying potential powers in advance, the approach could be to allow local organisations to identify whatever powers they need and focus instead on creating a mechanism through which powers could be created and approved both by the state and community.

Whatever avenue is developed, the overall goal should be to create a flexible system containing a series of checks and balances through which organisations can gain the authority and specific powers necessary to initiate effective management actions.

5) Information Generation and Dissemination

As noted in the discussion of the U.S. case, data are a fundamental currency for management. An enabling framework needs, therefore, to create a system through which basic information on resource condition is made available to all interested parties. At present, many communities in India do not have access to the technical tools and training found in the U.S. Dependence on sophisticated hydrologic models -- or even relatively simple analytical calculations -- can limit the ability of these communities to engage in debates over resource condition (Moench, 1992a, 1993a). At the same time, many direct indicators of resource condition exist that are readily understandable even by illiterate groups. Villagers are generally unable to challenge the scientific accuracy of recharge and extraction estimates -- but they understand the significance of dropping water tables and increasing salinity.

An information system that generates data suited to different levels of user sophistication and distributes it widely could be a key element of an enabling approach. Maps indicating water table and water quality trends or other basic parameters could serve as the primary coin for water management debates. Sophisticated modeling approaches would be used in a more limited range of situations where understanding of system dynamics requires their application.[14]

6) Mechanisms for Integration

The existence of mechanisms ensuring that most activities influencing groundwater condition are incorporated in management approaches seems to be the final basic requirement for an enabling structure. An enabling framework that attempts to generate a wide variety of different approaches suited to local conditions runs the risk of creating a "fragmented system." There is no assurance that local management systems, just because they are local, will take an integrated view of resource management needs. In many cases, local interests could generate management approaches that conflict with other local interests or regional management needs.

Conflicting approaches and organisations are an inherent problem in the current structure of water management in India. Individual agencies generally have responsibility for irrigation, groundwater, municipal water supply, rural drinking water and so on. Often development plans are initiated by one agency that directly conflict with the actions of other agencies. There is no effective mechanism for coordinated water resource planning.

As part of an enabling framework, specific mechanisms need to be developed to ensure that local management is sufficiently comprehensive to incorporate the range of local issues and needs and minimise conflicts with neighbouring regions. A variety of mechanisms could be used to achieve this goal. The management area formation processes might, for example, mandate a review of water management needs, existing activities, and potential points of

14. For further discussion of data and information alternatives see: Moench (1993b).

conflict before an organisation could be formed. This could be done both for the proposed area and for the surrounding region. Alternatively, all management organisations could be required to file regular management action summaries with an independent commission. This would review the summaries and, if any points of conflict were identified, have the power to require the organisation to resolve these by itself or through the dispute resolution forum. A third approach would be to rely on comprehensive rights definitions and the dispute resolution mechanism to gradually force the inclusion of all management needs into a single structure. This approach would require rights definitions that incorporate "public trust" or other concepts voicing broad social interests. It would also require the existence of organisations (such as environmental NGOs) with an interest in and formal standing to defend the public interest.

Many possible mechanisms for encouraging an integrated approach to groundwater development exist in addition to those identified above. The main point here is that any structure that encourages the development of locally appropriate management systems needs some counterbalancing mechanism to ensure that these local systems are, if not in full harmony, at least not in direct conflict. This will necessitate the creation of some technically competent organisation at the state, and perhaps national, level with the authority to review local management approaches and initiate action (perhaps via reference to an independent negotiating forum) to bring them into line with larger water management needs.

IV Summary

A wide variety of groundwater management problems are emerging in India. In some areas water-tables are falling rapidly, in others, it is rising and in yet others quality is declining. Often problems show a high degree of local variation both with regard to their physical character and their causes.

Despite great local variation in the nature of emerging problems, proposed approaches to dealing with these problems are unidimensional. The Model Bill circulated in September 1992 by the Ministry of Water Resources proposes the formation of water management agencies with a single clearly defined approach and a set of regulatory powers. This approach is likely to be unresponsive to the widely varying characteristics of local problems and may not be implementable. Furthermore, a number of equity, community participation, and rights issues are likely to arise if the approach goes forward.

This paper argues that, instead of creating a single centralised framework for regulating groundwater, it may be useful to create a legislative superstructure that would enable and guide the formation of locally appropriate management institutions and approaches. Key elements of this superstructure could include: 1) rights definitions through which public interest in groundwater use can be expressed and standing can be created for individuals or organisations to defend that interest; 2) a neutral negotiating and dispute resolution forum; 3) management area identification mechanisms; 4) recognised organisational forms for groundwater management with associated financing mechanisms and powers; 5) a system for informa-

tion generation and dissemination; and 6) coordination mechanisms to integrate local approaches with regional needs and counterbalance the tendency toward fragmentation inherent in decentralisation.

An enabling approach could create numerous opportunities for communities to participate in groundwater management. By doing this it would allow society as a whole to tap into the wellspring of concern and management capabilities that exist both at local levels and in the government. An enabling approach would not immediately address the full range of fragmentation, environmental and equity problems that are emerging with regard to water resources. It could, however, provide a framework and set in motion a negotiating process that would lead to their ultimate resolution.

BIBLIOGRAPHY

Arya, S. & Haque, T. (1989) "Structural and Organisational Constraints in Ground Water Management" presented at the Workshop on Efficiency and Equity in Groundwater use and Management, IRMA, Anand, Gujarat, India.

Baker, M & Romm, J. (1990) Emerging Institutional Linkages Between Land and Water: Opportunities for State Involvement in Watershed Management Institutions, Prepared for the State of California Forest and Rangeland Resource Assessment Programme, Contract 8CA74717, pp 59.

Bandara, C.M.M. (1977): "Hydrological Consequences of Agrarian Change" in Farmer, B.H. (ed): Green Revolution?: Technology and Change in Rice-Growing Areas of Tamil Nadu and Sri Lanka, Westview Press, Boulder. pp 323-339.

Bandyopadhyay, J. (1987): "Political Ecology of Drought and Water Scarcity" *Economic and Political Weekly*, Vol. xxii, No. 50, pp 2159-2169.

Bandyopadhyay, J. (1989): "Riskful Confusion of Drought and Man-Induced Water Scarcity', Ambio, 18(5).

Bhatia, B. (1992): Lush Fields and Parched Throats, Working Paper 100, UNU World Institute for Development Economics Research, Helsinki, Finland pp 83 + appendices.

Bird, J.W. (1986): "Water Resources and the Public Trust Doctrine" *Journal of Water Resources Planning and Management*, 112(1):64-70.

Bromley, D.W. (1989): Consultant's Report on Groundwater Resource Problems in Junagadh District, Gujarat, India, Report submitted to the Aga Khan Rural Support Programme (INDIA) and the Aga Khan Foundation, Geneva.

Chakravarthy, N.C.V.N. (1990): "Can Development and Conservation of Groundwater Resources Go Together?" pp 525-531 in International Conference on Groundwater Resources Management, Bangkok, Thailand, Nov 5-7.

Checchio, E. (1988): Water Farming: The Promise and Problems of Water Transfers in Arizona, Issue Paper Number Four, Water Resources Research Centre, University of Arizona, Tucson.

Coward, W. (1990):"Property Rights and Network Order: The Case of Irrigation Works in the Western Himalayas" *Human Organisation*, 40(1):78-88.

Dadlani, B.K. (1990): Status of Energisation of Irrigation Pump Sets" *Bhu-Jal News* 5(3):12-22.

Daines, S.R. & Pawar, J.R. (1987) Economic Returns to Irrigation in India, SDR Research Groups Inc. & Development Group Inc., report prepared for the U.S. Agency for International Development Mission to India, New Delhi, pp 95.

Dhawan, B.D. (1989): "Preventing Groundwater Over-Exploitation" paper presented at the Workshop on Efficiency and Equity in Groundwater Use and Management, Institute of Rural Management, Anand, Gujarat.

Dhawan, B.D. (1990a): Studies in Minor Irrigation, Commonwealth, New Delhi, India.

Dhawan, B.D. (1990b): "How Reliable are Groundwater Estimates?, *Economic and Political Weekly*, May 19, pp 1073-1076.

Emel, J.L. (1987): "Groundwater Rights: Definition and Transfer" *Natural Resources Journal*, 27:653-673.

Gangwar, A.C. & Panghal, B.S.(1989): "Trends in Groundwater Development and Management in Haryana" paper presented at the Workshop on Efficiency and Equity in Groundwater Use and Management, January 30-February 1, Institute of Rural Management, Anand, Gujarat.

Getches, D.H.(1984): "Controlling Groundwater Use and Quality: A Fragmented System," *Natural Resources Lawyer*, XXVII(4):623-645.

Ghosh, G. & Phadtare, P.N. (1990):"Policy Issues Regarding Groundwater Management in India" pp 433-457 in International Conference on Groundwater Resources Management, Bangkok, Thailand, Nov. 5-7.

GOG (1992) Report of the Committee on Estimation of Groundwater Recharge and Irrigation Potential in Gujarat State, Narmada and Water Resources Department, Government of Gujarat, pp 57 + appendices.

GOI (1970): Model Bill - Ground Water Act, 1970

GOI (1991): "Special Issue on Ground Water Statistics" *Bhu-Jal News*, Government of India, Ministry of Water Resources, New Delhi, pp 162.

GOI (1992): Model Bill to Regulate and Control the Development of Groundwater, Ministry of Water Resources, Government of India, New Delhi, September, 1992.

Goldfarb, W. (1989): Water Law, second edition, Lewis, Chelsea Michigan, pp 292.

Government of Karnataka (1987): Karnataka Groundwater (Regulation and Control) Bill -

1987, Compiled by M.G. Chandrakanth, Dept. of Agricultural Economics, UAS, Hebbal, Bangalore, from Department of Mines and Geology, Government of Karnataka, Bangalore, Courtesy: Sri Nagarajaiah, Chennappa, and Mahesha.

Government of Tamil Nadu (1990): Ground Water Development and Management Act No.... Year .... Draft act.

High Level Committee (1991): Report of High Level Committee on Augmenting Surface Water Recharge in Over Exploited Aquifers of North Gujarat, Vols. I & II, Narmada and Water Resources Department, Gandhinagar, Gujarat.

Jacob, A. (1989): "The Existing Legal Regime of Ground Water: Some Observations" paper presented at the Workshop on Efficiency and Equity in Groundwater Use and Management, Institute of Rural Management, Anand, Gujarat.

KON, GOI & GWSSB (1992): India, Hydrogeological Investigations for the Santalpur and Sami-Harij RWSS, Kingdom of the Netherlands Ministry of Foreign Affairs Directorate General of International Cooperation, Government of India and Gujarat Water Supply and Sewerage Board, mission report, pp 70.

Krupanidhi, K.V.J.R. (1987):"Ground Water Resources of Rajasthan," *Bhu-Jal News*, April-June, pp 4-9.

MacDonnell, L.J. & Howe, C.W. (1986) "Area-of-Origin Protection in Transbasin Water Diversions: An Evaluation of Alternate Approaches" *University of Colorado Law Review* 57:527-548.

Malhotra, K.C. & Poffenberger, M. *eds.* (1989): Forest Regeneration through Community Protection: The West Bengal Experience, Proceedings of the Working Group Meeting on Forest Protection Committees, Calcutta, June 21-22.

Moench (1993a): "Hydrology Under Central Planning" paper presented at the Workshop on Himalayan Water Resources, Kathmandu, February 27-28.

Moench (1993b): When Good Water Becomes Scarce: Objectives and Criteria For Assessing Overdevelopment in Groundwater Resources, draft monograph, Pacific Institute/VIKSAT collaborative groundwater project.

Moench (1992a): "Drawing Down the Buffer: Science and Politics of Ground Water Management in India" *Economic and Political Weekly*, XXVII(13)A7-A14.

Moench (1992b): "Chasing the Watertable: Equity and Sustainability in Groundwater Management" *Economic and Political Weekly*, XXVII(51-52)A171-A177.

Moench, M. & Kumar, M.D. (1993): Local Water Management Initiatives: NGO Activities in Gujarat, VIKSAT/Pacific Institute Collaborative Groundwater Project, Ahmedabad, India, pp 43.

Moench, M. (1991): Social Issues in Western U.S. Ground Water Management; An Overview, monograph, The Pacific Institute for Studies in Development, Environment, and Security, Berkeley, California.

Moench, M. (1992): "Groundwater and Electricity Co-management: Generating new Options," paper presented at the workshop on Groundwater Farmer-Managed Irrigation Systems and Sustainable Groundwater Management, May 18-21, Dhaka, Bangladesh.

Nunn, S.C. & Ingram, H.M. (1988): "Information, the Decision Forum, and Third-Party Effects in Water Transfers" *Water Resources Research* 24(4):473-480.

Oggins, C.R. & Ingram, H.M. (1990) Does Anybody Win? The Community Consequences of Rural-To-Urban Water Transfers: An Arizona Perspective, Udall Centre Issue Paper Number 2, Udall Centre for Studies in Public Policy, University of Arizona, Tucson, pp 74.

Pant, N. (1987): "Ground Water Depletion" *Economic and Political Weekly*, Vol. xxii, No. 6, pp 219-220.

Phadtare, P.N. (1988): Geohydrology of Gujarat State, Central Groundwater Board, West Central Region, unpublished, pp 103 + Appendices.

Poffenberger, M. *ed.* (1990): Forest Management Partnerships: Regenerating India's Forests, Executive summary of the Workshop on Sustainable Forestry, 10-12 September, Ford Foundation, New Delhi.

Rai, P.C. & Paliwal, B.L. (1988): Investigation of Ground Water in Jodhpur District, Rajasthan with Special Reference to Consequences of heavy Withdrawal on Aquifers and its effect on Environment, Ground Water Department, Government of Rajasthan, Jodhpur, pp 28.

Reddy, P.M., Venugopal, T.N., Reddy, G.S.S., Madhukeshwar, S. and Lingaraju, Y. (1992): Status of Groundwater Exploitation and Methodology for Recharging of Aquifers in Overexploited areas of Bangalore, Kolar & Tumkur Districts, Drought Monitoring Cell, Bangalore, pp 137.

Saksena, R.S. (1989): "Present Status of Ground Water Management in India and Perspective for the Future" paper presented at the Workshop on Efficiency and Equity in Groundwater Use and Management, Institute of Rural Management, Anand.

Sathi, M.D. (1989): "Pani Panchayat - A Theme in Common Property Resources of Water in

Maharashtra" paper presented at the Workshop on Efficiency and Equity in Groundwater Use and Management, Institute of Rural Management, Anand, Gujarat.

Sax, J.L., Abrams, R.H. and Thompson B.H. (1991): Legal Control of Water Resources, American Casebook Series, West Publishing Co., St. Paul, Minnesota.

Shah, J.V. (1993): "Irrigation by the Farmers for the Farmers" paper circulated at the Consultative Workshop on Farmer Government Partnership in Irrigation Development and Management, WALMI & AKRSP, at WALMI, Anand.

Shah, T. (1989a): "Groundwater Markets: A Review of Issues, Evidence and Policies" paper presented at the Workshop on Efficiency and Equity in Groundwater Use and Management, Institute of Rural Management, Anand, Gujarat.

Shah, T. (1989b): Efficiency and Equity Impacts of Groundwater Markets: A Review of Issues, Evidence and Policies, Research paper 8, Institute of Rural Management, Anand.

Shah, T. (1989c): "Externality and Equity Implications of Private Exploitation of Ground Water Resources" pp 459-482 in Custodio and Gurgui (eds.) Groundwater economics, Elsevier, The Netherlands.

Shah, T. and Raju, K.V. (1987): "Working of Ground Water Markets in Andhra Pradesh and Gujarat: Results of Two Village Studies" paper presented at the Workshop on Common Property Resources (Groundwater), Roorkee, 23-25 February, pp 50.

Shupe, S. J. (1986): "Water in Indian Country: From Paper Rights to a Managed Resource," *University of Colorado Law Review* 57:561-592.

Shupe, S. J. (1988): Issues and Trends in Western Water Marketing, Occasional Paper Series, Natural Resources Law Centre, Boulder, pp 12.

Sims, H. (1988): Political Regimes, Public Policy and Economic Development, Sage Publications, New Delhi, London.

Singh, C. (1990): Water Rights in India, mimeo, Indian Law Institute, New Delhi.

Singh, U. (1983): "Problems of Water Resources Planning in India" *Water Resources Bulletin*, 19(4):577-580.

Sinha, B.P.C. & Sharma, S.K. (1987):"Need for Legal Control of Ground Water Development - Analysis of Existing Legal Provisions," *Bhu-Jal News*, April-June, pp 10-13.

Vaidyanathan, A. (1991): "Critical Issues Facing Indian Irrigation" pp 8-26 in Meinzen-Dick

R. & Svendsen, M. (eds.), Future Directions For Indian Irrigation: Research and Policy Issues, International Food Policy Research Institute, Washington, D.C. pp 333.

Vermillion, D.L. (1991): "The Turnover and Self Management of Irrigation Institutions in Developing Countries," A Discussion Paper for New Programme of the International Irrigation Management Institute, IIMI, Colombo, Sri Lanka.

Water Strategist (1990): "Innovation Through Negotiation: The Fort Hall Indian Water Rights Agreement" Vol 4(2).

World Bank (1991): India Irrigation Sector Review, Report No. 9518-IN, Washington, pp 61.

Woodard, G.C. (1990):"Safe Yields and Assured Supplies or Dreams Deferred?" pp 19-26 in Taking the Arizona Groundwater Management Act into the Nineties, Water Resources Research Centre & Udall Centre, University of Arizona, Tucson.

Cooperative Property Rights as an Instrument of Managing Groundwater

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Abstract

Groundwater is a renewable natural resource that has a significant effect on agricultural production in India. De jure property rights in groundwater are not clearly defined but de facto it is accessible to all those who own the overlying land. Thus, it is a common pool resource (CPR), i.e., a resource that is used in common by an identifiable group of owners of the overlying land. Lack of well-defined property rights in it, its indivisibility, and insurmountable difficulties in assessing and monitoring its stocks and flows make groundwater unmanageable and hence prone to overexploitation. There is now plenty of evidence available to prove that groundwater in many arid, semi-arid, and hard rock areas in India is overexploited and that the damage caused to the aquifers could be irreversible in many cases. In this paper, the author explains why groundwater is bound to be overexploited under the existing institutional arrangements. He then argues that, despite the obvious difficulties, creation and enforcement of cooperative property rights in groundwater could make it manageable and help reduce its overexploitation. Finally, he outlines a practicable strategy for cooperative management of groundwater resources in India.

1. Introduction

Groundwater is a renewable natural resource that has a significant effect on agricultural production in India. Groundwater irrigation accounts for more than 50 percent of the net irrigated area in India (GOI, 1992: 33) and contributes more than 50 percent of the country's total agricultural production from irrigated areas. In India there are no explicit statements or acts which clearly recognise and define property rights in either surface water or groundwater. The public ownership of surface water is implied, however, in government appropriation and regulation of surface water through irrigation projects. It is also implied in the Northern India Canal and Drainage Act of 1873 (Veeman, 1978: 572-3). Where surface water is not appropriated/used by the state, riparian rights prevail, i.e., farmers owning land contiguous to the source of water stream, pond, or lake, have the first claim to water.

Groundwater has never been declared to be publicly owned nor is public ownership implied through the operation of state/public tubewells acts. The system of groundwater rights prevailing in India can be best characterised as a version of the English doctrine of absolute right (Veeman, 1978: 573). Under that doctrine, a farmer has an unrestricted right to exploit groundwater underlying his piece of land. In India, customarily, the ownership of groundwater

rests with the owner of overlying land. Thus de jure property rights in groundwater are not clearly defined but de facto it is accessible to all those who own the overlying land. In view of this, groundwater can be considered as a common pool resource (CPR), i.e., a resource that is used in common by an identifiable group of owners of the overlying land. But for members of a group, it is an open access resource, i.e., a resource that is nobody's exclusive property and hence not managed. Lack of well-defined property rights in it, its indivisibility, and insurmountable difficulties in assessing and monitoring its stocks and flows make groundwater unmanageable and hence prone to overexploitation. There is now plenty of evidence available to prove that groundwater in many arid, semi-arid, and hard rock areas in India is overexploited (Veeman, 1978; Dhawan, 1982; Shah, 1993: 129-33). It is also apprehended that the damage caused to the basins could be irreversible in many cases.[15]

There are no reliable estimates of the magnitude of the problem of overexploitation of groundwater basins/aquifers in India. But the problem exists on a substantially large scale in Haryana, Punjab, Western Uttar Pradesh, North Gujarat, Coastal Saurashtra and many hard rock areas in Andhra Pradesh and Tamil Nadu. The overexploitation of the groundwater aquifers in these areas has engendered many problems such as saline ingress in coastal areas, prohibitive costs of pumping water, and adverse effect on agricultural production. Thus in view of the very important role of groundwater irrigation in Indian agriculture and considering its wide-spread wanton exploitation in many areas in the country, there is an urgent need for a national strategy for management of groundwater.

In this paper, the author attempts to explain why groundwater is bound to be overexploited under the existing institutional arrangements. He then argues that, despite the obvious difficulties, creation and enforcement of cooperative property rights in groundwater could make it manageable and help reduce its overexploitation. Finally, he outlines a practicable strategy for cooperative management of groundwater resources in India.

2. The Logic of Overexploitation of Groundwater

As I mentioned earlier, groundwater is an open access resource for all those who own the land overlying it. Given its open access nature, increasing demand for it for various uses, availability of modern water extraction technology, the finite quantity of its stock as well as the finite recharge rate, groundwater is bound to be overexploited and its use subtractable/ competitive, i.e., if one of the co-users uses more of it, the less is left to that extent for the other co-users. In resource economics, this phenomenon is known as interdependence of the underlying appropriation/ production functions or existence of externalities in appropriation/ production. An externality is defined as an unintended and uncompensated side-effect of an

15. Groundwater basins can be irreversibly damaged by overextraction and pollution of water. If more water is extracted per year than the average annual recharge (also known as safe yield of a basin), eventually the sand and gravel in the water bearing strata will compact thus reducing the space that was earlier available for storage of water. If the groundwater basin is located near the sea and if its water level falls below the sea level, saline sea water will intrude into the vacant space and will thus pollute the entire basin rendering it useless both as a source of water and as a storage.

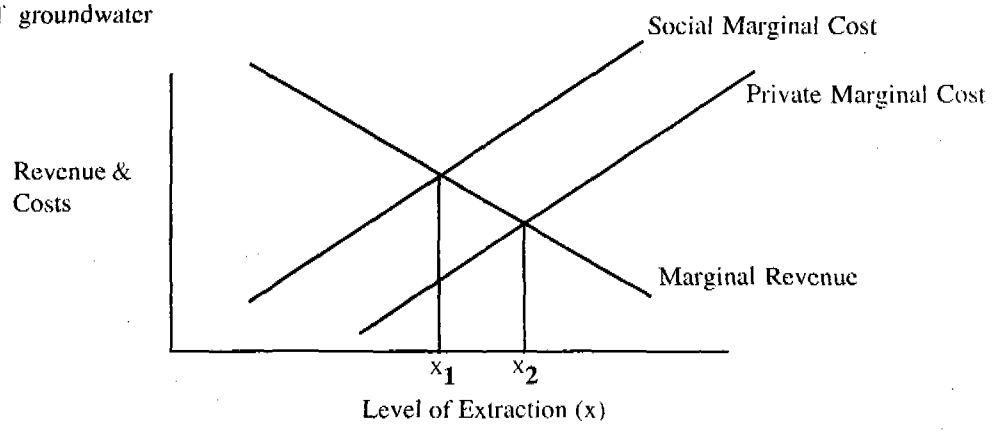
activity. It is the presence of an externality in the use of an open access natural resource that gives rise to a problem called, albeit erroneously, by Hardin (1968) as "the tragedy of the commons". The problem should correctly be termed as "the tragedy of the open access".

When an externality is present, the competitive equilibrium use of the resource (open access) is socially inefficient. We illustrate this with an example of a groundwater basin which is an open access resource for the group of owners of overlying land.

We presume that there are N identical owners of land overlying a particular basin each having a water extracting device (WED) and thereby having an access to the basin. Each land owner extracts only a very small fraction of the total stock of water available in the basin in the area and hence he cannot significantly affect the total stock of water available at a particular point in time. We presume that there exists a well-developed market for groundwater in the area and that each water seller takes the current market price as constant. We also assume that the current market price of water does not change over time.

Under the above-mentioned assumptions, each rational (profit maximising) water extractor will try to extract as much of the water as he needs to irrigate his own crops and to sell to others. In doing so, he would reduce the quantity of water available to the other water extractors operating within the same area/watershed. This shows that there exists the problem of a negative externality which causes the water table to fall down that in turn leads to increased cost of water extraction and hence a loss of revenue to all the water extractors. Every rational water extractor behaves in the same manner. The consequence of this rational behaviour on the part of individual water extractor is disastrous for all the water extractors as a group or community in the sense that the basin is overexploited and every extractor's revenue goes down. Why this happens can be explained in terms of divergence between the private marginal cost and the social marginal cost of water extraction, i.e., the existence of an externality. Each water extractor considers only his (private) costs of extracting water and not the cost of depletion of the basin (an externality) which he is inflicting on the other water extractors. This results in the private marginal cost of extracting water being less than the social marginal cost of extraction and therefore the competitive equilibrium level of groundwater exploitation being higher than the socially optimal level of exploitation. This is illustrated in Figure 1.

Figure 1: Competitive (open access) equilibrium level and socially optimal level of exploitation of groundwater



As shown in the figure, the competitive equilibrium level of water extraction is attained when the level of extraction is X_2 where the private marginal cost is equal to the marginal revenue and the socially optimum level of extraction is X_1 where the social marginal cost is equal to the marginal revenue. Thus, the open access equilibrium is attained at a higher level of extraction and hence a higher level of exploitation than the socially optimum level of exploitation, i.e., $X_2 > X_1$.

Algebraically, the equilibrium level of water extraction under non-cooperative competitive (open access) conditions and socially optimal level of extraction under cooperative (restricted) conditions can be determined as follows:

Assume: (a) there are N identical water extractors all operating in a given watershed of size, S; (b) the water yield function is $Y = f(X)$ where Y is the quantity of water extracted and X is the extraction effort (number of hours of extraction); (c) the average price of water is p; and (d) the average cost per unit of extraction effort is r. With these assumptions, we can specify the private net benefit function as follow:

$$B(X) = p.f(X) - r X \quad \ldots\ldots(1)$$

The necessary condition for maximising the net benefit can be derived by differentiating B(X) with respect to X and setting the (first) derivative equal to zero. This is done below:

$$d B(X)/d X = p. f'(X) - r = 0 \quad \ldots\ldots(2)$$

$$\text{or } p.f'(X) = r \quad \ldots\ldots(3)$$

In words, this means that for benefit maximisation, p.f'(X) or the value of marginal product or marginal revenue should be equal to the marginal cost of extraction. This is the familiar profit maximising condition under competitive equilibrium. Let the solution of Equation (3) be X which is the profit maximising water yield of each extractor. It follows that the total yield of water of all N extractors at this open access equilibrium is NX.

Now, we consider a case where the N identical water extractors arrive at an agreement that each one of them will bear his share of the total cost of depletion of the basin. The payment could be in the form of a tax per unit of water extracted, or in some other form. In other words, we assume that the water extractors have all agreed to cooperate in order to internalise the externality involved in the extraction of water. Since, the depletion of the basin is in proportion to the quantity of extraction which is a function of the extraction effort, we can define the externality (E) involved as a function of extraction effort, i.e., $E = g(X)$.

Now, we can incorporate the externality in the private net benefit function in Equation (1) and write the social net benefit function as follows:

$$B(X) = p.f(X) - [(rX + g(X)] \quad \ldots\ldots(4)$$

The profit maximising condition derived from this function is : $p.f'(X) = r + g'(X)$ .....(5)

Let us suppose the equilibrium solution of Equation (5) is X^*. It follows that the total water yield of all the extractors under the condition of cooperation is NX^*. A comparison between Equations (3) and (5) shows that $NX > NX^*$. Therefore, we can conclude that in the absence of cooperation or binding agreements among the extractors, the level of water extraction under open access will be more than the socially optimal level.

3. Why Water Extractors Do Not Cooperate

Given the water extraction behaviour of farmers as described in the preceding section, a natural curiosity arises as to why the water extractors behave the way they do. Or, in other words, why do they not cooperate with one another in coordinating and regulating the use of groundwater? One reason for the non-cooperative behaviour is obvious from the preceding discussion: the water extractors find it profitable in terms of their private costs and benefits to extract more and more water . The other reasons can be discerned from the N-person Commons' Dilemma game which we briefly describe here.

Envision a watershed in Western Uttar Pradesh comprising five villages and consisting of N number of farm households owning land there. Further, assume that most of the big and medium-sized farmers own tube-wells equipped with pump sets driven by electric motors of 5 to 10 horse power and that there is a well-developed water market in the area. The estimated availability of groundwater (safe yield) in a normal monsoon year is S and the estimated requirement of water for domestic, agricultural and industrial uses in the watershed is D. At present, the D exceeds the S by about 25 percent with the consequence that the water table has been secularly falling down year after year and the cost of pumping increasing. To arrest the falling water table and to sustain the safe water yield, it is necessary that all water extractors reduce their pumping by at least 25 percent. If all the water extractors agree to the required cut back, i.e., if they cooperate with one another, they would all benefit in the long run from the sustained safe yield of water. But if they do not reduce their pumping, i.e., if they do not cooperate, then they may gain in the short run but would all be worse off in the long run. On the basis of these assumptions, we can present the strategic decision problem confronting the pumpers in time period 1 in Table 1.[16] The minus signs reflect the loss of revenue due to cutback in pumping.

16. In subsequent time periods, pay-offs from cooperation will increase and from non-cooperation decrease. This may compel the pumpers to cooperate and regulate the rate of pumping.

Table 1: Expected pay-offs from cooperation and non-cooperation in pumping water from a common aquifer at time period 1.

All Other Pumpers at N-1	Pumper 1: Cooperate	Pumper 1: Not Cooperate
Cooperate	-2000 -2000	-2000 0
Not Cooperate	0 -2000	0 0

Given the payoffs as presented in Table 1, Pumper 1 may well reason: given all Other Pumpers'(N-1) decision, what is my best strategy? Suppose all other pumpers decide to cooperate, then Pumper 1 will find it profitable not to cooperate because no loss situation is better than the alternative of losing Rs. 2000. Alternatively, if the other pumpers decide not to cooperate, then also, Pumper 1 will be better off if he does not cooperate. Thus, both the groups home in on a non-cooperative behaviour that leads to the tragedy of the open access groundwater basins.

This non-cooperative behaviour can be attributed to : (a) the perception of water extractors that their private benefits from water extraction will markedly exceed the private cost of extraction ; (b) their feeling that the effect of their own action is too minuscule to have any tangible effect on the existing stock of groundwater; and (c) in the absence of any organisation or good leadership, they do not have any assurance that the other co-extractors will abstain from extracting water.

The outcome of the Commons Dilemma game is a paradox in that it shows that individually rational strategies lead to collectively irrational strategies and thus poses a challenge to many fundamental concepts in ethics, political philosophy, and social sciences (Campbell, 1985: 3). However, the paradoxical outcome of the game is very much contingent, like in other games, on the structure and rules of the game. Structures of many real world situations where open access problems exist are not similar to the structure of the game in that the resource users may be free to communicate with one another and enter into mutually binding contracts, i.e., both the structure and the rules of the game can be changed. When this is so, the dilemma or the "tragedy of the open access" can be resolved by cooperative action of the group members. Also, when a situation is repeated again and again, rational resource users could

learn from the past sub-optimal decisions and select strategies that yield collectively rational or optimum outcome (Braybrooke, 1985; R. Hardin, 1982).

Theoretical, experimental, and empirical studies of multi- person repeated games suggest that cooperation can emerge under a wide variety of circumstances and that issues of strategy, ethics, and expectations play bigger roles in multi-person games than in two-person games (Magrath, 1986: 33). Axelrod (1984) advances several propositions dealing with the emergence of cooperation in iterated prisoners' dilemmas. The most important among them is that the threat of and the willingness and ability to retaliate against defections is vital to the emergence of cooperation. In the Hawk-Dove game type situations, the "first come first served" or "weaker yields to stronger" convention could avoid conflict and produce cooperative behaviour (Hirshleifer, 1987: 225-226).

4. Some Experiences with Cooperative Management of Groundwater

There are many success stories of farmers cooperatively managing irrigation water in India, the Philippines, Indonesia, Sri Lanka and many other South East Asian countries. In India, many successful water users' associations/cooperative societies are operating in many canal command areas including the Ukai-Kakrapar Project command area in Gujarat (Datye and Patil, 1987; Singh, 1994:184-202). Besides, there are many cooperative lift irrigation societies also functioning successfully in many states including Gujarat. We now present a brief review of two cases - one success and one failure - of cooperative management of groundwater.

Ostrom (1990: 104-42) documents the process of evolution of groundwater management institutions in three basins, namely, Raymond basin, West basin, and Central basin in Southern California which is a semiarid region in the USA. According to her, before the new institutional arrangements, groundwater rights in California had been vested in owners of overlying land each of whom held a riparian right to the full supply of water underlying his land. Consequent to a court ruling, the riparian doctrine was replaced by the doctrine of "correlative rights". Under the latter, in times of water scarcity, the court, if called upon, would treat all overlying owners as correlative and co-equal owners and would permit each of them to have access to his proportionate share only rather than an absolute share as was implicit under the former. She mentions that for a long time there was no competition among farmers and other water appropriators in those basins for the use of groundwater as the quantity available was more than the quantity required. But over time due to increase in the population and growing industrialisation in the region, total requirement of water for various uses substantially exceeded the total quantity availability. This resulted in competitive pumping by owners of overlying land and other appropriators which led to falling down of water tables and consequently increased cost of pumping. Worried about the rising cost of pumping, many farmers and other water appropriators came together on a common platform and created water districts and established water users associations, one in each of three basins. The water districts were created to harvest rain water, import water from surplus districts, levy tax on water extraction

and replenish groundwater basins through a variety of artificial means. Public forums were involved in making the water users aware of the need for regulation of pumping and for imposing other constraints on the participants.

The initial steps in each basin were taken in response to a court order. The solutions to the competitive pumping race were not imposed on the participants by any external authority but gradually evolved from a long-drawn process of discussions, negotiations, and consultations among the participants. The participants raised resources to acquire best possible technical information about the basins and disseminate it widely among all interested water producers. This helped in increasing the understanding and level of cooperation among the participants. Consequently the participants agreed to have voluntary cutbacks of 25-30 percent in their normal water extraction quotas.

The water users' associations hired water masters to ensure that the provisions of the voluntary agreements reached by the participants were followed. The duties of the water masters included extensive monitoring and sanctioning of water withdrawals. The monitoring activities were transparent. Every pumper would report his withdrawals every year to the association and would receive a report about the withdrawals by other pumpers. Several agencies cross-checked the records of withdrawals so the reliability of the information was very high. In this way the problem of overexploitation of groundwater basins was resolved amicably and for ever.

India could learn many lessons from this experience and design a similar strategy for tackling the problem of overexploitation of its groundwater basins. First, it is necessary to create well-defined correlative property rights in groundwater.[17] Second, owners of overlying land need to be organised into some sort of formal association under some law so that their activities are legitimised and their decisions legally backed up. Third, the association should evolve its own strategy for overcoming the problem of overexploitation and implement and monitor it. Finally, access to reliable technical information about the basin is also necessary for groundwater management.

Ballabh (1991) documents an experience with group tubewells in Deoria district of eastern Uttar Pradesh. The district was richly endowed with good quality groundwater resources which were not adequately exploited. This was perhaps due to the predominance of poor marginal and small farmers who were not able to make the needed investments in private tubewells. Another reason for the underexploitation of groundwater in the district was relative backwardness of its agriculture which was characterised by very low level of use of modern farm inputs such as high yielding varieties of seeds, fertilizers, tractors etc.

17. Veeman (1978: 569-87) examines groundwater problems which emerged in northern India as a consequence of the Green Revolution. He attributes these problems to the existing system of groundwater rights and the lack of other groundwater institutions. He suggests that a system of correlative rights - a common property regime - as an instrument of alleviating these problems. Under correlative rights, a groundwater appropriator retains private property rights of use to a reasonable share of the groundwater supply. He also advocates public regulation of groundwater use and integration of the use of groundwater and surface water (conjunctive water use).

A scheme of group tubewells was launched in the district in 1974 under an Indo-Norwegian Agricultural Development Project (INADP). Over the period, 1974-1987, 40 group tubewells were installed under the Project. The tubewells were jointly owned by members of the groups and water was sold to both members and non-members. Each group was headed by a leader chosen by the group members from among themselves. The leader was responsible for managing the operation of the tubewell owned by the group, distribution of water, maintaining necessary records and accounts and collecting water dues from irrigators and remitting them to the INADP.

The author concludes that the group tubewell experiment did not succeed due to a variety of reasons. The main reasons were intragroup conflicts over such questions as collection of electricity charges and repair and maintenance of pump sets and electric motors; increasing competition over time with private tubewells and world bank- financed public tubewells that made it more attractive to the group members to buy water from those tubewells rather than patronize their own group tubewells at a higher private cost; uncertain/ irregular and inadequate power supply; inability of the groups to frame appropriate rules for distribution of water, pricing of water, recovery of water dues and repair and maintenance of motors and pump sets; and lack of participation of members in making crucial decisions.

At least two important lessons can be drawn from this experience. First, unless property rights in groundwater are vested in the groups/cooperative societies intended to manage it, cooperative management of groundwater is not likely to succeed. In our opinion, if the groups in Deoria district had been granted such rights, unnecessary competition with private and public tubewells could have been avoided. Second, it is necessary for the success of any group endeavor that rules for equitable sharing of benefits and costs and for preventing free riding behaviour are framed and enforced ruthlessly by the group.

5. Towards a Strategy for Groundwater Management

Given the nation-wide experience that groundwater basins have been overexploited more often than not, there is a case for some kind of intervention by someone including the government to regulate and co-ordinate the use of groundwater in the larger interest of the present and future generations of people. Since a national government can better look after the interests of the people at large than any individuals, or groups of individuals, government intervention seems to be, on priority grounds, most desirable from the societal point of view. Government intervention does not, however, necessarily imply direct action by government; it may include such indirect measures as enactment of necessary legislation, provision of funds, technical information, guidance, and training, establishing of new institutions and organisations, creation of basic infrastructure etc.

A pragmatic national strategy for groundwater management should have sustainability/ efficiency and equity as its main goals. The strategy should promote sustainable use of groundwater. By 'sustainable use' we mean using groundwater resources in such a way that the stock is not depleted beyond the socially and ecologically desirable level. To the extent,

sustainability subsumes socially optimum rate of resource use in perpetuity, it takes care of the goal of economic efficiency also. But maximisation of economic efficiency in the short run may conflict with the goal of sustainability but the latter is superior to the former as a goal of the strategy.

A responsible strategy should also provide for equitable distribution of benefits and equitable sharing of costs of groundwater development projects among their users. Many development projects have failed in the past because they ignored equity considerations in their design and implementation and did not legitimize the local use rights. Availability of benefits and their equitable distribution should be guaranteed through appropriate legal provisions. Similarly, cost sharing arrangements should also be legitimised to reduce or eliminate the problems of free riding and shirking by CPR users.

The Government of India (GOI) announced a National Water Policy (NWP) in 1987. The policy does not clearly specify its goals but highlights, inter alia, the need for efficient use of water, need for periodic reassessment of the groundwater potential, integrated development of surface and groundwater and their conjunctive use, equity in water allocation and farmers' participation in water management. The policy does not, however, specify how these goals will be achieved. After the announcement of the policy, no serious attempt seems to have been made to implement it (Singh and Shishodia, 1992). Besides, the NWP does not propose any specific measures to prevent the overexploitation of groundwater in the country.

As we mentioned earlier, groundwater in India at present is not managed at all. In the interest of society at large, especially future generations, it needs to be managed well. This is possible only if well- defined correlative property rights are created in groundwater, particularly in the areas where groundwater is scarce. In our opinion, like land, all groundwater resources in India should nominally be owned by the state and owners of overlying land granted usufruct rights on the condition that they will either form a cooperative society for managing the water or abide by rules and regulations framed by the government for the purpose. Still better, we suggest that the usufructary rights be exclusively vested in cooperative societies of owners of overlying land and the cooperative societies required to pay a specified user fee to the government. Membership of such societies should be compulsory. Every member should be required to buy shares of the society under whose jurisdiction his land lies in proportion to the size of his land holding. The shares should be transferable/saleable along with transfer/sale of overlying land. The society should frame rules regarding the number, size and location of tubewells or other WEDs and undertake to install new tubewells wherever and whenever they are needed. All the existing private and public tubewells and other WEDs in the jurisdiction of the society should be transferred to it.[18] The owners of tubewells must be paid appropriate

18. In one of the villages, Miroli, in Ahmedabad district of Gujarat, all private tubewells have voluntarily been placed at the disposal of the village water users' cooperative society. The existing public/state tubewells should also be handed over to the water users' cooperatives/ companies for better management. This is already being done on an experimental basis in Gujarat and the results have been encouraging. The government should however make sure that public tubewells do not become private property in the hands of pseudo cooperative societies.

compensation not lower than the current replacement cost. The society should then auction to its members the right to use the tubewells for irrigating their own fields as well as selling water to others. Such usufruct rights could be sold on lease for one or more than one year. The society should frame rules for governing pumpage, sale of water, pricing of water and cropping pattern and should enforce and monitor the rules. Violators should be divested of their rights to operate the tubewells/other WEDs. Pumpage for each tubewell/ WED may be determined in proportion to the area owned by the lessee. In addition, 25 percent of the pumpage may be allowed to be sold to other farmers. The society should make sure that the total pumpage by all the owners of tubewells and other WEDs does not exceed the long- run safe yield of the basin.

The role of the government should be to enact necessary legislation providing for granting of usufructary rights in groundwater to cooperative societies of overlying land owners, to provide technical information about availability of water in basins and funds for installing tubewells. The National Bank for Agriculture and Rural Development should provide long term refinance to the cooperative societies for installation of tubewells. The society should be authorized to levy pump tax, to fix price of water keeping in mind the availability of water and operating costs and to raise funds from its members as well as other sources for meeting its establishment and other operating costs as well as for taking up other activities such as purchase of water from outside, if needed, to directly distribute to its members or to recharge the basin.

We know that it is a novel idea beset with numerous legal, financial, operational and managerial difficulties in its implementation. But the consequences of not doing anything to solve the problem of overexploitation of groundwater basins are serious enough to warrant immediate remedial action, howsoever difficult that may be.

Drawing upon the experiences reviewed in this paper as well as the underlying causes of overexploitation of groundwater basins discussed earlier, we list below a few important components of a pragmatic strategy of groundwater management:

1. Delineate groundwater deficit areas, create groundwater districts, and organize overlying landowners in each such district into a water users' cooperative society/company for water management.

2. Create well-defined correlative property rights in groundwater and vest them in the cooperatives/ companies of owners of overlying land. Permit the cooperatives/companies to install new tubewells and acquire the already existing private and public tubewells in their jurisdiction.

3. Collect information about both surface and groundwater regarding their extent, stock, flow, recharge etc. district by district and make that available to water users' cooperatives/companies.

4. Educate the water users and make them aware of the imminent threat and hence the need to cooperate.

5. Frame practicable rules and regulations for regulating the number, size/capacity, and spacing of tubewells.

6. Lease out usufruct groundwater rights to only the members of the cooperatives subject to their adherence to the rules and regulations framed by the cooperatives. If they violate the rules, then withdraw the rights.

7. Allow sale/transfer of property rights along with sale/transfer of the overlying land.

8. Fix price of water taking into account its real resource cost including the cost of depletion of the aquifer.

9. Determine suitable cropping pattern for each area/ water district considering the availability of water and enforce it through the cooperative society concerned.

10. Plan for recharge of basins, if possible, and consider the possibility of importing water from those districts which have surplus water.

11. Promote conjunctive use of surface water and groundwater so as to avoid overexploitation of groundwater basins, on one hand and water logging and soil salinity on the other. Conjunctive use should be envisaged right from the planning stage of all irrigation projects.

6. Concluding Remarks

Groundwater in India is too valuable a natural resource to be left unmanaged. Under the existing system of lack of well-defined property rights and with rapidly growing water markets and wide spread use of modern water extracting technologies, it is prone to overexploitation and is in fact being overexploited in many arid, semi-arid and hard rock areas in the country. Of the three alternative management regimes, namely, privatization, nationalization/centralised public management and collective/cooperative management, the last one seems to hold the highest promise as an instrument of achieving sustainability and equity in groundwater management. Implementation of this alternative is, however, likely to be problematic. It would require, among other things, a change in the existing legal framework governing the use of groundwater, creation of water districts, organizing water users into some sort of formal associations, and helping the water users with technical information, funds and legal advice. All these tasks are difficult to perform under the existing environment of indifference and apathy on the part of the government. But all these problems can be overcome if there is a strong political will and sense of urgency at all levels for managing groundwater in a sustainable manner. It is high time that India made a beginning in this direction and pilot- tested the proposed strategy in a few selected areas in the country.

References

Axelrod, Robert (1984), The Evolution of Co-operation, New York: Basic Books.

Ballabh, Vishwa, (1991), Group Tubewells in East Uttar Pradesh and Peoples' Participation: A Case of Organisational Failure, paper presented at the Training Workshop on People's Participation in Natural Resources Management, 25- 30 November, 1991, Institute of Rural Management, Anand.

Braybrooke, David (1985), "The Insoluble Problem of the Social Contract", In : Campbell, Richard and Sowden, Lanning (eds.), Paradoxes of Rationality and Co-operation. Vancouver: University of British Columbia Press.

Campbell, Richmond (1985), "Background for the Uninitiated", In Campbell, Richmond and Sowden, Lanning (eds.), Paradoxes of Rationality and Cooperation. Vancouver: University of British Columbia Press.

Datye, K.R. and R.K. Patil (1987), Farmer Managed Irrigation Systems: Indian Experiences, Centre for Applied Systems in Development, Bombay.

Dhawan, B.D. (1982), Development of Tubewell Irrigation in India, New Delhi: Agricole Publishing Academy.

GOI (1992), Indian Agriculture in Brief, 24th Edition, Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, New Delhi.

Hardin, Garrett (1968), "The Tragedy of the Commons", Science, 162:1243-48.

Hardin, Russel (1982), Collective Action, Baltimore: Johns Hopkins University Press.

Hirshleifer, Jack (1987), "Evolutionary Models in Economics and Law : Co-operation versus Conflict Strategies", In Hirshleifer, Jack (ed.), Economic Behaviour in Adversity, Chicago: University of Chicago Press.

Magrath, William, B. (1986), The Challenge of the Commons : Nonexclusive Resources and Economic Development : Theoretical Issues, Working paper, Washington, DC :World Resources Institute.

Ostrom, Elinor (1990), Governing the Commons: The Evolution of Institutions for Collective Action, Cambridge: Oxford University Press.

Shah, Tushaar (1993), Groundwater Markets and Irrigation Development: Political Economy and Practical Policy, Bombay: Oxford University Press.

Singh, Katar (1994), Managing Common Pool Resources: Principles and Case Studies, New Delhi: Oxford University Press.

Singh, Katar and Anil Shishodia (1992), "Irrigation Management in India: Need for Reforms", Indian Economic Panorama, 2 (1).

Veeman, Terrence S. (1978), "Water Policy and Water Institutions in Northern India: The Case of Ground-water Rights", Natural Resources Journal, 18(3) : 569-87.

Water Quality and Water Rights: Issues for Groundwater Management in India

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A growing threat to groundwater supplies is degradation of quality. Water experts agree that prevention of groundwater contamination is the best and in many cases, the only means of maintaining a sustainable supply. The slow movement of groundwater relative to surface water means that groundwater is very much a local-level resource, requiring local-level protection. A number of analysts have noted the need for local-level management of groundwater to prevent excessive withdrawals. A second and equally important need is for local-level management of water quality.

Many analysts have asserted that groundwater management at the local level requires a well-developed set of groundwater rights. As quality is on a par with volumetric quantity in the availability of useable water, the development of groundwater rights should include rights to groundwater of useable quality. The availability of good quality local water is, of course, dependent on the collective actions of everyone in the recharge area to prevent contamination. Developing a set of institutions for management of groundwater quality is of paramount importance to the future availability of useable groundwater supplies in India.

As there is a great deal that we do not know about groundwater, this will not be an easy task. Most will agree with the assessment that groundwater resources are overstressed in some parts of India. Less widely acknowledged is the significance of groundwater quality as a factor limiting the useability of water, and therefore exacerbating water scarcity. In industrialized nations there is growing doubt that groundwater, once degraded, can feasibly be restored to acceptable quality levels.

This paper examines groundwater quality as a critical and overlooked dimension of water scarcity, and addresses several issues in considering what institutions may be needed to protect water quality. It outlines reasons why groundwater quality protection is to be appropriately managed at a local-level, although supported by important activities at a centralised level. The literature on common pool resources is reviewed for useful illustrations of the dilemmas of collective management of a common pool resource, and division of tasks between locally based associations and centrally based institutions which are appropriate to the goals of sustainable, efficient, and equitable management of groundwater. Finally, it offers suggestions for research to support the development of appropriate institutions.

19. The author is an environmental sociologist/anthropologist currently in India consulting and developing research projects on NGO activities in water quality management and on the ethnographic record of local management of groundwater supplies and quality.

I. INTRODUCTION: Water Scarcity as a Function of Accessible Volume and Quality

Water scarcity is a function not only of volumetric supply, but also of quality sufficient to meet demand. While drinking water is perhaps the largest demand for high quality water, many industrial uses require high quality water as well. Agriculture, by far the largest consumer of water, suffers when water supplies become too saline.

The issue of quality arises in groundwater management because the specific characteristics of water render it useful in more than one way. Among the common uses is waste disposal. Water dissolves many wastes as well as natural substances and carries them away. Using water as a receptacle for waste competes with using water for consumption, if the dissolved waste renders the water unusable for consumption. In quantitative terms, one might regard the use of water for waste disposal as a taking of quality units.

The types and sources of groundwater contamination (excluding bacterial contamination, which is not covered in this paper) include chemical contamination from "point" sources, which usually refers to wastes being discharged from a pipe,[20] and "nonpoint" sources, which means all other sources such as stormwater runoff (which picks up oils and other contaminants from road surfaces, parking lots, and auto repair facilities), irrigation (which carries fertilizer and pesticides into groundwater), leaks from storage tanks (such as underground petrol and diesel tanks at service stations) and leachate from disposal sites, especially industrial waste dumps or ponds.[21] The "nonpoint" sources are technically the most difficult to regulate, particularly those which originate from small events such as a discarded paint can, used motor oil, etc. It takes very little of a chemical to contaminate a large area of groundwater; the actions of a single individual can be sufficient to endanger the only groundwater supply available to an entire community.

The institutions needed to manage this variety of sources will vary according to the type of source, but groundwater protection will require efforts at both centralised and decentralized levels. These will be discussed later in this paper.

The importance of water quality as a factor constraining water use has often been unacknowledged in analysis of water scarcity. For example, Malin Falkenmark, from the Natural Science Research Council in Sweden, distinguishes four different causes of water scarcity:

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20. In the United States, point sources are regulated at the state level, usually by means of a permit system.

21. There are several other water quality issues important in India which will not be addressed in the current paper as they are a secondary consequence of inadequate supply to meet demand, and must be addressed by better management of withdrawals and site-specific solutions. They are (1) the salinization of water in coastal areas due to aquifer depletion and saltwater intrusion, (2) salinization of a fresh water aquifer when drilled wells open channels between the fresh water aquifer and deeper aquifers in geologic material which were formerly seabeds, (3) pumping from deeper water deposits never before tapped and where natural deposits of fluoride or other inorganics have been dissolved in high concentrations, and (4) health problems caused by inadequate supply of water to maintain adequate personal and household hygiene.

1. aridity, a permanent shortage of water caused by a dry climate;
2. drought, an irregular phenomenon occurring in exceptionally dry years;
3. desiccation, a drying-up of the landscape, particularly the soil, resulting from activities such as deforestation and over-grazing; and
4. water stress, due to increasing numbers of people relying on fixed levels of run-off (Clarke 1993:2).

To this list I would add two more causes of water scarcity. The first is seasonal drought, a topic of some discussion at the current groundwater workshop, and a form of water scarcity which is not only of particular significance in the Indian subcontinent, but one which results from the complex interplay of human agency and environmental factors.

My subject, however, is a second addition: the water scarcity induced or amplified by degradation of water supplies. This is by no means a problem limited to India. Groundwater contamination has become recognised as a problem resisting easy solutions throughout the industrialized world. Furthermore, while it creates an additional dimension of water scarcity in water-deficit areas, it poses the first widespread water crisis since the pre-chlorination era to populations in water-rich areas as well.

In the United States, an irony of the great progress of the 1970s in environmental protection legislation and implementation is that the focus on surface water and air quality inadvertently redirected the waste stream to land and groundwater. A decade later, the outrage accompanying public discovery of buried chemical wastes under a suburban neighborhood and school at Love Canal, near Niagara Falls in New York State, illustrated the folly of earlier assumptions that soil could absorb any pollutant, and that groundwater could purify itself.

The Love Canal episode eventually galvanized the U.S. federal government to create special legislation and an enormous, though still inadequate, dedication of funds to address soil and groundwater contamination from hazardous substances.[22] Yet the federal and state attention to "point sources" such as toxic waste dumps and industrial discharges addresses only the relatively easy fraction of the source of groundwater contamination. The more intransigent problem which remains is "non-point sources" of pollution: chemically-laced run-off which occurs when rainfall absorbs contaminants on the surface (oil from road surfaces, pesticides and fertilizers from agriculture) and then seeps into aquifers.

The environmental laws of the United States government have assumed that groundwater can be cleaned up. A recent editorial of the journal Ground Water offered a newly pessimistic challenge to that assumption, saying that "A decade ago, many of us thought it was feasible to clean up most groundwater. We now know that we did not understand the problem" (Parfit 1993:88).[23]

22. Though best known as the "Superfund," the official title of this legislation is Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA).

23. Quoted in Michael Parfit, "Troubled Waters Run Deep," National Geographic, Special Edition: Water, November 1993, p. 88.

The consensus among water experts even before this perception spread was that cleaning up groundwater is prohibitively expensive, even in those cases where it is technically feasible. The difficulty of cleaning up contaminated groundwater sets this resource in a class apart from air and surface water, where resource quality is usually more apparent and, importantly, responds relatively quickly to appropriate interventions.

The most cost-effective way to ensure the provision of adequate quality groundwater is to prevent its contamination, from non-point as well as point sources. Prevention of non-point source pollution, in particular, requires a multy-pronged approach which must include institutional structures and activities to influence individual decisions. Although well-enforced governmental carrots and sticks may succeed in shaping the behaviour of industries and economic sectors, collectively the decisions of millions of individuals contribute greatly to whether groundwater becomes contaminated or not.

A major challenge to designing workable institutions for groundwater quality protection is that the investment of time, energy, and financial resources must be made before contamination becomes extensive. Typically, water quality is not high on the investment priority list until it is a problem. Yet as was noted above, once groundwater contamination is a problem, it is often impossible to rectify. It is necessary to generate political will to address the problem, and then the resources and institutional designs must be identified. If the United States offers any lesson, it may be that the beliefs and wishes of the technical experts are different from people at the grassroots, and that the politicians respond more to the people than to the technical experts.[24]

In the United States, people's environmental beliefs may not be the basis for their actions if they come into conflict with other strongly held beliefs such as those involving private property. Research in the eastern United States, a country with a strong cultural tradition of individualism and decentralized governmental authority, has indicated that even when groundwater is the only source of supply and some wells have become contaminated, people who are encouraged by state-level governments to adopt local-level controls to protect groundwater from further contaminating land uses resist doing so (Turnquist 1993). Individuals were found whose wells had been contaminated by the activities of their neighbours and yet were unwilling to challenge the right of that neighbour to continue using the land in a manner which contaminates the groundwater. The property rights inherent in their concept of land ownership discourage the suggestion that any controls, even locally made, accrue enough benefit as to override the reduction in a landowner's right to use the land however he/she sees fit. The concept of individualism and the legal basis of private property rights are in some conflict with the goal of groundwater protection from the top down.

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24. Differences in perceptions of environmental risk between experts and members of the public have a significant impact on the allocation of resources for addressing environmental problems (see Turnquist [1993] for a review of research on risk perception and communication). The dilemma is far from resolved; a current research project of the Centre for Risk Management at the Resources for the Future institute in Washington, D.C. is the most recent effort to seek common ground (Centre for Risk Management Newsletter, 1993).

In India, however, there may be opportunity at this juncture in the development of water laws, policies and institutions to generate institutions for water quality protection by building on cultural traditions to establish a concept of property rights in groundwater which will reinforce cooperation to protect the resource. It would be useful to identify concepts common throughout the cultures of India which are congruent with the goals of groundwater management, and to build on these. The rest of this paper discusses selected goals of groundwater quality management and criteria for institutions for addressing these.

II. Scarcity is the Mother of Management: Goals and Criteria for Institutions for Resource Management

If necessity is the mother of invention, one might say that scarcity is the mother of management. In areas of water scarcity, management efforts and institutions become quite complex, but their development is regarded as essential to the economic activities of these areas, despite the high transaction costs to develop these institutions. By contrast, in areas where rainfall is generally adequate to meet crop requirements, such as the water-rich eastern USA, there is often no need to invest in water management institutions.

Reversing a trend towards water scarcity caused by deteriorating quality is perhaps the first goal of water quality management. If scarcity of high quality groundwater is a recently emerged concern in areas of water abundance, it should be even higher on the agenda in water-scarce areas. Persuasive arguments have been made that sustainable groundwater use requires a well-conceived set of water rights (Singh 1991; Devi 1991; Bhatia 1992). An implicit assumption in these discussions are that the water to which one has rights is useable; that is, it is of a quality which is adequate for the purpose for which the water will be used. This assumption must be made explicit: rights to water include both volumetric and quality dimensions.

A conclusion shared by many on the need for *de jure* water rights is that they should be separated from private land ownership, as the inequities in landholdings are then reproduced in the rights to groundwater.[25] The weight of logic for this belief is reinforced by the need for protecting quality. As noted earlier, beliefs in the United States toward the inviolability of private property (and a property owner's right to use the property as s/he wishes, regardless of its impact on the underlying water quality) superseded beliefs about any right to a high enough quality of water for a neighboring user's purpose.

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25. In addition to reproducing inequity, tying groundwater ownership to land ownership has no logical consistency with the gains in knowledge about hydrogeology. Groundwater does not move like surface water, and despite the cost of gaining information about groundwater movement, it is not unknowable, as the law has presumed. Goldfarb writes, "Our legal system is replete with 'legal fictions,' such as the undiscoverability of groundwater movements, which are demonstrably false but are nevertheless preserved in the interests of administrative stability" (1984:xix).

In the United States the legal basis of groundwater is ownership by the state, held in trust for the public, to whom access and withdrawal rights are distributed by each state according to one or a combination of several legal doctrines.[26] As yet, to my knowledge, no rights have been defined for quality, except as a landowner's land use activity degrades groundwater serving a public water supply. Degradation of private wells, which serve a significant portion of the population (and a majority of the rural population) is an increasingly frequent phenomenon, though it is one which is not well-captured by either systematically collected data nor policies for adjudication.

Separating groundwater ownership from land ownership may be the first step in developing institutions for water quality management in India. The goals of these institutions then are to promote equity, sustainability, and efficiency. A growing literature on common pool resources may provide guidance on what water quality management institutions might look like.

III. Common Pool Resource Management Regimes: Dilemmas and Possibilities

Much of the discussion of water rights has revolved around its characteristics as a common pool resource; that is, a resource shared by many. Groundwater has been considered as a common pool resource (CPR) insofar as it is a resource system to which many users have joint access, but analysis as a CPR has been confined mainly to the groundwater basins of arid areas, rights to which have been profoundly contentious (see Blomquist 1988; 1992). Elinor Ostrom defines a "common pool resource" as "a natural or man-made resource system that is sufficiently large as to make it costly (but not impossible) to exclude potential beneficiaries from obtaining benefits from its use" (Ostrom 1990:30). In other words, a resource is defined as a common pool resource not only in terms of its physical properties, but also in terms of its accessibility to human use.

As a common pool resource, groundwater has some characteristics similar to other such resources, and some characteristics unique to itself. These comprise the physical conditions to which management institutions must be adapted. Such characteristics include the localness and boundary definitions of the resource and of the user-group, and the vulnerability to competing uses.

1. Localness and exclusiveness. A strong argument can be made for the importance of local-level management of groundwater, as it is essentially a local-level resource with characteristics unique to each location. Groundwater is similar to forests and irrigation systems in this respect, yet it differs from them in that outsiders cannot easily be excluded from all uses.

26. Four doctrines are in use: **absolute ownership** (to owners of overlying land), **reasonable use** (landowner's share is limited to reasonable use on overlying land), **correlative rights** (reasonable use with proportional sharing of available supply), and **prior appropriation** (first in time, regardless of land ownership). With a few exceptions (Arizona, California, Nebraska, and Texas) all states in the arid areas of the west follow the prior appropriation rule, while most states in the humid east follow the absolute ownership rule. However, many states have amended their laws in recent years to address conflicts over well interference (Goldfarb 1984:24-28).

Non-landholders can be restricted from making withdrawals, but anyone can contribute contaminants through agricultural practices and other forms of contaminating land uses such as those listed earlier. The "quality rights," or pollution rights, are *de facto* available for the taking. Local users who do not need the water for drinking or other high quality demands have no established motives for restricting their use of the water as a waste receptacle.

2. Boundary definitions. Unlike forests, fishing grounds, or irrigation systems, knowledge of groundwater recharge areas is not gained either visually, intuitively or by accumulated experience. Groundwater movement and recharge area may correspond to surface topographical features, but are largely determined by subsurface geophysical features. The recharge area may easily extend far beyond the a day's travel from points of withdrawal, a distance which probably would inhibit communication among users as well as increase the likelihood of users in one area enjoying benefits of withdrawals and waste disposal yet externalizing the costs of these to others in the recharge area. A recharge area-based local management initiative would run into difficulties if unsupported by more centralised institutions.

3. Vulnerability to competing uses. While the term "competing uses" generally brings to mind competition for volumetric units, competition for mutually exclusive uses includes the use of water as a waste disposal receptacle versus the use of water for drinking. Few other common pool resources are as vulnerable to contamination as is water, and none so irreversible as groundwater.[27] Yet contamination is a matter of degree and interpretation --"pure" groundwater exists only hypothetically -- and the notion of pollution rights has been the basis for balancing competing uses elsewhere. All groundwater contains dissolved substances, and many of these hold no harm for any potential use of the water.

These dilemmas may best be addressed by a three- or even four-tiered system of quality management in India, in which the Centre provides certain resources to the states, who in turn provide certain rights and resources and designate responsibilities to smaller, hydrogeologically-based groups.

IV. Local-level Management: Necessary (but not sufficient) for several goals

Local level management is necessary for successful protection of groundwater quality. The individuals most affected by poor quality management are usually the neighbours of those who are most responsible for the groundwater degradation. At present, activities which contaminate the groundwater are largely cost-free for the individual or group which are

27. Groundwater contamination differs significantly from surface water contamination in levels of toxicity as well as fate of the contaminants. Many synthetic organic chemicals are toxic in small concentrations and can be ingested unknowingly over long periods of time. Adverse health effects may accumulate long before they are recognised or associated with the water. The concentration and persistence of chemicals are generally much greater in groundwater than in surface water, and their source and path may be difficult to trace, particularly in areas of fractured rock. Ingestion of chemicals through water consumption must be seen as only one source of ingestion, and combined with ingestion through air pollution and the food chain. See Patrick, Ford and Quarles (1986).

responsible; the costs are borne, rather, by others who need the water for high quality uses. Contaminating activities can be difficult to witness, much less to regulate. An effective programme of quality protection must incorporate measures addressed at changing individual attitudes and information, provide for local-level monitoring and sanctions, encourage the development and adoption of alternatives to current activities which contaminate groundwater, and provide centralised institutional and technical support such as a systematized set of groundwater rights, adequate data collection, and support for technical services to decentralized (sub-state and local level) management organisations.

Clearly, not all of these are possible by local groups alone; efforts at centralised and local levels are both necessary. It is important that they be structured to complement each other, and provide each with the necessary rights, resources, and responsibilities. Support is needed from more centralised political or hydrogeologically-based organisations for effective management of groundwater quality. Some models for State-local relations in management of other common pool resources may be useful. For example, fisheries are becoming protected in a number of places through restrictions placed on the types of technologies permitted to be used in those areas (Kendrick, 1993). This approach has a parallel in the incipient efforts in Gujarat to control groundwater withdrawals by restricting the technology. For quality management, this may have some effect on reducing the rate of salinization, although it does not affect other quality issues.

Another more useful approach can be seen in India's current experiment with joint forest management, an approach intended to protect and permit sustainable use of forest resources by giving use rights and protection responsibilities to surrounding villages. A comparable notion for groundwater protection and use would be to establish the hydrogeological boundaries, where possible, for all groundwater recharge areas throughout India, beginning with the areas most dependent on groundwater. Very large recharge areas would likely be most feasibly managed by a two-tier organisational structure based on a recharge-area-wide coordinating board, such as a river basin commission in the United States, and local-level management groups of users.

A third model, at least in theory, is that offered by irrigation systems, which may hold most relevant for groundwater management in terms of the technical expertise required to support local efforts. Without forgetting the value of local knowledge, institutions which facilitate the linkages between local users' groups and centralised sources of technical support may be most successful in marrying two of the most essential components of groundwater quality management: self-regulation and mediation at the local level, supported by centralised resources in the form of legal protection, data analysis, and technical services.

VI. Water Quality and Water Rights: Conclusions and Research Needs

The importance of quality has usually been undervalued in analyses of water management. As water management becomes seen in a more holistic sense, as the stewardship of a resource

which serves multiple competing, and sometimes mutually exclusive, purposes, the need for protecting water quality will be seen as integral to a system of water rights.

Just as groundwater quality management must take into account the physical features of the hydrogeological system, it must also address the institutional and sociocultural environments in order to develop feasible solutions to the problems of large recharge areas, data gaps, and individual efforts to take a "free ride" in waste disposal. Research and experience from other countries provide useful points for consideration and should not be overlooked.[28] Yet India must find solutions appropriate for it's own unique set of conditions.

It may be useful to research and analyze historical and ethnographic features to identify beliefs and practices about water rights and water quality. This would provide a basis for developing policies as well as legal and administrative institutions for water quality management which are appropriate for India's physical environment and congruent with cultural and social expectations.

28. Current research in the United States, where water scarcity in western states has forced the development of complex legal and management structures, is still asking basic questions. For example, the National Research Council's research projects on groundwater in 1993 and 1994 include studies on: 1. whether current analytical techniques have undervalued the future value of groundwater, by understating the full benefits of subsurface water or the full costs of activities that degrade it; 2. whether restoring contaminated groundwater to drinking water standards is technically feasible; 3. a re-examination of watershed management to assess factors of effective management, including impacts of nonpoint source pollution, interrelationships between surface and groundwaters, and the institutional complexities inherent in land use planning; 4. assessment of various issues in the artificial recharge of groundwater using water of impaired quality; and 5. an evaluation of the techniques for assessing groundwater vulnerability (National Research Council).

Centralised Versus Decentralized Approaches to Groundwater Management and Allocation in the Context of Overdevelopment

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ABSTRACT

The governance of groundwater resources is a universal and increasingly acute challenge for national and local jurisdictions around the world. The optimal design of groundwater management institutions will depend upon the management objectives and the physical, legal and cultural endowment of the local setting. Jurisdictions with well-developed regimes and substantial operating experience may be viewed as laboratories from which conclusions can be drawn regarding the advantages and disadvantages of various approaches with respect to specified performance criteria.

This paper is a modest subset of a much-needed, comprehensive and empirical evaluation of how various approaches perform. It draws predominantly upon groundwater management systems that have evolved in the western United States, principally in California, to illustrate how various degrees of centralization of management function correspond to the management desiderata of sustainable use and safe yield of groundwater, the ability to allocate groundwater usage through market mechanisms, the efficiency of administration and use of the groundwater resource, and considerations of social equity. The U.S. examples are emphasised because of the author's familiarity with them, because they have operated over a substantial period of time and in the face of significant political and economic challenges (and can therefore yield useful conclusions), and because they, like Indian institutions, operate within a common law tradition, perhaps rendering the conclusions more readily transferrable. The performance criteria were selected on the premise that groundwater management regimes that satisfy them will be relatively stable and durable.

The paper concludes that properly designed and delineated local groundwater management institutions consistently outperform the decentralized model, based on collateral rights among individual appropriators, and compares favourably with a highly-centralised allocation based on a state-wide permit programme, for all criteria except that the more centralised approaches are better able to foster conjunctive use of ground and surface water.

INTRODUCTION:

This paper seeks to derive, from groundwater management regimes that have evolved in the western United States, some lessons that may be useful in devising allocation and management systems in other settings also characterised by unsustainable levels of demand. For groundwater as for other amenities, allocative rules become necessary when the consequences of one person's consumption choices decrease the access or increase the costs for another consumer. That is the case, for instance, where "high extraction levels are associated with falling water tables", one of the express issues for this workshop.

Because the western United States reached this point where groundwater became "an economic good" somewhat earlier than other regions (in the 1930's in California), it has had several decades to experiment with an array of property rights concepts and management institutions. While time does not permit a rigorous or exhaustive comparison of the advantages and disadvantages of these approaches, some more casual observations are presented herein with respect to certain performance criteria that would be expected to be of universal pertinence to the design of resource management institutions: *sustainability* (do the rules prevent or discourage present consumption at the expense of future use?), *transferability* (do the rules foster relatively free market transactions to allocate the resource according to highest economic uses?), *efficiency* (do the rules maximise benefits relative to costs?), and *equity* (are the differentials in the distribution of the amenity generally viewed as "fair" and defensible?).

APPROPRIATIVE AND CORRELATIVE RIGHTS:

In general in the western United States (and rather uniformly throughout the world), groundwater is regarded as belonging in the first instance to the state or the people at large. For instance, in California, the Water Code provides:

"All water within the State is the property of the people of the State, but the right to the use of water may be acquired by appropriation in the manner provided by law". Water Code §102

And, a standard water law treatise states that "[an appropriative water right is real property that can attain the status of fee simple... The right is taxable, transferrable with or without the land, and constitutionally protected at both the state and federal levels".

Individual property interests in groundwater are acquired basically through the rule of capture, and as an incident of the ownership of the overlying land. But the amount and rate of extraction is governed by the correlative rights of other users with certain preferences being recognised. Correlative rights means that any individual pumper's right to extract water is limited to the rate and amount that will not harm any other pumper drawing from the same groundwater basin. In theory, that usually means that the right to extract is limited to the safe

yield (the long-term recharge rate) divided by the number of pumpers using the resource. In practice, the matter is much more complicated by issues having to do with the depth and spacing of individual wells. The rules are enforced, as other encroachments on real property rights, through demonstrations of actual injury in a court of law. The enforcement barrier is quite high in that the proof depends on hydrogeologic interconnections that are expensive to ascertain and demonstrate. Considerable impairments of rights will be tolerated before an aggrieved party will find it worthwhile to pursue a remedy.

That is one reason why the actual allocation of the resource will often be governed more by the preference rules than by the correlative use rule. The preference rules fall into a hierarchy which will vary from one jurisdiction to the next. Colorado, for instance, is a state that administers its groundwater with an unusual degree of hydrologic reality. Unlike most other western jurisdictions, Colorado law recognizes that surface and groundwater are not discrete resources but are often intimately connected. Thus, its allocative rules distinguish between groundwater that is tributary to surface water and groundwater that is non-tributary. Tributary groundwater is subject to the same allocation rules as the surface flows, namely the doctrine of prior appropriation. Under this doctrine, the user preference goes to the earliest user to physically control the water and put it to a "beneficial use" (providing that use is maintained thereafter and not abandoned). Beneficial uses include virtually any economic use, domestic water supply, or even instream uses such as fishery maintenance or recreational uses.

California preference rules basically work as follows: Overlying landowners have the first and best right to pump their groundwater, but this right is limited to the amount of water that is put to "reasonable use" for some beneficial purpose. With respect to each other, overlying owners had correlative rights and would share proportionately in water supply in water supply reductions in the event of shortages. In cases of groundwater basin adjudication, the court "equitably apportions" the available groundwater among the landowners overlying the aquifer. Surplus water, beyond that which is reasonably necessary for use on the landowner's property, is available to be appropriated for use elsewhere on the basis of temporal priority where the user who is first-in-time is first-in right. Reductions in water use are imposed in reverse order of seniority. Those who import water for groundwater recharge, as in a conjunctive use programme, have the preference right to withdraw that imported water, either for overlying uses or for export, irrespective of the effect on water tables or whether the aquifer is in overdraft. A final complication is the doctrine of "prescription" which essentially confers a property right in groundwater upon a user who has openly pumped the water for a period of five years or more and has developed a reliance on its availability, irrespective of whether that pumping was legal and pursuant to right. Thus, established uses ripen into enforceable rights over time. The principal limitation on the prescriptive right is that it does not attach in cases where the water has been pumped to the detriment of a public agency such as a municipality or an agricultural water district.[29]

29. Unlike California, most states, particularly those with centralised permit systems, have rejected this principle of acquisition due to their need "to estimate with some certainty the availability of unappropriated water; the possible existence of prescriptive rights make it difficult to do this". [Tarlock p. 5-99-5-100]. In California, "for prescriptive rights to be effective enough to oust an overlying owner or an appropriator, they

MANAGEMENT BY LOCAL WATER DISTRICTS

Local water management entities in the western United States take many forms. The forms described in this paper are the California Water Districts, which are governed by the irrigators whom they serve with voting power weighted according to acreage, and the California Irrigation Districts, which are governed by popular franchise within their service areas. These districts are quasi-municipal corporations, chartered by the legislature and are considered agencies and instrumentalities of state government for purposes of many statutes which empower and impose duties on state agencies, including notably the California Environmental Quality Act which requires public agencies to assess the environmental consequences of their actions before undertaking them. These districts, in the main, deliver surface water supplies contracted for from either the U.S. Bureau of Reclamation's Central Valley Project or the State of California's State Water Project. Water from these projects is delivered to a total of about 60 active water agencies responsible for various forms of water distribution and management. These projects are initiated and operated in a coordinated fashion. Together, they comprise the largest irrigation water development project in the world, delivering some 10 million acre feet, equivalent to 14 thousand million cubic meters (1.4×10^{10} m^3), of water on an annual average. These districts are featured not because they manage or deliver groundwater in California -- with rare exception they do not -- but because their form and structure are well developed and easily adaptable to groundwater development and allocation. They represent, in any event, the quintessential example of a local water management entity in the United States, organized, governed and financed by the farmers whom they serve.

In general, districts are organized as public corporations, and are empowered to levy taxes and obtain private property through eminent domain when required for legitimate district purposes (Frederick, et al., 1982). They are responsible for contracting with State and Federal water supply agencies, and may also be responsible for securing water rights. Districts range from small organisations of farmers with each district resident of voting age given voting rights, to limited corporate owners with vast tracts of land and voting rights granted on the basis of property ownership.

For example, the Central California Irrigation District contains over 1800 different farmers with equal representation (dependent upon resident status). In contrast, in 1979 the Westlands Water District was reportedly controlled by only four or five large owners, and in the Tulare Lake Basin Water Storage District a single corporation had dominant control of all elections and management decisions (DWR, 1979).[30]

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must infringe upon these rights in the traditional open, notorious and hostile manner for the requisite term.[five years]. This means that as soon as a lowering of the common water table is observed, the pumpers are put on notice that an overdraft is occurring and they should initiate legal steps to protect their interests."[Robert E. Beck, ed. Water and Water Rights, p. 211]. It should be noted that as of 1980, prescriptive rights can not be acquired against the state of California itself. [Tarlock p. 5-100].

30. Many of the larger water district landholdings have been gradually divested during the past five years in response to acreage limitations for receipt of low cost federal water set in the 1982 Reclamation Reform Act.

CENTRALISED GROUNDWATER MANAGEMENT THROUGH STATE-WIDE PERMIT SYSTEMS:

Centralised groundwater administration regimes have in common a unitary process for conferring and monitoring rights to extract water through the issuance of permits defining rates and timing. The regimes vary, however, with respect to the management objectives and criteria employed. For example, Arizona's permit system is designed principally to stabilize groundwater levels after a history of overdrafting. Thus, it principally governs (and reduces) already existing groundwater pumping under a rule of reasonable use. Reasonableness of use is an increasing demanding standard as water conservation criteria are articulated by the central permitting authority. In other jurisdictions, such as Colorado or New Mexico, the principal purpose is to systematise and prioritise future appropriations of groundwater as an adjunct of the surface water permit system, which is also governed by the doctrine of prior appropriation.

Under the Arizona model (management of groundwater overdrafts), the state is divided into management areas corresponding with groundwater sub-basins, each with its own director. Additional management areas can be created by the central authority or through initiative by local interests. The management goals are expressed as a timeline for achieving safe-yield, defined as long-term balance between annual withdrawals and natural and artificial groundwater recharge. The director of each management area is to promulgate management plans to achieve those goals after public hearings. In general terms, these management plans require the director to impose increasingly stringent mandatory conservation measures on all groundwater users within the area. In the event the management plans do not prove sufficient to meet the conservation goals, the director is empowered to purchase at fair market value (and retire) water rights for irrigated lands. The purchases are financed out of pump taxes on all persons withdrawing water within a management area. Domestic wells below a given threshold are exempt from the management programme and the fee, except that they like other wells, are required to register. In addition to recognising pre-existing pumpers, this regime also issues permits to seven types of groundwater withdrawals for industrial and mining purposes, in cases of poor water quality or for drainage reduction.

The approach in other western jurisdictions, such as New Mexico and Colorado, is to declare basins having "reasonably ascertainable" boundaries, and then issue permits for new appropriations based on findings that previous users (of either groundwater or surface water) will not be injured. Notice of the application for a permit is published in local newspapers and existing rights-holders have the opportunity to file protests. In the event of a protest, the applicant has the burden of demonstrating to the centralised permit authority that the requested groundwater use will not unreasonably interfere with the existing water rights. That proof can require complex and expensive hydrogeologic evidence.

However, several investigations have found that many apparent divestments are simply paper reorganizations which continue to be operated collectively as single large farms (GAO, 1989; NRDC, 1989; Villarejo and Redmond, 1988). New legislation has been introduced in the U.S. Senate to close the loopholes which have permitted acreage limitations to be exceeded (Bradley, S.2658 and S.2659, 18 May 1990).

Although centralised water management regimes differ in terms of objectives and permit criteria, the basic feature common to all such systems is that the state agency operating the regime is granted sufficient political power to implement and enforce its allocation decisions (Smith, 833). The responsible state agency is given the power not only to issue permits and establish criteria, but also to resolve conflicting claims, bring suit against violators, condemn property, and import (purchase) water from outside the district. Such powers are not merely implied, but rather are granted expressly in the enabling legislation.

Additional safeguards must also be incorporated to ensure that the responsible agency does not fall prey to corruption. The temptation of interested parties to improperly interfere with both the fact-finding and decision-making process must be addressed in the enabling legislation. These rules usually focus on avoiding employee's conflicting interests, requiring open hearings, and punishment for persons (both inside and outside the agency) who violate these conduct provisions (World Bank Paper #458, 133).

The United States' experience with centralised water management regimes indicates that such regimes have fairly predictable advantages and disadvantages. The advantage of the centralised approach is that it allows decisions to move beyond immediate local interests. The empowered agency can base its allocation programme on the interests not only of the local economies, but also of the public at large, future generations and the environment. These interests might be inadequately represented, or even missing, in a less comprehensive and structured allocation system.

The most significant disadvantage of the centralised model is the administrative and bureaucratic apparatus necessary to operate such a regime. A centralised water allocation system requires a professional staff of trained experts (in areas such as economics, law and hydrogeology) as well as an understaff to retrieve and compile facts (Lee, 607). Without such human resources, the responsible agency will be unable to make informed decisions. In choosing a groundwater management model, a state must determine whether it can provide the funding and personnel necessary to effectively implement a centralised regime.

FACTORS FOR COMPARATIVE EVALUATION:

SUSTAINABLE USE

Groundwater basins can be managed either as renewable or as exhaustible resources. In other words, groundwater may be managed to preserve the basin by balancing extractions with recharge over time or to mine the basin so that it is eventually depleted. The western states have occasionally decided that it was necessary to mine certain basins for short term stability and growth, but this is not a wise policy in the long term, particularly in the absence of some assurance that the groundwater source will be replaced by new, stable surface supplies when the basin has been depleted.

In evaluating the degree to which management approaches along the decentralized-to-centralised continuum foster sustainable use of groundwater, reference may be made to three interrelated considerations: (1) how successful is the approach in avoiding overdrafting of the aquifer(s)? (2) what is its ability to generate the information on the use of the resource that is critical to sustainable management decisions? (3) how well does it foster the conjunctive management of groundwater and surface resources? Each of these will be explained briefly.

Overdrafting of groundwater basins is generally considered the measure of unsustainable use of the resource and is the probable result of unrestricted or unmanaged usage. It results wherever withdrawals exceed natural or artificial recharge over the long term. Short term variations in water table levels are expected as a result of natural fluctuations in precipitation from year to year and become purposeful when the aquifer is utilised as a storage structure in a conjunctive use modality. Thus, the most effective system may involve depleting the basin below optimal levels in dry years and recharging it above the optimal level in wet years. Active recharge occurs when water is imported to maintain groundwater storage; it is passive when recharge is accomplished through the ordinary percolation of surface waters, such as from tributary groundwater. Managing a basin to preserve it over time may mean that growth will be more limited, but it ensures that there will not be an abrupt disruption of supply in the long term. Basin preservation also avoids effects associated with mining such as land subsidence, loss of wetlands, and salinity intrusion.

Long-term sustainable management of a groundwater basin requires that some entity -- the pumpers themselves, courts, regulatory bodies, local management districts, or permitting authorities --makes decisions on an ongoing basin regarding timing, volume, and location of groundwater extractions. These decisions can be made best only if based on information regarding pumping rates, recharge rates, surface-groundwater interactions, basin size and boundaries, hydrostatic pressures, potential sources of contamination, etc.

Often what is regarded as a water scarcity crisis is in reality a water management crisis. One management innovation that can alleviate scarcity and promote supply reliability is conjunctive management of surface and groundwaters. Conjunctive use is simply the coordinated management of ground and surface waters to even out the inter-annual variations in precipitation and thereby provide a more reliable water supply. Basically, underground basins are used to store water generated in years of above average runoff for use in years of below average runoff, just as a surface reservoir is utilised. Indeed, surface storage is usually a necessary part of a conjunctive management programme since the water must be stored during the periods of heavy runoff for "spreading" or percolation into the groundwater basin during drier periods when the soil is not already saturated. During wet years, all users rely primarily on surface supplies and store the excess underground. In drier years, the stored groundwater is pumped to supplement the inadequate surface supplies. Thus, groundwater is actively recharged and the sustainable use or safe yield rates are substantially augmented.

Conjunctive use must be understood as a purposeful strategy of coordinated use of developed surface and groundwater. This is to be contrasted with the common scenario of

excessive groundwater mining eventually creating a political mandate for large-scale surface water development to "bail out" the groundwater users. These types of projects are generally so expensive that the groundwater users cannot afford to use this substitute water supply unless the costs are heavily subsidized, as was the case with virtually all of the reclamation projects during the past 90 years in the United States. These projects are usually further subsidized through very large and uncompensated costs to the aquatic and riparian ecosystems. The extent of these costs is nowhere more graphic than in the Pacific region of the United States where the salmon fishing industry is on the brink of collapse as virtually every anadromous fish stock has been declared to be on the brink of extinction. The most important cause of the declines in these populations is irrigation water dams and delivery projects that were made necessary by historic patterns of unsustainable use of groundwater in the arid western states. The economic and environmental costs of this bail out scenario are believed to be much higher than the costs of a well-managed, sustainable, conjunctive use programme.

A conjunctive use programme is most likely to work optimally in an institutional environment with the following features:

- Legal: a system where rights and entitlement are predictable and easily enforced. Particularly, it is essential that the recharge and discharge of water from the groundwater basins be subject to central control and administration. It is also important that the rights system protects the ability of the entity that recharges aquifers to extract that water.

- Supplemental water supply: to augment yield, conjunctive management must store water that is not now controlled. Conjunctive use programmes must be entitled to replenishment water at a time and in a manner that permits recharge. Thus, conjunctive use programmes need to be structured to make better use of existing surface storage.

- Benefit streams: A water pricing scheme that assures financial (or water supply reliability) benefits for the cooperating overlying landowners as well as other programme beneficiaries.

- Insurance against hydrogeologic uncertainties: Good information is needed regarding groundwater hydrology so that reliable estimates can be made of the safe yield of the groundwater basins. Some groundwater managers may decline to participate in conjunctive use programmes unless they are assured that any resulting net depletion of groundwater will be replenished without undue cost to them.

A. Decentralized

As long as groundwater is plentiful, a decentralized system can work satisfactorily because there is little need to manage and allocate groundwater. The cost of setting up some kind of management institution is not justified in the absence of any noticeable depletion of the water supply. However, where groundwater is scarce, as in California, the decentralized system may result in significant overdraft of groundwater basins and related problems such as

salinity intrusion and land subsidence. These problems are often very serious because overlying owners fail to become sufficiently concerned about them until the basin has reached a critical state. (de Lambert, p. 373)

Unless rights are defined and limited through agreement or adjudication, a decentralized system does little to prevent overdraft or encourage conservation. Water users have little incentive to voluntarily undertake such measures because they have no assurance in a system of undefined rights that their efforts will benefit the basin as opposed to other water users. There are few legal or institutional limits on the rights of overlying owners to pump groundwater. While overlying owners must use groundwater reasonably and avoid harm to other overlying owners, the "reasonableness" standard tolerates substantial inefficiencies and it is usually difficult to judge when use begins to harm other owners in the absence of clearly defined rights and well developed information concerning extractions from the basin. Because of the costly and difficult hydrologic proofs required to demonstrate the fact and extent of injury, the threshold of injury is rather high before remedies will be sought.

The preference rules help to some extent. Water exporters (those using groundwater off of the overlying land) may be relatively easy to curtail because they enjoy the lowest priority and can therefore be curtailed by any of the overlying landowners, and water importers are protected because an importer of recharge water has first call on its extraction, there are at least no disincentives do so. However, a conjunctive use programme will generally shy away from use of a critically overdrafted aquifer because of the exorbitant costs of retrieving the stored groundwater.

A prerequisite to management and control of groundwater is the ability to measure groundwater pumping at particular wells. Yet, in a decentralised system, it is essentially impossible for one landowner to force another to monitor and report groundwater use. The individual water users within a decentralized system are also unlikely to have the means or the interest necessary to obtain sophisticated information concerning the characteristics of the groundwater basin, unless water users voluntarily join together to address the problem of water scarcity. Thus, where water is sufficiently scarce, water users in decentralized systems may seek adjudication or negotiation of their rights as a means of developing the information necessary to effective management of the groundwater basin.

In a number of areas in California, judicial solutions have been fairly successful in restoring the basins. In a water rights adjudication, a court establishes a physical solution to the overdraft problem by obtaining information about the groundwater in the basin, defining and limiting the water rights of all the users of the groundwater basin, and setting up a "watermaster" to administer the judgment. The court retains jurisdiction to amend the judgment in future if additional issues arise which the watermaster cannot address.

The watermaster can be a person or a committee of persons who are experts in water issues and possibly representatives of different water use interests in the basin. The most effective basin adjudications are those where the watermaster has broad, flexible powers to

administer the judgment and address situations as they arise. Watermasters generally have the power to require pumpers to file periodic reports, levy a pump tax, replenish water in an aquifer, import water for spreading and replenishment of aquifers and control storage within the basin. (Murphy at 34; Mallery, p. 1294) The watermasters do not usually work in isolation; they must coordinate with a number of state and local agencies to address issues of water supply and demand for the basin users. With sufficient powers and flexibility, watermasters have been successful in eliminating overdraft problems in groundwater basins by limiting demand and obtaining supplemental surface supplies with fees paid by the groundwater users.

Nevertheless, it should be noted that a court does not examine water problems comprehensively, but confines itself to the rights of the parties before it. It does not consider the interests of other right holders, the general public or the state in the management of the scarce resource. Moreover, by the time local water users are forced to seek a judicial remedy, the court may be loathe to reduce extractions because the local economies may have come to, depend on water than safe yield will allow. When a management structure has been created through negotiation or adjudication, however, compliance with management measures is quite good. The court generally retains jurisdiction to address any serious problems that cannot be handled by the watermaster.

Because critical overdraft of groundwater basins is likely in a decentralized system, water users in this kind of system are often forced to seek ways to increase surface water supplies. Whether they intend to or not, these water users effectively adopt a "mining" approach to the use of groundwater basins and rely heavily upon a surface water solution to arise when the basins are depleted. These supplies are necessary both as a replacement for water users who may not be able to pump groundwater anymore and as a remedial measure for the groundwater basin where there may be serious problems of land subsidence and salinity intrusion. These surface water solutions become less and less feasible over time as known sources are tapped out and contests for the remaining supplies become major battles. The cost of importing surface water is also quite high as a general rule. Conjunctive use arrangements, which may avoid the groundwater mining and surface water bailout cycle, are unlikely to emerge in a decentralized system lacks sufficient information and motivation. Individual water users will usually be unable to which determine the safe yield of a basin because they lack knowledge of the hydrogeology of the basin. They may also be unable to arrange for the recharge of groundwater unless they own lands suitable for recharge. Furthermore, individual water users have little incentive to pursue conjunctive management given that conjunctive use programmes can be very costly and no single owner has any guarantee that he will benefit from the recharge of the groundwater basin in a system of undefined rights.

If water rights have been adjudicated or negotiated and a watermaster or other authority has been appointed, conjunctive management may be more feasible. Once rights are defined, extractions can be controlled and the basin fully managed. Courts and locally appointed authorities may lack jurisdiction to order or facilitate interbasin transfers of surface water that may be necessary to implement a conjunctive use programme. (de Lambert, p. 384) However, such mandates will be unnecessary if a well-developed market transfer system is in place.

In an adjudicated basin, water users are much less likely to rely on surface water bailouts. Courts solutions in California have generally attempted to limit the demand of all water users so as to gradually restore the basin. However, watermasters have sometimes sought surface water supplies to aid in their management of adjudicated basins.

B. Local District

Management by local districts may be a less expensive and time-consuming alternative to adjudication. Local districts can control groundwater pumping by their members in several ways. Where the district supplies surface water, it can price that supply at a rate below the cost of lifting groundwater at a sustainable rate. It can also use surface supplies to replenish the groundwater. This is the technique of the Arvin Edison Water Storage District in Kern County California, for instance. The local district can also own or operate the wells on behalf of the members. Or, the local district can be vested with the power to orchestrate the pumping and recharge of groundwater by its members.

Where a local district management structure has been established by the water users, compliance with conservation requirements and other management measures tends to be quite high. In California, parties have demonstrated such a strong record of voluntary compliance of these management programmes that sanctions and enforcement measures have been unnecessary. (Blomquist, p. 302) This is explained in part by the fact that the management programmes are perceived as legitimate and fair because the districts are created and governed by the water users themselves. (Blomquist, p. 347) Individual water users also tend to believe that they are benefiting from basin management and feel confident that they are sharing the costs and burdens equitably. (Id. 302, 347) This sense is supported by the close contact between the district and the users and the readily available monitoring information concerning the problems of the groundwater source.

This harmony is a tenuous one, however. In California, the landowners have resisted direct control by the districts of groundwater use. This need not be the case in other circumstances. In theory, local districts generally have the finances and the legal authority to develop comprehensive information concerning the pumping and hydrogeologic characteristics of the basins they are managing. They can, for instance, require groundwater pumpers within the district to meter their pumps and report extractions to the district. They can also, in theory, impose limitations on groundwater pumping to assure sustainable yield, as a condition on the eligibility of the landowner to receive water deliveries. As a practical matter, however, this has not happened in California. The landowners regard their groundwater as private property and have been extremely resistant to any outside control or even monitoring. This xenophobia extends even to the water districts that supply their surface water. Since California Water Districts are controlled wholly by their member-farmers, and even the Irrigation Districts are dominated by farm interests, the districts have not sought to place any direct restrictions on groundwater use and often do not even know who is pumping how much water or when. Since the right to receive a specified share of the district-supplied surface water is a contract right,

the districts have not been able to place groundwater management preconditions on the provision of surface water.

This managerial impotence is, however, an artifact of the way in which the California districts are established and governed, and not a necessary attribute of the district management model.[31] Districts could certainly be formed under an arrangement where eligibility to receive water from the district was contingent upon the farmer/landowner agreeing to reasonable controls on the extraction of groundwater. Indeed, NHI is currently defining a conjunctive use programme for California in which the right to receive recharge water (above current entitlement) would depend upon a contractual agreement permitting the district to orchestrate both the recharge and discharge of the supplemental water.

There are also several notable cases of groundwater management districts in Southern California achieving a high level of success in imposing monitoring and reporting requirements on groundwater pumpers. However, these are districts with relatively few member-pumpers, and most of these are municipalities where long-term reliability of supply is a very high priority. This information reported is quite detailed and accurate because the districts work closely with the water users. (Blomquist, p. 344) The primary deficiency may be a lack of information on the hydraulic interconnections among basins and districts.

The primary limitation on the ability of local districts to effect sustainable use of groundwater is that district boundaries often reflect political considerations rather than the hydrogeologic boundaries of the groundwater basins on which they draw. The result, of course, is that individual districts act like individual landowners drawing from a common resource. The incentive is to capture as much as possible before the neighbouring district does so. While this can be controlled through contractual arrangements among districts, it is more readily controlled through a groundwater permit system administered by an authority superior to the individual districts.

Another weakness of local districts in terms of promoting sustainable use is that they are more easily pressured by the water users they serve to avoid limitation on extraction. An important element of the management systems adopted by most local districts to date has been use of a supplemental surface water supply, particularly in agriculturally-dominated basins. The most extreme example of this is the Orange County Water District which has made no attempt to limit demands on groundwater but rather has purchased whatever additional surface

31. In 1977, the Governor of California created a Commission to review California water rights law. Based on this review, the Commission recommended the formation of local management units in areas where groundwater was not already managed through adjudication or local districts. The Commission further recommended that these units should have powers similar to those exercised by many existing districts and court-appointed watermasters. Finally, the Commission recommended that a central state agency should have authority to evaluate and approve local management programmes and to seek judicial relief through the attorney general in the event local programmes failed to meet broad, state-management objectives. (Smith, p. 241) These recommendations suggest that the system best able to promote sustainable use may be one that uses elements of both the local district and the central agency approach.

water supplies are necessary to recharge the groundwater basin. This programme has been successful to date because additional surface water has been available for purchase. However, this approach is not advisable in the long run as it merely transfers water management problems from one region to another. If surface supplies are not available or become more limited in future, some districts will have to revise their management strategies. (Mallery, p. 1292)

In California, local districts generally have the power to establish a conjunctive use system. The problem is that the boundaries of the local districts may not coincide with those of the groundwater basin, making it difficult for them to operate an efficient basinwide conjunctive use programme. This problem might be addressed as an initial matter by setting up districts with boundaries that correspond to groundwater basins. Local agencies that already exist may enter into contractual arrangements to jointly run a basinwide conjunctive use programme. However, the transaction costs involved in joint management of a basin between assorted local districts may be high, and the success of such joint management arrangements has not yet been tested seriously. A better solution might be to create an overarching state agency with the power to organise and mandate conjunctive management by local districts. (See Krieger, p. 75)

C. Centralised

As a general proposition, groundwater is more likely to be used sustainably under a more centralised management structure. Groundwater permit systems are structured specifically to assure sustainable use of the resource over the long term. Analysts contend that a centralised state management system is better able to protect groundwater basins because the state is less constrained by contractual and fiscal considerations than are the local water districts. The remoteness of a central agency from the demands of particular areas or water users also makes a central agency better able to resist short term pressures to exploit basins and allows the agency to take into account the broader water situation of interrelated basins and the state as a whole. A central agency can also construct large projects more easily and import water more efficiently to overdrafted regions. (Mallery, p. 1293)

In a centralised system, voluntary compliance is less likely because water users are more remote from the management structure. This means that they are less likely to be convinced that the system is responsive to their interests, that they are benefiting from it, or that others will fairly share the sacrifices. A central agency must rely more heavily on enforcement and sanctions to ensure compliance. However, the agency may be slow to discover violations because it is more difficult for a remote central agency to monitor activities closely. To increase effectiveness, a central agency might seek assistance from local agencies and/or institute citizen suit provisions designed to encourage citizens to become enforcement watchdogs.

A centralised agency may have the power and the finances necessary to develop general information on basins and pumping, but it is less likely to be motivated and able to develop extensive and comprehensive information on every basin within its jurisdiction. Large systems

have more difficulty in collecting, acting upon and communicating information, especially about complex problems, and they are more vulnerable to information losses. (Blomquist, p. 344, 350) On the other hand, a central agency may be more motivated to investigate the relationships between basins and the impacts of pumping practices across different areas.

A centralised agency should be well situated to manage a conjunctive use programme taking into account long-term management opportunities. Unlike local districts, a centralised agency is not constrained by boundary problems. All groundwater basins are within its jurisdiction. Moreover, if surface waters are already regulated by a centralised agency, some argue that it makes most sense for the same agency to manage groundwater since these are interrelated resources. (Mallery, p. 1307) On the other hand, setting up and managing a conjunctive use programme for all the basins in a state might be a burdensome undertaking for a single agency, leading to unnecessary delays and poor responsiveness to changes in circumstances. Providing for input from local agencies might alleviate these problems, but would probably not eliminate them.

Centrally administered water management is best suited to foster conjunctive management of surface and groundwater with respect to all the considerations described in this paper. Where use of water is defined by permits, the rights and obligations are prescribed and can, as necessary, be adjusted. The use of water for groundwater recharge can be accorded as an appropriate preference in the issuance of surface water permits. Basins for storage can be designated and used without restricting the benefits to the overlying landowners. And, the state authority can take steps to either eliminate the hydrogeologic uncertainties associated with basin boundaries and their hydrologic inter-connections, or provide mechanisms for spreading the costs and risks associated with the residual uncertainties. A centralised authority can, for instance, assess a pumping tax on all groundwater extractions and use the funds to generate recharge water (by, for instance, financing water conservation improvements, retiring marginal irrigated lands, or creating surface storage reservoirs).

For the same reason that a central agency is well situated to promote sustainable use, it is likely to avoid reliance on surface water bailouts. A central agency is not subject to such immediate pressures from particular water users with depleted groundwater supplies, and must consider the effects of surface water importation on the areas from which the water is taken as well as the area to which it is supplied. Thus, a central agency is much less inclined to turn to surface supplies as a remedy for overdraft except insofar as they can be used to set up an effective conjunctive use programme.

TRANSFERABILITY

This section examines the degree to which the rights created in the groundwater resources under the various management approaches foster or inhibit the transfer of groundwater from the person or entity that pumps it to the broader array of users, generally remote from the land holding on which the tubewell is located, who depend upon it. Thus, we take maximal transferability to be a virtue in achieving the greatest beneficial use of the groundwater resource. It

also notable that a developed water market tends to place a relatively high value on groundwater that reflects its relative scarcity. This creates financial incentives to use the resource efficiently compared to the situation where water users may not be placing an appropriate value on the water they use because they either receive it for free, pay a subsidized rate for it, or use more than they need. If wasteful users could sell quantities of excess water, they would realize that wasted water is wasted money. (Gregory, p. 249) Similarly, water users may decide that the value of selling their water is higher than their intended use of the water. The sale of this water is efficient in that which transfers the water to a use with greater economic value.

There are some threshold issues to consider in setting up a market-oriented approach to distribution of water. Although a market system should ensure that water is used most efficiently for the highest valued uses, the transfer to efficient, highly valued uses may be politically problematic. For example, rural communities where prosperity has depended on the availability of large supplies of low-cost water might be faced with a declining economic base. This result may be equitable and logical from a market standpoint, but it may be disruptive to the extent that it causes serious social change. (Murphy p. 43) If such changes are politically unacceptable, a market system is probably still recommended, but protections or subsidies of some sort may be necessary for certain groups who will not be able to afford the new water prices.

In order for a groundwater transfer system to function properly, rights to groundwater must be well defined and enforced. Indefinite rights have little appeal to potential purchasers. Another important requirement for a successful groundwater transfer system is a method of preventing unreasonable impairment of the rights of others who may be affected by the transfer. In the absence of formal limits on the effects a third party must endure, the market commodity is not as well defined as it can be. (Emel, p. 654). It is interesting to note here that the worst cases of overdevelopment in the United States have occurred in states using the "reasonable" impairment approach as opposed to formal rules setting forth more specific limits on third party impacts. (Emel, p. 671, n. 60)

A. Decentralized

Unless rights are clearly defined through adjudication or agreement, a transfer system is unlikely to be successful under a completely decentralized groundwater rights system. Water users in such a system know only that they have the right to reasonable use of the basin without specific quantification of how much use is reasonable. Moreover, water users in a completely decentralized system are unlikely to have the means to evaluate the effects of transfers on third-parties. Finally, in a system such as the one in California, transfers to non-overlying owners are prohibited unless there is "surplus" water in the basin (i.e. water not needed by other overlying owners). These conditions greatly inhibit a water market.

Once rights in a basin have been determined through adjudication or negotiation, a transfer system becomes more feasible, although courts in the United States have been somewhat

leery of water "speculation." The watermaster or other administrative body can gather the data and apply the models necessary to evaluate the hydrologic responses of proposed pumping scheme changes. Presumably, an overlying owner could even transfer his right to a non-overlying water user as long as this transfer did not impermissibly impair the rights of other water users. However, when basins are locally managed transfers out of the basin are likely to be discouraged or prohibited, limiting the effectiveness of the overall market transfer system.

Some analysts assert that a decentralized, privately run water market will threaten both environmental quality and the rights of non-urban constituencies by ignoring the non-economic values of water. The transfer of water under a decentralized system may redistribute water to those most able to purchase it without necessarily taking into account communal values, traditional cultural patterns and other factors that may not be represented in the water market. In other words, there may be tradeoffs between efficiency and equity.

It may be possible to avoid these problems in a decentralized water market system by establishing public interest provisions regarding water rights transfers in water codes or constitutional provisions. This may be done by placing the burden of proof upon the applicant for a water transfer to demonstrate that the transfer is in the public interest or that other factors outweigh public interest concerns. (Cummings p. 750-1)

B. Local District

The operation of a transfer system under the management of local districts should be quite similar to systems administered by local watermasters or other locally appointed authorities. The rights of water users in a local district should be known and easily transferable within the basin. The local district generally has powers which enable it to set up a transfer system to reduce the transaction costs involved in the functioning of the market. For example, the district may set up a "common pool," gather information identifying interested buyers and sellers and assist in the recording and oversight of the transaction. Local districts also have the information necessary to assess the impacts of particular transfers on the basin and third parties and the power to prevent unreasonable impacts or infringement on the public interest.

The primary shortcoming of the local district system, like the adjudicated system, is that it may tend to interfere with transfers outside the basin. Local districts represent the interests of local water users who benefit from return flow and recharge when water is used on lands overlying the basin. Local districts are likely to protect these interests unless prevented from doing so by state laws or a state agency with oversight powers in this area.

C. Centralised

A centralised agency is least likely to place protectionist restrictions upon a market transfer system because it is charged with responsibility for state rather than local water management. A centralised agency may also have greater financial resources enabling it to assist transfers of large amounts of water which otherwise might be prohibitively cumbersome

and costly. Additionally, a state-wide agency faces less legal obstacles than a more limited regional agency. A regional transfer decision could be challenged on the grounds that the regional agency lacks authority to manage resources outside its limited jurisdiction. A similar state-wide agency transfer, however, would be immune from such a challenge. Its jurisdiction, by its very geographic nature, is more far-reaching and thus less susceptible to attack.

On the other hand, a centralised agency might be less able to efficiently assist local transfers within particular basins throughout the state. The agency would be removed from the context of local communities, and therefore would be less aware of the specific needs and dynamics of the parties involved in the proposed transfer. This could result in a knowledge gap and a subsequent lack of responsiveness. Thus, while the centralised agency possesses the legal power to make water transfers less cumbersome, it may lack the regional sensitivity to make such transfers beneficial and responsive.

ADMINISTRATIVE EFFICIENCY

This factor has two aspects. One is the simplicity, predictability, affordability and enforceability of the management and allocation decisions. The ideal is a system that can be understood and used by any potential beneficiary, regardless of sophistication, at minimal transaction costs (i.e. without lawyers and hydrologists, if possible), where the decisions are transparent and reliable without the necessity of intervention by courts, and where the decisions will be enforced without elaborate administrative or judicial processes.

The second aspect concerns how accurately the administrative decisions reflect the physical realities. A groundwater management programme is not administratively efficient if it complicates surface water administration or environmental management decisions because it fails to appreciate the interconnections. When surface and groundwaters are interdependent, a management programme recognizing this relationship may achieve optimum beneficial use and conservation of both sources. Similarly, when groundwater basins are interdependent, a management programme must take this into account for optimum use and protection of the water. Finally, good management should account for the relationship of pumping in one area of a basin with pumping in other areas of the basin.

A. Decentralized

The decentralized system is the simplest from an administrative standpoint and the one that relies most heavily on the judiciary to resolve the problems that arise. Where water is plentiful, the simplicity of this system is attractive because disputes should be rare and the savings in time and money spent on administration is substantial. However, where water is scarce, the merits of this system are questionable.

Heavy reliance on the judiciary is problematic for a number of reasons. First, parties are not often spurred to action until basin overdraft becomes a serious problem. By that time,

equitably reducing allocations by adjudication is very difficult because economic damage is likely to be substantial. Second, a great number of necessary parties make consensus difficult to obtain and cause the litigation to be lengthy, complex and expensive. When the number of water users in a basin is large, it may be virtually impossible to join them all. Interested parties may also be excluded by oversight or objection and, therefore, may not be bound by the judgment or stipulation. Third, the rules of court may not be well-suited to groundwater adjudications. Overdraft presents the possibility of immediate and irreparable harm, yet the complexity of groundwater litigation makes adjudication lengthy, cumbersome and expensive. Fourth, an adjudication is limited and local in nature. A judgement cannot decide issues that the parties to a case do not raise, and may not reflect sufficient concern for overall management of state resources. (de Lambert, pp. 389-90) Finally, reliance on the judiciary may be problematic in a state where the judiciary is politicized or lacking in objectivity.

Nevertheless, parties willing to endure the time, expense, and limitations of litigation have adjudicated basin rights and set up effective management systems in California. These management systems are fairly simple from an administrative standpoint and inexpensive to administer once the litigation is completed because voluntary compliance levels are high and the watermaster or administrative committee is close to the water users. The court retains jurisdiction to address issues if necessary.

When rights are litigated, the court hearing the case must perform a fairly comprehensive investigation of the hydrogeology of the basin at issue in order make a rights determination that will lead to sustainable basin management. However, a court will not usually investigate the interrelationship of a litigated basin with other basins or the general water situation in the state. Thus, management in an adjudicated basin may take into account hydrogeologic realities within a basin, but not much beyond this.

In a decentralized system such as that in California, percolating groundwater is not generally recognised as being interconnected with surface water. Surface water and groundwater are not even managed under the same legal system. Nor is there much information or awareness of the relationship between groundwater basins or even the effects of pumping within a single basin. An overlying landowner may withdraw percolating groundwater without regard to, and usually without knowledge of, how this affects surface water users and other basin users. If there is a notable connection and impact, a dispute may arise, and a court will attempt to devise a physical solution.

B. Local District

The administrative complexity of a local district system is similar to that of a system where a water master or other authority oversees an agreement reached through negotiation or adjudication. A certain level of bureaucracy is necessary to the function of any such institution, but local districts are smaller and less inhibited by bureaucracy than a large centralised agency. Most significantly, the local districts are governed by a board representative of the

members to which they deliver water and therefore immediately responsive to their needs and preferences. They can also adapt their programmes to address geological, hydrological, and political differences in their basin.

In California, local districts may be more administratively complex than they need to be because they have developed on an *ad hoc* basis and because they have been tailored specifically to mesh with the different water management or supply institutions already in place in their areas. However, they have been fairly successful and economic in their function; water users have a significant incentive to devise management systems that are not wasteful or inefficient because they bear the costs of operation, as they do in local districts. (Blomquist, p. 343) They may also be less reluctant to pay management costs and more willing to comply with restrictions imposed by a local district or adjudicated system that they have been instrumental in establishing, resulting in significant savings in administrative time and expense. In fact, at least one analyst asserts that the overlapping, polycentric systems developed in California reflect efficient functional specialization rather than wasteful duplication and chaos. (Blomquist, p. 341)

A local district system does not rely on the judiciary for the basic rights determination and information gathering needed in a decentralized system. The local districts have the power to undertake these tasks themselves, although parties may still demand recourse to the courts in some cases. Recourse to the courts is also necessary to resolve disputes between local districts unless a central agency is empowered to resolve such disputes in an oversight role.

Like a court, a local district generally limits its investigation of hydrogeology realities to the basin for which it has responsibility. A district may investigate interrelationships with other basins to the extent that use in those basins is negatively impacting its own basin, but otherwise it has little interest in such information.

C. Centralised

A centralised system is likely to be highly complex from an administrative standpoint for many reasons including the fact that the task of administering a management programme for all groundwater basins in the state would be enormous. It is also well known that central agencies with broad powers tend toward bureaucracy and conservativism, resulting in general delay and resistance to taking action or changing policy. Further, studies show that central agencies tend to develop their own agendas, distinct from the mission entrusted to them, based on a desire to survive and expand as an institution. (Anderson, p. 158; Ostrom, pp. 36-37). The expenses involved in running a central agency almost always escalate over time as the agency follows a natural course of expansion and specialization.

These tendencies are problematic where dynamic and innovative management is needed, and is perhaps the most important reason to resist complete centralization of a groundwater management system. On the other hand, some centralised control is beneficial because a central agency is generally more balanced in terms of its consideration of local and statewide

interests and provides broader long-range planning. A centralised system is also least reliant on the judiciary, given the power to resolve many conflicts that would otherwise be taken to court. Ultimately, however, a central agency must rely on the judiciary for the enforcement of its orders if they are disputed.

A central agency is much more likely to take an interest in investigating basin relationships and general interaction between different water supplies throughout the state because it is responsible for statewide management. Moreover, a central agency will have better resources to undertake such investigations. With respect to individual basins, however, a central agency may be less interested in generating detailed information on the hydrogeologic realities which are of much concern to local districts.

Many states with centralised water management regimes have attempted to bring their laws into conformity with the hydrogeologic "realities" discussed above. Foremost among such attempts is the integration of surface water and groundwater management. Many sources of groundwater are fed directly or indirectly by surface waters. Thus a diversion or reduction of surface water will have an impact on the level or flow of groundwater and *vice versa*. Despite this close interrelationship, most states subject surface water and groundwater to independent, and often irreconcilable, management schemes. (Gregory, 257). Colorado is among the first states to address this concern.

Colorado recently enacted legislation which distinguishes between "tributary" groundwater (fed by surface water) and "nontributary" groundwater (not fed by surface water). Under the Colorado approach, tributary groundwater is governed by the same rules as surface water, while nontributary groundwater retains its distinct management rules. Such an approach is welcomed for two reasons. First, by bringing the law into conformity with existing natural systems, it will no longer struggle to force square pegs into round holes. Allocation decisions, for groundwater and surface water alike, will more accurately reflect scientific realities. Second, by integrating the two allocation and agency apparatuses, the state will improve administrative efficiency.

The best way to obtain the benefits of centralised control while minimising the problems of bureaucracy may be to create a system that relies principally upon local districts for day to day management but places certain limited powers in the hands of an overseeing central agency. These powers would be focused on the goal of reducing conflict between basins and promoting a comprehensive, statewide solution to groundwater management uninhibited by the parochial perspective of the districts. This type of mixed system is particularly appropriate where population and water supplies differ greatly from one area to another.

Another approach with more concentrated decision-making authority at the state level is a system like the one established in Arizona. In Arizona, the state Department of Water Resources administers all state water laws except those directly relating to water quality. Active Management Areas ("AMA's") are established for different areas following hydrological rather than political boundaries. Each AMA has an area director appointed by the director

of water resources and a five-member Groundwater Users Advisory Council appointed by the governor.

EFFICIENCY OF USE

This factor is concerned with the extent to which the management approach allocates the use of groundwater in a manner that leads to greatest overall social benefit. There are two aspects to this factor. First is the policing and elimination of wasteful applications of water. Before waste can be policed, it must be defined. Waste is generally considered to be a failure to put water to a reasonable beneficial use. However, whether a use is considered reasonable and beneficial may vary from area to area and time to time depending upon the scarcity of water and other physical circumstances and social customs.

Overapplication of irrigation water, beyond the amounts minimally needed for crop evapotranspiration and salt leaching (where applicable) may be a waste, for instance, unless the excess percolates to usable groundwater. One should not assume, however, that all such incidental groundwater recharge is beneficial. Timing and location are critical issues. Recharge should take place during relatively wet years, not during years of scarcity. Thus, inefficient irrigation practices, in effect, exacerbate shortages during droughts and deprive some users of a share. Also, it is important that recharge be confined to areas where the water can be recovered economically and without impairment of quality. Thus, overapplication of irrigation water is inefficient when it occurs in areas where the depth to groundwater is long, where perched groundwater contributes to drainage problems, where salts and other minerals tend to leach into the groundwater, or where chemicals in the soil are likely to contaminate the recharge water.

The second factor of concern is the ability of the management system to allocate scarce groundwater supplies to the most valuable and valued uses. Markets will tend to do this with respect to relative economic value, where water transfers are relatively unfettered. Promoting water use efficiency is one of the primary purposes for adopting a water market system. Consequently, the difference between ability of different water management institutions to promote efficient water use is probably best judged based on the ability of these institutions to promote water transfers. But market transfers are often inhibited, as described in the previous section, and economic value is not the only touchstone. Often, questions of social equity and non-economic values such as recreation, aesthetics, and biological diversity intrude. These are dealt with to some extent in the next section.

A. Decentralized

As noted at the beginning of this paper, decentralized systems allocate groundwater according to the doctrines of prior appropriation and reasonable use. Appropriative rights allocate groundwater according to priority in time, not priority in value of use. The underlying philosophy is that economic development is best promoted by putting this factor of production to work early, even if not particularly well. Thus, as long as the use is regarded as "benefi-

cial", the law does not ask how beneficial. Moreover, non-use of a portion of the right leads to its loss. "Use it or lose it" is the watchphrase. This philosophy is a prescription for inefficient use of groundwater, and the examples of wasteful use abound in the jurisdictions that employ this principle.

The doctrine of reasonable use implies a certain limitation on the types of uses that will be recognised. In a jurisdiction such as California, both the courts and the water administration authority have the power to curtail wasteful uses of groundwater. However, that power has rarely been exercised because the legal test of what constitutes waste is not very demanding. For example, in California, the standard of reasonableness has historically been judged by the prevailing practices in the community. Thus, if irrigation practices are rather uniformly wasteful, as many observers have concluded, the courts are unlikely to impose sanctions on any particular irrigator. In a 1935 case, carriage losses of over 50% of the water delivered by one water district was judged not to be unreasonable. The modern conception of reasonable use is likely to be more demanding in that prevailing practices is no longer the sole consideration and the general water conservation ethic has increased considerably. Still it remains the case that the threshold of unreasonableness is likely to remain fairly high and either administrative or judicial interventions to curtail wasteful practices will probably not be frequent enough to inspire substantial changes in water use techniques. Individual users are unlikely to have sufficient information to identify those who are committing waste or sufficient motivation to prosecute wasteful water users in the absence of information demonstrating a serious and direct affect on their own water consumption. This situation may change once users in a decentralized system have adjudicated or negotiated their rights and developed information on the process concerning water use in the basin.

Local water users in a completely decentralized system rarely take voluntary action to apportion insufficient groundwater supplies or enjoin pumping causing overdraft. Because groundwater is a common pool resource, the costs of additional withdrawals are spread among all users of the basin. Users have little incentive to conserve because their efforts will not necessarily go towards preservation of the basin but may instead go toward increasing the supply for other users. In fact, users may be deterred from conserving if there is any chance that they will lose a portion of their water right in a future proceeding defining rights based upon past use. This kind of decentralized system eventually leads to the situation known as the "tragedy of the commons" unless the structure of decision making arrangements can be modified to enable persons to act jointly in relation to the common resource. (Ostrom, p. 16)

Under a basin management structure set up through negotiation or adjudication, there is more incentive to conserve because the rights of all users are defined and limited so that saved water benefits the overall basin rather than other individual users. Conservation is encouraged by the need to meet limits on demand and by a desire to reduce the fees usually charged for pumping.

B. Local District

Local districts, like watermasters, should be well situated to police waste in that they are most likely to develop good, detailed information concerning the water use in their basin. However, local districts have historically been reluctant to police for waste by their members who elect the district directors. This is now changing in California as a result of two developments. The first is simply the growing scarcity of water supplies available to the districts as a result of reallocation of a portion of the developed water to environmental restoration purposes. When water is scarce, the district members themselves have a lower tolerance for wasteful use, and this is reflected in the willingness of the district managers to reform water rates to induce conservation or otherwise assist their growers. Second, district that receive federally supplied water are now required to develop and submit water conservation plans for approval by the U.S. Bureau of Reclamation. These plans are likely to cast the districts into a much more proactive role in improving water management practices on the farms. Good performance by the districts is all the more likely in an environment in which the renewal of the contracts for the federal water may, in part, depend upon it.

Districts are well situated to stimulate and assist farmers in adopting efficient water management practices. The local districts act in many respects like a public utility and, as such can provide an array of incentives and assistance to the customers to cause them save water. This saved water is a source of incremental supply to the district/utility, and worth paying for at a level that reflects the marginal costs of alternative supplies. Some ways in which districts can promote more efficient water use include (1) progressive (or tiered) water rate designs which discourage excessive water use by charging at higher rates for consumption beyond the minimum amount necessary for particular crops; (2) repurchasing water from willing farmers at rates equivalent to the "avoided cost" of alternative supplies, thereby creating an internal water market that makes it financially attractive to save water, or (3) directly investing in water conservation techniques or technologies on the customer's farm in exchange for a share of the water that is saved. All these devices are the subject of experiments being conducted by California water districts today.

C. Centralised

In contrast, a more remote central agency will have more difficulty obtaining information about the wasteful practices of individual water users, but less ambivalence about sanctioning users for waste that is discovered. It is critical that the central agency devises a system by which it can effectively monitor and enforce its allocation programme. One method for accomplishing these goals is to employ a large staff of information gatherers and enforcement personnel. There are many difficulties with adopting such a system. First, the administrative costs of maintaining such a staff are significant. Second, there is no incentive for local interests to cooperate with the agency information gatherers.

A second approach to monitoring and enforcement has been adopted by Arizona. Arizona requires all persons withdrawing water to maintain detailed records, and to submit annual

reports to the state. In addition to imposing fines on parties who fail to maintain such records and submit timely reports, Arizona also makes these reports readily available to the public. By subjecting water users to the scrutiny of their fellow water users, Arizona provides private parties with strong incentives for both compliance and enforcement.

Along with the monitoring and enforcement systems discussed above, many states have also provided incentives for the more efficient use of water. Arizona, for instance, has established a programme by which farmers are paid to retire their agricultural lands (Smith, 861). This reduces the demand for irrigation water and thus benefits water conservation. Additionally, Arizona has also set minimum standards for casings, pipes, fittings, wells, and valves. These incentives and minimum standards are particularly attractive in that they impose a fairly minimal administrative burden on the state.

EQUITY

Equitable distribution of an essential and common resource such as water is an objective that tends to temper and counterbalance, in some respects, the economic efficiency objective. A system that allocates the resource according to the ability to pay (as economic efficiency, considered alone, might require) would place the resource beyond the reach of the poorest strata of society for whom it is no less critical for both domestic and food production. A system that makes water available to all for essential needs at affordable prices may be preferred to a system that is maximally efficient in an economic sense.

In addition to the issue of universal access, and equity also implies enfranchisement in the processes of deciding on the development and distribution of the resource. The premise is that in some fundamental sense the water is a common property resource that belongs to all the people, and all should therefore have a voice in its disposition. In this section, therefore, we look at both equitable access and equitable participation in decision-making.

Finally, we include environmental assessment and protection as another equity concern on the premise that environmental quality, like the water resource itself, is a an asset held in common which should not be compromised to benefit the few. Thus, we regard a groundwater management regime that is regardful of environmental values and seeks to prevent damage as superior to one that does not. Environmental amenities associated with groundwater development would include effects on wetlands and vernal springs and on riparian habitats, and the disposal of drainage water, contaminated by materials leached from soils, which can be generated due to the overapplication of irrigation water.

Some systems have evolved based on the idea that it is equitable to protect the interests of the water users who were first in time. This type of system was popular on the Western frontier of the United States because it originally served to promote economic development, fair allocation and stability of water rights. However, as frontier conditions disappeared, water management objectives and their interrelationships changed. (Grant, p. 73). Critics of the priority system note its failure to promote the most productive use of water and its harshness in

barring new uses of water and in shutting down junior appropriators completely during shortage to fully satisfy the demands of senior appropriators.

Another system that might be considered equitable is one based on the idea that there should be equality of access to water by all potential users, with pro rata sharing in times of shortage. The group of water users might be limited geographically or by requiring ownership of land overlying the water source but not by seniority of water use.

As reflected above, questions of equity are not resolved simply by choosing a framework for water management. For example, in an "equal access" system, is it equitable to limit access based on a water user's ownership of land overlying the water or location within the general watershed? Should water rich areas be required to share their wealth with less fortunate areas? Are some uses valued more highly than others by society and should these uses be protected in the event that a water market transfer system will not do so? Different systems of groundwater management may be more or less appropriate depending upon how a particular society answers these questions.

A. Decentralized

In theory, the benefits of groundwater access are equally available to all overlying owners in a decentralized, correlative rights system. However, the consequence of progressive overdraft is to increase the cost of pumping groundwater, with the greatest effects being caused nearest the apex of the "cone of depression," causing those with the shallower wells, or those least able to absorb the increasing (power) costs of lifting the groundwater to be shed from the system until the point is reached where the remaining usage equals the recharge rate. The increased costs of pumping are shared by all users regardless of their contribution to the depletion in the water supply. In effect, the resource is allocated according to the ability to pay the increasing costs of pumping, with those least able to pay, including poor domestic water users, being deprived of their share. Many would consider this kind of effect to be inequitable.

The effect is not unlike the allocative effects market transfers of water on any other increasing scarce good, except that, in the case of groundwater, the cost escalations are preventable through more active management of the resource. Groundwater basins can be managed to ensure that they are not depleted in ways that cause those least able to pay loosing true access to the supply.

When water users in a decentralised system decide to adjudicate their rights, the court attempts to fashion a physical solution that will comport with notions of equity. A court will generally look at past use in an effort to determine the vested rights of the water users to the basin. Water users are then assigned rights based on their past use, diminished by the amount necessary to operate the basin in a sustainable manner. However, the very process of adjudication may be inequitable in that it can eliminate many small water producers who cannot pay the costs of defending their right to a few acre-feet or less of groundwater. (Blomquist, p. 314). Nevertheless, water users with relatively limited finances who are able to participate in the

adjudication will be better protected in future because the improved management of the basin will enable them use it more economically.

In a decentralized system without identified rights, the water users of the basin do not generally make allocation decisions as a group because they are not united under a management structure. The management goals of such a system in California are to ensure that water is put to beneficial use, that users do not unduly infringe on the rights of others in the basin, and that only surplus water is applied on non-overlying lands. However, water users do not generally make conscious management decisions in pursuit of these goals in the absence of litigation bringing particular issues to their attention.

When rights are adjudicated or negotiated, water users in California have often chosen their own watermaster or administrative committee and have created a management structure giving them guarantees of representation. (See Blomquist p. 212) As noted previously, such participation can have important consequences in terms of the level of voluntary compliance.

In a decentralized, correlative rights system, there is essentially no management structure in place to provide for the needs of the environment. Nor there is any incentive for individuals to take steps to protect the environment because of the "tragedy of the commons" pressures inherent in the system. When a court adjudicates rights in a basin, it may provide some indirect protection of the environment to the extent that it imposes a physical solution that involves basin restoration. However, the court's goal is to resolve a dispute over the rights of water users. Protection of the environment is not generally a consideration.

B. Local District

For irrigation water, the local district approach to management in California has differed from that of adjudicated basins in that small producers have not been eliminated from the system. Generally, each farmer's share of the water supply is a pro rata amount based upon irrigated acreage. Sometimes the entitlement is established contractually. More often, water shares are specified in the by-laws of the district, which is constituted as a quasi-municipal corporation. Of course, the right to receive the water is contingent upon payment. Charges generally are comprised of a water service charge, which is based on the quantity of water delivered, and a general assessment based on the number of acres under the ownership or control of the district member. Water rates are established at a level that will defray the actual costs incurred by the district. For domestic water supply, the local districts operate as a public utility, delivering water to all who demand it within the service area at a rate that defrays the costs of water acquisition, management and conveyance. In both cases, a user will be suspended from the system for failure to pay the water charge. It is conceivable, however, that minimal amounts, regarded as essential for subsistence purposes, could be provided at reduced costs or even without charge under a rate schedule that recouped the revenue loss through higher rates for marginal consumption. Indeed, tiered rates of this sort are a highly effective water conservation tool in the agricultural sector, as discussed in a previous section.

As with adjudicated basins, water users are usually closely involved in establishing a local district management structure and ensuring their representation in that structure. It is interesting to note that the basin governance structures constituted by water users in successful California cases have shown a preference for decision making by consensus. (Blomquist, p. 345) These decision making processes have required water users to take into account, and attempt to accommodate, one another's interests in order to reach a desired outcome. (Id.) This has encouraged cooperation and promoted compliance.

In the U.S. setting, water districts are generally state agencies for the purposes of application of environmental protection laws. In California, for instance, this means that water districts are required to assess and mitigate environmental impact associated with their water development and distribution activities. Preparation of environmental assessment reports is a common occurrence.

C. Centralised

A centralised water management system, as discussed above, is particularly well positioned to integrate interests that are not directly involved in immediate regional water allocation disputes. Such interests include economically disadvantaged persons, future generations and the environment. One method by which water regimes have attempted to help the economically disadvantaged is through the adoption of "lifeline" rate schedules (United Nations Paper #8, 9). These schedules start with low block rates for small users and work up to high marginal or penalty rates for large users.

Issues of equity can also be addressed by the centralised agency's method for ranking preferred water uses. If an agency adopts a rigid preference hierarchy, in which certain uses will receive the lion's share of water resources, then those preferred interests will also gain the subsequent economic benefit. If, however, the agency adopts a more flexible and equitable preference system, in which smaller and less politically powerful interests are assured a greater share of the water resources, then this will have the opposite effect. Each centralised agency must strike its own balance, but the power and effect of such preference schemes must be considered if equity is to be served.

Lastly, a central agency is also well situated to incorporate environmental considerations into its allocation decisions. Doing that successfully however, requires more than political goodwill. The enabling legislation must include provisions which specifically require the agency to address environmental factors. These environmental objectives could be accomplished through a variety of possible requirements, such as a notice and comment period prior to approval of water management plans, the completion of environmental impact statements, or specific environmental criteria which all water management plans must consider. Requiring central agencies to incorporate environmental considerations helps protect ecosystems, as well as the water resources necessary to sustain future generations of consumers.

CONCLUSIONS

Properly designed and delineated local groundwater management institutions consistently outperform the decentralized model as against the criteria examined in this paper. The local management option also compares favourably with a highly-centralised allocation based on a state-wide permit programme, for all criteria except that the more centralised approaches are better able to foster conjunctive use of ground and surface water. The local management option has the strong advantage of being sensitive, adaptable and responsive to local conditions and perceptions of need. It also has the virtue of depending largely upon local rather than state or national initiative to create, finance and govern the management institution and avoids the type of ponderous bureaucracy which has been the bane of too many natural resource management regimes historically.

BIBLIOGRAPHY

Anderson, Water Rights: Scarce Resource Allocation, Bureaucracy, and the Environment, Pacific Institute for Public Policy Research (1983).

Anderson, *Some Thoughts on Conjunctive Use of Groundwater in California*, 16 Western State Univ. Law Rev. 559 (1989).

Blomquist, Dividing the Waters, ICS Press, San Francisco (1992)

Cummings and Nercissiantz, *The Use of Water Pricing as a Means for Enhancing Water Use Efficiency in Irrigation: Case Studies in Mexico and the United States*, 32 Natural Resources Journal 731 (1992).

Department of International Economic and Social Affairs and Department of Technical Co-operation for Development, Efficiency and Distributional Equity in the Use and Treatment of Water: Guidelines for Pricing and Regulations, Natural Resources/Water Series No. 8, United Nations (1980)

Emel, *Groundwater Rights: Definition and Transfer*, 27 Natural Resources Journal 653 (1987).

Frederick and Hanson, Water For Western Agriculture, Resources for the Future, Washington, D.C. (1982).

Goodall, Sullivan and DeYoung, California Water, A New Political Economy, Landmark Studies, Allanheld, Osmun/Universe Books, New York (1978).

Grant, *The Complexities of Managing Hydrologically Connected Surface Water and Groundwater Under the Appropriation Doctrine*, 22 Land and Water Law Review 63 (1987).

Gregory, *Groundwater and Its Future: Competing Interests and Burgeoning Markets*, 11 Stanford Env. Law Journal 229 (1992).

Johnson, *The 1980 Arizona Groundwater Management Act and Trends in Western States Groundwater Administration and Management: A Minerals Industry Perspective*, Mineral Law Institute 1031 (1981)

Kletzing, *Imported Groundwater Banking: The Kern Water Bank -- A Case Study*, 19 Pacific Law Journal 1225 (1988).

Krieger and Banks, *Groundwater Basin Management*, 50 California Law Review 56 (1962).

de Lambert, *District Management for California's Groundwater*, 11 Ecology Law Quarterly 373 (1984).

Lee, *Managing Water Resources in Latin America*, 30 Natural Resources Journal 581 (1990)

Mallery, *Groundwater: A Call for a Comprehensive Management Programme*, 14 Pacific Law Journal 1279 (1983).

Murphy, *The Potential for Legislative Choice Concerning Groundwater and Aquifers*, 4 Journal of Land Use & Environmental Law 23 (1988).

Nunn, *The Political Economy of Institutional Change: A Distribution Criterion for Acceptance of Groundwater Rules*, 25 Political Economy and Groundwater 867 (1985).

Ostrom, Institutional Arrangements for Water Resource Development, Indiana University (1971).

Smith, *Rewriting California Groundwater Law: Past Attempts and Prerequisites to Reform*, 20 Cal. Western Law Rev. 223 (1984).

Smith, *Coercion and Groundwater Management: Three Case Studies and a Market Approach*, 16 Environmental Law 797 (1986).

Smith, *Centralised Decision-making in the Administration of Groundwater Rights: The Experience of Arizona, California and New Mexico and Suggestions for the Future*, 24 Natural Resources Journal 641 (1984)

Trager, *Emerging Forums for Groundwater Dispute Resolution in California: A Glimpse at the Second Generation of Groundwater Issues and How Agencies Work Towards Problem Resolution*, 20 Pacific Law Journal 31 (1988).

Villarejo and Redmond, Missed Opportunities, Squandered Resources, Why Prosperity Brought By Water Doesn't Trickle Down in the Central Valley; California Institute for Rural Studies (1988).

World Bank, Staff Working Paper No. 458; Comparative Study of the Management and Organisation of Irrigation Projects, prepared by Anthony Bottrall, Consultant (1981).

Managing Groundwater in the Western United States: Lessons for India

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December, 1993

In the United States, groundwater has traditionally been managed by states and local governments. Sometimes management systems have been established by state governments and regulated at the state level, other times groundwater management decisions have been entirely local -- either through a local management entity, such as a water management district, or by the individual decisions of pump owners. As a result of this local orientation, groundwater management systems have developed in very unique and different ways in the States. To varying degrees the western states incorporate one of four different groundwater management legal regimes, and within each legal system the states vary as to how they have applied that system. This diversity presents a rich experience for understanding how different systems operate, and what one might anticipate through the adoption of one particular system of groundwater management as opposed to another. Analyzing those types of groundwater administrative arrangements is the focus of this paper. After examining groundwater management systems in the U.S., we will explore the question of what is good groundwater management? and try to identify the values that certain types of management arrangements further, and the interests (economic and otherwise) which we can expect to be benefited from one type of management system as opposed to another. Finally, some recommendations will be made for incorporating different aspects of management systems to devise a model groundwater code that may be of use to policy makers studying groundwater management in India.

Legal Systems

Groundwater law in the western states has evolved during the 20th century from the English or common law rule of absolute ownership to the American rule of reasonable use and correlative right, to the doctrine of prior appropriation. Since these systems vary considerably both in their doctrines and in their application, we will discuss each in detail below.

The common law or absolute ownership doctrine holds that the water beneath one's land is the property of the landowner and, absent malice, may be withdrawn without regard to the effect such withdrawals have on other adjacent landowners. The common law doctrine was developed in relatively wet England and, as with common law generally, brought to the relatively wet east coast of the United States. The common law or absolute ownership doctrine worked relatively well in the east where there was little competition for groundwater supplies and few shortages. Many states in the western U.S., through court decision or legislative action, adopted it. It was not long, however, before the drawbacks of the absolute ownership doctrine, particularly in arid states, became apparent and various modifica-

tions of the rule were adopted. In the west, variations of the common law doctrine were initially adopted in California, Nevada, New Mexico, Oklahoma, South Dakota, Texas, Utah and Wyoming. All these states, with the exception of Texas, have abandoned or greatly modified the common law doctrine.[32]

The reasonable use doctrine, sometimes called the American Rule, was the modification made by many courts to the absolute ownership doctrine. Basically, the reasonable use doctrine limits a landowner's right to use water beneath the land for some reasonable beneficial purpose on the land. Under the doctrine, the waste of water or the transport of water to other lands is not considered a reasonable beneficial use when such uses interfere with the right of adjacent landowners to use water beneath their own lands for beneficial uses on those lands. Many states including Arizona, North Dakota, Oklahoma, Oregon, Utah, Washington and Wyoming at times adopted forms of the reasonable use doctrine.[33]

Similar in application to the reasonable use doctrine, the correlative rights doctrine recognizes a landowner's right to use water beneath the land, but tempers that right by providing that landowners overlying a common source of groundwater have equal or correlative rights to a reasonable amount of water when applied to a reasonable beneficial use on the land overlying the groundwater basin. The correlative rights doctrine was developed by the California courts.[34]

Finally, the doctrine of prior appropriation. Currently most western states have adopted the prior appropriation doctrine and issue permits for the extraction of groundwater -- although several states, as we shall see below, have established permit systems under the other doctrines. In states that follow the prior appropriation doctrine, the first appropriator of water, by putting water to a beneficial use without waste, has a right to continue that use. Western states that have adopted the prior appropriation doctrine include Alaska, Colorado, Idaho, Kansas, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Utah, Washington and Wyoming.[35] These states issue permits for the extraction of

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32. See, e.g., Vineland Irrigation District v. Azusa Irrigation Co., 126 Cal 486, 58 P. 1057 (1899); Hanson v. McCue, 42 Cal. 303 (1871); Mosier v. Caldwell, 7 Nev. 363 (1872); Vanderwork v. Hewes 15 N.M. 439, 110 P. 567 (1910); Metcalf v. Nelson, 8 S.D. 87, 65 N.W. 911 (1895); Houston & Texas Centennial Railroad v. East, 98 Tex. 146, 81 S.W. 279 (1904); Herriman Irrigation Co. v. Kecl, 25 Utah 96, 69, p. 719 (1902); Hunt v. City of Laramie, 26 Wyo. 160, 181 P. 137 (1919); Territory of Oklahoma statutes S 4162 (1890).

33. See, e.g., Maricopa v. Southwest Cotton Co., 39 Ariz. 65, 4 P.2d 369 (1931); Volkman v. Crosby, 120 N.W.2d 18 (N.D. 1963); Canada v. City of Shawnee, 179 Okla. 35, 64 P.2d 694 (1937); Bull v. Siegrist, 169 Or. 180, 129 P.2d 832 (1942); Horne v. Utah Oil Refining Co., 59 Utah 279, 202 P. 815 (1921); Evans v. City Of Seattle, 182 Wash., 450, 47 P.2d 984 (1935); Binning v. Miller, 55 Wyo. 451, 102 P. 2d 54 (1940).

34. Katz v. Walkinshaw, 141 Cal. 116, 74 P. 766 (1903)

35. See, e.g., ALASKA STAT. S 46.15.010-.270 (1966); COLO. REV. STAT. ANN. SS 37-90-102 and 37-92-101 (1973 & Supp. 1980); IDAHO CODE ANN> S 42-226; KAN. STAT. S 82a-703 (1977); NEV. REV. STAT. S CODE, S 61-01-01 (1960 & Supp. 1975); OAKLA. STAT. ANN., tit. 82 S 1020.1 (Cum. Supp. 1976); ORE. REV. STAT. S 537.505 (1979); S. DAK. WASH. REV. CODE ANN. S 90.44.010-.250 (1962); WYO. STAT. ANN. S 41-144 (Supp. 1975).

groundwater. Although a number of states have established local boards or districts with varying responsibilities over groundwater matters, permit systems are usually centrally administered by a state official (often a state engineer), state board or commission. Although it is important to be familiar with the four basic doctrines of groundwater law in the United States, it is equally important to remember that water management in practice varies significantly from state to state — even when states are following the same doctrine. New Mexico, for example, follows a prior appropriation doctrine and manages groundwater quite differently than does North Dakota, which follows the same doctrine. In New Mexico, where many groundwater basins are virtually non-recharging, those basins are managed with the understanding that eventually they will be depleted. North Dakota, in contrast, manages its recharging groundwater basins on a safe yield basis. (So that the amount of water withdrawn from the aquifer roughly equals the amount of water returning naturally or artificially to the aquifer over an extended period of time.) Adoption of a prior appropriation system would seem to suggest that certain uses, those with prior rights, would be protected. Well yes and no. It depends on how the prior appropriation systems is managed. As we shall see, in many states prior appropriation systems are managed in ways which will result in the ultimate depletion of the resource for most uses. In short groundwater management is not merely the adoption of a legal rights system -- although that is the place to start -- but is also about policy and the polities that govern the policy which drive the system of rights.

Let us begin our examination of western groundwater management practices by summarising the experiences in the western states.[36]

Alaska

Alaska's groundwater problems have been local and limited and concern some overdrafting and salt water intrusion. Nonetheless, Alaska is a useful state to examine, for the state has integrated some relatively unusual approaches to its groundwater management system in which public supply systems are given preference. Water use in Alaska must be for a beneficial and reasonable use (reasonableness is, as in most western states, defined as almost anything except for waste), and groundwater use in Alaska must be for a purpose which is in the "public" interest."

Although there are few problems in Alaska which are useful for examining the Indian experience, the "public interest" notion is not common in western groundwater law, and hence is worth exploring.

In determining what is in the public interest, the Alaska Natural Resources commissioner is directed to consider : (1) the benefit to the applicant resulting from the proposed appropriation, (2) the effect of the economic activity resulting from the proposed appropriation; (3)

36. Much of the material in this section has been taken from Zachary A. Smith, Groundwater in the West (San Diego: Academic Press, 1989) and has been supplemented through interviews.

the effect on fish and game resources and on public recreational opportunities; (4) the effect on public health; (5) the effect of loss of alternate uses of water that might be made within a reasonable time if not precluded or hindered by the proposed appropriation; (6) harm to other persons resulting from the proposed appropriation; (7) the intent and ability of the applicant to complete the appropriation; (8) the effect upon access to navigable or public waters.[37]

Although the "public interest" in Alaska would seem to be broad, legal scholars have found that the courts have interpreted it largely in economic terms — where there is competition between two projects, that project producing the most economic benefits is most likely to proceed.[38]

Domestic users of less than 1000 gallons of water a day are exempted from the act.

Arizona

Arizona has faced serious overdrafting problems for many years leading to fissuring of the land, land subsidence, the drying up of wells, and declines in water tables to the point where the water becomes uneconomic for certain uses. Arizona is also a common law or absolute ownership state — for both of these reasons, comparisons with India might be fruitful. Like India, Arizona landowners associate water use with the ownership of the land. Also in Arizona part of the political culture includes a general distrust of centralised government, particularly the national government, making the implementation of a centralised administrative groundwater rights system in Arizona difficult. For example, at one point in 1952 the Arizona Supreme Court ruled that groundwater was public property and therefore subject to prior appropriation. This decision caused a great deal of controversy, and political backlash, and as a result the Arizona Supreme Court reversed itself and reinstated the common law absolute ownership doctrine only one year later.[39]

It is quite likely that Arizona would have followed Texas in following the common law absolute ownership doctrine in groundwater up to the current time. What changed the situation in Arizona were threats by the national government to withhold funding for a massive surface water delivery system called the Central Arizona Project. So essentially the national government bought off local opposition. The result was the 1980 Arizona Groundwater Management Act (hereinafter referred to as the act). The act created mechanisms for forming groundwater management districts. Initially four groundwater management districts, which are referred to as active management areas, were created. Although additional active management areas may be created by the director of the Department of Water Resources or, upon petition, by registered voters within a proposed active

37. ALASKA STAT. S 46.15.080

38. See Frank J. Trelease, "Alaska's New Water Use Act," Land and Water Law Review, Vol. 2, No. 1 (1967), p.22.

39. See, Bristor v. Cheatham, 75 Ariz. 227, 225 P.2d. 173 (1953)

management area. Water withdrawals in active management areas are governed by the Arizona Department of Water Resources, and are designed to ensure that all active management areas reach a safe yield pumping basis by the year 2025. This goal is to be achieved by mandating conservation through management plans for each active management area which are promulgated every ten years.

Within the management plans, allowable pumping rates are determined by the crops historically grown on the land and reasonable expectations from current conservation methods. In the event that conservation goals are not met the act provides that pump taxes may be used to purchase and then retire lands, thereby decreasing groundwater extractions in order to meet safe yield goals.

Although there is undoubtedly more conservation of agricultural water use in Arizona since passage of the act, it remains to be seen whether or not the long term goals of the act will be achieved. In nearly every session of the legislature agricultural interests have pressed for modifications of the act. Now that the Central Arizona Project is completed, farmers show no inclination of voluntarily reducing their groundwater withdrawals in favour of Project water. This is due in large part, to the fact that at current Project rates it is less expensive for farmers to pump water from the ground. Hence, additional subsidies to agriculture may be necessary to achieve safe yield groundwater management in Arizona.

A possible lesson to be learned here is that local opposition to centralised administrative arrangements can be overcome through income transfers, in the case of Arizona the building of a water project, but if the transfer is a one-time deal and that deal is consummated (e.g., the project is completed) the central government may no longer be in a strong position to enforce its will. Hence, a series of incentives that stretched out over time or could be otherwise apportioned over time (such as withholding deliveries of surface water in the new project or threatening to transfer future project water rights to third parties) would appear to be more beneficial from the standpoint of those advocating a centralised administrative system.

California

California has every problem associated with groundwater use one might imagine. Overdrafting in some parts is extremely severe causing land subsidence, fissures and salt water intrusion. Groundwater is managed on the local level in California by more than 1,000 various types of special districts. These districts take a wide variety of forms —some are created specifically by the state legislature, others are created under general legislative acts which allow for the creation of such districts. The governing boards of these districts are selected in variety of ways -- in some cases through a vote of property owners within a district, all district voters, or in other cases by appointment. Most districts have the authority to issue revenue bonds and levy taxes. In some cases governing boards are appointed by courts as the result of adjudication over groundwater rights within an area.

Until 1903 California followed the common law rule of absolute ownership. In 1903 the California Supreme Court rejected the common law doctrine and established the correlative rights doctrine. As indicated above, the rule of correlative rights and the requirement of reasonable and beneficial use provide that landowners overlying a common source of groundwater have equal or correlative rights to a reasonable beneficial use on the land overlying the groundwater basin. In practice, when these rights have to be adjudicated (which has been often), the courts have used historical rates of pumping within a basin, established the projected safe yield of the basin, and provided each landowner with a ratio of water in proportion to the landowner's past use and the safe yield in the basin. That's when the system works reasonably well. In many cases landowners are not anxious to have rights adjudicated since it would interfere with their often unlimited pumping. This, of course, creates common pool depletion problems and benefits those landowners with the economic resources that allow them to sink deeper and more powerful pumps.

Where districts have been created with adequate powers, the Orange County Water District is a good example, groundwater can be managed on a safe yield basis. The Orange County Water District has extensive powers to require data from groundwater pumpers, regulate pumping patterns, levy a pump tax through a taxing system, and regulate the amount of groundwater being used. In Orange County the system has worked quite well, although as Marcus Moench has pointed out, the adoption of such a system in India is problematic for both cultural and political reasons.[40]

In a system such as California's smaller farmers, those lacking economic resources, are disadvantaged. Such disadvantages could be overcome through the adjudication of water rights -- although in areas that are already heavily overdrafted, such as in much of California's central valley, the cost of capturing one's water would still be relatively high.

Colorado

Colorado is suffering from problems related to overdrafting in much of the eastern portion of the state. Prior to 1965 Colorado followed the common law of absolute ownership in groundwater. In 1965 the Colorado legislature applied the appropriation doctrine to all Colorado waters, including groundwater. Since surface waters in Colorado had been governed by the prior appropriation doctrine prior to the extension of that doctrine to groundwater, groundwater uses which interfere with surface water flows are inferior (meaning that such groundwater pumping won't be allowed to reduce surface water flows unreasonably). Overall groundwater use is overseen by a stated engineer in Colorado assisted by seven divisional engineers in each of the seven divisions which have been created in the state (divisions generally follow the major watershed boundaries in the state). Each of these divisions also may have one or more local water commissioners, and each division has a

40. Marcus Moench, "Chasing the Water Table: Equity and Sustainability in Groundwater Management" *Economic and Political Weekly*, Dec. 19-26, 1992, p. A-171.

water judge who has authority to rule in cases of conflict over water rights within the division. Groundwater basins that are not hydrologically connected surface water sources in Colorado are called "designated groundwater basins" and are managed by the Colorado Groundwater Commission — a twelve-member body consisting of nine members appointed by the governor and confirmed by the senate as well as the director of the Colorado Department of Natural Resources, the state engineer, and the director of the Colorado Water Conservation Board. The commission identifies groundwater basins which will come under its authority, and holds hearings to determine the extent of such basins. The commission may establish reasonable pumping levels and limit extractions when they interfere with prior appropriators. According to commission guidelines, a well will not be permitted if it causes greater than a 40 % depletion in 25 years of the saturated rock underlying the area within a three mile radius of the proposed well. Stated another way, wells may cause up to 40 % depletion in 25 years. This means essentially, that Colorado, like other states we will examine, has decided that in essentially non-recharging groundwater basins the state will regulate pumping in a manner which will see the ultimate depletion of the resource for most economic uses, but in a timely manner (the assumption being that coordinating depletion will limit economic and social disruption).

Smaller wells, (wells pumping 50 gallons of water per minute or less) are exempted from state control.

Although the Colorado system seems logical and neat, the public, as in most western states has very little involvement in the process (beyond the hearings held when the commission is determining the boundaries of a designated groundwater basin). Furthermore, although small wells are exempted in areas where the groundwater is being mined to eventual depletion, smaller pumpers may not be able to capture the water, for economic reasons, that they otherwise are entitled to.

The marketability of groundwater rights in Colorado mitigates the potential for conflict between agricultural users and current or future municipal or industrial users. Marketing schemes can also protect the rights of prior appropriators (or in the case of India overlying landowners) without the economic wherewithal to take advantage of their water rights. In such cases money would replace water -- a beneficial arrangement for those unable to capture the water (such as those who own land but do not have the resources necessary to develop the water).

Hawaii

Hawaii has suffered from limited overdraft and some salt water intrusion problems. For our purposes, Hawaii is most useful as an example of what one might not want to do when establishing a centralised groundwater system at the state level.

The Hawaii Groundwater Use Act of 1959 vests in the Hawaii Board of Land and Natural Resources (a board appointed by the governor and confirmed by the senate) the

power to designate "designated groundwater areas." With such a designation the board has broad powers to limit pumping through a permit system and otherwise regulate groundwater extraction. The board's power kicks in when it, at its sole discretion, decides to designate a groundwater basin. That process entails filing a notice that a designation is under consideration, holding hearings, and the determination, among other things, that an overdraft situation is, or is likely, to exist.

The combination of the fact that the Board of Land and Natural Resources in Hawaii is appointed by the governor, and the fact that groundwater pumpers in Hawaii, particularly those who find an immediate economic advantage to groundwater overdrafting, are often major economic and political actors in the state, suggests that the designation of a groundwater basin will be difficult. In fact, there are many areas in Hawaii that are experiencing overdrafting problems which have not been declared as designated groundwater areas. Furthermore, by the time overdrafting becomes a problem serious enough for the Board of Land and Natural Resources to act, there is an excellent chance that capital investments will have been made in extraction and distribution equipment which need be repaid based on economic activity sustainable only through maintaining existing extraction rates. Although the latter may be true in any overdraft situation, an administrative system that only kicks in when there are serious problems and is easily subject to political manipulation is not likely to be successful.

Idaho

All waters in Idaho are property of the State and subject to prior appropriation for beneficial use. Idaho's prior appropriation system is administered by permits which are issued subject to the approval of the director of the Idaho Department of Water Resources. Domestic wells are exempted from state control. The director of the Idaho Department of Water Resources can, after notice and hearings, establish either "designated critical groundwater areas" or "groundwater management areas," the latter for those thought to be approaching the critical stage. A critical area is defined as one in which the director feels there is not enough water to provide a reasonable safe supply. These designations empower the director to require additional pumping data, prohibit new pumping, or limit pumping from existing wells.

Although Idaho follows a prior appropriation system, when there are competing uses the law states that the full economic development of groundwater will not be blocked. In practice this has, on occasion, led to competition between certain economic interests over which use provides the maximum economic development and benefit. In Idaho the competition is centered around irrigators, power companies and land developers. In other states, as we shall see below, there are conflicts over priorities when those priorities have not been stipulated. Such a stipulation of priorities would, it would seem, reduce future conflict and litigation. But, of course, politics can't be taken out of anything, so the battleground would merely be moved to the process by which priorities were established.

Kansas

Kansas is heavily dependent on groundwater. In the western part of the state, overlying the Ogallala aquifer, overdrafting for the last several decades has led to declining water levels and the conversion of much farming from irrigated to dry farming. Western Kansas had approximately 16,000 wells in 1977 and it is estimated that by the year 2000 there will be 4,602 wells — the impact of overdrafting on irrigated agriculture has been severe.

In Kansas all water uses are regulated via a permit system administered by the chief engineer of the Division of Water Resources of the Kansas State Board of Agriculture. No one may appropriate water or acquire water rights in Kansas without the approval of the Kansas chief engineer -- domestic uses, meaning water for household purposes or for the irrigation of up to two acres, are exempted. Like Alaska, the Kansas water code includes a requirement that the chief engineer take the "public interest" into consideration when issuing permits, but in this case what the public interest is unclear.

Kansas law provides a mechanism for creating groundwater management districts, through local initiative, at the local level. Should a group of local citizens desire greater local control, they must: identify fifteen eligible voters in the proposed district and file a declaration of intent to form a district with the chief engineer. An eligible voter is defined as a landowner (40 or more acres) or someone who withdraws and uses one acre foot of groundwater or more per year within the proposed district. The chief engineer then, in consultation with local district organizers, makes any modifications he or she feels necessary in the boundaries of the proposed district in order to have a manageable area. Then the local organizers are given twelve months to file a petition with the Secretary of State signed by the smaller amount of 40 eligible voters, or 50 % of the eligible voters in the district. The petition is then submitted to the chief engineer for his or her approval. Such approval is based primarily on technical considerations but also includes the engineer's determination that the "public interest" will be served by the creation of this new district. After it is approved by the chief engineer an election is held in the proposed district to elect a governing board. Districts are required to develop groundwater management plans which are submitted to the chief engineer, but otherwise have rather broad powers to build waterworks, exercise the power of eminent domain, levy water charges and sell bonds, among other things. Those wishing to appropriate water in a created district must still apply to the chief engineer for a permit, but the engineer follows the guidelines of the district management plan when issuing permits and, as of the late 1980s, the engineer has rarely made changes in management plans when submitted for approval.

It would seem that Kansas groundwater management district system provides a good and democratic mechanism for letting local interest determine their groundwater future. In Kansas some districts are using their local management authority to oversee the gradual depletion of the resource for agricultural activities while others are attempting, through well spacing and other limitation measures, to retain the irrigated farming economy as long as possible. The interests served by the creation of such a district would depend, in large part,

on the system used to determine voting rights. Eligibility for voting depends, in Kansas, on a defined land holding or water use level but the number of votes allocated to an individual does not vary with the size of the land holding or the amount of water used. Should this system be adopted in India we might anticipate that in many possible districts smaller and poorer irrigators could have an electoral advantage over larger, wealthier farmers. The opposite result would occur if, as is the practice in some districts in California, one's vote was weighted by the total acreage irrigated. Although the latter approach appears more egalitarian, there is a certain fairness in giving larger landowners more voting authority in as much as they will carry a greater risk and a higher amount of bonded indebtedness if and when the district enters into contracts or sells bonds.

Montana

Montana groundwater is administered under a prior appropriation/beneficial use/permit system. Generally the permit system simply acts as a device to put existing property owners on notice that new wells are being dug so that they may opt to protect their rights. The law also authorizes the designation of "controlled groundwater areas" when withdrawals exceed recharge or threaten to do so. In such areas permits are required for all new appropriations and withdrawals may be limited or drilling of additional wells forbidden in order to prevent overdrafting.

As a percentage of total water used, Montana uses relatively little groundwater (3%) and there have been very few aquifer depletion problems in Montana when compared to the other Western states.

Nebraska

Nebraska is heavily dependent on groundwater. Sixty percent of the total water used in Nebraska comes from the ground, with 94% of the total water withdrawn annually being used for irrigation. Overdrafting is a serious problem in many parts of Nebraska — in some parts of the state water level declines of up to 50 feet have been measured.

Nebraska follows what has come to be called the "Nebraska Rule of Reasonable Use." It essentially seems to be a combination of the American rule and the California rule of correlative rights. In the ruling court case, the court found that: "The owner of land is entitled to appropriate subterranean waters found under his land, but he cannot extract and appropriate them in excess of a reasonable and beneficial use upon the land which he owns, especially if such is injurious to others who have substantial rights to the water, and if the natural underground supply is insufficient for all owners, each is entitled to a reasonable proportion of the whole."[41]

Where there are conflicts over water rights, Nebraska has prioritised uses recog-

41. Olson v. City of Wahoo, 124 Neb. 208, 248 N.W. 304 (1933).

nizing domestic use as the highest preference over all other uses, and then agricultural use having preference over manufacturing and industrial use. In addition to this preference, Nebraska law provides a variety of other preferences for municipalities. Municipalities may use their power of eminent domain to take over land for its water value, and may, unlike other water users, transfer water out of the basin.

Although their powers vary, Nebraska has provision for the creation of groundwater management districts on the local level similar to those found in Kansas -- and with similar results.

Nevada

Nevada has serious overdrafting problems which have resulted in the major metropolitan areas of Reno and Las Vegas, as well as Carson City, being declared critical groundwater basins (discussed below). Overdrafting has resulted in, among other things, serious land subsidence problems -- particularly in the Las Vegas area. Until 1939 Nevada followed the common law doctrine of absolute ownership of groundwater.

In 1939, the Nevada Legislature enacted a groundwater use statute declaring all groundwater within the state belonging to the public and subject to appropriation for beneficial use. The act exempted domestic uses of no more than 1800 gallons a day. There are two basic systems of groundwater management in Nevada — designated and undesignated basins. In designated basins, the Nevada State Engineer has a great deal of authority. In a designated basin a permit is necessary to drill a well, and withdrawals are limited and administered according to a system of preferred uses. In nondesignated basins, the state engineer does not prioritise uses, nor are permits required prior to drilling a well. In a nondesignated basin after the water is diverted and put to a beneficial use, then an application and permit are required. In designated basins the state engineer may order the establishment of a groundwater board if the basin's boundaries include three or more incorporated cities. Local groundwater boards, which serve in an advisory capacity to the state engineer, are made up of seven basin residents appointed by the governor. A state engineer is to confer with the local board before issuing drilling or extraction permits, although ultimate authority lies with the engineer. Close to half of Nevada's 232 groundwater basins have been designated.

So in Nevada we see a combination of centralised state authority through a prior appropriation and permit system managed by a state engineer yet tempered, in some instances, by local boards which provide oversight and input. In India such an arrangement might allow the broader and regional interests of the state to play a major role in groundwater management while being tempered by local input.

In practice the prior appropriation system in Nevada has done little to curtail the overdrafting in its major metropolitan areas, particularly Las Vegas. Politically, the economic interests at state in the immediate and near future have prevented management

in a way that comes anywhere close to safe yield. Legally, the state engineer may be able to restrict the withdrawal of groundwater. Politically, it is difficult.

New Mexico

There are varying rates of overdrafting all over New Mexico -- although in many areas it is planned. As former New Mexico State Engineer Steve Reynolds wrote, "It is New Mexico's position that it is not intrinsically evil to deplete groundwater resources at a rate greater than the rate of recharge...where the quantity in storage is far greater than the annual recharge and there is no intimate relationship to fully appropriated streamflows."[42] Until 1927 New Mexico followed the English common law of absolute ownership. In that year New Mexico's first groundwater appropriation statute was passed declaring groundwater to belong to the public and subject to appropriation for beneficial uses.[43]

Within a declared groundwater basin the state engineer has authority to issue permits prior to the drilling for drilling or extraction of groundwater. If not a declared basin then the state engineer has no jurisdiction and any conflicts over appropriation rights must be settled in court -- a costly undertaking that benefits dominant economic interests. To appropriate groundwater in a declared basin, an application is filed whereupon the state engineer publishes notice once a week for three consecutive weeks. If no objections are filed to the application and the state engineer finds there is unappropriated water in the basin, the application is approved and a permit is issued. If objections are filed, which is common, or if the state engineer feels that all water is appropriated, the permit will be denied with or without a hearing.

New Mexico law directs the state engineer to routinely grant all applications for watering livestock, irrigating one acre or less of non-commercial trees, lawn, or gardens, or other household and domestic uses. Such applications need not follow the ordinary permit procedure.

In research undertaken by the author in New Mexico, it was found that groundwater users were, to a very great extent, satisfied with the groundwater rights administrative process in the state. Although the New Mexico State Engineer has much more authority over groundwater withdrawals than in most other states, and consequently one might anticipate that local water users would resent this centralised control on the state level, such was not the case. Interestingly that approval was based on the personality and management practices of the then-longtime state engineer Steve Reynolds.

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42. Steve Reynolds, letter dated 13 June, 1980 to the U.S. General Accounting Office, reprinted in U.S. General Accounting Office Groundwater Overdrafting Must be Controlled (1980. p.49.

43. Although the New Mexico Supreme Court found the act unconstitutional in 1930 because of a technical error, it upheld the principals and intent of the Act. In 1931 the New Mexico Legislature corrected these technical deficiencies. In 1950 the constitutionality of the 1931 act was upheld.

North Dakota

Groundwater in North Dakota is subject to prior appropriation for beneficial use and is regulated via a permit system that is administered by the North Dakota State Engineer. The North Dakota State Engineer has been managing the state's groundwater resources in a manner to prevent groundwater overdrafting. Consequently, with minor exception, there is very little overdrafting in the state.

Although the groundwater management regulatory system in North Dakota (prior appropriation through permit subject to beneficial and reasonable use) is similar to many other western states, North Dakota is somewhat unusual in that the state engineer has opted to manage the resource on a long term safe yield basis. This decision is based in part on the fact that many of North Dakota's aquifers are relatively shallow (i.e. close to the surface) and small. Under these circumstances a position of groundwater mining -- such as that followed by New Mexico -- would lead to a rapid depletion of the resource and an end to irrigated agriculture.

The North Dakota State Engineer is overseen by the North Dakota State Water Conservation Commission, a nine-member body chaired by the Governor of the state that meets eight to ten times a year to make major water policy decisions in the state. Permits are issued for groundwater extraction when it is found that there is unappropriated water in an aquifer, and denied when there is not. In situations of conflict between given uses the state engineer is directed to give preference to domestic and livestock uses over irrigation and industrial uses, and preference to irrigation and industrial uses, over recreational uses. Permits are not required for domestic, livestock, or fish or wildlife purposes when the amount extracted does not exceed 12.5 acre feet a year.

The North Dakota code provides the means for the local creation of water resource districts and irrigation districts. These bodies have a broad range of powers to raise taxes and sell revenues bonds, exercise the power of eminent domain, acquire water or property rights, develop rules to prevent pollution, and construct irrigation works, canals, and other improvements. These local districts do not, however, have the power to make water allocation decisions -- which is the responsibility of the state engineer. Local districts have been created throughout most of the state.

So what we see is declining levels of authority with broad policy set by the state in the form of a state water conservation commission, implemented by the state engineer, and then adjusted or augmented at the local level by local districts with the power to tax themselves. This system of shared responsibilities has worked reasonably well.

Oklahoma

Overdrafting of groundwater in Oklahoma is widespread. Water levels in northwestern Oklahoma declined more than 50 feet between 1940 and 1980, and it is predicted that

central and western Oklahoma will have "hard-core" water shortage by the year 2020.

Until 1937 Oklahoma followed the common law or absolute ownership doctrine. Since 1937, through a variety of court cases and statutes, the Oklahoma has followed the reasonable use doctrine (or American rule). Responsibility for the management of groundwater, as well as all other waters in Oklahoma, lies with the Oklahoma Water Resources Board. The Water Resources Board issues permits and makes allocations of groundwater to overlying landowners if the water is being put to a beneficial use without waste. Permits are not necessary for withdrawals by landowners for domestic purposes.

As in North Dakota, and other western states, provisions are made for the creation of local water and irrigation districts.

Unlike many other states which are practicing groundwater mining unintentionally, Oklahoma, like New Mexico, issues permits with the understanding that they will lead to the eventual depletion, for most economic uses, of the resource. After determining the safe yield of a basin, permits are issued on the basis of a 20-year life plan for each aquifer (i.e. based on a minimum 20-year life). Hence the state has opted for an orderly exhaustion of the state's groundwater resources. Oklahoma does not prioritize between beneficial uses; hence, in a decision granting Mobil Oil Company a permit to mine fresh groundwater for use in secondary and tertiary oil recovery, the Oklahoma Supreme Court found that there was no difference between that use and use for irrigation or drinking water-since the state provided no prioritization of beneficial uses.

It would seem that at a minimum one would want to establish rough priorities so that, to the extent there are conflicts between, for example, drinking water and water for industrial purposes, whatever decision making body is in place will have some guidance.

Oregon

Groundwater in Oregon is managed under a prior appropriation/beneficial use system administered via permit issued by the Oregon Water Resources Directors (an appointee of the Governor who serves a four-year term). Those wishing to appropriate groundwater must request a permit and provide the water resources director with information regarding the amount of water to be appropriated, the type of well and the use the water will be put to, along with other information. The typical exemptions are made for domestic purposes which do not exceed withdrawals of 15,000 gallons a day or for small industrial commercial purposes not exceeding 5,000 gallons a day, as well as stock watering and for watering the grounds of a school not larger than three acres in a town of less than 10,000 people.

The Oregon Groundwater Act of 1955 provides for a different system of groundwater regulation once an area is designated as critical. A groundwater regulation area may be determined to be critical by way of a motion from the state engineer, petition by the state

geologist of the State Department of Geology and Mineral Industries, or by petition from anyone within the area in question. Procedures for declaring an area as critical may be initiated when: 1) there is a decline in groundwater levels; 2) the wells of two or more claimants interfere with one another; 3) available groundwater supply is overdrawn or about to be overdrawn; 4) the quality of the groundwater is threatened; and 5) there is interference between groundwater and geothermal production. Public hearings are held before an area can officially be declared critical. Once an area is designated as critical the water resources director may close the area to further appropriations and limit withdrawals to those currently authorised. Within critical areas residential and livestock watering have priority over other uses.

One difficulty Oregon has had in managing its groundwater resources has been in local political opposition to the designation of a groundwater area as critical. Agricultural interests have been opposed to the designation of certain areas as critical -- in as much as such a designation could lead to the revocation of existing water permits. The problem is one of balancing the authority of the Water Resources Department to designate an area as critical unilaterally with the desire to provide local entities with input into the management process. Due to budgetary constraints, Oregon has also had difficulty in adequately inventorying its groundwater resources. Obviously in a prior appropriation state, inadequate information makes the allocation of permits difficult at best. Groundwater pumpers, particularly farmers, have in the past opposed increased funding for the Water Resources Department as well as any changes in the law that would have increased the authority of that department (notably the authority to declare groundwater basins as critical).

While one can be sympathetic with local interests desiring to make their own decisions in groundwater management, even if that means the ultimate depletion of the resource for most purposes, one would hope that such a system would take other, usually smaller, groundwater users in mind. The Oregon statute, like most prior appropriation permit systems as well as other systems in the West, exempts domestic and other small users. Such exemptions are meaningless absent water or cash transfer programmes, should large overlying landowners successfully draw water tables down to the point where they are no longer available, or become uneconomic, for smaller, exempted uses.

South Dakota

South Dakota follows a combination of American rule and correlative rights doctrine system. Although interbasin transfers and surface water management have been major issues in South Dakota water politics, the overdrafting has yet to be a major state problem.

Texas

Overdrafting is the rule rather than the exception in much of Texas. Water levels have declined by as much as 200 feet in northwest Texas since groundwater development

began after the turn of the century. The total volume of water in the High Plains of Texas has been decreased by approximately 23% — the greatest percentage of depletion of any state overlaying the Ogallala Aquifer. Some estimates would exhaust the Ogallala in Texas soon after the year 2000. This prospect raises the specter of an end to irrigated farming in the region with serious impacts on the region's economy, a decline of some cities, and a possible exodus of inhabitants. The southeast and upper Gulf Coast regions of Texas have suffered significant amount of land subsidence. The Houston area is one of the most affected by land subsidence in the United States. The water table has been lowered some 350 feet since the 1940's with a resulting land subsidence of as much as 10 feet.

India may be able to learn something from Texas. If nothing else, what to avoid or the consequences of following the status quo in the arid parts of the country. Texas is a good example of a state experiencing problems adapting the English common law doctrine to the realities of an arid environment. Following the common law in Texas, which for practical purposes means the right to capture, has created common resource pool problems leading to competition which has, or soon will, lead to the depletion of the resource for most economic uses in the near future. Groundwater can be, and is, managed at the local level in Texas.

In 1949 the Texas Legislature authorised the voluntary creation of underground water conservation districts. These districts were provided with discretionary power to regulate groundwater withdrawals as long as the landowners did not lose their "ownership" of groundwater. Districts may space wells, and regulate the production of wells. For most parts these districts have failed to decrease overdrafting. This failure is due to the fact that landowner's absolute right to the water beneath his or her land cannot be abrogated by a district. Also, a county can opt to exclude itself from a district's jurisdiction. With that option available to local pumpers, a district is not likely to pursue management practices that threaten the economic activities of groundwater extractors within their borders.

The absolute ownership doctrine in Texas has been described as "one of anarchy rather than law." The doctrine has led to competition within the state, with bordering states and Mexico, and various other problems including land subsidence, saltwater intrusion, and other forms of pollution. In the long term clearly groundwater governed by right of capture, or absolute ownership, benefits superior economic interests -- those with the economic resources to utilize the water as water tables fall. Ultimately in a common pool competitive situation, such as that exists in much of Texas, only the wealthiest farmers will be able to compete for water resources — and even then that competition will lead eventually to a conversion of the economy to dry farming with resultant negative economic impacts.

Utah

Although there have been localised overdrafting problems in Utah, the state gets most of its water from surface water sources and in many areas, due to the abundance of surface water, groundwater withdrawals declined through the 1980's.

Utah follows a prior appropriation system, limited by beneficial use and administered by a state engineer via a permit process. As with many western states, what exactly is a beneficial use is unclear. However, domestic uses are to be given priority over agricultural uses, which are to be given priority over other uses. In the event that there is a request for an appropriation in an area in which there is inadequate groundwater available for those claiming it, the state engineer is authorised to hold a hearing to determine whether or not there is adequate water to satisfy existing claims. In the event that it is determined that there is inadequate water to supply existing claims, the state engineer may divide the waters available among existing claimants according to their relative priorities.

Washington

Washington has experienced overdraft problems in various areas — particularly in the eastern and southeastern parts of the state. Washington follows a prior appropriation systems, governed by reasonable use, and administered by the Washington Department of Ecology. Although this sounds like most of the states that we have examined here, there are some things that are unique about Washington. The Washington State Department of Ecology attempts to manage water resources on a recharging basis on a steady state basis. In case of an essentially non recharging basin the Department of Ecology issues permits which will allow the planned groundwater mining and depletion of the resource. Hence, we see a combination of management ranging from safe yield to groundwater mining depending upon the nature of the resource, that's not a pattern we have seen in most states, and it seems most advisable. As in most states, any water appropriated in Washington must be put to a beneficial use. But unlike many states the beneficial uses (which include such uses as domestic, industrial, commercial, agricultural, power, and mining) in Washington also includes water for aesthetic and fish or wildlife purposes. This is an important distinction as beneficial uses related to instream flows and maintaining and repairing habitat are some times ignored (as in Arizona where instream flows are not considered a beneficial use) or given very low priority (the case in many states).

As we have seen in some states, management entities are directed to allocate water on the basis of the "public interest" variously defined — often meaning "highest economic use". In Washington the Department of Ecology has the authority to administer water rights according to principals of highest and best use. Specifically, the Washington code directs the department to allocate water according to securing the maximum net benefits for the state using cost-benefit analysis. Finally, the Department of Ecology has adopted regulations and issues permits in such a manner such that a certain amount of groundwater may be reserved for some public water supply purpose in the future. The Washington code also provides that the Department of Ecology can designate groundwater areas or subareas, when necessary, for more intensive management.

If it sounds as though the state of Washington is trying to do a lot in its administration of groundwater (in terms of satisfying many needs), it is — and this is a potential problem for Washington or any other state developing a groundwater management code. Many of the

above statutes conflict with one another — such as the prior appropriation and priorities established by the Washington code or the cost benefit analysis requirements and the prior appropriation or beneficial use requirements. The lesson to be learned, perhaps, for India is to keep it simple. Complexity and ambiguity in the law will only lead, as it has in Washington and many other western states, to confusion, poor management, and litigation.

Wyoming

Wyoming has experienced localized overdrafting problems, often associated with energy development and rapid population growth. Wyoming follows a prior appropriation system, tempered by reasonable use, administered by a state engineer via a permit system. The prior appropriation system created in Wyoming in 1947 overturned the previously court-mandated absolute ownership doctrine. In 1957 Wyoming revised its prior appropriations statute and directed the state engineer to issue permits for any application of groundwater in areas not designated as a "control area." The state engineer is also empowered, by a 1969 amendment, to deny an application if he or she should finds the permit not in the "public interest."

When a "groundwater control area" has been created, the state engineer's authority over groundwater increases significantly. Within a groundwater control area the state engineer has the authority to refuse to grant permits for drilling of any wells without hearings. The state engineer also has the authority, after hearing, to order junior rights holders to reduce their withdrawals or to require some system of rotation of withdrawal. Within control areas there are five-member control area advisory boards established to provide the state engineer with local input.

Most of what Wyoming does, as we have seen, is not much different from many other western states. One possible exception is in its designation of standards and classifications for water quality. Wyoming identifies four classes of non-industrial water and three classes of industrial water according to quality and then determines which uses are appropriate for which water based on quality. Class 1 is suitable for domestic use, Class 2 for agricultural use, Class 3 for livestock, Class 4 for fish and aquatic wildlife. In each of these first four classes the water should not contain biological, hazardous or toxic waste above the amounts established as minimum by the U.S. Environmental Protection Agency. Class 4 is suitable for industries, Class 5 are water associated with hydrocarbon deposits or other minerals, to be used for geothermal purposes, and Class 6 is groundwater unsuitable for any use. Various types of discharges are allowed into waters that fall into classes 4 through 6. This classification scheme is used primarily for determining what levels of discharges (i.e. pollutants) will be let into which aquifers and under what circumstances.

What's It All Mean?

What is good groundwater management? There is no real correct answer to this question. The answer depends upon what values a system seeks to maximise. As we have seen

different systems in the different states allow varying flexibility of management at the state and local level. These systems may or may not choose to maximise some values (such as economic efficiency) over other values (such as protecting small farmers). To provide another example, cultural and economic stability is a possible value that might be maximised through groundwater management. The rapid depletion of groundwater resources can destabilise communities by shifting uses (i.e. putting small pumpers and others out of business). Any groundwater management system, be it common law absolute ownership and right of capture or a prior appropriation system or a system of correlative rights, can lead to instability and the unequal distribution of resources. It would seem that a prior appropriation system with quantified rights administered via a permit system subject to beneficial and reasonable use requirements with adequate authority either at the state level or through a local board that has equal representation of all participants (i.e. not weighted by property ownership) would, if there is the political will, have the highest success in balancing the equities and maintaining long term groundwater availability.

Clearly any system has to include local input. As we have seen in many states in the western United States, local input is no more than an advisory body -- but that is certainly preferable to a strictly centralised decision making system at the state level. But local input is more important for an even more fundamental reason. Without the acquiescence of the local population, any groundwater management system is likely to fail.

This raises another issue. What are the prerequisites for local cooperation? It would seem that local actors need to have a stake in the system. At minimum that might mean participation in groundwater management decision making, or it may mean shifting responsibility for groundwater management entirely to local entities. Cooperation might also be purchased -- as we saw in the case of Arizona.

Although our preference may be for local decision making, surely the central government must, no matter that the system, provide data, analysis, and expertise to aid local decision making. It is unrealistic to expect local boards -- and if this option is pursued it is possible that there could be thousands of them in India -- to maintain the expertise necessary for the quantification of groundwater rights.

It goes without saying that any attempt to control India's groundwater extractions will entail the development of some system of rights. At the risk of sounding redundant, it is worth repeating that any system of rights is not value neutral. The question is, whose values? One way of measuring or determining values is through participation of the various publics that have a stake in groundwater use. Where this becomes problematic is determining who these "various publics" are. Participation can be either limiting or expanding. For example, are current groundwater users the only participants? If so are there societal, communal, or other interests that may not be represented in their decision making? I would argue that there are and that participation should be broad-based to include those who have indirect as well as direct economic stakes in the outcome of water allocation decisions. As we have seen in the western United States, local participation varies significantly. If participation (e.g. voting

rights) is based on land ownership then the dominant economic interests and the values they pursue will have the highest influence on groundwater management decision making. Often, the U.S. experience shows, these interests favour continued expansion of groundwater pumping to maintain current levels of economic activity (which may be necessary to retire incurred debt). If, on the other hand, participants represent local as well as regional interests (including those that may not currently be pumping water), decisions are obviously more likely to reflect concerns of a community as a whole.

In order for rights to be meaningful they have to be enforceable. As we have seen in the western United States, although the courts are the ultimate arbitrators of groundwater rights, there are a number of intermediate forums for the resolution of disputes. In some states such as Colorado there are specific adjudicative bodies established to deal specifically with water rights. Given the cost and time involved in adjudication, systems that rely on the courts for dispute resolution are likely to benefit the economically powerful. Arbitration, binding or otherwise, would seem to better equalise the playing field for all participants.

The implementation of a system of groundwater rights can go a long way towards minimising the need for future dispute resolution. Consequently administrative systems that maximise input opportunities (through hearings or other means) and are sensitive to the concerns of all participants are most likely to result in decisions that do not require further dispute resolution. Towards this end I would recommend that any system maximise input and consultation opportunities of all participants and that resultant decisions -- and the reasons behind those decisions -- be made available to all participants.

Although mentioned only briefly in the summary of U.S. Western water law above, the states vary significantly in their ability to transfer water rights or water. In many states such as Colorado and Utah, transferability is not difficult; in many others it is nearly impossible. One of the issues associated with water transferability is the negative impacts that transferring water out of a groundwater basin might have on the basin (e.g. by being removed from the local ecosystem). Water transfers can, therefore, have negative impact on third parties that may not be involved in the transfer. That raises the question of how to compensate for negative impacts on third parties.

Transferability has the advantage of facilitating the movement of water to its highest economic use, and it also could provide, depending on the rights system in place, for compensation to overlying landowners who may not otherwise be able to benefit from their resource.

Finally let us close with one last point. The author undertook an extensive study and comparison of groundwater management systems in three states, in the early 1980s, to determine the effectiveness of different systems.[44] The states -- Arizona, California, and New Mexico -- utilise very different management systems (the American Rule, correlative rights,

44. Zachary A. Smith, Interest Group Interaction and Groundwater Policy Formation in the Southwest (Maryland: University Press of America, 1985).

and prior appropriation respectively) yet all experience overdrafting. In interviews with representatives of groundwater users and policy makers in each state it was determined that satisfaction with their system varied significantly. Nearly all parties in New Mexico, for example, were satisfied with the system in place. In contrast, nearly none of the parties in California were satisfied with their system. What is interesting is that dissatisfaction or satisfaction was not related to the legal or formal administrative regime in place but was rather a function of acceptance of the people behind a given system. This would suggest that any system for administering groundwater rights should be structured so as to produce administrators acceptable to the relevant publics (either by consultation or election).

Trickle Down?
Decentralisation of Water Resource Administration and Financing in Post-Mao China

Jennifer L. Turner[45] & James E. Nickum[46]

Introduction

Since it was formed in 1949, the state of the People's Republic of China (PRC) has vacillated between centralising and decentralising development strategies. During the Great Leap Forward (1957-1960) and the Cultural Revolution (1966-1976), a considerable amount of administrative and financial decision-making authority was transferred to the provincial levels of government. A decentralisation strategy, extending to the sub-provincial levels and relying increasingly on the market, has also dominated the post-Mao period (1978-present). In the water sector, decentralisation is viewed as a means of improving the efficiency and quality of water service delivery and water project construction, and, importantly, of lessening the financial burden on the centre. This is particularly true of surface delivery systems, as wells have always been under village or subvillage management for rural uses, and are commonly dug and operated by the beneficiary in urban areas as well.

Decentralisation, the devolution of administrative or economic power to the local or lower levels in a territorial hierarchy, may or may not be accompanied by market reforms. In China, where those units are provincial and sub-provincial (prefectural, municipal and county) governmental agencies, decentralisation before 1978 was accompanied by a restriction in the scope of the market. Some theorists argue that decentralisation promotes more efficient implementation of policies and fosters more equitable development (Conyers 1984; Rondinelli 1981). Much of this literature presumes that local officials are more responsive to local needs and capable of adapting policies to them (e.g., Bryant and White 1982). Often central governments and international donors advocate decentralisation as a means of involving both lower-level officials and citizens more effectively in policy implementation or infrastructure development. Democratic theories maintain that citizen participation improves the quality of information to decision makers at both the local and central level. Moreover, citizens are more likely to support policies and projects which they help to create (Ostrom, et al. 1993).

Yet local officials do not always have broader local interests at heart in the absence of accountability. Examples abound where local elites use discretion over decision making and financial resources to benefit themselves (Caiden and Wildavsky 1974; Cheema and Rondinelli

45. Indiana University, School of Public and Environmental Affairs, and Political Science Department, Bloomington, Indiana

46. Programme on Environment, East-West Centre, Honolulu, Hawaii

1983). Also, when they regard recentralisation as likely, local officials and residents may opt for a short-term extraction strategy, thereby ironically providing a strong pretext for that recentralization. Hence it is necessary to have credible commitments at the central level backed by appropriate institutions and incentive structures at the local level in order to prevent the degradation of natural resources which otherwise results from decentralisation. (Tobin and White 1993).

In order to stem local officials' abuse of power, much of the development literature, as well as the policies of international aid organisations, advocates that decentralisation be accompanied by empowering local people. Hence decentralisation cannot be viewed as a cure-all, particularly when carried out rapidly without preparing lower levels of government and society to take on new administrative and financial responsibilities and adopt more participatory management styles.

The literature concerning rural infrastructure development, local institution building, and common pool resource governance complements on decentralisation, in that it addresses in greater detail *how* local institutions and governments can become more effective. In other words, the local organisation and development literature can be drawn upon for possible solutions to the problems that decentralisation often creates or fails to solve. In order to promote efficient and sustainable management and use of common pool resources such as water, some scholars have stressed the need for greater local self-governance and self-organisation as opposed to central government control or privatisation (Ostrom 1990; Tang 1992). Ostrom et al. (1993) argue further that failure to address incentives of local people and local governments has been one of the main reasons for the failure of sustaining infrastructure projects, such as irrigation systems.

After examination of 18 case studies of local organisations in rural areas in Asia, Uphoff and Esman find that *linkages* between and among institutions, both horizontally with organisations at the same level and "vertically between local organisations and structures at the centre of government which set policy and allocate resources" are keys to the success of local institutions and rural development (1974:xii). They also point out that effective local organisation not only needs considerable investment of resources, authority, and information, but also power derived from local initiative and local resource mobilization. Although Uphoff and Esman accent the importance of local organisations having some accountability to local constituencies and local citizen participation, they also note that effective local, particularly rural, institutions cannot exist in the absence of strong central support. This support should not, however, be translated into central dominance, that can deprive local organisations of local accountability.

The data for this study were drawn for the most part from primary Chinese sources, which included publications from the PRC's Ministry of Water Resources (MWR) as well as water law and regulation documents. All of the issues of *Zhongguo Shuili* (China Water Resources), the monthly journal of the MWR from January 1988 through May 1993 were

examined for articles relating to financing and managing local level water activities and projects.

This review of the water policies of the PRC does not attempt to provide definitive answers on the merits of centralisation and decentralisation for environmental protection and natural resource management. In particular, it focuses on those areas where the primary concern is excessive centralisation, most commonly, surface water systems, although we do touch upon the regulation of water withdrawals from both surface and subsurface sources, where a certain amount of centralisation may be called for. What it does indicate is that the PRC provides fertile ground for analysis, for in the past decade China has undertaken a dramatic shift from a highly centralised to fairly decentralised administration and financing of water policies, water projects and management.

Although water pollution is severe in China, the focus here is on water development, utilisation and management. Mismanagement and poor development of facilities such as hydroelectric power plants, pumping stations, irrigation districts, and dam projects all represent situations where water is wasted or land is subjected to salinisation, water logging, or flooding. This paper focuses on the question of whether the devolution of administrative, financial, and managerial decision making to lower level water bureaus and stations has produced better fund raising abilities, improved water resource management, and successful implementation of a water withdrawal permit system and water law enforcement measures.

A plethora of water laws, regulations, and policies in the post-Mao era have devolved more administrative and financing power to local levels. Analysis will here be limited to the effectiveness of water fee collection, economic sideline operations, management reforms, and a newly introduced water withdrawal permit system. The paper closes with two examples of organisational innovation at the lower levels in the area of water law enforcement and river basin planning. These cases illustrate the types of organisational changes necessary to enable local level government and water agencies better utilize their newly acquired administrative and financial discretion. To put the decentralisation measures in context, an overview of water resource legislation and water administration institutions in the PRC will first be presented.

Legislation

Beginning in 1978, Deng Xiaoping ushered in a new era of economic reform and opening to the outside world. This phase of economic liberalization brought with it a surge in reforms of the legal system and a restoration of legal institutions. The legal reforms have been aimed primarily at providing an adequate framework of law to support economic reforms and encourage foreign investment (Dicks 1989), and to reduce the dependence of policy on individuals in power. Environmental protection and natural resource management were the focus of new laws and regulations. The 1982 Constitution for the first time included declarations that the state had the responsibility to protect the natural environment and natural resources (Blomquist and Xi 1992). During the mid 1980s a myriad of environmental laws and regulations were promulgated (Ross and Silk 1987).

The flood of environmental legislation was accompanied by an expanded administrative structure, with new institutions, as well as increased decentralisation of environmental protection, resource management and pollution control to lower levels. In the area of water development and management, the Ministry of Water Resources has also stressed the importance of laws, financial self-sufficiency, and devolution of administrative and financial decision making. These methods represent a significant step away from past practices which relied on short-term mobilization campaigns and centralised planning with uniform policies imposed across the whole country that did not allow for local discretion vis a vis natural resource management, utilisation, and protection (Ross and Silk 1987).

Administrative Structure

In China, water resources are administered by a nested hierarchical administrative system. The Ministry of Water Resources is at the centre, with Water Resource Bureaus at the provincial, prefectural and county levels. Water Management Stations at the township level and their equivalents are the lowest level of water administration. This system is supplemented by seven river and lake basin commissions, which are agencies directly under the Ministry of Water Resources administratively. Special water districts have also been formed to operate irrigation, drainage or flood control programmes.

The picture is complicated by disagreements among government ministries over the State Council's 1988 Accountability Policy (*sanding fang'an*) that designated the Ministry of Water Resources as the administrative department in charge of carrying out all the unified management of water resources, administering the water withdrawal permit system, planning for urban and rural water resources, and managing rural water conservancy and village-township water supplies. In particular, officials in the Ministry of Urban Construction continue to assert the right to collect fees and implement the water withdrawal permit system in urban and suburban areas. Ironically, in 1988 and in 1990 the State Council also issued documents that declared the Ministry of Urban Construction responsible for the management of urban water resources. This division of water resource management between urban and rural, firmly embedded into the administrative system, infuses the debate over control of water resources. The situation is made even more complex by the inclusion until recently of environmental protection in the former Ministry of Urban Construction and Environmental Protection.

1988 Water Law

The first comprehensive water law was promulgated in the PRC in 1988. In addition to stipulating the basic principles for formulating water law and regulations at lower levels, the Water Law also initiated a water withdrawal permit system and new enforcement mechanisms, as well as procedures for mediation and arbitration to resolve water conflicts. The State Council, Ministry of Water Resources, provincial, and sub-provincial levels subsequently issued numerous implementing laws, regulations, provisions, and plans. The Water Law appears to have served a planning function and accelerated reform and experimentation in the water management and policy sector in China. A large number of pilot projects were conduct-

ed throughout China on areas such as water management, fee collection, protection of small river basins, financial diversification, and investment.

Although the list of water legislation promulgated in the 1980s is impressively long (see appendix), it should be noted that many are regulations (*tiaoli*), not laws. Some are "temporary," and many lack implementing provisions.

By 1991 the People's Standing Committees or People's Governments in nine provinces (or province-level "autonomous regions") had promulgated Water Law implementation measures or water resource management regulations. Such regulations are seen as building the foundation for the formation of more local water legislation (Ke 1991). The slow pace of formulation of provincial level implementation measures may indicate that lower levels have given low priority to the measures stipulated in the 1988 Water Law. Another possibility is that the provinces are still carrying out experiments in water management and development and will produce implementing legislation. Yet another explanation could be that political in-fighting over the right to manage water and other issues at the sub-provincial levels (i.e., financing difficulties) have hindered the promulgation of implementing legislation at provincial levels. Since 1991, more provinces have passed implementation measures (e.g., Hunan and Hubei in 1993).

The problem has replicated itself at subprovincial levels. In Hebei Province near Beijing, the People's Congresses or governments in 63 of the 85 areas, cities, and counties had not promulgated any sort of unified water resource management document by 1992. One article stated that a major cause of conflict is between governmental departments over the right to manage water, in particular, to collect water fees and give out water withdrawal permits, especially in urban areas (Cao 1992). Local leaders evidently complain that disputes between ministerial departments over control of urban groundwater combined with disputes at the centre in Beijing and in the provinces over the control of other water resources create considerable uncertainty and make it increasingly difficult for lower levels to manage water or formulate local laws (Cao 1992).

Financial Channels

Central to water resource management, development, and reform has been the issue of financing. *Zhongguo Shuili*, which is aimed in part at educating lower level water officials, has frequently proposed methods for local water bureaus or units to achieve greater financial independence from the central government. The most common suggestions, stemming from the early 1980s, have been for the water units to increase fee and tax collection rates, stimulate investment from private sources, create joint stock cooperatives, auction off small river basins, borrow from domestic or foreign banks, solicit aid from international organisations, and/or establish and manage sideline "economic entities" to earn extra money (*Zhongguo Shuili* 1988).

Despite the accent on monetized instruments such as fees, taxes, and loans, farmers are still required to contribute free labour to water project work. In 1989, a State Council decision stated that each rural labourer would be required to devote 10-20 "labour days" (probably but not necessarily equal to calendar days) in "farmland capital construction" each year. In some areas with developed economies, this obligation is often discharged through cash payment.

The 1988 Water Law states that fees should be paid according to the regulations of the unit supplying the water or building a water project. Despite a number of laws and regulations formed by the central government stressing the necessity of enforcing fee collection, it appears that local levels are often unwilling or unable to collect water fees. Since the reforms began in 1978, peasants are increasingly being subjected to fees and taxes from many local government offices. Difficulties in affording the numerous fees have led peasants to refuse payments and to riot and attack local officials in some rural areas, leading to the issuance of a policy in 1993 aimed at reducing "excessive fee burdens." The inability of the rural water users and industrial mangers to accept that water is no longer a free resource is also one commonly reported hindrance to fee collection from both peasants and industries. Therefore, many articles in *Zhongguo Shuili* accent the need to use education and propaganda to change the thinking of the "masses" (Li 1993). At every level of local government some officials, especially in the agricultural agencies, argue that water fees place too heavy a burden on rural water users, and succeed in having fee standards set below those recommended by the State Council (Guo 1991). Hence resistance from local government officials in other agencies has often succeeded in denying water bureaus and stations access to much needed financial resources to fund operations and worker salaries. The resulting low salaries in the water sector are often cited as a cause of low work quality in water facility development and maintenance, forming a vicious circle.

China has not been constructing many new water facilities in recent years, while existing works have generally been in need of funding. A major cause of this dilemma has been the inability to collect water fees. For example, remote Gansu Province collected only 44.23 percent of the water fees that it levied in 1991. Although these rates of assessment and collection appear low and cases still exist where water supply projects not even charging fees, at the aggregate level the present effective rates have still increased significantly over the past decade. Water fee collection increased from 4.36 hundred million *yuan* in 1984 to 18.3 hundred million *yuan* in 1991 and in 1992 they nearly doubled to 35.7 hundred million *yuan*. In addition to increased charge levels, collection rates increased from 30 percent in 1984 to 70 percent in 1991. One of the main reasons cited for the improvement was the growth in power of law enforcement agencies (Zhang 1993). Clearly, the reduction in funds and subsidies from the central government, especially in the early 1980s, acted as a catalyst to improved fee collection in many places.

Although fee collection has increased, not all the money obtained is channeled into water facility development, management and maintenance. Some leakage occurs because of the kaleidoscope of collection methods and channels. Some fees can be paid through a water ticket system, others use internal ministry receipts; some are given to a general government body or

grain procurement agency, while others are collected by rural water managers. Each of the organisations that collect fees using these different methods deducts some overhead. In some cases, this has resulted in water bureaus and stations receiving only half of the fees which were actually collected (Li 1993).

In the past, irrigation fees often ended up in general government revenue accounts, which naturally dampened the incentives for local water officials to collect the fees and for the local people to pay them, as there was no mechanism to ensure that the money was allocated back into the irrigation system. Today, however, the new water laws and regulations limit the use of water fees to operations and maintenance (O & M) for the system from which the fees were collected (Svendsen 1992). It is still too early to state the impact of this change, but central officials feel that guaranteeing local areas the right to use locally collected fees will increase their incentives to collect fees and local users to pay them. Collection and cost-sharing methods are still very complex.

Some areas in China have experienced problems with water conservancy funds being "eaten" by being overdrawn, embezzled, lent-out, or even used to build roads or houses or to supplement wages. Such local "corruption" has often been cited as a significantly growing problem since the economic reforms and policies were initiated in late 1980's granting greater local discretion over local matters without commensurate improvements in revenue generating authority. Such abuses, it is alleged, have had a serious impact on the progress and quality of water projects.

One county's solution to local financial corruption was to "unify" its management, contracts, and budgets. To unify its management of water project construction, the Anyi County Hydroelectric Bureau in Jiangxi Province formed a special funding management office to provide accounting and disbursement of funds as well as to deal with the financial budgeting of special projects. All of the various water fees that are collected in the county go through this office. This funding office is also subject to audits from the county office of financial administration office and to monitoring by banks (Liu 1992). The same county government also now carefully evaluates possible projects in an attempt to prevent too many projects from beginning and funds falling short. Another type of "unified" action that Anyi County adopted was the formation of a small feasibility study group made up of the county financial bureau, auditing bureau, agricultural bank, the rural government, and the county hydro-electric bureau. The group strictly evaluates all water projects in terms of financing and quality and has led to improved economic efficiency in all projects (Liu 1992). Such streamlining of management, financial, and construction operations is a new concept to the water sector in China that has not yet been widely duplicated.

This consolidated interagency approach has strengthened Anyi County's institutional capacity to better manage water in that the county was able to create a monitoring system sufficient to guard against corruption. Such "unification" at the local level could represent a effective method to halt the corruption and compartmentalization that may otherwise attend increased local discretion over financial resources. In hindsight, to mitigate problems of

financial mismanagement, the central government should have first promoted the establishment of local financial funding offices before devolving financial authority. The questions remain, however, whether local governmental agencies are inclined to become more integrated in the management and financing of water resources.

In addition to corruption, the *ability* of lower level water bureaus to manage financial affairs could be called into question. Presently the financial and accounting systems in the water conservancy system are deemed inadequate. Most water units have not established independent financial accounting organisations, while in those that exist financial accounting personnel are poorly educated and supplied. This weakness in the financial system reflects the inability or unwillingness of local water bureaus to set prices at adequate levels.

Despite all the talk by central officials that local water units should become financially self-sufficient, an abundance of stories throughout the past five years relate the difficulties some water units are having in accomplishing this goal. A question worth investigating is whether the central government has actually lowered investment in water resources, especially at the provincial and sub-provincial levels. In other words, how self-reliant has the local water sector actually become in investment funds?

In 1989, central state investment in water conservancy capital construction was approximately 75 percent of the total; by 1991 this had decreased to only 50 percent (Almanac 1991). It should be noted, however, that these aggregate level numbers mask what is happening in individual provinces. According to 1990 statistics, in 18 of the 30 province-level units, over half of the water conservancy capital construction investment came from the central government. In 4 of the 30 (Heilongjiang, Shanghai, Jiangxi, Hubei) the central government's investment was approximately half of the total investment, while in the remaining eight provinces (Shandong, Liaoning, Fujian, Guangdong, Guizhou, Yunnan, Gansu, Qinghai), most of the funding came from local or foreign sources and not from the central government (Almanac 1991).

The continued funding from the central government in over half of the provinces indicates that Beijing is targeting its support on key projects. Nonetheless, areas receiving this support may have reduced incentives to become more efficient in their financial management unless they are required to repay the portion contributed through the national budget. In none of the material reviewed for this paper was there mention of a time frame for lowering central subsidies in the water sector. In addition, implicit subsidies from default on advances from the financial system may not show up in the water resource accounts. Therefore, it appears that lower level water bureaus may continue to count on a safety net of subsidies for some time to come. As long as their operations are deemed necessary to ensure food security and bankruptcy or its equivalent is not a viable option, subsidies will remain.

Although responsibility for financing has been devolved to lower levels, Article 30 of the 1988 Water Law provides that the planning for local water use and distribution is still determined by governments at the next higher level. These governments in turn base their plans on

regional or provincial plans. While hierarchical structures of planning are not necessarily inefficient, and may be necessary, this arrangement could limit the discretion that local water bureaus and stations can exercise.

Economic Entities

In *Zhongguo Shuili* one of the key strategies advocated to help water bureaus, hydroelectric stations, pumping stations and other water units become economically independent of central government funding has been the development of "diversified operations" and "economic entities." These terms refer to economic activities that are often independent from the water resources a water bureau or station is managing or developing. Such operations are viewed as a method to help water bureaus raise funds, put excess workers to productive use, and to relieve the pressures on the central government coffers. For example, a water pumping station might plant fruit trees on land near the pumping station it is managing, open a small plant to make shirt collars, or invest in a hotel or barber shop. Output value of the economic entities of water units and bureaus in 1986-1987 reached 1,800 million *yuan* with an aggregate profit of 200 million *yuan* . (Xu 1988) To put this amount in context, central government investment alone in the water sector has recently averaged around 3 billion *yuan* a year (Almanac 1992). Hence, despite their growing importance, economic entities still only supply a fraction of the investment needed in the water sector.

Officially, the profit from these sideline activities is to be used for the operations and maintenance of the water unit in question, but often the profits are reinvested in the sideline operation itself or paid out to employees as bonuses. Some water units are evidently neglecting water management in their pursuit to earn profits from economic sideline activities (Xu 1988). These inefficiencies represent an unintended outcome or necessary evil resulting from the government's policy to encourage economic entities. Beijing cannot and should not monitor every economic sideline operation undertaken by every reservoir and pumping station in China. This example exemplifies how increased local discretion without the development of local monitoring institutions can lead to inefficient management of water facilities, resources, and finances. A critical question is why do these lower level water units lack incentives to carry out their main functions?

On the other hand, not all water units have succeeded in keeping the sideline activities in operation and have subsequently been unable to use this means to finance their water activities. The main reason cited for this has been the lack of scientific, technological and managerial experience, leading to the production of items that are not competitive. Another problem facing economic entities has been taxation by revenue-starved local governments (Xu 1988).

The central government has been formulating economic policies and water laws to encourage the development of economic entities and help water management units function better. Regulations on water conservancy economic entity management were promulgated in 1988. In the period of the Eighth Five Year Plan (1981-1985), every water management unit that used its own natural resources to plant crops, raise fish, or construct its own agricultural

processing plants or water conservancy projects was to be exempted from all state industrial taxes. Regulations on water conservancy economic entity management were promulgated in 1988. The State Tax Bureau also issued a document in 1992 which stated that "water management and water protection stations, and water production station units that provide technological expansion, irrigation and technological management for a fee shall be exempted from state taxes on their revenue" (Li and Du 1993:18).

Many water bureaus and units do not appear to be taking advantage of these tax breaks or using other water conservancy economic policies to look for opportunities to develop economic entities and raise funds. Why have the government's attempts at providing incentives for better management proved unsuccessful? One possibility is that lower level water bureaus and stations lack the time, expertise and experience to become financially self-sufficient. A structural problem limiting the development of economic entities in much of the interior of China is the lack of market-oriented infrastructure such as roads and railways. Also, economic entities are a possibly self-defeating attempt to jury-rig a solution to the underlying unprofitability of many water management operations.

Water Withdrawal Permit System

The 1988 Water Law initiated a water withdrawal permit system tied to the levying of water fees. Briefly, under this system, all individuals and units that withdraw water directly from rivers, lakes, or the ground must apply and pay for a permit if their use goes beyond that necessary for household uses or for the watering of livestock and poultry (Almanac 1990). The motive behind the permits is for the local water bureaus to discover where and how much water is being withdrawn, and to charge for water use to promote water conservation.

In 1993, nearly five years after the promulgation of the water law, specific implementing legislature on the water withdrawal permit system was issued. Prior to this time, the water withdrawal permit system was rarely mentioned in *Zhongguo Shuili*, a striking omission. This silence most likely reflects the difficulties the local officials have faced in implementation. In light of the rapid growth of rural industry, one could imagine the difficulty the already financially-stretched water bureaus would have in tracking down all of the rural enterprises that have not applied for withdrawal permit, especially as agricultural uses are exempted. Another formidable task would be to find, much less monitor, all of the nearly 3 million tubewells in the rural areas. In the Water Law and the literature there is also no information regarding the cost to the user of the permit or whether the permits need to be periodically renewed. Perhaps the vagueness of the system will be clarified after further local experimentation. Perhaps the "self-sufficiency" policies have given local levels greater ability to ignore the central government's legal orders. Local ability to evade, ignore or change Beijing's policies and laws has become an increasingly common phenomena in the post-Mao era (Oi 1989, Shue 1988).

Another major obstacle to local implementation of the permit system appears to be the ministerial disputes over implementation rights. The local Urban Construction Ministry's departments and the Ministry of Water Resource's local bureaus have been competing for the

right to implement their own water withdrawal permit systems. Officially, the water bureaus have the ultimate right to manage and develop water resources nationwide, but they have experienced difficulties in stopping other departments (including geology, agricultural and forestry departments as well as urban construction) from mining water without applying for water extraction permits (Cao 1992). The Ministry of Water Resources has also faced problems in forcing other governmental departments to pay various water fees (Cao 1992).

A national meeting in 1989, however, declared that unifying water fees and permits under the Ministry of Water Resources would be enforced in order to prevent the problem of "many dragons harnessing water" (*duolong zhishui*). But this did not solve the problem, for in 1992, the Commodity Bureau and the Finance Ministry issued a document on controlling "chaotic" fee collection and fining. The 1992 document was aimed specifically at the water conservancy system of administering fees and setting standards. This document deemed the water department's collection of water fees as legal and orderly but noted that other departments, particularly the Urban Construction Ministry, should not be collecting water fees or issuing water extraction permits. Nevertheless, the Urban Construction Ministry and its lower level departments are evidently still collecting water fees.

The lack of compliance by the ministerial departments to the new water regulations and fee requirements does little to encourage local governments, industry, and rural water users to comply. Moreover, uncertainty over which ministry has the responsibility to carry out the water withdrawal permit system and fee collection has perhaps also provided the local governments and water users with an excuse to ignore the proposed system and demands to collect fees. While the Ministry of Water Resources perceive these interministerial conflicts as hindrances to their work, the disputes could perhaps be viewed as constructive efforts at property rights definition and bargaining. To be fair, we must note that *Zhongguo Shuili* is the house journal of only one of the ministries concerned.

Management Reforms

In addition to advocating water fee reforms and establishing economic entities, the central government has strongly encouraged management reforms at all local levels. The government's major proposal in this arena is the implementation of a "Production Responsibility System" (PRS), as in farm operations. The application of PRS to water management emphasizes management efficiency, incentives, and profitability. In irrigation systems the PRS has produced the "Net Output Delivery Contract" system. Under this system a village-based collective is permitted to lease land or farm facilities to a third party. While these third parties can use the land to make private profit, they are responsible for producing part of the collective's agricultural sales and tax quotas. The "Economic Contract Responsibility System" applies to collectively owned irrigation systems and can involve either the entire system or a part. The service delivery functions are either leased or sold outright to contracting water management organisations. These contracting organisations can be companies, groups, joint households, households or even individuals (Svendsen 1992).

According to Svendsen, the agreement between collective and contracting organisation is something akin to a franchise arrangement, in that contract managers pay the collective for their rights to a contract and agree to carry out certain functions. The contracting organisation must take all the responsibility for profit and loss, and establish their own budgets and fee collection systems.

Individual farming households or groups of farmers can also assume contracts to manage water resources to increase their own agricultural production or earn money from providing others (Cao 1992). One major advantage in allowing farmers to contract and develop water conservancy facilities has been an increase in the number of investment channels, for the farmers are more willing to invest money or labour into projects and facilities that will serve their own private interests. An unplanned outcome in this period of increased decentralisation and management reform has been that farmers, either independently or jointly, tend to demand or simply take actions to create their own water facilities and/or water enterprises. Some local officials have used their authority to oppose this move, others have tacitly approved, while still others provide open encouragement (Cao 1992).

The relative success of the PRS reforms can be attributed to the involvement of water users and the provision of financial incentives for efficient management of water facilities and resources. The challenge lies in extending these lessons to higher levels of management.

Success Stories

Enforcement

In addition to stipulating how water should be rationally developed and utilised, the water law also devotes seven fairly long articles to defining illegal behaviour and how violators will be dealt with. In 1990, two temporary provisions were promulgated outlining the procedures for administering punishment for violations of water law regulations. It should be noted that law enforcement problems concerning levies and dikes being damaged from the weight of illegally built structures, fish poaching, and general destruction of water facilities through carelessness appear to have become quite serious in the reform era (*Zhongguo Shuili* 1991), although they were far from absent before.

The continued destruction of water facilities is often attributed to the absence of laws at the lower levels to protect them (Liu 1993). In addition, water bureaus have not exercised their administrative power to enforce the water law, in part out of reluctance to take action against illegal acts committed by the farmers, water bureaus, or even their own leaders (*Zhongguo Shuili* 1992). Successful prosecution of cases also appears to be a very time-consuming and expensive undertaking, which could represent great disincentives for financially-strained local water bureaus or stations to act.

One notable success in developing a water law enforcement system has taken place in Hunan province. In 1992, twenty-nine counties and cities in Hunan province began imple-

menting a water law enforcement system in pilot projects. One year later the system was expanded over the whole province. Some water project management units and key water basin districts have established water security agencies or supervisory stations and an enforcement network has been set up between provinces, cities, countries, and townships. Presently, at every level, water administration departments in Hunan depends on these enforcement teams, judicial, and security departments to aid them in enforcing water laws and regulations. In the first half of 1992, these enforcement agencies and stations handled 1742 water violation cases and mediated 995 water conflicts. Moreover, with an effective enforcement system, the implementation of the water withdrawal permit system and water fee collection became more feasible. In Hunan, over 60 counties have carried out the permit system and 20 counties have begun to implement measures for levying water resource fees (*Zhongguo Shuili* 1993). The development of this enforcement system illustrates how new experiments at forming networks and promoting cooperation among the various levels of government have helped implement the enforcement provisions in the 1988 Water Law.

River Basin Management

In order to meet the demands of economic reforms, the Ministry of Water Resources has suggested a more comprehensive management of water projects. For example, the Yellow River Water Resources Hydroelectric Development Company was set up in 1989 to provide a competitive for-profit construction organisation to build and operate water conservancy, hydroelectric projects in the river basin. This company embodies a new approach to operations. For example, acting as owner of the enterprise, the company handles the technical and economic appraisal of development projects. carries out project surveys and designs, and assumes the responsibility for operating the completed project. By having a single company oversee projects from beginning to operations, the organisation may be able to overcome the problems of guaranteeing the quality, time frame, and cost containment encountered when water projects are done by outside construction teams. By being more able to guarantee performance in project construction, the Yellow River Hydraulic Development Company has been successful in competing with foreign and private Chinese companies bidding for project work within the basin (Xi 1991). This experiment illustrates how the creation of new, more integrated organisations at the lower levels can be used to promote more efficient management and development of water resources.

Conclusion

It appears that decentralisation has not *yet* led to significant improvements in financing and administration of water facilities and projects. *Zhongguo Shuili* provides stories of successful water project construction, management and maintenance, but these cases have not been fully replicated nationwide. In other words, it does not appear that devolving responsibilities to the lower levels has of itself led to significant increases in investments in the design, construction, operation and maintenance of water infrastructure projects. Although most water bureaus and water stations are able to meet their operating expenses, they lack the funds to cover repairs, expansion, and depreciation costs. This lack of success at raising funds is in

great part due to the inability of most lower level water bureaus and governments to create the necessary organisations and agency integration to facilitate fee and tax collection or investment in water activities. Notably, the success stories in financing and enforcement illustrated above all included either the formation of either new lower level organisations, including public corporations, or the integration of existing government agencies.

Beijing began devolving financial and administrative authority in the water sector in 1980. The financial necessity for decentralisation has been great for the central government, with its need to relieve itself of the financial burdens that it inherited of large and growing subsidies to water, agricultural, and industrial sectors.

Although decentralisation measures began nearly 15 years ago, the lower level governments and water bureaus appear not to have adapted to the changes by forming new organisations or streamlining their administration. One could speculate that the central government's desire to free itself from its financial burdens produced rapid, somewhat ill-planned decentralisation measures in the early eighties, but why are lower level agencies still unable to generate adequate finances internally? *Zhongguo Shuili* predictably places considerable blame on local officials for the lack of improvement in water project construction and management, but provides little commentary on the upper level's responsibility. Yet water use and distribution are still based on plans passed down from above. This raises the question whether enough responsibility has trickled down.

According to Uphoff and Esman (1974), central government support can play a crucial role in promoting efficiency in local organisations and institutions. For example, more training programmes from the central or provincial governments could help lower level water bureaus and stations cope with the increased responsibilities. Another approach could be the formation of revolving funds for water projects. Loans could be provided to local level water bureaus, but with enforced repayment so that those funds do not become de facto subsidies. Forms of central support which stress partnerships and accountability would be an improvement over the continuation of central government subsidies, which have not given many lower level water bureaus the incentive to raise their own funds. Most importantly, a mechanism should be found whereby units which cannot cover costs cut back on service or cease operating altogether.

Limited assistance from the central government, however, will not improve lower level water agency performance if constraints which limit the effectiveness of the provincial and subprovincial water bureaus and agencies are not removed. The low rates of fee collection signal that incentive structures have not yet been devised to ensure the stakeholders involved, particularly peasants, that they will receive their fair share of benefits. This reflects a central argument of the common pool resource literature that unless users of a resource respect and acknowledge the authority of the governing institution, the temptation to free ride or shirk shall be great (Ostrom 1990). The question of local water unit accountability to water users in the PRC is one which merits further investigation. Aside from the management reforms, however,

the issue of local water institutions enhancing local citizen participation does not appear to be receiving priority in *Zhongguo Shuili* articles.

The implementation, monitoring, and enforcement of more stringent fee and tax regulations, including a nationwide water withdrawal permit system all entail huge transaction costs for under-funded water agencies with small staffs who often lack the technical and financial training needed to carry out the new water laws and policies. Decentralisation efforts continue, as they are recognised as both desirable and unavoidable, but it is clear that the process of downshifting is likely to be long, tortuous and not without its pitfalls. For example, the need to reduce subsidies and improve performance may stand in direct conflict with China's food "security" goals which insist on maintaining irrigated agriculture even when it does not pay economically.

Bibliography

Almanac of Chinese Water Resources. 1990. "Water Law of the People's Republic of China. Beijing: Water Conservancy and Electric Power Publishing Company: 3-6. (In Chinese)

Blomquist, Robert F. and Wang Xi. 1992. "Developing Environmental Law and Policy of the People's Republic of China: An Introduction and Appraisal." The Georgetown International Environmental Law Review. 5 (1):25-75.

Bryant, Coralie and Louise G. White. 1982. Managing Development in the Third World. Boulder, Colorado: Westview Press.

Caiden, Naomi and Aaron Wildavsky. 1974. Planning and Budgeting in Poor Countries. New York: John Wiley.

Cao Zhongzhu. 1992. "Discussion of the Establishment of Unified Management Law, Regulations, and Policy for Water Resources." *Zhongguo Shuili*. (Chinese) (July):23.

Cheema, G. Shabbir and Dennis A. Rondinelli. Eds. 1983. Decentralisation and Development: Policy Implementation in Developing Countries. London: Sage Publications.

Chen Zhikai. 1992. "Water Resources Development in China." Country Experiences with Water Resources Management: Economic, Institutional, Technical and Environmental Issues. World Bank Technical Paper #175. Washington D.C.: the World Bank:175-181.

Conyers, Diana. 1983. "Decentralisation: The Latest Fashion in Development Administration?" Public Administration and Development. 3:97-109.

Dicks, Anthony. 1989. "The Chinese Legal System: Reforms in the Balance." China Quarterly. 119 (Sept):540-576.

Guo Wanrong. 1991. "Discussion of Collecting Water Supply Fees According to Cost," *Zhongguo Shuili*. (Chinese) (October):18.

He Xiaoqiu. 1991. "Comprehensive River Planning in China." *Zhongguo Shuili*. (Chinese) Qian Zhengying, ed. Beijing: Water Conservancy and Electric Power Publishing Company:454-573.

Ke Liban. 1991. "Principles and Measures for Formulating Local Water Law Implementing Measures." *Zhongguo Shuili*. (Chinese) (July):30.

Li Dechan and Du Chunming. 1993. "Grasp Firmly Three Major Points, Pay Attention to Three Major Links." *Zhongguo Shuili*. (Chinese) (January):18.

Li Wenzhi. 1993. "The Difference Between Levying and Collecting Water Fees." *Zhongguo Shuili*. (Chinese) (January):30.

Liu Ning. 1992. "Water Conservancy Investment Channels Increase, Funds Should be Managed Well." *Zhongguo Shuili*. (Chinese) (July):27-29.

Liu Shu. 1993. "What does Market Economics Offer Water Administration Work?" *Zhongguo Shuili*. (Chinese) (March):22-23.

Oi, Jean. State and Peasant in Contemporary China: The Political Economy of Village Government. Berkeley: University of California Press.

Ostrom, Elinor. 1990. Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge: Cambridge University Press.

Ostrom, Elinor, Larry Schroeder, Susan Wynne. 1993. Institutional Incentives and Sustainable Development: Infrastructure Policies in Perspective. Boulder: Westview Press.

Shue, Vivienne. 1988. The Reach of the State: Sketches of the Chinese Body Politic. Stanford, California: Stanford University Press.

Su Tie. 1993. "Actively Developing Checking and Supervision of Funds to Promote the Development of Water Project Construction." *Zhongguo Shuili*. (Chinese) (April):4-5.

Svendsen, Mark. 1992. "Management Devolution In China." IIMI Review. 6, 2 (November):14.

Ross, Lester and Mitchell A. Silk. 1987. Environmental Law and Policy in the People's Republic of China. New York: Quorum Books.

Tang, Shuiyan. 1992. "Designing Complex Institutional Arrangements: Linking Bureaucratic and Local, Self-Governing Organisations." in Institutions and Collective Action: Self- Governance in Irrigation. ed. Shuiyan Tang. San Francisco, California Institute for Contemporary Studies Press.

Tobin, Richard J. and Alan T. White. 1993. "Coastal Resources Management and Sustainable Development: A Southeast Asian Perspective." International Environmental Affairs. 5 (1):50- 65.

Uphoff, Norman and Milton J. Esman. 1974. Local Organisation for Rural Development: Analysis of Asian Experience. Ithaca, New York: Rural Development Committee, Centre for International Studies.

Zhongguo Shuili. (Chinese) 1988. "Use Subsidized Interest Loan to Develop Multiple Operations Well," (February):32.

Zhongguo Shuili. (Chinese) 1991. "Circular on the Establishment of a Water Conservancy Law Enforcement System." (September):21.

Zhongguo Shuili. (Chinese) 1992. Guangdong Hydroelectric Bureau Administrative Office, "Strengthening Awareness of Responsibility to Protect and Support the Honor of the Water Law." (February):31.

Zhongguo Shuili. (Chinese) 1993. "Hunan Reforms Strengthen Functioning of Water Administration Departments." (February):3.

Wen Boping. 1987. "On the Water Pollution Prevention and Control Law." in Environmental Law and Policy in the People's Republic of China. Lester Ross and Mitchell A. Silk eds. New York: Quorum Books:122-132.

Xi Meihua. 1991. "New Type of Water Basin Development Industry: Yellow River Water Conservancy Hydroelectric Development General Company." *Zhongguo Shuili*. (Chinese) (August):35.

Xu Tougao. 1988. "Analysis of Ocean and River Basin Water Resource Diversified Operations." *Zhongguo Shuili*. (Chinese) (April):34.

Zhang Linxiang. 1993. "Strengthening Structural Reforms in Water Administration Work." *Zhongguo Shuili*. (Chinese) (February): 14.

Appendix

IMPORTANT DOCUMENTS IN WATER LAW, POLICY, AND MANAGEMENT

6/5/80 State Council Report issued to Ministry of Water Resources, Financial Ministry, and National Aquaculture Central Bureau concerning reservoir fish industries and developing diversified operations.

5/4/81 State Council circular report issued to national aquatic products central bureau concerning several problems with present and previous aquaculture work.

6/30/82 Water and Soil Protection Work Regulations.

2/17/83 State Council circular issued to farming, livestock, and fishery departments concerning regulations on several problems in the development of agricultural wasteland, agricultural business and unified industry.

5/18/84 Ministry of Urban and Rural Construction and Environmental Protection issue Water Pollution and Prevention and Control Law.

7/13/84 Ministry of Water Resources Provisional Regulations on Rural Livestock and Domestic Water Works.

7/13/84 State Council Circular Report on solving problems with rural domestic water.

5/8/85 Water and Electric Power Ministry Circular concerned with problems in the reform of water conservancy project management system and the development of diversified operations.

6/25/85 National Water and Soil Protection Working Cooperative Group circular on conditions and opinions regarding development of water and soil protection work.

26/25/85 Water and Electric Power Ministry prevention plans for major floods on the Yellow, Yangtze, Huai, and Yongding rivers.

7/22/85 Measures for the appraisal, collection and management of water fees for water projects.

8/8/85 National Water and Soil Protection Working Cooperative Group Emergency Report concerning mining, road repair, factory construction, and other capital construction work that needs to do water and soil protection work well.

10/7/85 State Council Circular reply to the Water and Electric Power Ministry concerned with strengthening irrigation and water conservancy facility management and work.

10/31/85 State Council Circular on halting indiscriminate fee collection from farmers.

1/22/86 Fisheries Law

1987 State Planning Council, Financial Ministry and Water Ministry joint document demanding the solution of solving existing problems in water project construction and enterprise fee collection.

1/21/88 Water Law

5/3/88 Ministry of Water Resources Accountability Policy Plan (*sanding fang'an*).

6/10/88 PRC Water Canal Management Regulations.

9/1/88 Water and Soil Protection and Special Regulations on development and construction in the contiguous area of Shanxi, Shaanxi, and Inner Mongolia.

9/15/88 Ministry of Water Resources Directive outlining safety and construction of flood storage and detention areas.

1988 Agricultural Bank circular concerning rural water resources loan work.

1988 Ministry of Water Resources promulgated measures for comprehensive utilisation of the contract responsibility system for water units. (trial implementation)

10/15/89 State Council decisions concerning the vigorous development of irrigation and on-farm infrastructure.

12/21/88 Provisional Regulations on water resources diversified operations management.

1988 Finance Ministry and Ministry of Water Resources management rules on small scale irrigation and water resources and subsidies to mitigate soil erosion.

1/5/89 State Council Document concerning the administrative problems in the key upper Yangtze flood protection districts.

9/1/89 National Environmental Protection Agency Implementing Rules for the PRC Water Pollution Law.

1990 Party, State, and State Council decision concerning the control of chaotic fee collection, chaotic fining and other expenses.

5/4/90 Ministry of Water Resources Pearl River Water Resources Commission Accountability Policy Plan (*sanding fan'gan*).

5/4/90 Ministry of Water Resources Tai Lake Basin Management Bureau Accountability Policy Plan.

5/5/90 PRC Ministry of Water Resources Party Organisation decision concerned with learning from the "*Lei Feng* style" of Wen Qingcheng.

5/8/90 Ministry of Water Resources Huai River Water Resources Commission Accountability Policy Plan.

6/15/90 Decision concerning the prevention of sudden pollution accidents in the Huai River basin (for trial implementation). (Issued simultaneously by NEPA, Ministry of Water Resources, People's Government of Henan, Anhui, Jiangsu, and Shandong provinces)

6/20/90 Management measures for collecting fees on sand mining in river canals. (Simultaneously issued by Ministry of Water Resources, Finance Ministry, and National Commodity Bureau)

8/10/90 Guiding regulation (*daoze*) on the formulation of long-term supply and demand plans for water. (Issued by Ministry of Water Resources)

8/15/90 Water administration supervisory organisation and work rules (*zhangcheng*) (for trial implementation)

8/15/90 Temporary provisions concerning the procedures for administering punishment for violations of water law regulations.

11/24/90 State Planning Committee, Ministry of Water Resources, Chinese Water and Electric Power work meeting committee decision concerned with commending village electrification experimental construction units (*shidian jianshe*) and progressive workers.

12/15/90 PRC Ministry of Water Resources Party Organisation decision concerned with learning from the activities of comrade Zhou Jingwen.

3/22/91 Water reservoir and large dam safety management rules (*tiaoli*).

4/9/91 PRC national and social development Ten Year Plan and the eighth year Five Year Plan outline.

6/28/91 PRC flood prevention regulations (*tiaoli*).

6/29/91 PRC water and soil protection special law.

11/19/91 State Council decision concerning advancement in the harnessing of the Huai River and Lake Tai.

11/25/91 Regulations (*tiaoli*) for land compensation and population resettlement for large- and medium-sized water conservancy hydroelectric engineering construction.

11/29/91 PRC Central Government decision concerning advancing and strengthening agriculture and village work.

1992 Commodity Bureau and Finance Ministry document concerning water resources system of administering fees and setting standards. (Based on 1990 "chaotic fee decision")

Sources: Volumes 1990, 1991, and 1992 of Almanac of Chinese Water Resources.

Effective Approaches for Relaxing Crisis of Groundwater

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ABSTRACT

In the arid and semi-arid regions of northern China surface water supplies are scarce and groundwater overdraft has occurred in a large number of areas. This has caused serious water table declines, land subsidence, sea water intrusion and pollution of groundwater resources. Administration of water supplies is now being done on the basis of the new "Water Law." This involves formulating long-term water demand and supply plans as a basis for macro control. Extraction is controlled through a permit system, imposition of water resources fee and water charge. Conjunctive use of surface and groundwater is planned and efforts are made to exploit slightly saline water for irrigation. In addition, water savings are attempted through canal seepage control, adoption of low pressure pipes for water transport, land leveling, small border irrigation, mulching crops with straw and PVC film, and water saving irrigation scheduling. Industrial water savings are also being attempted through increasing the ratio of reused water, technological improvements, enforcing water use and quota regulations and charging new or enlarged enterprises the corresponding cost for new water supplies. Finally, new supplies could be developed by constructing interbasin diversion projects including diverting supplies from the Yantze River transfer water from south to north and Yellow river diversion.

OVERDRAFT OF GROUNDWATER CAUSED SERIOUS ISSUES OF WATER-ENVIRONMENT

Surface water is scarce in the arid and semi-arid regions of northern China. Since the beginning of 1970's, the groundwater resource has been developed and utilised on a large scale. Exploitation has now reached 60 billion m^3 per year. Well irrigation covers 11.7 million ha. in the 17 provinces, cities and autonomous regions of northern China. (1) Many cities also depend on groundwater as the main water source. Over the past 20 years, the development of groundwater has contributed greatly to agricultural production in the north and helped reverse historical patterns of food transfer from south to north. Groundwater development has also contributed to economic and social development of the region. In the course of this, however, overdraft of groundwater has occurred creating serious environmental issues.

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1. Continued drawdown of groundwater table

In Haihe river basin 96% of available surface water has been controlled and utilised. Over the past 10 years, shallow groundwater resources have been overdrawn by 2.2 billion m^3 per year in Hebei Province. The area of cone groundwater table depression has reached 340 km^2 in extent. The deepest depth at the centre was 37 m in Shijiazhuang city in the beginning of the 1990's, with the annual drawdown more than 1 m. (2) Throughout the central and eastern part of Hebei with plain, deep groundwater resources have been overdrawn by 0.66 billion m^3 per year. The rate of drawdown in the centre of cone depression in Hengshui and Cangzhou cities was 3-5 m per year. Water table depths at the centre were 52.5 m and 85.6 m respectively in 1991. (2) There are 56 cones of depression in the groundwater table underlying a total area of 87000 km^2 in the country. (8)

2. Land subsidence in large area

Groundwater overdraft, especially of deep confined aquifers, has caused land subsidence. Land has subsided by 2514 mm in Tianjing city, (3) and adjacent areas in the central and eastern part of Hebei plain. In Cangzhou city land subsidence increased from 25 mm in 1971, to 1311 mm in 1990. In recent years, subsidence has occurred at a rate of 96.8 mm per year. The top of the Great Canal dike subsided by 500 mm inside the city area. Land subsidence has caused water to accumulate in the rainy season, cracks in highway bridges and under ground pipes, broken wells and decreased flood drainage.

3. Sea water intrusion in parts of coast area.

Sea water intrusion affects 500 km^2 in Ponglai, Longkou, and Laizhou of Shandong province in the bay of Bohai sea. (1) It also affects 55.4 km^2 in the sea harbour area of Qinhuangdao city and the outlets of Yanghe and Daihe rivers. The maximum oil content measured in this area was 1875 mg/l. (2) In some areas away from the coast, sealed old saline water has also intruded into the cone of depression created by recent pumping. Sea water intrusion has affected rice growth and the quality of production decreased in township enterprises.

4. Pollution of groundwater quality

In addition to water table drops, pollution from untreated sewage is a growing concern. According to the "Survey and Assessment of Groundwater Quality in Hebei Province" 3 billion m^3 of sewage drained into rivers and water bodies. Of this 70% was untreated. Groundwater pollution from untreated sewage affects townships and enterprises in the distant suburbs of Beijing. The ratio of various elements examined in 140-180 monitoring wells: C^6H^5OH 23.8%, CN 7.1%, As 40.%, Cr 40%. (9)

STRENGTHEN ADMINISTRATION OF GROUNDWATER RESOURCE

As a result of the above depletion and pollution problems, decisions have been taken to strengthen administrative controls over the groundwater resource and its utilisation.

1. Water administration according to "Water Law"

The "Water Law of the People's Republic of China" (6) (adopted at the Meeting of the standing committee of the People's Congress in 1988) now serves as the basis for water resources administration. The Ministry of water resources is the department of water administration under the State Council, which is in charge of the unified administration of water resources throughout the entire country. They exercise a system of unified administration in association with other governmental organisations at various levels (local people's governments, districts and departments under the State Council). The State Council has established the National Leading Group of Water Resources and Soil conservation to coordinate important water affairs among the departments and districts. The river basin commissions are the outside branch offices of the Ministry of Water Resources (Fig 1). (7)

The "Water Law" stipulates that: "In the areas deficient of water, urban growth and the development of high water consumption industries and agriculture shall be restricted." "When drawing groundwater, unified planning must be conducted based upon the findings from the survey and assessment of water resources, supervision and management shall be strengthened. In areas where groundwater has already been overdrawn, strict control on drawing shall be imposed and effective measures shall be taken to protect groundwater resources and control land subsidence." For drawing water directly from aquifers, rivers or lakes, the state shall exercise a water-drawing permit system, "Strengthen supervision and management of prevention and controlling of water pollution."

For controlling land subsidence in Tainjing city, the government closed down 600 deep wells after 1986 and the groundwater drawing decreased 30 million m^3 per year, thus slowing the rate of land subsidence.

2. Long-term plans

Since deciding to formulate long-term water demand and supply plans as the main basis for macro control over water resources in 1980, the Ministry of Water Resources and Electricity has focused on estimating demand and supply in the northern water deficient provinces and municipalities. The long-term plan is based on analysis of existing water resources and the demands on them. The goal is to realize the strategic objectives of national economic and social development through forecasting demand and supply and identifying comprehensive countermeasures for resolving the contradictions. By 1989, seven water deficient provinces (municipalities) had completed long-term plans for water demand and supply.

3. Water-drawing permit system

Water-drawing permits are the basic system stipulated under the "Water Law" for management of water use. Any production unit that needs to develop and utilise water resources must submit an application to the local department of water administration. This must indicate the amount of water to be drawn and the site of water source. It must also provide essential technical information. Following this the unit must get certificates for exploration and use authorisation. It is necessary to perform supplementary procedures for approval when sources are already being exploited by existing projects. The Shanxi province stipulated that developers can't drill deep wells in areas where the groundwater has already been overdrawn. Furthermore, when extraction is planned to exceed 10000 m^3 per day proposals must be submitted to the provincial water resources committee for approval. For exploiting shallow groundwater (up to a depth of 50 m), approval by the county (area) level department of water resources is required. Applications for using water with a temperature over 30°C must be approved by the provincial water resources committee. For springs with discharges >2m^3/sec, 0.5-2 m^3/sec and <0.5 m^3/sec approval from the province, prefecture (city) and county are respectively required. This system has been in place since 1983 in Shanxi province and has changed the nature of competition for groundwater by various departments. This has played a positive role in achieving a unified administration of water resources and ensured that demands for water to meet energy base and social development. (10)

4, Imposition of water resources fee and water charges to promote water savings through economic measures

The "Water Law" stipulates that "Water resources fee shall be charged to those urban units directly drawing groundwater; the fee to be charged to others drawing water directly from ground aquifers, rivers, lakes shall be decided by the people's governments of province, autonomous region, or municipality under the Central Government". The water resources fee shall be imposed by the department of water resources administration and the revenue shall be used as a special fund for management of water resources. The view of water as an inexhaustible resource has changed and been replaced by a view that water is limited and valuable. Shanxi province has adjusted the water resources fee from 0.03-0.06 to 0.06-0.12 yuan per m^3. After adopting the comprehensive measures of management including imposition of water resources fee, the water extraction dropped to 330.5 m^3 in 1990 from 883 m^3 in 1980 per 10000 guan out put value. Water applied per ton of steel produced dropped to 20 m^3 from 60 m^3.(10) Prior to this, for historical reasons, water policy supported low charges for extraction in the long-term, which seriously affected the rational utilisation of water resources and caused major gaps between water demand and supply. Since 1985, the State Council has published a "Method of checking, calculating and administration for Water Charge of hydraulic engineering." The Ministry of Water Resources has formulated unified methods for calculation of water charges. The standard water charge is based on the cost of water supply which includes operation and management costs, repair costs, depreciation charges and all other

associated costs. The new approach raised the charges for water supply substantially. Water supplied by large and medium size projects before 1982 was 1.2 billion m^3 and the income generated only 10 million yuan. Since 1990, calculated according to the new criteria, the cost of water supply for agriculture was 0.0416 yuan per m^3, and 0.0711 yuan per m^3 for industry. Despite the fact that the amounts of water supplied has decreased somewhat, imposition of the new water charge has increased revenue to 60-70 million yuan. Thus, rectification of water charges has successfully promoted water use savings and improved the economic situation of water supply units. (10)

RATIONAL REGULATING AND UTILISING LOCAL WATER RESOURCES

1. Conjunctive use of surface and groundwater

The goal of rational water resources management is to increase available water supply through regulating and transforming rainfall, surface water, soil water, groundwater and plant water. The key to realizing this objective is regulating groundwater depth. By doing this it is possible to control evaporation of phreatic water, increase the rainfall infiltration for groundwater recharge, reduce the surface run off and enhance the leaching of soil salts. The basic approach to regulating groundwater depth is to use ground and surface water resources in conjunction through a combination of canals and wells.

In areas without fixed canal irrigation water sources that depend on well irrigation, excessive rainwater in flood season is diverted for groundwater recharge through canals and other infrastructure designed specifically for this. In Longfang city, for example, the total volume of surface water diverted and stored in 1975-1989 was 5 billion m^3. This was done through a "deep canal network" and caused rises in the groundwater table ranging from 1.87 m to 3.44 m. It also restrained groundwater table declines. The river flows diverted by the "canal network" in flood season in Xung county from 1988-1991 was 0.255 billion m^3. This caused the groundwater depth to reduce from 10 m to 4 m. Shandong province retained and stored river flows after the flood season for recharging groundwater and reduced the areas affected by large cones of depression by 3770 km^2 over the entire province between June 1991 and June 1990. Beijing exploited the groundwater on both sides of the Chaobaihe river on the down stream of Miyun reservoir as a supplementary water source for the city area. At the same time a sluice was constructed to retain and store the abandoned surface water for groundwater recharge. Nanpi county exploited weak saline water (2-5) g/l) for irrigation. The groundwater table in this area, which had dropped to 5-6 m before the flood season, was raised to 2-3m and the quality improved by utilising summer rain water and river flows after flood season for recharging groundwater.

In districts with both fixed surface canal irrigation water and groundwater sources, conjunctive use allows optimal delivery of surface and groundwater. The "People Victory Canal" irrigation districts diverting the Yellow River for irrigation and the Guanzhong basins

diverting river flows for irrigation in Shanxi province, all utilise a combination of wells and canals. In these areas, groundwater accounts for about one half of the total irrigation water applied. Utilisation of groundwater in areas served by canals allows enlarged irrigation areas and prevents the disasters of waterlogging and salinity. The irrigation district of Yellow river diversion in the northern part of Yinchuan in Nin xia, contains areas of salty groundwater. In response they either mixed groundwater and surface water for irrigation or drained off the saline water and recharged the groundwater aquifers with fresh water. The Zhaoquan pilot area of Shijing canal irrigation district when there is no surface water for irrigation in dry years draws on groundwater for irrigation. This has enabled regulation of the underground reservoir and resulted in increased yields for wheat and cotton. In this area the optimum ratio of groundwater extraction to surface water diversion is 3:2, and groundwater depth is regulated at 3.22-6.99 m.

2. Exploiting saline water for irrigation

The unique experiment in Nanpi pilot area in 1980-1990 made by the Hebei Institute of Hydrotechnics has shown that wheat and corn yields of 6960-8355 kg/ha could be achieved through irrigation with saline water (4-6 g/l) and weak saline water (2-4 g/l). The yields increased 1.2-1.6 times over that of non irrigated plots. Additional salts deposited in the soil by using saline water are leached out by the concentrated rainfall during the flood season under monsoon climate and drainage conditions.(12) Exploiting saline water for irrigation lowers the groundwater table and increases rainfall infiltration for both recharging groundwater and improving groundwater quality. There is great potential for exploiting saline waters in the north China plain. In Hebei province, for example the available amount of weak saline water is 1.5 billion m^3.

WATER SAVING

1. Water saving in agriculture (13)

Agriculture accounts for more than 80% of total water use. As a result, water saving in agriculture is the focal point of conservation efforts. This includes reductions in transportation losses and increase in water use efficiency.

To control canal seepage low pressure pipes are being adopted for water transport. The low pressure pipes save 10-30% of water losses and 1-2% of the land as compared to unlined field canals. Well irrigation districts utilising pipes for water transport have an average irrigated area per well of 7 ha. In contrast areas using open furrows for water transport in Hebei province averaged only 4.3 ha.

Land levelling and small border irrigation are utilised for increasing water application efficiency. Water savings in irrigation have also been achieved by intercropping wheat and cotton and covering the soil with a PVC film. This method reduced evaporation from the soil.

The irrigation quota for wheat and cotton was reduced to 1575 m^3/ha -- a savings of 1/3 than that required in traditional irrigation. In this experiment, the water use efficiency of wheat was 9.75 kg/mm.ha, the yield per unit of water was 2 kg/m^3 -- twice that in uncovered fields. The yield of cotton was 750-1020 kg/ha after 3000-3750 kg/ha of wheat had been harvested from the same field. Aside experiments with PVC and straw mulching in farmland are often utilised to reduce evaporation from the soil and conserve field moisture. Wheat fields irrigated 1-3 times are covered with corn straw at a rate of 6000-7500 kg/ha. The water use efficiency in these fields was 16.5 kg/mm.ha, saving 23% of the water normally applied. The yield per unit of irrigation water was 1.55-2.67 kg/m^3, an increase of 53-130%

Recently experiments have been done with soil water storage approaches to irrigation for wheat. Soil water was stored corresponding to 85-95% of field capacity in a 2 m soil layer for wheat before seeding by irrigating 1-3 times in spring. The yields achieved were 5250-6000 kg/ha and the total water consumption was reduced to 0.6-0.84 m^3/kg. These water saving were achieved by reducing the soil evaporation and utilising soil water in the deep layer (1-2 m).

Adoption of water saving irrigation schedules is another approach to reducing irrigation water needs. For this, the principle is to adopt irrigation schedules that maximise income for the whole irrigation district. In the areas where there is a scarcity of water, crops are deliberately allowed to sustain some degree of water deficit and yield reduction. Owing to water savings, however, the irrigated area is enlarged and the income of the entire irrigation districts is maximised. Generally, irrigation is essential before seeding. After that, the number of waterings is reduced as far as possible to reduced soil evaporation. Decisions on when to irrigate are based mainly on the lower limit of suitable soil moisture. This is, for example, 60% of field capacity for wheat.

2. Water saving in industry

Industrial water accounts for 60-80% of total water use in cities. As a result, it is the focal point for water saving in cities. (4)

A major goal is to raise the ratio of water reuse. In the 1970's, the ratio of water reuse in industry was generally not over 50%. In the recent decade, the ratio of reused water has exceeded 70% in many cities including Qingdao, Delian, Beijing and Taiyuan. This has been achieved through forcing industries to set up installations for water reuse on cooling and air conditioning, and to reuse the water used in other industrial applications after treatment. The ratio of water reuse in industry reached 64% in Tianjing in 1984. Water application per 10000 yuan output value was 168 m^3. Dalian city fully utilised sea water for cooling. By doing this the fresh water utilised per 10000 yuan output value reduced to 90 m^3. (4)

Reforming industrial technology, equipment and extending new technologies for water saving is another approach for reducing demand. (4) In recent years, some enterprises reduced

the water required for product processes. For example in 1979, the No.2 blast furnace of Capital Steel Factory adopted evaporation cooling and achieved water savings of more than 80% (4). In the regions of Beijing, Tianjing and Tangshan cities, water application per 10000 yuan output value was 463 m^3 in 1980. By using reformed the water cooling-systems and implementing technologies for water reuse it had been decreased to 249 m^3 by 1987. Current forecasts indicate that the water requirement will be 139 m^3/10000 yuan in 2000. (3)

Finally, economic approaches are taken through exercising a planned quota water use system. Quotas are enforced by raising the price of water if use exceeded the quota. Water meters are installed to monitor the amount of water use. The water saved in domestic uses between 1982-1986 totalled 0.317 billion m^3 after installing water meters in Beijing. (4) In addition to imposing water resources fees, additional costs of water supply installations for new or expanded enterprises are being charged. These water resources fees are used to assist enterprises to construct water saving projects.

CONSTRUCT INTERBASIN DIVERSION PROJECT FOR SUPPLEMENTARY WATER SOURCES

As the sustainable development of the national economy increases, water demands for agriculture and industry will increase continuously. The contradiction between water demand and supply will be felt more sharply in northern China. As a result, interbasin diversions of water for supplementing available water supplies will be imperative.

1. Water transfer from south to north

China's government has decided construct canals for water transfer from south to north by diverting the Yantze River. The diversion project starting from Danjiangkou water reservoir sited on Hanjian River Hubei province, will mainly supply water to the western part of the Huang-Huai-Hai plain. The area to which water will be supplied is 137000 km^2 and belongs to Hubei, Hehan and Hebei provinces and Beijing and Tianjing cities. There are 17 large to medium-size cities which lack sufficient water including Beijing, Tianjing, Shijiazhuang and Zhengzhou. Similarly, there are 7467 thousand hectares. of farmland lacking access to irrigation. The volume of water transferable is 14.46 billion m^3. The route of canal for water transport (fig.2) will follow the west side of Beijing-Guangzhou railway in Hebei province. Water supply will be by gravity flow. The water quality of Danjiangkou reservoir belongs to national I and II types (i.e. it meets the water quality criteria for domestic, industrial and agricultural uses. (14) This project will be completed before 2000.

2. Yellow river diversion

At present projects have been initiated to divert water from the Yellow river to Hebei province by means of the Shandong Weishan-Linqing main canal of the Yellow river diversion in order to address serious water scarcity problems. The amount of water supplied will be 0.5

billion m^3 over the period from November to February each year. This will be done through canals, ditches and lakes regulated to storing water and recharge groundwater. In addition, plans have been made to divert the Yellow river flow from Henan People Victory Canal of Yellow river diversion for transport to Hebei Baiyangdian. The goal is to improve the supply of water to oil development in north China, Hengshui power plant and for groundwater recharge in water deficient agricultural areas. In addition, addressing the serious groundwater over extraction problems in the western suburbs of Beijing is also a goal.

REFERENCES

1. Minutes of exchange conference on scientific technology of groundwater in entire country Ninan Groundwater Information news No.7-8 1993

2. Investigation team of leading group of groundwater administration, Ministry of Water Resources 1993 Investigation Report on Groundwater in Hebei province

3. Xio Ye Qu Jian Development and Protection for Groundwater resource in Beijing, Tianjing and Tangshan regions 1991 No.3 Groundwater

4. Xu Wende Potentiality and Measures of water saving in cities 1991 No. 3 Groundwater

5. Zhang Zhenxong Shi Zhenge Study on Sea Water intrusion and control measures in coast area of eastern part of Hebei province, Hebei Technology of water resources and Hydropower No.2 1993

6. Water Law of People's Republic of China 1988

7. Ke Lidan Water resources administration in China World Conference on Water Law and Administration Spain 1989

8. Groundwater information news No.9-10 1993

9. Zhu Jicheng Dynamics of development and utilisation of groundwater No.3 1991 Groundwater

10. Jia Zeming et al.Reflection on the administration of water resources of Shanxi province in the recent decade (1982-1992) 1993 Shanxi people publishing house

11. Fang Sheng Chen Xiuling Realizing comprehensive control for multiple objectives in irrigation districts by conjunctive us of surface and groundwater. Irrigation and Drainage No.1 1993

12. Fang Sheng Chen Xiuling et al. Study on comprehensive control of saline alkali land with low yield 1991 Proceedings of 8th Asian-Afro regional conference of ICID. Bangkok

13. Chen Xiuling Develop Research on water saving for agriculture to raising the benefit of water for yield increase water resources of Haihe River No.5 1991

14. Zhang Fucun: Talk about the urgency of water transfer from south to north Hebei Technology of water Resources and Hydro-power No.2 1992

Research Agenda For Groundwater Law in India

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At least four different types of legal research need to be carried out to explore alternatives for appropriate groundwater legislation. First, examination is needed of the existing and possible legal regimes where private rights to groundwater can be contrasted with common property or common access rights. Second, research is required to understand situations in which water rights are separated from land rights and the possible legal alternatives and consequences of this separation. Third, understanding of legal regimes in which environmental and other multiple-use values (such as conjunctive use of groundwater with other natural resources), play significant roles is required so that appropriate elements for reflecting these values can be incorporated in any new legal structures created in India. The fourth type of research required relates to legal regimes for different hydrological or ecological situations.

To explain why these four types of research need to be undertaken urgently it will be necessary to first outline the existing background of groundwater law in India. This background needs to be understood keeping at least four specific legal issues in mind. First the existing statutory law; second, the constitutional and legislative framework within which new alternatives can be sought; third, areas where sanctions are relevant or meaningful; and fourth the types of sanctions possible.

Rapid increases in the exploitation of groundwater resources in India for irrigation, domestic, industrial requirements, livestock consumption and other uses has led to over development of available resources in many areas. The magnitude of emerging problems is indicated by the fact that the Central Groundwater Board of the Government of India has been engaged in drafting a National Groundwater Bill.

The people worst affected by over-exploitation of groundwater are small and marginal farmers. This is borne out by a study conducted by the Administrative Staff College. This study concluded that drops in the groundwater table affected small and marginal farmers throughout large sections of the Indo/Gangetic belt.[49] The number of people affected numbered about 200 million in 1983! While small and marginal farmers are the most affected by dropping water tables, regulation is unlikely to address their problems. Regulation tends to disproportionately exclude those who's access to the resource is already limited. Well spacing regulations, for example, work against those who have small land holdings. Deepen-

[49] Pant, Niranjan, "Groundwater Depletion" *Economic & Political Weekly*, 7th February, 1987, page 219.

ing restrictions affect those who's wells already have poor yields more than those who's wells now have sufficient yield. In general, any attempt at regulation should take into consideration the various socio-economic and political interests which play an important role in the use of groundwater. Dominant interests tend to be able to avoid the effects of regulation to a much larger extent than those having limited social, economic or political capital.

Groundwater Rights

The existing legal framework for groundwater is as follows: Groundwater is under a totally private legal regime. Rights in groundwater belong to the land owner. It forms part of the dominant heritage, and, as with land ownership, is governed by the tenancy laws of the state. The Transfer of Property Act, necessitates that the right to groundwater can be given to anyone only if the dominant heritage (land) is transferred. Conversely, the Land Acquisition Act, asserts that if someone is interested in getting rights over easement (over groundwater in this case) he would have to be interested in land. In short, groundwater is attached, like a chattel, to land property. There is no limitation on how much groundwater a particular land owner may draw.

The consequence of this legal framework is that only land-owners can own groundwater in India. Landless individuals and tribals (who may have group (community) rights over land but not private ownership) are left out. The legal framework also implies that rich land-lords can be water-lords and indulge in openly selling as much water as they wish.

To ensure proper and equitable distribution of groundwater to even those who do not own land, it is necessary to separate water rights from land rights. No such legal step has been taken in India so far and there is no separate national groundwater law. . The only state to move in this direction is Gujarat. In this case, the state has attempted to partially de-privatize groundwater. The law has been applied in only one district so far. Gujarat's approach has been to add sections to the Bombay Irrigation Act (Gujarat Amendment) Act, 1976, in 1979. These sections were brought into force in 1988. These laws do not touch the issue of water rights. They merely try to regulate water harvesting and marketing by restricting the depths of tubewells and introducing licensing procedures. Section 94 of the Bombay Irrigation Act prohibits construction of tubewells beyond 45 m in depth. Beyond this depth, special permission is required from the authorities. Section 99 of the same Act stipulates wastage of groundwater. In addition to Gujarat, Maharashtra recently enacted a Groundwater Act which is similar to the draft Bill circulated by the Groundwater Board. This only applies, however, to the protection of drinking water sources. Evidently, even the limited regulatory attempts of Gujarat and Maharashtra appear welcome in a situation in which groundwater exploitation is free-for-all situation by property owners. A great deal of thinking and research needs to be done to come up with appropriate groundwater rules, specially from the point of view of the people's water rights. While some degree of social ownership or use regulation appears essential, de-privatization of water rights need not mean total state control, as is the case in Kumaon and Garhawal Water Act, 1975, which abolishes community rights.

In this context the recent Kerala High Court's decision in Attakoya Thangal vs. Union of India, becomes relevant. This was a public interest litigation from Lakshwadeep Islands in which the residents claimed that the excessive pumping of groundwater by the rich farmers was threatening the very availability of groundwater for all. They claimed, under Article 21 of the Constitution that their life opportunities were being threatened since the depleting groundwater resource was likely to become saline. The court upheld the claim. Such a decision once again makes the right to water a natural or fundamental right under Article 21 - right to life, and a common property resource for the island.

This briefly summarise the water rights situation from the side of the people and the state. The conflicting and contradictory legal complexity can be summarised as in the following table:

Legal Rights to Water Sources

Source	Rights of the People	Rights of the State.
Tanks, & Lakes (Artificial)	Individual rights of owners Customary usufruct rights of the people.	No rights if tank on public land. Powers of the government to regulate use of private tanks in some states. Rights vested the panchayats or municipality if tank is on public land.
Tanks, Lakes (Natural)	Customary rights of the people recognised by the courts, and under Easement Act.	Absolute rights of owner-ship and use.
Wells (Private)	Absolute rights of the land/owners.	No rights.
Wells (Public)	Customary rights of groups, castes or communities; but rights for all under the Con-situation and the civil Liberties Act.	Power to regulate.
Tubewells (Private)	Unlimited right to draw water from tubewells . on private land.	No rights to own or regulate
Tubewells (Public)	Usufruct rights granted	Power to regulate by the state.

CONSTITUTIONAL AND LEGISLATIVE FRAMEWORK FOR REGULATION

The Government of India mooted the Groundwater (Control and Regulation) Bill in 1970 through the Ministry of Agriculture. The draft Bill was circulated to all states with advice to enact it with any necessary incidental modifications to reflect considerations in the state. As the development of water is essentially a state subject under the constitution, only the states are empowered to legislate on the matter. As previously noted, until now only Gujarat and Maharashtra have enacted any groundwater laws. In Gujarat this was done as the Bombay Irrigation (Gujarat Amendment) Act, 1976, and came into force on the 24th of March 1988. In Maharashtra it was done as the Maharashtra Groundwater Act, of December 1993. These Acts are extremely limited and only applicable to certain specified areas. The states of Tamil Nadu and Karnataka have prepared draft Bills but have not enacted them.

Since water is a state subject, national groundwater regulation can be brought in only if there is a constitutional change. This would require shifting water, or at least groundwater, to the Union or Concurrent List. Alternatively, regulation could occur if groundwater is given the status of a mineral. Mineral extraction is already under the constitutional control of the Central Government. Since groundwater is often a combination of many chemical compounds, defining it as a mineral could be relatively feasible legally.

At present, the only check on groundwater development with widespread application is through limitations on the flow of institutional finance from agencies like NABARD (the National Bank for Agriculture and Rural Development). Reductions in credit for well development from these agencies affect the middle and lower class farmers disproportionately and may not actually have much impact on the number of wells constructed. Wealthy farmers can still develop wells using private financing. The poor and middle class farmers who depend on government supplied credit are the primary ones these restrictions affect as they are most in need of loans.

AREAS WHERE SANCTIONS ARE RELEVANT

Once it is clear that legal regulation is essential, it is necessary to identify the areas where sanctions are needed. The following situations are some areas which can be considered for active research regarding the need for sanctions to control use.

1) Where there is an over-extraction of groundwater:
   a. For agricultural use;
   b. For domestic use (rural -- including livestock, urban)
   c. For industrial use
2) Where there is a dispute between two parties regarding exploitation of water:
   a. between two private parties (Rural and urban)/rural agencies;
   b. between two states (as groundwater basin do not generally follow political boundaries).
   c. between sectors (agricultural, domestic, industrial..)

3) Where there is environmental degradation due to over-exploitation;
4) Where there is groundwater pollution

TYPES OF SANCTIONS

Once areas where sanctions are required have been identified; it is necessary to find out what type of sanctions are most suited for different types of problems. The positivist theory of legal sanctions under which the existing laws have been framed does not accord incentives a major role in regulating human conduct. This underlying theory may itself have to be questioned here. The entire emphasis of the 1970 model bill is on penalties. It proposes typically negative, coercive, criminal sanctions such as fines and imprisonment. How these sanctions will -- or can -- be implemented is very unclear. If they are implemented, the bill contains little provision to ensure that implementation is equitably done. The only provision in the Bill for appeal are to a body created by the state government and there is a bar on the jurisdiction of the Civil Courts. In such a set up, ample scope is provided for misuse of power.

When planning a legislative framework, more thought has to be given to the cost-effectiveness of the proposed sanctions and the likely manner of their implementation. Given the problems inherent in implementing negative sanctions and the potential for abuse, alternate theoretical approaches to the management of sanctions are relevant. Some research has been done on the unsuitability of criminal sanctions in other areas of law. It has to be seen whether more positive, conciliatory sanctions are relevant for the purpose of groundwater regulation and management. More research needs to be done for determining suitability of different types of sanctions for managing groundwater in a socially and environmentally equitable manner.

The range of types of sanctions that require research and some of the factors affecting our ability to implement them are discussed below according to the problems they may help to address.

Problems relating to the first area, over-extraction :

a. The possibility of having licensing procedures to regulate digging of wells, number of wells and depth of wells, installation of tubewells etc., for extraction of water in rural and urban areas for domestic, agricultural and industrial use is an area that requires extensive research. Questions exist regarding both the implementability of licensing and the equity effects it is likely to have.

b. The possibility of measuring, extraction. Some measure of extraction rates in relation to the available resource is important for management purposes. The effective metering system prevalent in U.P. can be studied. The claims of the Central Groundwater Board that measurement is practical can be explored.

c. The problem of sanction in case of contravention. If a regulatory approach is followed, what types of sanctions are likely to prove effective when laws are contravened. Laws need to be at least nominally accepted by large portions of society if they are to be effective. Research is required into the types of sanctions that would find substantial social acceptance. Traditional use rights and sanctions for water and other resources may have implications for this in the groundwater case and require research.

d. The question of alternative, positivist, approach effectiveness. Will approaches such as: 1) awareness campaigns, 2) involvement of NGOs (given due protection under the laws), and 3) charging of cess (not as a fine but for water used under the same principle currently applied in the case of surface water supply), make use more efficient or limitations on extraction more practical ?

Problems relating to the second area, disputes between two parties:

a. Situations where a rich landlord or industrialist digs deep and extracts large amounts of water affecting the water supply in the shallow tubewells (and then selling water at exorbitant rates to the affected farmer) are not unimaginable. This problem may be taken care of by licensing. The cess can be used for recharging groundwater by building percolation ponds.

b. In cases where both parties have contesting claims, mediation can be provided by local panchayats or other municipal bodies in urban areas. NGOs can play an important role here. Whether this is more effective, or out of court settlement procedures more prudent is a researchable issue.

c. Conflict resolution has to be seen at a different level for interstate disputes. Even in highly developed countries, development of interstate groundwater has not been looked into very seriously. Legal frameworks will have to be looked into after consulting the available data and the broad powers of the federal governments to allocate water use rights among the municipalities or panchayats when they are unable to reach agreements. Though compacts are the most effective means of conflict resolution, in U.S.A., for instance, they have seldom been agreed to without resort to the court's decision. In India, the Interstate Water Disputes Act of 1956 gives power to the Central Government to establish Tribunals when a negotiated settlement is impossible. Whether such strategies are suited for groundwater regulation has to be researched.

Research issues relating to water quality:

a. Whether management of groundwater pollution has more serious implications than surface water pollution, since groundwater is more difficult to clean up once polluted.

b. Whether it is more cost effective to clean polluted aquifers or control pollution before it is released?

c. Whether legislative approaches used overseas and by international conventions have any bearing upon the Indian situation given the political, economic and social set-up of India.

d. What kind of administrative set up is most suitable for regulation of pollution. Is the existing framework in the Water (Prevention and Control) of Pollution Act, 1981 impossible to change? If not, what other alternatives can be suggested?

To summarise, given that the groundwater situation is different in varying hydrological and ecological conditions, it may be necessary to seek totally different types of legal regimes for different areas. This may demand area-wise decentralisation rather than an administrative, area-wise groundwater law. Where ecological issues are primary, the law may have to take into account surface water laws as well as those concerning forests and wild life. In other words, conjunctive use of water in a broad sense would have to be reflected in the law concerning groundwater. All these issues require extensive field research and consideration of their hydrological, ecological, social and institutional dimensions.

Selected Titles on *Forestry* from VIKSAT

Publications

1. Trees and Plantation Techniques (G)
2. Nursery Techniques (G)
3. Fruit Nursery (G)
4. Grasses For Wasteland Development
5. Nursery and Plantation Calendar (G,E,H)
6. Byelaws of Tree Growers' Cooperative Society (G)
7. Development of People's Institutions for Management of Forests (E)
8. *Naseeb Nu Pandedu*- Manual on Timru leaves Collection (G)
9. Footprints in Forest Protection (E,G)

News letter on Natural Resource Management

NIYATI- Bi-monthly (G)

Video

1. *Ekta No Vagdo* (People's Forest)- 20 Min (G,E)
2. *Jaja Hath Raliyamana* (Joining Hands Together)- 20 Min (G,E)
3. Nursery: Planning & Management - 20 Min (G)
4. *Sapnana Vavetar* (Microplanning Processes) 20 Min (E,H,G)

Slide Show

1. Nursery: Planning & Management- 55 Slides (G)
2. Soil-Water Conservation Techniques- 55 Slides (G)
3. Wastelands: Causes & Effects - 77 Slides (G)

G = Gujarati E = English H = Hindi

VIKSAT

VIKSAT was set up in the year 1977 as an activity of the Nehru Foundation for Development (NFD), a registered public charitable trust, founded by Dr. Vikram A. Sarabhai. VIKSAT's activities are governed by a Council of Management consisting of eminent persons in the field of natural resource management.

MISSION

VIKSAT aims, through interaction with Government Organisations, NGOs and People's Institutions, at promoting and strengthening People's Institutions with active involvement of men and women from all sections of the community for equitable, gender sensitive and sustainable development and management of natural resources.

ACTIVITIES

VIKSAT's major programme areas are Joint Forest Management (JFM) and Participatory Groundwater Management. At the grassroots level, VIKSAT works with the village communities in its field projects in Bhiloda taluka of Sabarkantha district and Kheralu taluka of Mehsana District in Gujarat.

The role of VIKSAT in the field programmes is to facilitate emergence of People's Institutions, build their technical and organisational capacities through training, enable their increased access to government schemes and assist them in implementing resource management activities. The focus of field programmes is to expand the scope of participatory natural resource management both in magnitude and quality.

VIKSAT also performs the role of a Resource Centre. VIKSAT provides support to NGOs, Government Organisations and People's Institutions working in the state through newsletters, publications and audio-visuals for information dissemination, training for capacity building and process documentation for experience sharing.

VIKSAT publishes a bimonthly newsletter NIYATI in Gujarati for wider dissemination of knowledge about issues, concepts and practices in environment and natural resource management. In 1995, VIKSAT initiated SAKSHAM - a network of People's Institutions and NGO's working in the forestry sector in the state - with a view to promote and strengthen People's Institutions.

VIKSAT is the Regional Resource Agency, appointed by the Ministry of Environment and Forests, for facilitating the National Environment Awareness Campaign (NEAC) in the state of Gujarat since 1988.